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DNA Barcoding-Applications in Insect Ecology

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Abstract: DNA barcoding has great potential as a species identification tool because it is practical and affordable to perform and, more often than not, shows species-level separations. Currently, efforts are on to barcode all major groups of animals including insects and millions of species have been barcoded. Other than as a species identification tool, DNA barcoding has been applied to solve many complex ecological phenomena. DNA barcoding is emerging as a simple and very reliable tool for studying host-parasitoid interactions and to establish the host range of phytophagous insects which has changed the perspective of many food webs. DNA barcoding has shown potential as incontestable identification tool for biosecurity purposes with global application. DNA barcoding is also being utilised to document the biodiversity of past and present with reasonable efficiency.

Key Words: Barcode of life, Biodiversity assessment, Cytochrome-*c* oxidase, Food web, Host range, Invasive species

Hebert *et al.* (2003a,b) proposed a technique to amplify a 648-base pair (bp) region of the mitochondrial cytochrome-*c* oxidase subunit 1 (*COI*) gene to ensure rapid and accurate identification of a broad range of biological specimens. They named this technique "DNA barcoding". Then, the Barcode of Life project was proposed to promote DNA barcoding as a global standard for sequence-based identification of eukaryotes. In 2004, this project was formally initiated by the establishment of the Consortium for the Barcode of Life (CBOL), aiming to develop a standard protocol for DNA barcoding and to construct a comprehensive DNA barcode library. Recently, the Barcode of Life project entered a new phase with the launch of the International Barcode of Life project (iBOL; International Barcode of Life, 2010). As for insects, campaigns for Lepidoptera, Trichoptera, ants (Formicidae), bees and other groups have been started (Jinbo *et al*., 2011). The Barcode of Life Data Systems (BOLD) is the official informatics workbench for the Barcode of Life project (Ratnasingham and Hebert, 2007), developed by the Canadian Center for DNA Barcoding (CCDB). BOLD provides a data repository for DNA barcodes, an identification support system based on them, and web services for other system developers.

Molecular-based identification is not a new concept. Many molecular identification systems have been developed, including a bacteria identification system using SrRNA sequences (Busse *et al.,* 1996). However, DNA barcoding has several advantages over previous methods. One advantage is its availability. The standard DNA barcode region, a fragment of *COI*, is very efficient for species identification. This region has good discrimination power for most animal groups. The universal primer, originally designed for marine invertebrates, can be applied to all animal phyla (Hebert *et al.,* 2003a,b, 2004a). A 648-bp fragment has enough information and can be directly sequenced with a sequencer. The alignment process is not difficult because this is a protein-coding region. Errors can be detected by checking whether the obtained sequence is translatable. These useful features are the reason why the *COI* region was selected as the standard DNA barcode. Verifiability of identification of voucher specimens through relationships with taxonomy is another advantage of DNA barcoding.

DNA barcoding and insect taxonomy

DNA barcoding has great potential as a species identification tool because it is practical and affordable to perform and, more often than not, shows species-level separations that mirror established taxonomy *(Boykin et al.*, 2012). Identifications using molecular data can help elucidate the relationships of morphologically variable individuals of the same species, such as individuals in different developmental stages, castes in social insects and sexually dimorphic individuals (Kathirithamby *et al.,* 2010; Murría *et al.,* 2010; Pauls *et al.,* 2010). In addition to the features of typical non-barcode molecular markers, the advantages of DNA barcoding include primer universality, the accumulation of information on a wide range of taxonomic groups, and its association with taxonomy. These advantages may aid the study of ecologically interesting insect phenomena, such as host plant alternation among aphids, extreme sexual dimorphism and heterotrophic heteronomy of Strepsiptera (Kathirithamby *et al.,* 2010). DNA barcode can detect illegal trade of endangered or protected insects, such as birdwing butterfly used for ornaments and some stag beetles kept as pets. For epidemiological purposes, rapid identification methods would facilitate the

monitoring of disease vectors such as mosquitoes. DNA barcoding has the potential to become a standard tool for species identification in these fields (Floyd *et al.,* 2010). Rapid identification of the larvae of pest species is very important for pest control. Doskocil *et al.* (2008) investigated the species composition and seasonal occurrence of turfgrass-infesting larvae of the *Phyllophaga* beetle (Coleoptera: Scarabaeidae) using a DNA barcode and proposed an efficient control strategy based on their results.

There is considerable controversy regarding the taxonomic perspective of molecular data, including DNA barcoding (Meier, 2008). There are two principal issues: species identification and species discovery. The most reliable way to obtain a DNA barcode that accurately represents a species is to base it on the type specimen of that species (Brown *et al.*, 2003). On the contrary, species discovery is defined as the taxonomic process of recognizing a cluster of individuals and/or populations as a single species. The DNA barcode can accelerate species discovery. First, DNA barcoding can be used to identify cryptic, previously overlooked species (Hebert *et al.,* 2004a; Janzen *et al.,* 2005). Second, DNA barcode information helps sort all specimens of related taxa, especially when taxonomic studies of these taxa are inadequate (e.g. Smith *et al.,* 2008). DNA barcoding cannot detect all candidates of undescribed species, especially for recently divergent groups. It is quite apparent that the DNA barcode itself is not a new species concept (i.e. a species cannot be defined based on the barcode only); neither does it provide enough information to describe unknown specimens as a new species. The results of barcoding can only suggest new species candidates (Waugh, 2007) as well as other valuable supporting information (e.g. distribution, life history, host plants and region of origin of species) for taxonomic studies (e.g. integrative taxonomy: Yoshitake *et al.,* 2008 and Schlick-Steiner *et al.,* 2010). Species descriptions using barcodes based on type specimens will become more common and important in the near future.

One of the most critical issues regarding DNA barcoding is its accuracy of species identification. Generally, the accuracy fundamentally depends on the extent of overlap between interspecific divergence and intraspecific variation. That is, the larger the "gap" between intra- and interspecific differences in genetic distance, the more successful the species identification (Hebert *et al.,* 2004b). When intra- and inter-specific distances are widely overlapped, DNA barcoding-based identification is not effective (Elias *et al.,* 2007; Wiemers and Fiedler, 2007). Overlap can be caused by several factors, including large genetic diversity in a species (DeSalle *et al.,* 2005) or paraphyly or polyphyly of species. Species may appear to be polyphyletic or paraphyletic in phylogenetic analyses due to incomplete lineage sorting of mitochondrial DNA, introgression or incongruence in the definition of morphological species. In such cases, supplemental analyses combined with other traits, such as nuclear genes, are required (Hebert *et al.,* 2003a; Baker *et al.,* 2009). Another factor that may lead to overlap is the incongruence between molecular data and the traditional definition of species, in particular when a group is poorly studied taxonomically (Meyer and Paulay, 2005). Such cases may be improved by integrative taxonomic revisions that combine genetic and morphological data (Kehlmaier and Assmann, 2010). The most important factor affecting the accuracy of species identification is the coverage and reliability of available barcode libraries (Ekrem *et al.,* 2007). As mentioned above, *COI* barcodes do not provide adequate information for species identification when intra- and interspecific distances are widely overlapped. However, one can identify samples by combining supplementary molecular data with *COI* barcodes.

Not surprisingly, insect DNA barcoding has hitherto produced contradictory results. Several studies showed that it is a reliable tool for the molecular identification of Lepidoptera (Burns *et al.*, 2008), Hymenoptera (Smith *et al.*, 2008; Fisher *et al.*, 2008), Coleoptera (Greenstone *et al.*, 2005) and Diptera species (Smith *et al.*, 2006, 2007). Yet, other studies questioned the adequacy of DNA barcoding in Lepidoptera (Elias *et al.*, 2007) and Orthoptera (Trewick *et al.*, 2007), while Meier *et al.* (2006) reported a remarkably low identification success for Diptera (<70% in simulations based on >400 taxa). The limited success of DNA barcoding evidenced by Meier *et al.* (2006) was attributed to the use of GenBank sequences, which supposedly include a high proportion of misidentified sequences (Ward *et al.*, 2009). Virgilio *et al.* (2010) reported that misidentification of queries without conspecifics in the databases (Type II error) is major reason for low identification success. Virgilio *et al.* (2010) proposed that the detrimental effects of Type II errors could be circumvented if insect DNA barcoding is used to verify the lack of correspondence between a query and a list of properly referenced target species (*e.g*. insect pests**).** Jinbo *et al.* (2011) accessed the data on number of insect barcodes in BOLD and reported a total number of insect specimens barcoded as 664,924 and total number of insect species barcoded as 79,320 (Table 1).

DNA barcoding for unravelling trophic relationships

Accurate description of host–parasitoid interactions is crucial for understanding host specificity, arguably the main parameter of host–parasitoid food webs. Knowing host specificity is important for estimates of arthropod diversity

Table 1. Current status of DNA barcoding library of insects (in the BOLD system)*

Insect order	Number of specimens barcoded	Number of species barcoded
Diplura	8	4
Archaeognatha	4	24
Thysanura	11	3
Ephemeroptera	7192	513
Odonata	3521	219
Dictyoptera	4	2
Blattaria	494	60
Isoptera	467	134
Mantodea	228	140
Dermaptera	49	6
Plecoptera	3221	400
Orthoptera	3395	654
Phasmida	87	25
Embioptera	19	11
Grylloblattodea	1	1
Mantophasmatodea	2	1
Psocoptera	70	3
Phthiraptera	527	85
Thysanoptera	880	103
Hemiptera	14518	2129
Neuroptera	769	99
Megaloptera	829	103
Raphidioptera	10	5
Coleoptera	18926	4428
Strepsiptera	9	7
Mecoptera	32	26
Siphonaptera	75	11
Diptera	61140	6182
Trichoptera	24003	3457
Lepidoptera	433843	47732
Hymenoptera	91024	12247

*Modified after Jinbo *et al.*, 2011

and explanations of its origin (Schemske *et al.*, 2009). In an applied context, it is crucial for the selection of biological control agents (Miller, 2007). The structure of the food web itself provides important information, as it can differ both qualitatively and quantitatively among habitats, seasons and guilds, and it is thus important to describe it as precisely as possible. The predator–prey relationships of insects are among the most poorly documented links of terrestrial food webs. (Rougerie *et al.*, 2010; Valentini *et al.*, 2008). The diet analysis of the animal species present in a given environment can improve our understanding of the functioning of the ecosystem as a whole (Duffy *et al.*, 2007). Furthermore, the study of feeding ecology becomes crucial when it concerns endangered species. A precise knowledge of the diet of these species can identify key environmental resources for designing reliable conservation strategies. DNA barcoding makes it possible to establish the diet of an individual from its faeces or stomach contents. This is helpful when the food is not identifiable by morphological criteria, such as in liquid feeders, for example spiders, mites and hemipteroid insect orders (Valentini *et al.*, 2008). Herbivory is the most widely observed feeding mode in insects (May, 1988) and tight ecological links exist between herbivores and their food plants. Therefore, information on the precise feeding source is important for studies of ecology, speciation, coevolution and applied sciences (Jurado-Rivera *et al.*, 2009).

To date, host–parasitoid interactions have been mapped by rearing the host larvae, until either a host or a parasitoid adult emerged. Rearing provides adult specimens that are tractable for taxonomic identification. The main caveat of rearing is that host identification must be based on the immature stage. This is often difficult or impossible and commonly leads to misidentifications. Thus, many literature records on trophic interactions are unreliable (Shaw 1994). Furthermore, low rearing success in combination with a naturally low rate of parasitism means that tremendous effort must be expended to get sufficiently large data sets for analysis of host–parasitoid interactions. Currently, there are two prevailing approaches to molecular identification of trophic links in host–parasitoid food webs and predator–prey food webs: species detection by PCR with specific primers and sequence based detection with general or group-specific primers. (King *et al.*, 2008; Traugott and Symondson, 2008). (Gariepy *et al.*, 2008). However, PCR approach does not allow recognition of unknown species, a crucial step for studying complex communities, where new species are commonly encountered in the course of the study (Janzen *et al.*, 2009). An alternative approach is sequence-based detection. Sequences of the target gene can be obtained by various ways that separate the DNA from the different organisms involved in the interaction. Another possibility is to use group specific primers (Deagle *et al.*, 2009). DNA is resilient to degradation when ingested by organisms with diet or prey (Symondson, 2002). Valentini *et al.* (2009) reported that from three grasshopper faeces (two from *Chorthippus biguttulus*, and one from *Gomphocerippus rufus*) and other animals, about 50% of the taxa can be identified to species using the *trn*L approach. Thus, the presence of prey DNA in predator samples has been successfully exploited to identify prey species (Greenstone *et al.*, 2007). DNA barcoding when used in comparative studies, e.g. for the analysis of host plant associations, the sequence fragments are used by linking them to a named species or DNA-based group to which ecological information from literature or field observations has been associated (Hebert *et al.*, 2004b).

These groups and their host information provide the starting point for analysing coevolutionary relationships of plants and herbivores. A key aspect in these studies is the authentication of the feeding source, whereby the strongest evidence linking an individual to the food plant is provided through analysis of ingested host tissue (Jurado-Rivera *et al.*, 2009). DNA based approaches could greatly facilitate this step, in particular if the DNA of the food source could be obtained directly from the insect tissue.

Li *et al.* (2010) revealed actual host utilization of fig-associated *Sycophila* wasps (Hymenoptera: Eurytomidae) using both barcode and non-barcode sequences. Jurado-Rivera *et al.* (2009) estimated host specificity of Australian leaf beetles (Coleoptera: Chrysomeridae) and their associations with plants using the DNA barcoding approach and identified the DNA barcodes of undiscovered host plants, revealing previously unknown host plants for beetles. The study also revealed that phylogenetic analysis of beetles shows general conservation of host association but with rare host shifts between distant plant lineages, including a few cases where barcodes supported two phylogenetically distant host plants. Matsuki *et al.* (2008) showed that food habit of phytophagous insects can be estimated by amplifying plant DNA from their faces. Numerous studies have been conducted to reveal the trophic relationships between predator and prey or herbivore and plant by detecting prey or host DNA from the gut contents or faeces of the predators or herbivores using specific primers or antibodies (reviewed in Sheppard and Harwood, 2005; Fournier *et al.,* 2008; King *et al.,* 2008). Tokuda *et al.* (2009) identified gall midge larvae inducing gall on cultivated roses in Japan using DNA barcode and revealed that the gall midge species which associated with wild roses occasionally feed on cultivated roses. Clare *et al.* (2009) amplified DNA barcodes from guano of the Eastern red bat *Lasiurus borealis* to estimate the composition of the bat's prey. Quantitative analysis of DNA barcodes revealed that the bats prey mostly on Lepidoptera except for Arctiidae. DNA barcode enables researchers to trace not only trophic links, but also changes in diet according to season or the developmental stage of an insect (e.g. Davidson and Evans, 2010). Quantitative analyses such as pyrosequencing may make trophic studies using the DNA barcode more comprehensive, quicker and easier, as discussed by Deagle *et al.* (2009). Despite this, DNA barcoding is not a perfect tool for trophic ecology. For instance, researchers can not estimate a target animal's complete feeding habit only by animal barcodes when the target is omnivorous (polyphagous), consuming not only animals but also plants, fungi and detritus. In addition, PCR does not reveal whether an amplified fragment originated from predation or scavenging. Furthermore, the high sensitivity of PCR-based methods may lead to misleading results about feeding habit based on gut content: universal primers amplify DNA fragments originating not only from predator's gut contents but also from prey's gut contents. These problems can be reduced by combining DNA barcoding with other methods such as stable isotope analysis using d13C and d15N in animal tissues, as discussed in Okuzaki *et al.* (2010). **Kishimoto-Yamada *et al.* (2013)** employed DNA barcoding to reveal the trophic associations of adult leaf-chewing chrysomelid beetles and revealed a complex plant-insect network of the Bornean rainforest. **Pumariño *et al.* (2011)** provided a useful tool to detect and to identify plant food sources of arthropods and to evaluate crop colonization from surrounding vegetation in conservation biological control programs. The results are of particular importance as many of the predators are omnivorous.

Through the application of a DNA analysis of gut contents in adult parasitoid wasps, Rougerie *et al*. (2010) were able to selectively sequence a diagnostic DNA marker that permitted the identification of the host used by these wasps during their larval stages. By reproducing these results in species with different life histories, other potential sources of host DNA were excluded, confirming that after ingestion by the parasitoid larva the host DNA can persist through metamorphosis in the abdominal contents of the adult wasp. Hrcek *et al.* (2011) tried to unravel complex caterpillar–parasitoid food web from tropical rainforest of Papua New Guinea. The study affirmed 93 hitherto unknown trophic links between 37 host species from a wide range of Lepidoptera families and 46 parasitoid species from Hymenoptera and Diptera by identifying DNA sequences for both the host and the parasitoid involved in the interaction. Smith *et al.* (2011) DNA barcoded over 10% of the insects collected from the SBW food web and postulated that food web barcoding provides an effective tool for understanding the cascading effects for future outbreaks in case of spruce budworm. Insect parasitoids play a major role in the processes governing the population dynamics of spruce budworm (*Choristoneura fumiferana* – SBW) throughout eastern North America. However, these species are at the leading edge of the taxonomic impediment and integrating standardized identification capacity into existing field programs would provide clear benefits.

Host–parasite systems have been models for understanding the connection between shifts in resource use and diversification (Wilson *et al.,* 2012). Kitson *et al.* (2013) tried to quantify dietary variation across populations and to characterize the nature of a trophic shift of *Cratopus murinus*

and its close relative *C. ovalis*. Data suggested that local diet variation is largely explained by food availability, and locally specialist populations consume food plants that are not phylogenetically novel, but do appear to represent a novel preference. Kaartinen *et al.* (2010) used DNA sequence 'barcode' identification to screen a complex web for morphologically cryptic species and to re-examine key descriptors of food web structure. This system consisted of the communities of leaf-mining and gall-inducing insects associated with pedunculate oak, *Quercus robur*. Based on morphological characters, 51 parasitoid species and 5 inquilines were distinguished. Molecular markers revealed four morphologically cryptic parasitoid taxa and completely changed the view of species limits among the inquilines. Itou *et al.* (2013) used DNA barcoding to evaluate the preying efficiency of *Nesidiocoris tenuis* an important predator of greenhouse pests such as whiteflies, thrips, leafminers, lepidopterans, and spider mites.

Barcoding for Biosecurity

Biosecurity is emerging as one of the most important issues facing the international community (Armstrong and Ball, 2005). Traditionally it has been associated with risks from infectious diseases, living modified organisms and biological weapons, but in the very broadest sense it encompasses minimizing risk through 'biological harm' (Meyerson *et al.*, 2002). Not least is the economic risk from invasive alien species (IAS) that threaten ecosystem stability, producer livelihoods and consumer confidence (Cock *et al.* 2003). That risk is facilitated by the movement of exotic species around the world through increasing international tourism and trade, and is influenced by changes in climate and land use. Of those species introduced to novel environments an estimated one percent is anticipated to become invasive and with serious economic impacts (Williamson, 1996). Globally as many as 80% of the endangered species are threatened and at risk due to IAS (Mandal, 2011).

Several studies demonstrate the efficacy of DNA barcoding as applied to invasive species detection and determination of native provenance, including work on agromyzid leafminers, tephritid fruit flies, ants, siricid wasps, true bugs, the cactus moth, the European poplar shoot borer, and nocturnal moths (deWaard *et al.*, 2010). Scheffer *et al.* (2006) surveyed outbreaks of invasive leaf miner pests (Diptera: Agromyzidae) in the Philippines and found the presence of three species of *Liriomyza.* Another barcoding study reported four unrecorded alien species at an urban park in Vancouver, Canada (deWaard *et al.,* 2009). Identification performance was tested using three important pest groups of Lepidoptera, a species group of *Lymantria*, yellow peach moth (Crambidae: *Conogethes*) and fall web worms (Arctiidae: *Hyphantria*) by Armstrong (2010) with good results. Jinbo, *et al.* (2011) tested the applicability of DNA barcoding for two groups, tussock moths (Lepidoptera: Lymantriidae: *Lymantria* and *Orgyia*) and fruit flies (Diptera: Tephritidae). The integration of DNA barcoding into national bio-surveillance programs has been protracted, but acceptance by certain agencies is apparent which incorporates barcoding into the diagnostics of various invasive species (deWaard *et al.*, 2010).

The rapid and accurate identification of invasive species is indispensable in terms of biosecurity being perceived as the most serious threat to biodiversity. For this purpose, global coverage in the DNA barcode library is of great value. *Boykin et al.* (2012) examined the genetic data coverage and availability in the Barcode of Life Database (BOLD), versions 2.5 and 3.0, and GenBank for the 88 invasive insects listed in the Global Invasive Species Database (data are recorded in either BOLD or GenBank for seven of those species. As a dedicated repository of curated barcode data BOLD is either missing data or contains inaccessible private data for 37 (42%) of the species while no data are available in GenBank for nine (8%) of the species. An evaluation of the Barcode Identification Number (BIN) scheme in BOLD ver. 3.0 was also evaluated and in 41% of cases the BIN contained more than one species. This essentially arose due to the 1% delimitation thresholds associated with the BINs and would result in misidentifications. Overall, more information is available from GenBank for the 88 invasive species listed on the Global Invasive Species Database, but quality checking is required to ensure that the data extracted from GenBank are of sufficient quality to make it useful.

deWaard *et al.* (2010) studied the taxonomic and geographic coverage of the DNA barcode reference library to test the utility of this diagnostic method, both for species/subspecies assignment and for determination of geographic provenance of populations of species in the tussock moth genus *Lymantria.* Cytochrome oxidase I (COI) barcodes were obtained from 518 individuals and 36 species of *Lymantria*, in Canada. A maximum likelihood tree was constructed, revealing high bootstrap support for 90% of species clusters. The performance of barcoding was also compared against the commonly employed NB restriction digest system (also based on COI); while the latter is informative for discriminating gypsy moth subspecies, COI barcode sequences provide greater resolution and generality by encompassing a greater number of haplotypes across all *Lymantria* species, none shared between species. deWaard *et al.* (2010) concluded that the efficacy of DNA barcodes for

diagnosing species of *Lymantria* reinforces the view that the approach is an under-utilized resource with substantial potential for biosecurity and surveillance and that the biomonitoring agencies currently employing the NB restriction digest system would gather more information by transitioning to the use of DNA barcoding, a change which could be made relatively seamlessly as the same gene region underlies both protocols.

Boykin *et al.* (2012) described and recommended a novel 'tip to root approach' where careful consideration of species delimitation is required to support crucial biosecurity decisions based on accurate species identification. They used the approach for species delimitation of two highly invasive insect pests, *Bemisia tabaci* (sweetpotato whitefly) and *Lymantria dispar* (Asian gypsy moth). Both species are of concern to biosecurity, but illustrate the extremes of phylogenetic resolution that present the most complex delimitation issues for biosecurity; *B. tabaci* having extremely high intraspecific genetic variability and *L. dispar* composed of relatively indistinct subspecies. They tested a series of analytical options to determine their applicability as tools to provide more rigorous species delimitation measures and consequently more defensible species assignments and identification of unknowns for biosecurity. Data from established DNA barcode datasets were used as an example employing various analytical approaches. In the species cases studied, the results clearly indicate that there is a need for more gene sampling to substantiate either the new cohort of species indicated for *B. tabaci* or to detect the established subspecies taxonomy of *L. dispar*. Given the ease of use through the Geneious species delimitation plugins, similar analysis of such multi-gene datasets would be easily accommodated.

DNA barcoding has become increasingly common since it was proposed and will become a standard identification protocol for various organisms. Despite some pitfalls, the technique has emerged as a blessing for quick identification of such diverse taxa as insects. It has been shown to that DNA barcoding can increase the pace and efficacy of such ecological endures as biodiversity assessment and trophic ecology. For its extensive use for biosecurity purposes, the barcode libraries need to be strengthened with global collaboration.

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Insect Biodiversity of Brinjal Crop in Kashmir

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Abstract: Field research was conducted in Kashmir to investigate the arthropod biodiversity in the brinjal. Total 13 species of plant harmful arthropods belonging to 6 different orders, including 12 species of foliage feeders. The brinjal shoot and fruit borer (*Leucinodes orbonalis*), Epilachna beetle (*Epilachna* sp.), white fly (*Bemisia tabaci*), jassid (*Amerasca biguttula biguttula*) and aphids were dominant and major insect pests of the brinjal. Coleoptera had higher diversity index of 0.186 followed by ants with diversity index of 0.762.Predaceous arthropods belonged to eight orders, occupied by ten families. Spiders mainly Lycosidae family contributed higher frequency and ranked as second most important arthropods with relative abundance of 0.230 followed by family formicidae.

Key Words: Arthropods, Biodiversity, Brinjal, Diversity, Insect 295

Eggplant (*Solanum melongena* L.) also called aubergine or brinjal, is one of the top ten vegetables in the world. India is the second largest producer with total area and production of 0.639 mha and 106.83 MT respectively, and average productivity of 17.7 MT/ ha (Anonymous, 2014). Among the states, area under this crop in Jammu and Kashmir is 850 hectare with the production of 17057 metric tons and productivity of 21.03 metric tons per hectare (Anonymous, 2014).

Arthropods are important components of ecosystem (Klink *et al*., 2015) occupying a vital position in the food web dynamics of populations and communities. In vegetable ecosystem the population ecologists discussed diversity of arthropods in two aspects, species richness (i.e. number of species in a set of samples) and equitability that is number of individuals of each species in each sample (Chakraborty *et al*., 2014). In the brinjal field various arthropod species both pests and natural enemies prevail during seedling to harvesting stage. El-Shafie (2001) observed 28 species of insect pests under seven different insect orders from brinjal ecosystem, whileas; Nayer *et al* (1995) reported 53 species of insect pests of brinjal crop. Aphid (*Aphis gossypii*), jassid (*Amrasca biguttula biguttula*), white fly (*Bemicia tabaci*), brinjal shoot and fruit bore(*Leucinodes orbonalis*) and epilachna beetle (*Epilachna* sp.) were the major insect pests in brinjal field (Hossain, 2012). Although several researchers published reports on pests of brinjal elsewhere however, information about total arthropod community in brinjal agroecosystem is limited. So our objective was to observe arthropod biodiversity in under temperate conditions of Kashmir.

MATERIAL AND METHODS

The experiment was laid out in the field of SKUAST-K, Shalimar in the summer season during the cropping period from June to November of 2011 and 2012. Geographically it is stretched between 32° 17 to 37° 60 N latitude and 73° 26' to 80° 30 E longitudes, with an elevation of 1650 m from mean sea level. The site was located in the temperate climatic zone, characterized by scanty rainfall during the growth season of the crop. The soils of the experimental location were clay loam in texture and acidic in the PH of 5.8-6.0.The study field was divided into the three plots of equal size, each plot was divided further into twelve sub plots with plant to plant and row to row distance of 45x60m.The 12 brinjal genotypes like Shalimar Brinjal Long-217, Local Long, Brinjal Oblong, Brinjal Purple Long, Shalimar Brinjal Purple Long-42, Shalimar Brinjal Hybrid-1, Shalimar Brinjal Purple Round-8, Dilruba-2, Brinjal-85, Shalimar Brinjal Long-208, Shalimar Brinjal Hybrid-2 and Shalimar Brinjal Purple Round-1were grown as per package of practices recommended by SKUAST-K, Srinagar.

Data Collection

The data were collected from all the subplots and no comparison were made between the different resistant categories of the brinjal genotypes screened. The number of species was simple measure of species diversity. However for limitation of species identification, concept was restricted to order and family level in most cases. The counting of individuals was done by following one absolute method *viz*, visual searching method and two relative methods viz., pitfall trap and sweeping net.

Visual searching method : Adult whiteflies, jassids nymphs, and aphids were counted by random sampling of

the ten plants taken from each plot. Five leaves were chosen randomly on each plant, two from bottom (older leaves), one from middle and two from top (younger leaves). The lower surfaces of leaves were properly examined for the presence of any insect. The counting of insects was done before 8:30h to avoid the mobility of the insects from the leaves, nevertheless movement of fast moving insects from one plot to another could not be totally avoided. The data of the years 2011-2012 were pooled over cropping seasons (June to November) and were combined to provide an overall average per plot. The population of spider, lady bird beetle, ants and sessile insects' nymphs and larvae of flying insects on the brinjal plants were counted for five branches selected randomly from ten plants of each plot randomly at weekly interval. The population densities of each insect were expressed as number of insects per 10 leaves of plant.

Sweeping method : This method is mainly used for counting all insects (flying and sessile) on the brinjal plants to determine the abundance pattern of the insects in the experimental field. Five to six times return sweeping was done in each plot to draw a composite sample by a sweeping net after every two weeks interval. Each sample was examined separately without killing the insects and released them in the same plot after counting. The individuals of each sample were counted by family.

Pitfall method: Ground beetles, spiders, ants, beetles, earwigs, crickets and collembolaetc were determined by this method as these insects roam in the soil surface. Plastic pots having diameter of about 10cm and 8.0cm deep were used. Three traps were placed in soil in each of the plots and mouth of the plot was kept at ground level so as not to disturb the insect movement. Pot was filled to 3/4 of volume with 2% formalin-water, a drop of detergentand 2% formol as a trapping fluid during the investigation. After 48 h of the setting traps, the trapped arthropods were emptied with a sieve and funnel into small plastic bottles filled to the half with 70% alcohol. The samples were labeled and stored at room temperature until sorting, counting and finally were identified. The traps were set at two weeks interval throughout the cropping season and insects were collected and counted separately from each experimental plot.

Sex pheromone trap: Lucilure were used in the bottle traps installed in the brinjal plots for the estimation of the nocturnal lepidopteran moth population e.g, brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee).

Insect Diversity Index

Estimate of the diversity are usually dependent on the sample size, and pooled and quadrant plots revealed at what sample size estimates stabilize. The species richness is one of the important and difficult to measure. Examining the species accumulation as a function of the number of individuals provides the information about the species density, but the species accumulation as function of the number of the individuals is the better method for investigation of the species richness of the whole community. Abundance pattern and Species richness in brinjal field were determined by Simpson's diversity index given by formula

Where, P_i is the proportion of individual for the ith insect family and S is the total number of the insects in the community that is richness. The value of index depends on both the richness and the evenness with which individuals were distributed among the families. Equability was quantified by expressing Simpson's Index (D) as a proportion of the maximum possible value of the D.

RESULTS AND DISCUSSION

Plant dwelling harmful arthropods : Total of nineteen species of insect pests were observed from the brinjal agroecosystem throughout the cropping season from June to October, 2012, plant dwelling harmful arthropods belonged to 13 different insect families under 6 orders (Table 1). Two species of insect pests belonging to orders lepidoptera (Family: *Pyralidae*) and diptera (family: *Muscidae*) were found to damage the reproductive parts such as flower buds and fruits, one species belonging to order diptera (Muscidae) was found to damage stem and roots and, overall 12 species caused injury to the foliage. Maximum of the insect pests belonged to two orders such as Lepidoptera and Orthoptera, while as only two species belonging to orders coleoptera and diptera each. Minimum of the insects belonged to orders Hemiptera and Homoptera were one species each. In terms of species composition Lepidoptera and Orthoptera occupy the top composition with 4 (One unidentified) and 3 (two unidentified) species, respectively. In coleopteran order the family *Carabidae* had the diversity index of -0.18621, followed to the hymenopteran (Ants). Hemiptera and Homoptera were least diversified among the plant dwelling arthropods. Two important sucking insect pests are jassid and white fly causing serious damage in brinjal during the current study. Insects like leaf rollers, leaf beetle, red pumpkin bug, flea beetle, semilooper, hairy caterpillar (*AntobaOlevacea*), green vegetable bug (*NezaraViridula* L.), hooded hopper (*Oxyrachisterandus*Fab.), elaterid beetle etc. were observed as phytophagous but they cause very little damage to the brinjal crop and were less conspicuous. Although the number of harmful species seems to be high, the significant crop damage was caused by only 4-5 key pests. Among beneficial insects spiders, lady bird beetles and carabid beetles were the most frequent. Both pest and natural enemy population of arthropods were observed in the

brinjal agroecosystem. Among pests species, five were found as major pests in the study and sucking pests were becoming alarming for the crop. Whereas, ants, beetles and spiders were the most common predatory arthropods in the brinjal field.

Relative abundance of the different insect pests: Brinjal shoot and fruit borer (Guenee) was ranked first with respect to the frequency followed by epilachna beetle (*Epilachna* spp. Mots.).Therefore, by number the sucking insects such as whitefly and aphids occupied the top position in the brinjal agroecosystem. Relative abundance of surface dwelling arthropod recovered from the pitfall trap method in the brinjal field. Shoot and fruit borer was lower than Jassids in the field, but it was the major pest of the brinjal in terms of shoot and fruit damage. Due to the nocturnal habit of shoot and fruit borer the adult moths were collected through the sex pheromone trap during the night. Next to the brinjal shoot and fruit borer are white fly, epilachna beetle and aphids as the important pests of brinjal.

Plant Dwelling Predaceous Arthropods: Predaceous arthropods were grouped into10 families under 7 taxonomical orders. Coleoptera was the most important order of plant dwelling predatory insects, occupied about 40.98 % of the total predators under 3 different families such as *Coccinellidae,Staphylinidae* and *Carabidae*. The rest of plant dwelling predacious insect orders were Hemiptera and Hymenoptera causing damage at adult stage. Diptera and Dictyoptera, comprised of about 26.68% of total arthropods. Spider was the single major plant dwelling predaceous arthropods under the family Lycosidae comprised of about 29.55% of the recorded total predatory arthropods found. Over the flowering brinjal the predatory arthropods found were common dragonflies of different species.

Surface Dwelling Arthropods: The arthropods captured by pitfall traps from the brinjal agro-ecosystem during the study period were considered as surface dwelling. They were grouped into 15 families as shown in Table (2), falling under different orders, species of order Collembola were very little, therefore remain unidentified. Formicidae was the most abundant family and ranked as first in terms of frequency followed by *Lycosidae* and *Carabidae*, which occupied the 2nd and 3rd position, respectively. The other frequently occurring arthropod families were *Collembola*, *Muscidae, Gryllidae Cicadellidae* and *Forficulidae.* Although insects of some families such as, *Asilidae, Tetranychidae* and *Cicadellidae* etc., were plant dwelling or flying however, they fell into the pitfall trap during their movement and were thus included in the surface dwelling arthropods. The faunistic analysis of pitfall catches further revealed that the number of surface dwelling predaceous arthropods families were 7 such as

Table 1. Diversity of plant dwelling insect pests in the brinjal (2011-12)

S. No	Order	Family	Total abundance	Pi	Diversity index (D)
1	Coleoptera	Carabidae	54	0.070039	0.18621
		Cicindilidae	6	0.007782	0.03779
		Staphylinidae	8	0.010376	0.04743
		Elateridae	19	0.024643	0.09126
2	Hymenoptera	Formicidae	590	0.765240	0.08075
3	Lepidoptera	Pyralidae	5	0.005431	0.02764
4	Diptera	Muscidae	28	0.036316	0.12041
		Asilidae	6	0.007782	0.03779
5	Dermoptera	Foriculidae	22	0.028534	0.10149
6	Orthoptera	Gryllidae	24	0.031128	0.16840
		Acrididae	4	0.005188	0.02731
		Tettigoniidae	3	0.003891	0.02159
		Gryllotalpidae	7	0.009079	0.04269
7	Aranae	Lysocidae	178	0.230866	0.14320
8	Acarina	Tetranyhinichidae	9	0.011673	0.04802
9	Homoptera	Cicadellidae	32	0.041504	0.12609 0.07012
		Allerodidae	13	0.019821	0.07329
		Jassidae	15	0.021091	0.09801
		aphididae	20	0.025019	
10	Collembola	VeryLittle, unidentified	53	0.700170	0.00908
Total	10	16	1096	-	-

Table 2. Diversity and population contribution of arthropod (2011-12)

Order	Family	Site of damage	Equability (%)	Population frequency
Coleoptera	Cicindilidae	Leaf	0.43	0.772
	Carabidae	Leaf		7.001
	Staphylinidae	Leaf		1.031
	Elateridae	Leaf		2.463
Diptera	Syrphidae	Stem/shoot		0.778
	Muscidae	Fruit		3.631
Hemiptera	Cicadellidae	Leaf/stem		1.298
	Allerodidae	Leaf/stem		1.09
	Jassidae	Leaf/stem		1.75
	aphididae	Leaf/stem		2.12
Dermoptera	Foriculidae	Leaf/stem		2.853
Orthoptera	Gryllidae	Leaf		3.113
Aranae	Lysocidae	Natural enemy		23.08
Acarina	Tetranyhinichidae	Leaf/stem		1.167
Homoptera	Cicadellidae	Leaf		4.150
Lepidoptera	Pyralidae	Shoot/ fruit		1.031
Hymenoptera	ants	-		28.98
Total : 10	16			59.31

Formicidae, Lycosidae, Carabidae, Gryllidae, Forficulidae, Staphylinidae and *Cicindellidae* under 5 orders (Table.3). Among the surface dwelling predaceous arthropods, *Formicidae* ranked top (69.33%) followed by *Lycosidae*, which occupied the second position (16.37%). Considering frequency, *Carabidae* was 3rd major family of predaceous arthropods (7.50%) and *Gryllidae* occupied the 4th position (2.86%). The individuals under the *Staphylinidae* and *Cicindellidae*families were 0.89% and 0.69%, respectively.

The findings on the insect diversity in brinjal added some new species and variations in status of the recorded insect pests, although there is cognizance in many cases as reported by other researchers. Alam*et al*. (2003) reported that three insects were becoming alarming pests of brinjal in different regions of Bangladesh, among them white fly (*Bemisia tabaci*) and red mite (*Tetranychus biculatus*) in Jessore regions and jassids (*Amrasca biguttula biguttula*) in Gazipur region, however these had less significant incidence in the present study. Although the number of insect pest species of brinjal in the present study compared to Bangladesh and other brinjal growing countries, the difference and similarity in composition and the variations might be due to climatic conditions. The present results also partially agree with the findings of the El-Shafie (2001) who recorded 28 species of insect pests under 7 different insect orders from the eggplant ecosystem of tropical areas of Sudan. In present investigations 12 species of insect pests were associated with damage on the foliage and 3 species were associated with fruits, stems as well as shoots. Bhadauria *et al*. (1999) recorded only 13 species of insect pests on brinjal during the summer and Kharif season in Madhay Pradesh, and pests *viz.* shoot and fruit borer, jassid, aphids, leaf roller and stem borer (*Euzophera perticella*) were the most common. Similarly Latif *et al*. (2009) from Bangladesh recorded 26 species, including 17 species of predaceous arthropods. The major insect pest of brinjal in present study was the *L.orbonalis* which caused serious damage especially during the fruiting stage. Although, some researchers reported thrips and red mites as important sucking pests in some location (Aganon *et al*., 1997) but they were not found so serious in the present study. However, the variation of the results is logical because arthropod complex may vary in different geographic locations and season of the year. The results regarding the plant dwelling predaceous and surface dwelling arthropods of the present study suggest that Coleoptera are the most important plant dwelling predaceous arthropods in the brinjal ecosystem. Moreover, most of the surface dwelling arthropods are predators. *Formicidae, Lycosidae, Carabidae* and *Forficulidae* are the most frequently occurring surface dwelling predator families in the brinjal agroecosystem. The present findings also agree with the results of El-Shafie (2001), who reported that Coleoptera had occupied 60% of the total plant dwelling predators and *Formicidae* and were also the most frequently appearing surface dwelling predators in brinjal agroecosystem in present study.

Table 3. Relative abundance of soil arthropods in the brinjal field during the cropping seasons (2011-12)

Order	Family	Common name	Stage observed	Frequency (Rel. abundance)
Hymenoptera	Formicidae	Ants	Adult	76.52[e]
Neuroptera	Chrysopidae	Green lace wing	Nymph and adult	0.012[a]
Coleoptera	Carabidae	Carabid beetle	Adult Egg, larvae,	11.28[b]
	Coccinellidae	Lady bird beetle	pupa and adult.	7.86[b]
	Staphylinidae	Staphylinidae beetle	Adult	6.66[b]
			Larvae and adults	
Diptera	Syraphidae	Hover fly	Larva and adult	4.41[a]
Lepidoptera	Pyralidae	Shoot and fruit borer	larva	2.34[a]
Homoptera	-	Bugs	Adult	72.53[d]
Dictyoptera	Mantidae	Praying mantid	Nymph and adult	2.22[a]
Aranae	Lycosidae	Lynx spider	Adult	23.08[c]
Orthoptera	Gryllidae	-	adults	4.93[a]

*Superscripted figures defines the significance of the data at P<0.05%

Table 4. Brinjal shoot and fruit borer moth catch by lucilure (2012)

Pest activity period	Moth catch/trap/night
4th week (June)	3.26[c]
Ist week (July)	4.0[c]
2nd week	5.0[d]
3rd week	5.25[d]
4th week	5.24[d]
Ist week (August)	3.25[c]
2nd week	3.10[c]
3rd week	2.85[b]
4th week	1.75[b]
Ist week (September)	0.50[a]
2nd week	0.25[a]

Means followed by the same letter in a group are not significantly different P= 0.015 by Newman- Keuls multiple range test on log (x + 1) transformed data

To sum up various arthropod species both pests and natural enemies prevail during the seedling to harvesting stages. Among the natural enemies the insects predominately belonging the diptera, neuroptera and coleoptera was most dominant. Among the pest complex brinjal shoot and fruit borer (Lepidoptera) was very destructive.

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Floristic Analysis of Peri-Urban Homegardens of Southern Kerala, India

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Abstract: Field survey was conducted to study the structural and functional features of the peri-urban homegardens of southern Kerala, India. 90 homegardens with 30 each belonging to three holding size classes viz. large (> 0.08 ha), medium (0.04-0.08 ha) and small (0-0.04 ha) were surveyed from Neyyatinkara Municipality area, Trivandrum. Altogether, 95 species were recorded belonging to 80 genera and 35 families in large homegardens. Shannon's diversity index was 3.77, 3.23 and 3.87 respectively for large, medium and small homegardens and respective value for Simpsons Dominance Index 0.92, 0.89 and 0.81. The average tree density of small, medium and large classes was 147, 165 and 76 and number of species per homegarden was 24, 48 and 94, respectively. Implicit in the floral diversity is high in large homegardens compared with small and medium holdings. The overall decline in tree diversity, density and low dependence of homegardens for livelihood and nutritional demand suggest the ill fated status of the traditional homegardens of Kerala.

Key Words: Floristic diversity, Functional diversity, Shannon diversity index, Simpson's floristic diversity index, Tree density

Agroforestry combines biophysical stability and socioeconomic adaptability, which are critical for a vibrant and diversified agriculture to address both ecological and socioeconomic concerns (Guillerme *et al.,* 2011). Tropical homegardens are typically such unique land-use systems involving the deliberate management of multipurpose trees and shrubs in intimate association with herbaceous species (mainly annual, perennial, and seasonal agricultural crops), and livestock, all managed within the compounds of individual homes. It is a traditional land use practice around a homestead where several plant species are maintained by members of the household and their products are intended primarily for household consumption (Shrestha *et al.,* 2001). In addition to efficient nutrient cycling, high biodiversity, low use of external inputs and soil conservation potential, they provide a diverse and stable supply of socioeconomic products and benefits to the families that maintain them.

The state of Kerala is known for the traditional homegardens from time immemorial. Compared to many tropical homegardens, species diversity and abundance are high in homegardens of Kerala (Kumar and Nair, 2004). A new species may be introduced because of its properties, i.e., food, wood, medicinal, religious, ornamental, and based on self interest or information passed on by neighbours and relatives. The women members play a vital role in the introduction and maintenance of gardens (Akhter *et al.,* 2010). Despite the multifunctionality and the perceived ecological benefits, the traditional homegardens of Kerala are passing through undesirable transformations. The demographic pressure on the land and resources is all time high in the recent times that has lead to changing land use and cropping patterns in Kerala. There has been substantial decline in homegarden size and diversity. Yet another reason for the decline in the diversity and structure of homegardens of Kerala could be attributed to the faster urbanisation (Gangopadhyay and Balooni, 2012). However, such information on these unique land management systems under transformation and the potential drivers of such changes are to be further explored. This will help to devise sound strategies that help to conserve this unique ecosystem without compromising economic and ecological viability. In this back drop, an attempt has been made to study the structural and functional characteristics of homegardens in the southern Kerala that are subjected to urbanisation.

MATERIAL AND METHODS

Detailed house-hold survey of individual farmers belonging to various holding size such as small (< 10 cents; 400 m^2), medium (10- 20 cents; 400-800 m^2) and large (> 20 cents; > 800 m^2) in 44 words of Neyyattinkara Municipality, Kerala was conducted. The wards were selected through a stratified random process at 10% sampling intensity. A total of 90 homesteads were surveyed, 30 each belonging to small, medium and large farmers during 2012-13. The survey included detailed analysis of various components in respect of their nature (species composition), arrangement in space and time (vertical and horizontal), cropping pattern, etc. The species were classified according to their functional

attributes into categories such as timber, fruits, food crops, spices, medicinal plants, multipurpose trees (MPTs) and others. Plants were identified in respect of taxonomic position with the help of the standard flora (Hooker, 1872 and Gamble, 1915; Manju *et al.*, 2008). For assessing the plant species diversity, Simpson's diversity index, Shannon –Wiener diversity functions and Equitability index were assessed (Simpson, 1949; Shannon & Wiener, 1963).

RESULTS AND DISCUSSION

The traditional homegardens of Kerala, has been subjected to large scale changes in the recent times. Ninety five tree species were recorded from Neyyattinkara municipality. The number of trees per homegarden was highest (46) in large homegardens as compared with the medium (18) and small (3) homegardes. Principal species was coconut regardless of the holding categories. Other common tree species present in the homegardens included *Ailanthus triphysa, Mangifera indica, Artocarpous herterophyllus, Tectona grandis, Artocarpus hirsutus, Thespesia populnea* and *Psidium guajava.*

There has been large variability in the diversity of plant species in the traditional homegardens of Kerala, which was strongly bound by regional differences. For instance, the earlier reports ranged from 30 (Nair and Sreedharan, 1986) to 127 species (Kumar *et al.,* 1994). Recent reports indicate high diversity of 463 species from high rainfall humid central Kerala, of which 208 were trees, 86 shrubs and 169 herbs (Kumar, 2011). Such variable accounts of species diversity have been reported from other parts of India as well. 122 species from homegardens in Barak valley of Assam (Das and Das, 2005), while high figure of 294 species from the upper Assam (Devi and Das, 2012).

The large homegardens represented 94 species while the medium 48 and lowest of 24 by the small gardens. Saha *et al.* (2009) observed 96 species from smaller (size < 0.4 ha) while 105 species from large (> 0.4 ha) homegardens. However, this trend is not in line with the earlier observations where species diversity declined with increasing homegarden size (Kumar *et al.,* 1994). The primary reason for such high diversity associated with small homegardens is that the farmers maintained high assemblage of plants that are closely related to the livelihood and nutritional requirements of the household. The presence of Neyyar natural forests and the Neyyar river adjacent to the Neyyatinkara Municipality may have positively contributed to this high diversity. Implicit in this high diversity is the potential of homegardens to serve as repositories of genetic diversity (Kumar and Nair, 2004). Yet another observation was the presence of good proportion of exotic fruit trees in the small gardens of Neyyatinkara (Table 2). Such decline in native species with a corresponding increase in exotic species has been reported from farm lands of southern Kerala (Guillerme *et al.,* 2011).

The tree diversity in the Neyyatinkara suburban regions also followed an increase in number with increase in holding size (small, 3 species; medium, 18 species; large, 46 species). This was fairly low as compared to earlier reports. The number of woody species was 127 based on the study from 17 districts in Kerala (Kumar *et al.,* 1994), which is indicative of reduction in the tree wealth from the homegardens. The farmer's preference for trees has been on the decline during the past two decades. The paradigm shift in land use practices in tune with the changing socio-economic equations has seriously affected the homegarden tree diversity in Kerala (Kumar, 2011; Kumar and Nair, 2004). Structural and ecological changes in the homegardens as function of garden size probably one of the priority areas of homegarden research. In addition to size, religion, custom and traditions also influence homegarden floristic diversity that demand good deal of focus.

Medium sized homegardens recorded highest 165 trees while large and small gardens 76 and 147 trees ha^{-1}, respectively. As compared with urban areas densities were

Table 1. Area survived and floristic attributes of traditional peri-urban homegardens

Homegarden category	Large (>0.08 ha)	Medium (0.04-0.08 ha)	Small (0-0.04 ha)
Average homegarden size (ha)	0.14	0.06	0.02
Total homegarden area surveyed (ha)	4.28	1.82	0.83
Number of trees per homegarden	46	18	3
Tree density (No. p er ha)	76	165	147
Number of species	94	48	24
Number of genus	80	42	23
Number of family	35	25	18
Maximum number of trees encountered from the family	9	7	3

Table 2. List of species in home gardens

Species	Utilization classes**	Important uses***
Adenanthera pavonina L.*	T3	1, 10, 13, 16
Aegle marmelos (L.) Corr.*	M3	3, 4
Ailanthus triphysa (Dennst.) Alston	T2	4, 18
Albizia chinensis (Osb.) Merr.	M1	4, 5, 6, 19
Albizia odoratissima (L.f.) Benth.	T3	1, 6, 8, 13, 16, 18, 20
Alstonia scholaris (L.) R.Br.	T4	1, 16
Anacardium occidentale L.*	M4	1, 2, 4, 8,13
Annona muricata L.*	X	2, 4, 16
Annona reticulata L.*	X	2, 4, 16
Annona squamosa L.*	M4	4, 17
Aporusa acuminata Thw.	T2	1, 2, 4,
Areca catechu L.	PL	1, 2, 15, 16, 22
Artocarous heterophyllus Lamk.	M2	1, 2, 3, 4
Artocarous hirsutus Lamk.	T2	1, 3
Azadirachta indica A. Juss.*	M3	1, 3, 4, 5, 8, 12, 13, 16, 17, 20
Bixa orellana L.	X	10
Bombax ceiba L.	T4	1, 7, 19
Briedelia retusa (Muell,-Ham.) Oken.	M3	13, 16
Caesalpinia sappan L.*	M2	2, 5, 10, 16
Calophyllum inophyllum L.	T2	1, 22
Canarium strictum Roxb.	M2	1, 8, 16
Carallia brachiata (Lour.) Poir	T2	4
Ceiba pentandra (L) Gaertn.	T4	7
Chrysophyllum cainito L.*	X	2
Cinnamomum malabatrum (Burm.f.) Bl.	X	11
Cinnamomum verum Presl	X	2, 11, 16
Citrus limon (L.) Burn. F.*	M2	2, 15, 16
Citrus grandis (L.) Osbeck	M2	2, 15, 16
Cleistanthus collinus (Roxb.) Benth.ex Hk. F.	X	16
Cocos nucifera L.	PL	1, 2, 7, 13, 15, 16, 22
Coffea arabica L. *	M4	1, 2, 4
Dalbergia latifolia Roxb.	T1	1
Elaeocarpus serratus L.	T2	1, 2, 3, 5, 16
Erythrina indica Lamk.*	M3	1, 3, 6, 18
Ficus nervosa Heyne ex Roth	X	22
Ficus racemosa L.	X	22
Ficus religiosa L.*	M1	15, 16, 22
Garcinia gummi gutta (L.) Rob.	T2	2, 13
Garuga pinnata Roxb.	T4	2, 3
Gliricidia sepium (Jack.) Kunth. ex Walp.	M3	1, 3, 4, 5, 12
Gmelina arborea Roxb.	T3	1, 4, 8
Grewia tiliaefolia Vahl.	T2	1, 3
Haldina cordifolia (Roxb.) Ridsd.	T2	1, 16
Hevea braziliensis (H.B.K.) M.-A.*	M1	4, 8
Holarrhena pubescens (Buch.-Ham.) Wall.Ex Don.	T3	1, 16
Holoptelea integrifolia (Roxb.) Planch.	M2	1, 16
Hydnocarpus pentandra (Buch.-Ham.) oken.	M3	13, 16
Lagerstroemia microcarpa Wt.	T2	1
Lannea coromandelica (Houtt.) Merr.	T3	1, 3, 4, 5, 16, 18, 20
Leucaena leucocephala (Lamk.) de Wit	M3	3, 4
Litchi chinensis (Gaertn.) Sonner*	X	2
Mangifera indica L.	M3	1, 2, 3, 4, 5, 12
Manilkara zapota (Roxb.) Dubard	M2	1, 2
Melia dubia Cav.	T2	1, 3, 4, 5, 8, 13, 18, 21
Mimusops elengi L.	T2	10, 13, 16, 20
Morus alba L.	M3	1, 3, 7, 12, 13, 18, 20
Murraya koenigii Spreng.	M4	1, 2, 13, 16
Myristica fragrens Lamk.	X	2, 13, 16
Oroxylum indicum (L.) Vent.	T2	1
Pajanelia longifolia (Willd.) K. Schum.	T4	1
Paraserianthes falcataria (L.) Fosberg*	T3	1, 3, 4, 18, 19
Persea macrantha (Nees.) Kosterm.	T3	1, 19
Phyllanthus indofischeri Bennet	X	2, 16
Phyllanthus emblica L.	M3	1, 2, 3, 4, 5, 16, 20
Pouteria campechiana (Kunth) Baehni*	M2	1, 2, 16
Psidium guajava L.*	M4	1, 2, 4
Pterocarpus marsupium Roxb.	T2	1, 3, 5, 6, 8, 10, 16

Pterospermum reticulatum Wt. & Arn.	X	16
Racosperma auriculiforme Cunn. ex Benth.	M3	1, 4, 6, 18, 20
Racosperma mangium (Willd.) pedley, comb. Nov.	M3	1, 4, 6, 18, 20
Samanea saman (Jacq.) Merr.	T4	1, 5
Santalum album L.	T1	1, 3, 13, 16
Schleicheria oleosa (Lour.) Oken	T2	1, 4, 10, 12, 13, 18, 20
Spondias pinnata (L. f.) Kurz	M1	1, 2, 16
Sterculia guttata Roxb. ex DC	T4	1, 7
Stereospermum colais (Buch.-Ham. ex Dillw.) Mabber.	T3	1
Strychnos nux-vomica L.	T3	1, 16, 17
Swietenia macrophylla King*	T2	1, 13
Syzygium aqueum (Burm. F.) Alston*	X	2
Syzygium cumini (l.) Skeels	T2	1, 2, 3, 4, 10, 13, 16, 18, 20
Syzygium malaccense (L.) Merr. & Perry	X	2
Tabernaemontana heyneana Wall.	X	16
Tamarindus indica L.*	M3	1, 2, 3, 4, 10, 12, 14
Tectona grandis L. f.	T1	1, 4, 13, 20
Terminalia bellirica (Gaertn.) Roxb.	T3	1, 16, 19
Terminalia catappa L.*	M3	1, 4, 5, 12, 13, 16, 20
Terminalia crenulata Roth	M3	1
Theobroma cacao L.	M3	1, 4, 6
Thespesia populnea (L.) Soland. Ex Correa	T2	1, 3, 4, 10
Trewia nudiflora L.	X	16
Vitex altissima L.	T3	1, 16
Wrightia tinctoria (Roxb.) R. brown	X	5
Zanthoxylum rhetsa (Roxb.) DC.	M2	1, 16
Ziziphus mauritiana Lamk.	X	12, 16

*Exotics

**Use code: 1. Timber, 2. Food and beverage, 3. Fodder, 4. Fuel/charcoal, 5. Green manure, 6. Nitrogen fixer, 7. Fiber/flosses, 8. Glues/resins, 9. Latex, 10. Dyes, 11. Spices, 12. Apiculture/Sericulture/Lac culture, 13. Essential oils/fatty acids, 14. Cleaning/polishing agents, 15. Religious, 16. Medicinal, 17. Poisons/repellents, 18. Paper/pulp, 19. Matchwood, 20. Tannins, 21. Waxes, 22. Use other than those listed from 1-21.

***Utilization classes: T=Primary timber yielding species, M=Multiple use species, PL=use other than listed above (1, 2, 3, 4=Classification based on durability: 1=Perishable, 2=Moderately durable, 3=durable, and 4=Very durable).

Table 3. Homegarden area, mean number of tree species and diversity indices of peri-urban homesteads of Neyyattinkara Municipality

Homestead size	Homestead area sampled (ha)	No. of species encountered (S)	Number of individuals (N)	Shannon's diversity index	Simpsons dominance index	Equitabilityindex
Large	4.28	94	1394	3.77	0.92	0.83
Medium	1.82	48	550	3.23	0.89	0.83
Small	0.83	24	102	3.87	0.81	0.84

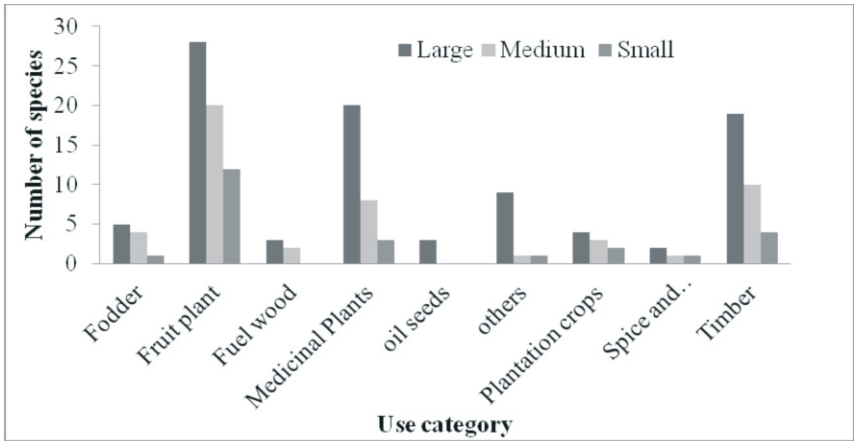

Fig 1. Functional distribution of plant species in various size categories of peri-urban homegardens of Neyyattinkara Municipality

recorded high due to the less industrialization and presence of agriculture. Despite this good plant density, the tree proportion was modest among the homegardens surveyed. Vast regional differences in plant density was also visible among homegardens across the tropics. While the Meitie homegardens of Assam maintained fairly high density (831 numbers ha^{-1}; Devi and Das, 2012), further higher number were observed in the homegardens of Dargakona Village of Assam (1535 individuals per ha^{-1}) (Das and Das, 2005). The tree densities were quiet high in upper Assam compared with the south Kerala. Saikia *et al.* (2012) observed 4574, 4046 and 3448 individuals per ha respectively for the small, medium and large holdings of Upper Assam.

Diversity indices computed for tree species separately for different size categories suggest moderate changes. The Shannon index was higher for small (3.87), while lowest for medium (3.23) holdings. A similar trend was observed for the Kerala homegardens (Kumar *et al.,* 1994). Despite the higher species richness in the large homegardens, the lower Shannon index could be attributed to the lower evenness associated with the different species in the large homegardens. The lower diversity index for large gardens also suggests progression towards monoculture such as rubber in the large homegardens. Similar reports have been observed from homegardens of North-East India (Sahoo *et al*., 2010) with a decrease in the Shannon index with increases in size of holdings (3.28, 2.59 and 2.98, respectively for small, medium and large land holdings. The reports from central Kerala suggest large (> 0.4 ha) and small (< 0.4 ha) homegardens having Shannon index value of 2.27 and 2.38, respectively (Saha *et al.,* 2009). Pandey *et al.* (2006) observed Shannon dominance index for homegarden (1.38) and home forest gardens (3.168) from South Andaman.

The Simpson's dominance index showed modest variation among garden size classes (0.92 to 0.81). Contrary to Shannon index, Simpson's index was highest for large (0.92) and least for small gardens (0.81). The indices are comparable with the evergreen forest diversity (0.90). Other studies reported from Kerala suggest a lower Simpson index within the range of 0.251 to 0.739 for different thaluks of Kerala (Kumar *et al.,* 1994). Probably, these lower values of diversity indices could be attributed to the fact that those studies considered only tree species for computing diversity indices while the present study included total plant diversity. A high value (0.834) was reported in different size categories in a village of Thiruvavanthapuram. Pandey *et al.* (2006) reported 0.4018 and 0.698 in homegardens and home forest gardens, respectively. Kumar (2011) reported there was a reduction of Simpson index with increase in holdings. Central Kerala had a value of 0.64, 0.41 and 0.46, respectively for small, medium and small homegardens. Simpson's diversity index is a measure of diversity, which takes into account both richness and evenness.

The greater species were recorded in the large homegardens when compared with other holdings, trends were same for number of genus and families. Similar high distribution of species under diverse genera and families has been reported from Assamese and other N-E homegardens. Saikia *et al.* (2012) reported 92 families and 217 genera from the homegardens of upper Assam while species distributed in 60 genera and 35 families from South Assam (Devi and Das, 2012).

Functional diversity: The major functional groups included timber trees, fodder, fruit, medicinal plants, plantation crops, multipurpose tree species, etc. Medicinal plants, fruit trees and timber trees were the most dominant tree species. In all the functional groups, the number of species increased with increase in the land holdings. The highest was observed for the medicinal plants (20 species) of large homegardens followed by fruit plants and timber tree species (Fig. 2). The prominent timber tree species in the tract included *Ailanthus tripysa, Thespesia populenea* and fruit trees like *Artocarpus heterophyllus* and *Mangifera indica*.

The drastic decline in the garden size is a strong indicator of decline in the homegardens of Kerala. Kumar *et al.* (1994) categorized them into larger size classes such as < 0.4, 0.4 to 2.0 ha and > 2.0, respectively for small, medium and large gardens while in the present study, the peri urban gardens at Neyyatinkara were categorized into 0-0.04, 0.04-0.08 and > 0.08 ha, for small, medium and large gardens, respectively. The never-ending escalation in population size, and concomitant pressure on the land together with fast changing socio-economic preferences mooted by commercialization has increased the opportunity cost of the homegardens manifold leading to large-scale conversion to non-agricultural purposes. Unless consistent efforts are made to improve the economic viability of the homegardens, the days are not far away for this unique system vanish to oblivion.

Adoption of agroforestry practices in Kerala is generally determined by interplay of farmers' preferences (mainly economic rationale) and public policies. Even if the new policy proposed by the Kerala government tried to address farmer issues, contradictions exist between the dichotomous approaches adopted in the agriculture and forestry sectors. State policies promote agroforestry and agrobiodiversity, a vertical integration across multiple layers as well as horizontal co-ordination across the farming communities.

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Land Use and Land Cover Change Analysis of Hussainiwala Wetland Ecosystem Using Remote Sensing and GIS

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Abstract: Land use/land cover dynamics was studied for Hussainiwala wetland using IRS-1C/1D LISS-III satellite data for the year 2002 and Cartosat -1 PAN + LISS-IV Mx merged data for the year 2010. The change analysis indicates increase in agricultural land from 6154.09 ha to 6306.87 ha indicating encroachment on the wetland ecosystem. The increased spatial resolution facilitates to identify for the agriculture in year 2010, which comprising of an area of about 2.04 ha. For 2002, area under built up was about 98.44 ha, which increased to 167.16 ha in 2010. Considerable decrease in swampy area from 398.06 ha in 2002 to 64.37 ha in 2010 with scrub/aquatic vegetation has been observed. Significant decrease in vegetation area has been observed through time.

Key Words: GIS, Land use/Land cover dynamics, Remote Sensing, Wetland, Wetland conservation

Wetlands have varying functions favouring the existence of flora, fauna and mankind and are often biodiversity hotspots and function as filters for pollutants from both point and non-point sources, and being important for carbon sequestration and emission. The hydrologic functions of wetlands consist of surface and subsurface water storage, energy dissipations and moderation of groundwater flow or discharge. The biogeochemical functions of wetlands include nutrient cycling, retention of particulates, removal of imported elements and compounds, and the import and export of organic carbon. Denitrification is fast in soils in the vicinity of wetlands (Ullaha and Faulkner, 2006).

The conservation and management of wetlands requires exhaustive survey (mapping) of their distribution and monitoring their extent over time. Ground based surveys of wetlands are time consuming and have limitations due to area inaccessibility. The use of remote sensing technology facilitates cost-effective delineation, mapping and monitoring of wetlands. Traditionally, Landsat MSS/TM, SPOT and IRS data have been used to study wetlands (Shaikh *et al.*, 2001; Toyra *et al.*, 2001; Chopra *et al.*, 2001). However, the optical data has limitation to penetrate vegetation canopies (Bourgeau-Chavez *et al.,* 2001). There has been some research on wetlands using radar data (Alsdorf *et al*., 2001; Rio and Lozano-Gracia, 2000) as well as LIDAR (Mackinnon, 2001).

Recent developments in geographical information system (GIS) and Remote Sensing Technologies are providing valuable tools to assist with monitoring, inventory and management of wetlands. Many studies were undertaken regarding change detection in wetlands by using GIS/Remote sensing technologies across the world. The aim of the study is to quantify wetland-land use dynamics and estimate wetland loss/conservation.

MATERIALS AND METHODS

Hussainawala wetland is situated on the bank of river Satluj in Firozpur district of Punjab. The area under study covering 7627.1 hectares is located between 30°58'8.132"N to 31°3'24.29"N latitude and 74°31'15.456"E to 74°39'47.945"E longitude (Fig. 1). The river Sutlej runs through the area forming a large lake at the Hussainiwala head works.

The climate of the area on the whole is dry and is characterised by very hot summer, a short rainy season and a bracing with winter. From end of March, the temperature increases rapidly till June, which is generally the hottest month and on individual days, the maximum temperature may be about 47° ºC. After October, both the day and night temperatures decrease rapidly till January, which happens to be the coldest month when the minimum temperature occasionally drops to about a degree below the freezing point of water.

Land use and land cover maps of Hussainiwala wetland ecosystem were prepared through on-screen visual interpretation of IRS-1C/1D LISS-III satellite data of the year 2002 and using Cartosat -1 PAN + LISS-IV Mx merged data for the year 2010 using ArcGIS 9.3 (Fig. 2). The roads, railways, settlements, canals and major drains were also mapped (Fig. 3). Various elements of visual interpretation like shape, size, association, pattern, tone, texture, colour, etc. were used to identify the various land use categories. The false colour of LISS-III data and true colour composites of Cartosat -1 PAN + LISS-IV Mx merged data was used for

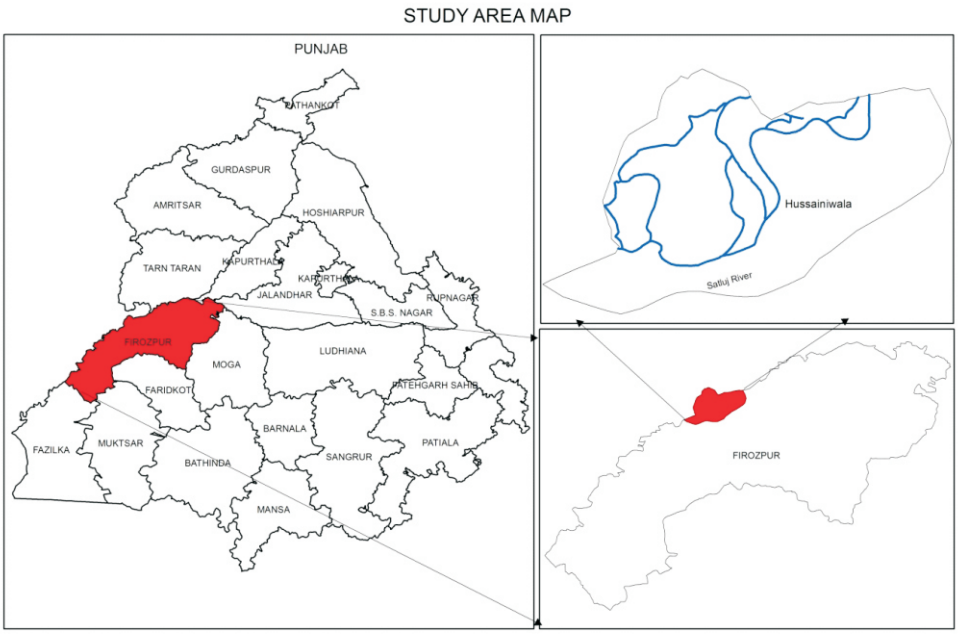

Fig. 1. Location map of the study area

preparation and interpretation of land use and land cover mapping and change analysis. The maps were finalized after making necessary modifications based on the ground truth data.

RESULTS AND DISCUSSION

The study area was classified into nine land use categories viz. built up land, crop land, tree clad area, sandy area or riverine sand, scrub, canal, lake/pond, river, waterlogged, and swampy area with scrub/aquatic vegetation for the year 2002, whereas, thirteen land use categories viz., built up land, cropland, plantation, tree clad area, sandy area or riverine sand, scrub, canal, pond/tank (artificial), lake with aquatic vegetation, lake without aquatic vegetation, river, waterlogged, and swampy area with scrub/aquatic vegetation were mapped for 2010 from satellite data and their areas computed. From the data in table 1 it has been observed that from 2002 to 2010 there has been considerable increase in agricultural land (6154.09 ha to 6306.87 ha). With increase in spatial resolution agricultural plantation comprising an area of about 2.04 ha has been identified in 2010. In 2002 area under built up was about 98.44 ha, which increased to 167.16. In 2002, we could hardly map hamlets and the area covered by the villages was also exaggerated but in 2010 with the help of merged data, it was possible to map the exact boundary of the villages, which was possible only due to increased spatial resolution. Even the small hamlets, which comprised of about 69.03 ha was also mapped in 2009-2010.

Considerable decrease in tree clad area has been observed from 168.51 ha to 136.73 ha within the duration of 2002 to 2010 and might be converted into agriculture and scrub land. It has also been observed that wasteland has decreased from 2002 to 2010 within study area from 181.74 ha to 166.31 ha. Within wasteland category decrease in sandy area or riverine sand has been observed from 145.92 ha to 8.94 ha, whereas, area under scrub has increased from 41.99 to 157.37 ha. With advancement in spatial resolution, we could easily demarcate area under pond/tank (artificial), which covers 0.48 ha of the total study area.

In 2002, wetland category has been subdivide into lake/pond, river, and swampy area with scrub/aquatic vegetation with an area of about 7.04 ha, 612.92 ha, 398.06 ha. Whereas, in 2010 due to increase in spatial resolution, we were able to classify the category lake/pond into two sub categories viz., lake water with vegetation and lake water without vegetation with an area of about 0.79 ha and 6.11 ha, respectively. In 2010, river consist of 688.92 ha area. We were able to map waterlogged area under wetland category because of high resolution satellite data with an area of 75.35 ha. Considerable decrease in swampy area with scrub/aquatic vegetation has been observed from 398.06 ha in 2002 to 64.37 ha in 2010.

The temporal change analysis (Fig. 4) indicates significant changes like area under riverine sand being converted into agriculture, lots of new area coming under scrub. Significant decrease in vegetation area has been observed through time being converted into agricultural land.

Threats to Hussainiwala wetland: The study indicates that expansion of settlement and intensive agriculture is causing encroachments on the wetland habitat. Around 150 ha of land have been encroached upon for carrying out agricultural operations. Anthropogenic pressure for agriculture and other purposes pose a great danger for this wetland. The lake is virtually a receptacle of domestic, agricultural and industrial waste, which flows in from the Satluj and the Beas. The other main reasons of the degradation are weed infestation, illegal fishing and siltation.

Profuse growth of water hyacinth (abnoxious weed) is adversely affecting the ecology of this lake. The pollution of lake water is the result of the nutrient input from sewage, industrial effluents and washes down fertilizers/pesticides rich soil from agriculture area. Disposal of affluent from a large number of industries and sewage from various cities into Satluj river ultimately adversely affect the Hussainiwala wetland. Hussainiwala wetland has a very high potential of

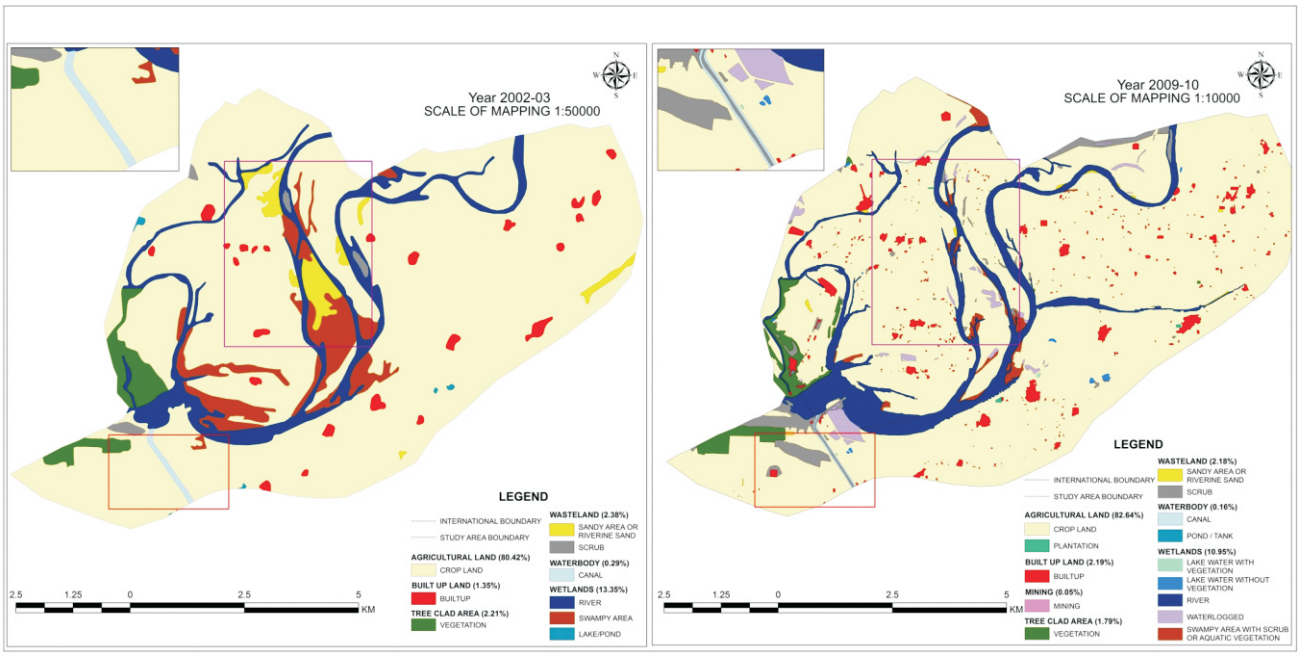

Fig. 2. Land use and land cover change map of Hussainiwala wetland ecosystem

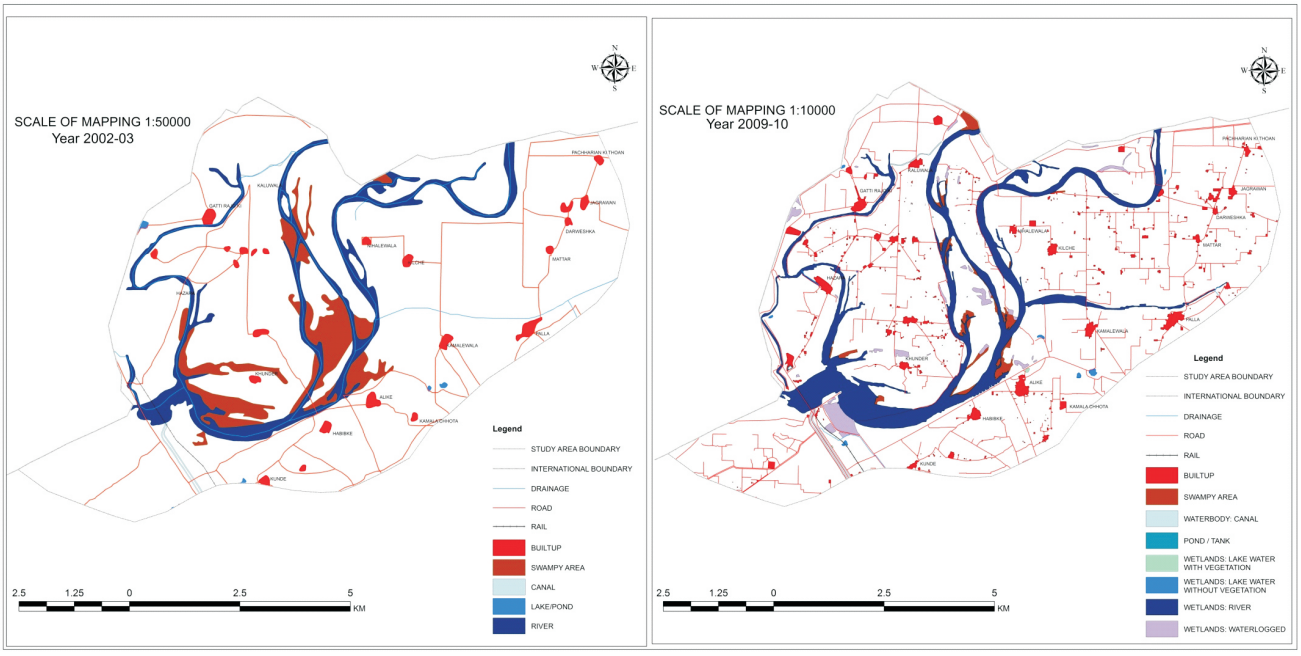

Fig. 3. Roads, railways, settlements, canals and major drain map of Hussainiwala wetland ecosystem

Table 1. Area under various land use categories in Hussainiwala wetland ecosystem

Land Use Description			Area			
			Hectares 2002	% of TGA* 2002	Hectares 2010	% of TGA* 2010
1. Agricultural land		1.1 Crop land	6154.09	80.69	6306.87	82.69
		1.2 Plantation			2.04	0.03
		Sub Total	6154.09	80.69	6308.91	82.72
2. Built up land		2.1 Built up village	98.44	1.29	98.13	1.29
		2.2 Hamlets			69.03	0.91
		Sub Total	98.44	1.29	167.16	2.19
3. Tree clad		3.1 Tree Clad	168.51	2.21	136.73	1.79
		Sub Total	168.51	2.21	136.73	1.79
4. Wasteland		4.1 Sandy area or Riverine sand	145.92	1.91	8.94	0.12
		4.2 Scrub	42.01	0.55	157.37	2.06
		Sub Total	187.93	2.46	166.31	2.18
5. Water bodies		5.1 Canal	12.01	0.16	12.01	0.16
		5.2 Pond/Tank (Artificial)			0.48	0.01
		Sub Total	12.01	0.16	12.49	0.16
6. Wetlands	6(a) Lake/Pond 2002	6.1 Lake water with vegetation	7.04	0.09	0.79	0.01
		6.2 Lake water without vegetation			6.11	0.08
		6.3 River	601.07	7.88	688.92	9.03
		6.4 Waterlogged			75.35	0.99
		6.5 Swampy area with scrub/aquatic vegetation	398.06	5.22	64.37	0.84
		Sub Total	1006.17	13.19	835.55	10.95
		Grand Total	7627.15	100	7627.15	100.00

* TGA = Total gross area

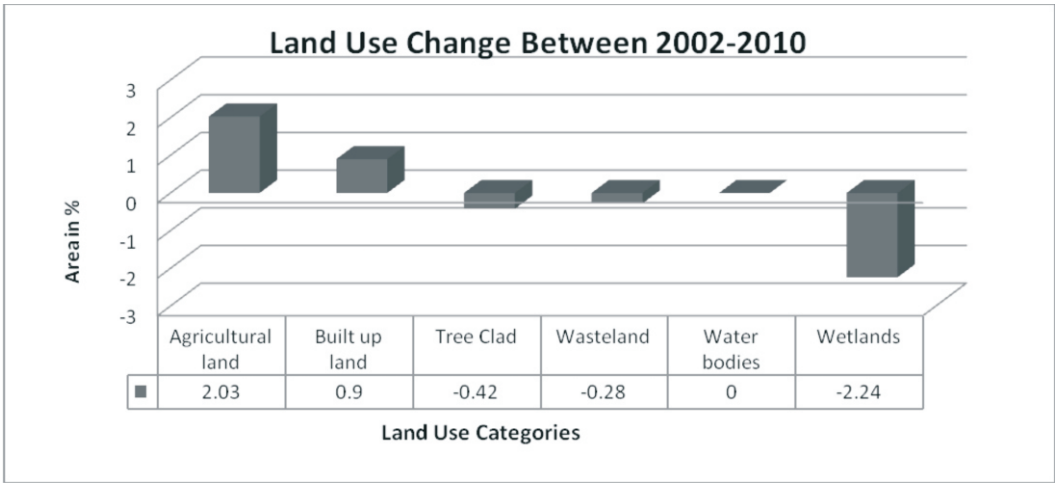

Fig. 4. Space-time dynamics of land use

fish production. Illegal fishing and poaching does take place and it has been a cause of concern. Indiscriminate grazing in the ecosystem is damaging the wetland ecology. The wetland ecosystem is bearing the brunt of modem development.

Conservation measures: A number of conservation measures have been taken by various development Departments of the State to conserve Hussainiwala wetland; these measures include eradication of water hyacinth, regulation of fishing, fencing some of the selected portion from encroachment and afforestation of the catchment area.

Disposal of affluent from a large number of industries and sewage from various cities directly into Beas or Satluj rivers or their tributaries warrant for monitoring the water quality of this ecosystem. Anthropogenic pressure for agriculture and other purposes pose a great danger to this wetland. To protect already endangered ecosystem, fencing and afforestation of certain strategic area is utmost required. Hussainiwala lake is also threatened by the silt deposition due to soil erosion in upper reaches and catchment areas of rivers and their tributaries, which require afforestation and other measures to check soil erosion in the upstream and catchment areas of rivers. An integrated effort comprising education and awareness for public, wetland monitoring using remote sensing, fencing of vulnerable areas, and management of water hyacinth menace is essential for conservation of this valuable wetland ecosystem.

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Carbon Mineralization in Soil Amended with FYM, Urea and DAP under Simulated Conditions of Aerobic and Flooded Ecosystems

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***Abstract*:** Carbon mineralization was determined in terms of carbon dioxide production (mg 100 g soil^{-1}) over a period of 90 days, which indicated that the cumulative and rate of carbon dioxide production was maximum in DAP+FYM amended treatment followed by Urea +FYM > DAP > Urea > FYM > control. The rate of carbon dioxide (mg 100 g soil day^{-1}) produced was maximum during first 10 days among various treatments under both aerobic and flooded ecosystems. During early stages of incubation period, the treatment amended with DAP + FYM recorded highest peak production of carbon dioxide during first 10 days and further decreased up to 50 days and another peak was noticed between 51 - 60 days and after 60 days carbon dioxide evolution remained a constant. Irrespective of systems, cumulative and rate of carbon dioxide evolution was higher in soils amended with fertilizers and FYM compared to all other treatments including control. The maximum cumulative and rate of carbon dioxide produced was higher in aerobic ecosystem as compared to flooded ecosystem.

***Key Words*:** Carbon mineralization, aerobic ecosystem, flooded ecosystem, urea, FYM, DAP

Carbon mineralization is a useful tool for quantifying the impact of various organic and inorganic amendments on soil functions. Carbon dioxide evolution from the soils have been measured to gain information about decomposition of organics with resulting release of nutrients and soil respiration. One to three tons of carbon dioxide is produced in the ploughed layer of one hectare of soil during the first few weeks of submergence. Being chemically active, it forms carbonic acid, bicarbonate and insoluble carbonate, the excess accumulates as gas. The most striking difference between anaerobic and aerobic decomposition lies in the nature of the end products (Zhang *et al*., 2007). In normal well drained soils, the main end products are CO_2, H_2O, NO_3, SO_4 and resistant humus. In flooded soils, CO_2, H_2O, CH_4, NH_4, H_2S and partially humified residues are found. The time course of organic manure decomposition in paddy soil is relatively low due to environment limitations. Mineralization of carbon as CO_2 from soil under field capacity and flooded condition reveal that higher per cent of carbon mineralization occurs under field capacity than submergence (Mikha *et al*., 2005). C-mineralization in soil depends on nature of organics, soil characteristics and temperature. In this context, the present study was undertaken with an objective to study the carbon mineralization in soil amended with FYM, Urea and DAP under aerobic and flooded ecosystems.

MATERIAL AND METHODS

An incubation experiment on CO_2 evolution in soil under simulated conditions of aerobic and flooded conditions was set up in the laboratory conditions at Department of Soil Science and Agricultural Chemistry, UAS, Bangalore. The physico-chemical properties of soil is presented in Table 1. The compost used for the experiment contain 33 % moisture, C:N ratio was 16:1 including 1.05, 0.53 and 0.93 % nitrogen, phosphorus and potassium, respectively. The carbon and nitrogen per cent of FYM was 16.8 and 1.05, respectively. FYM along with urea and DAP of 0.2 per cent nitrogen on w/w basis as per treatment was incorporated in 500 grams of soil. The experiment set up was placed in a completely randomized design and replicated thrice with the treatment T_1: Soil, T_2: Soil + 0.2 % N through FYM, T_3: Soil + 0.2% N through Urea, T_4: Soil + 0.2% N through DAP, T_5: Soil + 0.2 % N through FYM + Urea, T_6: Soil + 0.2 % N through FYM + DAP. The same treatments were adopted for both aerobic and flooded condition.

The materials for each treatment combination were mixed with 300 g of soil on polythene sheet and transferred to a series of 1000 ml capacity conical flask. Appropriate controls were maintained, which did not receive any nutrients. Sufficient amount of distilled water was added to create flooded and saturated conditions. Mouth of the flask was tightly covered with a rubber stopper having a hook inside. Before closing the flask a test tube containing 40 ml of 0.5 N NaOH was hung on the hook to trap CO_2 released. The edge of flask was sealed with paraffin wax to avoid loss of CO_2.The flasks were incubated at 28^0 C. The CO_2 was

Table 1. Physical and chemical properties of soil used in incubation experiment

Sl. No	Properties	Content
I	Physical properties	
1.	Coarse sand (%)	44.56
2.	Fine sand (%)	35.42
3.	Silt (%)	6.60
4.	Clay	13.35
5.	Soil textural class/Soil t axonomical class	Alfisol/oxic haplustalf
6.	Bulk density (g cm^{-3})	1.16
7.	Maximum water holding capacity (%)	36.5
8.	Field capacity (%)	12.5
II	Chemical properties	
9.	pH	6.68
10	Eh (mV)	+408mV
11	EC (dSm^{-1})	0.13
12	Organic Carbon (g kg^{-1})	3.4
13	CEC (c.mol[p^+] kg^{-1})	10.30
14	Ammoniacal nitrogen (mg kg^{-1})	34.83
15	Nitrate nitrogen (mg kg^{-1})	39.17
16	Available nitrogen (N kg ha^{-1})	168.0
17	Available phosphorus (P_2O_5 kg ha^{-1})	13.84
18	Available potassium (K_2O kg ha^{-1})	174.0

trapped in alkali and determined at suitable intervals upto 90 days. On the day of observation alkali traps were removed and flasks were closed immediately to prevent loss of carbon dioxide. Immediately another trap with 40 ml of sodium hydroxide was hung in the flask. Carbon dioxide trapped in alkali in test tube was determined with 0.5 g of saturated $BaCl_2$ and titrated against standard sulphuric acid. The quantity of carbon dioxide produced during decomposition and lost as gas was calculated as described by Wilde *et al.* (1972).

RESULTS AND DISCUSSION

Decomposition of organics led to increase in carbon dioxide evolution in both aerobic and flooded conditions, further addition of fertilizers along with FYM led to increased carbon dioxide production as a result of enhancement of decomposition of organic manure and there was predominant increase in carbon dioxide evolution from soil when fertilizers such as DAP was applied compared to urea. The decomposition of organic manure was enhanced with addition of fertilizers irrespective of flooding or saturation and maximum carbon dioxide evolution was recorded in aerobic soils than flooded soils throughout the incubation period of 90 days (Table 2). With application of FYM to soil irrespective of aerobic or flooded conditions, there was increase in cumulative amount of carbon dioxide production. With addition of only chemical fertilizers, carbon dioxide production further increased in DAP amended soil than urea irrespective of moisture conditions. In soils amended with FYM and fertilizer, the carbon dioxide production was maximum when DAP along with FYM was added compared to integration of urea with FYM in both aerobic soil and flooded soil.

Table 2. Cumulative carbon dioxide evolution (mg 100 g $soil^{-1}$) from soil amended with urea, DAP and FYM in aerobic and flooded ecosystems

Treatments	Aerobic system					
	10	30	40	60	70	90
			Days after flooding			
T_1=Soil alone,	129.7	181.2	298.1	399.2	413.1	472.0
T_2=Soil +FYM	583.9	932.4	1132.6	1464.1	1596.7	1711.4
T_3=Soil+urea	421.2	913.0	1043.1	1411.1	1509.0	1784.4
T_4=Soil+DAP	792.0	963.0	1173.7	1492.0	1593.0	1863.8
T_5=Soil+FYM+urea	863.9	1218.1	1363.1	1593.0	1702.0	2007.4
T_6=Soil+FYM+DAP	905.7	1404.1	1493.1	1812.1	1999.4	2203.0
			Flooded system			
T_1=Soil alone,	118.5	166.0	274.3	342.6	355.5	404.3
T_2=Soil +FYM	403.4	891.7	1012.6	1363.1	1530.1	1696.7
T_3=Soil+urea	436.2	782.0	1010.0	1393.4	1513.4	1702.4
T_4=Soil+DAP	556.9	1110.0	1281.0	1521.0	1631.0	1806.3
T_5=Soil+FYM+urea	496.3	963.0	1134.0	1406.2	1615.1	1813.3
T_6=Soil+FYM+DAP	657.2	1361.7	1403.7	1702.9	1819.9	2010.4

Rate of CO_2 evolution among different treatments was maximum during first ten days in aerobic and flooded ecosystem (Table 3). The rate of carbon dioxide produced was maximum during first 10 days on addition of FYM and DAP as compared to all other treatments. Minimum rate of carbon dioxide production was recorded in control. The CO_2 production decreased after 10 days up to 60 days and again another peak was noticed between 61-70 days and later carbon dioxide production remained constant in both aerobic and flooded soils. Irrespective of the systems, the rate of carbon dioxide production in soil was higher in treatments amended with FYM, urea and DAP as compared to control. Between aerobic and flooded ecosystems maximum rate of carbon dioxide evolution was noticed in aerobic ecosystem.

Cumulative carbon dioxide evolution in all treatments increased over control in both aerobic soil and flooded soil. During the initial ten days after saturation and flooding, maximum rate of CO_2 production was observed and decreased after 10 days and another peak was observed between 51 - 60 days. This could be due to a lag period present during the production of CO_2 in flooded soils and the peak production of carbon dioxide was reached after seventh day of incubation.

Cumulative carbon dioxide production was maximum in DAP+FYM treatment followed by Urea +FYM > DAP > Urea > FYM > control. These results were similar to findings of Meenakshi *et al*. (2000) who reported that increasing soil moisture increased carbon dioxide evolution upto optimum level above which it would reduce carbon dioxide evolution and periodic drying and wetting soil had a pronounced influence on carbon dioxide production. Further these observations corroborated with findings of Cassals *et al.* (2000) who attributed that rewetting a dry soil resulted in large increase in carbon dioxide production at high temperature, while Borken *et al.* (1999) observed that drought reduced soil respiration while rewetting increased the same.

Second peak production of CO_2 was noticed between 40-60 days after flooding in almost all the treatments. After 90th day of flooding, the carbon dioxide production per day remained constant. When organic materials are applied to soil, they provide energy and substrate C required for heterotrophic microorganisms. Availability of labile C sources will be very high in beginning of incubation and such compounds are readily utilizable by the decomposers. Thereby high activity of microorganisms resulted in higher oxidation of C to CO_2 in the beginning. The higher CO_2 production rate during the initial periods might be due to higher soluble substances in manure, which provide readily available source of energy for the growth and activity of micro-organisms

Addition of fertilizers along with FYM resulted in increase of cumulative CO_2 production in the present study. Soils amended with fertilizer nitrogen alone reduced carbon dioxide evolution while integration with organics enhanced the decomposition of manure resulting in higher carbon dioxide evolution (Rochette and Gregorich, 1998 and Datta and Devi, 2001). FYM applied without fertilizers showed

Table 3. Rate of carbon dioxide evolution (mg 100 g soil day^{-1}) from soil amended with urea, DAP and FYM in aerobic and flooded ecosystems

Treatments	Aerobic system								
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90
	Days after flooding								
T_1=Soil alone,	12.97	3.30	1.85	11.69	1.49	8.62	1.39	5.00	0.88
T_2=Soil +FYM	58.40	17.82	17.03	20.02	6.94	26.21	13.26	6.64	4.83
T_3=Soil+urea	42.12	27.69	21.49	13.01	15.79	21.01	9.79	10.41	17.13
T_4=Soil+DAP	79.20	10.06	7.04	21.07	12.93	18.90	10.10	12.90	14.18
T_5=Soil+FYM+urea	86.39	48.80	30.54	14.50	6.79	16.20	10.90	10.40	20.14
T_6=Soil+FYM+DAP	90.57	18.50	31.34	8.90	7.06	24.84	18.73	12.10	8.30
	Flooded system								
T_1=Soil alone,	11.85	3.01	1.74	10.83	1.09	5.74	1.24	4.42	0.46
T_2=Soil +FYM	40.34	22.91	25.92	12.09	15.04	20.01	16.70	7.20	9.43
T_3=Soil+urea	43.67	20.30	15.13	22.80	24.30	14.04	12.00	11.20	7.73
T_4=Soil+DAP	55.96	17.91	37.40	17.10	6.11	17.90	11.00	8.31	9.22
T_5=Soil+FYM+urea	49.63	36.40	10.30	17.07	12.91	14.31	20.89	14.92	4.90
T_6=Soil+FYM+DAP	65.72	34.59	35.86	4.20	8.94	20.98	11.63	8.75	10.37

lower C-mineralization compared to addition of FYM along with fertilizers. Most of the enzymes present in microbes participating in the decomposition of organic matter show zero order kinetics *i.e.* after a point of substrate saturation, capacity decreases and such excess carbon dioxide starts accumulating in flooded soils (Sahrawat, 2005).

Irrespective of systems, cumulative and rate of carbon dioxide evolution produced was higher in soils amended with fertilizers and FYM compared to all other treatments including control. Between aerobic and flooded system, the maximum cumulative and rate of carbon dioxide produced was higher in aerobic system as compared to flooded system.

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Response of Maize (*Zea mays* L.) + Mashbean (*Vigna mungo* L.) Intercropping System on Available Soil Nutrients Status and Economics in North-Western Plain Zone of India

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Abstract: Maize+mashbean intercropping under different planting arrangements with recommended NPK+Zn+PSB to maize and mashbean gave highest growth, yield, gross/net returns and benefit under paired planting. Besides, this combination also improved the soil nutrient status.

Key Words: Economics, Fertility levels, Intercropping, Maize+mashbean,Planting geometry, Soil nutrients status

Cereal-legume intercropping is a more productive and profitable cropping system in comparison with solitary cropping (Evans *et al*., 2001). In the absence of nitrogenous fertilizer, intercropped legumes will fix nitrogen from the atmosphere and not compete with maize for nitrogen resources (Adu-Gyamfi *et al.,* 2007). However, judicious use of inorganic fertilizers is far away the problems of nutrients deficiencies in order to boost up their crop yields. Biofertilzers are cost effective, non bulky and environmental friendly agricultural inputs, which are used as a supplementary and complementary component for chemical fertilizers, which could improve plant nutrition (Sahai, 2004). Thus, present study was evaluated the agronomic implications, soil nutrients status and economic feasibility of maize+mashbean intercropping system under the different planting geometries and different fertility levels in semi-arid conditions of Western Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season 2012 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), located at a latitude of 29^0 40' North and longitude of 77^0 42' East with an elevation of 237 metres above mean sea level. The mean annual rainfall in the region is about 650 mm and the area lies in the heart of Western Uttar Pradesh. The experimental field was well drained, sandy loam in texture (46.2 % sand, 18.4 % silt and 17.4 % clay) and slightly alkaline in reaction (pH 7.8), It was medium in organic carbon (0.570 %), available nitrogen (222.6 kg/ha) and available phosphorus (16.6 kg ha^{-1}) but high in available potassium (249.0 kg ha^{-1}) with an electrical conductivity (1:2, soil: water suspension) and Bulk density of 1.6 dS/m and 1.42 Mg m^{-3}, respectively. The treatments comprised of 2 cropping systems (maize+mashbean and maize alone), 2 planting geometries (normal and paired planting) and 3 fertility levels (control, 100% NPK and 100% NPK+Zn+PSB), replicated thrice in a factorial randomized block design. Varieties PAC 712 (Maize) and PU 19 (Mashbean) with the row spacing of 50 cm (normal) and 30/70 cm (paired) were grown with recommended agronomic package of practices. The seeds were sown manually in the furrows at a plant to plant distance of 20 and 10 cm with a seed rate of 20 and 15 kg ha^{-1} for maize and mashbean, respectively and sown on 30 July 2012. The 100 per cent NPK (for maize) is characterized by 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} and Zn is applied @ 0.5% $ZnSO_4$ as spray, whereas, PSB is used as seed treatment @ 20 g kg^{-1} of seed. Irrigation was applied as per need of crop. Crop were kept weed free by regular hand weeding. The data on yield soil nutrient status and economic analysis was recorded as per the standard procedure.

RESULT AND DISCUSSION

Plant height, plant spread and dry matter accumulation of maize: Maize + mashbean intercropping resulted significantly tallest plant (171.6 cm), spread (58.8 cm) and dry weight (38.8 g) than their sole cropping (159.4 cm, 56.2 cm and 31.8 g, respectively) at 75 days after sowing (DAS). Although, significantly lower plant height (158.3 cm) and plant spread (46.2 cm) under paired planting as compared to

normal planting (176.9 cm and 58.2 cm, respectively) except dry matter accumulation, which was non-significant with planting arrangements. However, the use of 100% NPK+Zn+PSB resulted in tallest plant (183.6 cm), plant spread (59.6 cm) and dry matter accumulation (39.9 g) as compared to control and recommended 100% NPK alone. The increased values of growth parameters were probably due to fact that intercropped legume will fix the nitrogen from the atmosphere, which can be utilized by the maize coupled with better resource utilization by the border rows. Similar findings were also reported by Sadashiv (2004).

Grain yield and stover yield: Significantly higher grain (4.0 %), stover (2.5 %) and maize grain equivalent yield (47.88 %) per hectare were recorded under intercropping system than sole cropping. Significantly higher stover (1.6 %) was obtained under paired planting than normal planting, but grain yield and maize grain equivalent yield remain at par under both the planting geometries. Grain, stover and maize grain equivalent yield per hectare varied significantly due to each increment in fertility levels, except grain yield, which remained at par between 100% NPK and 100% NPK+Zn+PSB treatments. The increase in grain, stover and maize grain equivalent yield might be due to increase in yield attributes, which were also influenced due to more dry matter accumulation. Our results had the support of Jeyakumaran and Seran (2007).

Plant height, plant spread and dry matter accumulation at maturity of mashbean: Normal planting noticed significantly higher growth attributes of mashbean *viz.,* plant height (41.0 cm), plant spread (24.6 cm) and dry weight (9.3 g) than 70/30 spacing (38.2 cm, 21.5 cm and 7.2 g, respectively). However, the combine use of 100%

Table 1. Plant height, plant spread, dry matter accumulation (75 days after sowing), grain yield and stover yield of maize as influenced by various treatments

Treatment	Plant height (cm)	Plant spread (cm)	Dry matter (g/plant)	Grain yield (q/ha)	Stover yield (q/ha)
A) Cropping systems					
Sole maize	159.4	56.2	31.8	38.89	69.90
Maize+Mashbean	171.6	58.8	38.8	40.46	71.61
C.D. (P=0.05)	3.8	0.5	0.8	0.56	0.82
B) Planting geometries					
Normal (50 cm)	172.7	58.9	35.6	39.45	70.20
Paired (30/70 cm)	158.3	56.2	35.1	39.90	71.32
C.D. (P=0.05)	3.8	0.5	NS	NS	0.82
C) Fertility levels					
Control	140.3	54.5	30.8	32.01	60.96
100% NPK	172.8	58.4	35.3	43.15	74.72
100% NPK+Zn+PSB	183.6	59.6	39.9	43.82	76.59
C.D. (P=0.05)	4.7	0.5	0.9	0.68	1.00

Table 2. Plant height, plant spread, dry matter accumulation (50 days after sowing), grain yield, straw yield of mashbean as influenced by various treatments

Treatment	Plant height (cm)	Plant spread (cm)	Dry matter (g/plant)	Grain yield (q/ha)	Straw yield (q/ha)
A) Planting geometries					
Normal (50 cm)	41.0	24.6	9.3	5.4	15.5
Paired (30/70 cm)	38.2	21.5	7.2	4.5	14.7
C.D. (P=0.05)	1.6	1.1	0.6	0.3	0.03
B) Fertility levels					
Control	36.0	20.6	4.9	4.8	14.9
100% NPK	39.7	22.3	8.1	5.0	15.1
100% NPK+Zn+PSB	43.0	25.8	10.2	5.3	15.4
C.D. (P=0.05)	2.1	1.5	0.8	0.3	0.03

Table 3. Organic carbon, Organic matter, available nitrogen, phosphorus and potassium, as influenced by various treatments

Treatment	Organic carbon (%)	Organic matter (%)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
A) Cropping systems					
Sole maize	0.573	0.987	222.7	16.3	250.0
Maize+Mashbean	0.561	0.967	220.6	16.0	248.5
C.D. (P=0.05)	0.002	0.003	0.3	0.17	0.06
B)Planting geometries					
Normal (50 cm)	0.579	0.998	226.7	16.4	246.2
Paired (30/70 cm)	0.554	0.955	219.6	15.6	248.3
C.D. (P=0.05)	0.002	0.003	0.3	0.17	0.06
C) Fertility levels					
Control	0.519	0.895	209.7	14.5	235.3
100% NPK	0.574	0.989	226.4	15.9	256.0
100% NPK+Zn+PSB	0.587	1.012	226.8	16.7	256.4
C.D. (P=0.05)	0.002	0.003	0.5	0.20	0.05
Initial values	0.570	0.983	222.6	16.6	249.0

Table 4. Gross return, net return and benefit ratio as influenced by various treatments

Treatment	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit: cost ratio
A)Cropping systems			
Sole maize	51298	31686	1.62
Maize+Mashbean	74741	53370	2.52
C.D. (P=0.05)	-	-	-
B)Planting geometries			
Normal (50 cm)	63023	42531	2.07
Paired (30/70 cm)	63017	42525	2.07
C.D. (P=0.05)	-	-	-
C)Fertility levels			
Control	52841	36481	2.20
100% NPK	67268	44813	1.98
100% NPK+Zn+PSB	68950	46290	2.03
C.D. (P=0.05)	-	-	-

NPK+Zn+PSB registered the tallest plant (43.0 cm), plant spread (25.8 cm) and dry weight (10.2 g), whereas, the minimum under untreated plot (36.0 cm, 20.6 cm and 4.9 g, respectively). The probable reason is more penetration of light and efficient utilization of resources than 70/30 row ratio of mashbean. Pandita *et al.* (2000) opinioned these to more penetration of light and better utilization of resources as compared to paired planting.

Grain yield and straw yield of mashbean: Significantly grain and straw yields per hectare were noticed under normal planting than paired planting and the improvement was to the tune of 20.0 % and 5.4 %, respectively. Grain and straw yields per hectare were increased by increasing levels of fertility up to 100 % NPK+Zn+PSB. The higher grain yield was mainly due to higher dry matter accumulation and also more translocation of photosynthates toward sink.

Organic carbon, organic matter, available nitrogen, phosphorus and potassium: After harvest, slight variations were observed in soil nutrient status than initial (0.570 %, 0.983 %, 222.6, 16.6 and 249.0 kg ha^{-1} organic carbon, organic metter, available nitrogen, phosphorus and potassium, respectively). Available soil nutrients were significantly lower under intercropping system than sole cropping. Moreover, significantly higher available soil nutrients were noticed under normal planting than paired planting. The combined use of 100 % NPK+Zn+PSB recorded significantly higher available soil nutrients (0.587 %, 1.012 %, 226.8 kg ha^{-1}, 16.7 kg ha^{-1} and 256.4 kg ha^{-1},

respectively) as compared to control and 100 % NPK alone. However, significant differences were also observed in available soil nutrients between 100% NPK+Zn+PSB and 100% NPK alone, except available nitrogen. These were probably due to higher nutrient uptake under intercropping, better growth parameters, yield attributes and yield under paired planting and full dose of NPK, which maintained available soil nutrient status. PSB solubilised the native phosphorus and Zn, which are capable of increasing the uptake of nitrogen and also activating the several nutrients.

Gross return, net returns and benefit: cost ratio: Maize+mashbean intercropping system recorded the highest gross return (Rs.74741 ha^{-1}) net return (Rs. 53370 ha^{-1}) and benefit: cost ratio (2.52) than sole maize. In planting geometries, gross return, net returns and benefit: cost ratio were almost similar under both the planting geometries. The application of 100% NPK+Zn+PSB registered significantly higher gross return (Rs.68950 ha^{-1}) and net return (Rs. 46290 ha^{-1}) than control and 100% NPK. However, benefit: cost ratio was slightly higher under control (2.20) than 100% NPK (1.98) and100% NPK+Zn+PSB (2.03). This might be due to the fact that lower cost involved in control and substantial amount of nitrogen fixed by mashbean from atmosphere and release of organic carbon into the soil by mashbean. Similar finding were also reported by Dwivedi *et al.* (2012).

The study show that maize+mashbean intercropping under paired/normal planting proved to be better out yield of growth parameter, available soil nutrients and gross/net returns and benefit : cost ratio on fertilization with 100% NPK+Zn+PSB.

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Evaluation of Prominent Bio-intensive Complementary Cropping Systems in Relation to Intensification and Diversification Under Assured Input Conditions

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Abstract: The impact of twelve crop sequences on productivity, profitability, water efficiency, soil fertility and soil micro fauna was evaluated. Maximum rice equivalent yield was recorded by the cropping system of maize (furrow) + turmeric (bed) - barley + linseed (furrow) (25.7 t ha^{-1}). Diversified cropping systems produced an additional rice equivalent yield of 7.9 to 13.3 t ha^{-1} and saved 117 to 132 cm irrigation water over the rice-wheat system. Maize (furrow) + turmeric (bed) - barley (bed) + linseed (furrow) gave highest production efficiency (70.3 kg day^{-1} ha^{-1}), net returns (Rs 1,92,121), highest viable counts of bacteria ranging (56.5 x 10^6), highest viable counts of actinomycetes ranging (39.3 x 10^4) and highest number of fungi (31.1 x 10^3 cfu g^{-1}), respectively. The soil fertility status did not show much difference from their initial values.

Key Words: Cropping systems, Productivity, Soil fertility, Soil micro-fauna, Water efficiency

The continuous cultivation of rice-wheat cropping system has created many problems related to low water use efficiency, land degradation, indiscriminate exploitation of groundwater, in-efficient land use, decline in factor productivity, imbalance in fertilizer use, build up of diseases, pests and concerns of environmental quality. Diversification and intensification of rice-wheat based system to increase productivity per unit resource is very pertinent. The area under rice has increased tremendously at the cost of area under maize, groundnut, pulses, etc. and presently rice is grown on about 28.3 million hectares. Crop diversification shows lot of promises like, fulfilling basic needs for cereals, pulses, oilseeds and vegetables and, regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity (Gill and Ahlawat, 2006). Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hedge *et al*., 2003). In the era of shrinking resource base of land, water and energy, resource use efficiency is an important aspect for considering the suitability of a cropping system (Yadav, 2002). Hence, selection of component crops needs to be suitably planned to harvest the synergism among them towards efficient utilization of resource base and to increase overall productivity (Anderson, 2005). Therefore, the present experiment was carried out to evaluate the most suitable cropping system with respect to high productivity levels and rational use of resources and to test the feasibility and economics of different cropping systems.

MATERIAL AND METHODS

The study was conducted at Punjab Agricultural University, Ludhiana centre of All India Co-ordinated Research Project on Integrated Farming System during 2009-10 to 2010-11. The soil of experimental field was sandy loam in texture and classified as Typic Ustrochrept having pH 7.2, EC 0.40 dS m^{-1}, organic C 0.53 % and available N 186 kg/ha, P 44 kg ha^{-1} and K 132 kg ha^{-1}, respectively. Twelve cropping systems were evaluated for their production potential and economics, viz., S_1, rice 'PR 114' (*Oryza sativa* L.)-wheat 'PBW 343' (*Triticum aestivum* L. Fiori & Paol.); S_2, basmati rice (*Oryza sativa* L.)-hayola (Brassica *campestris*) (transplanted)–summer moongbean (*Vigna radiata* (L.) Wilczek) (G+R); S_3, basmati rice-radish (*Raphanus sativus*) - spring maize (*Zea mays* L.); S_4 maize 'Paras'-potato (*Solanum tuberosum* L.)-spring maize; S_5, maize (furrow) + Turmeric (*Curcuma longa* L.) (bed) – barley (*Hordeum vulgare* L.) (bed) + linseed (*Linum usitatissimum*, Linaceae) (furrow); S_6, maize (furrow) + turmeric (*Curcuma longa* L.) (bed)-wheat (bed) + linseed (furrow); S_7, maize (furrow) + radish (bed) - wheat (Bed) + linseed (Furrow)-summer moongbean; S_8, groundnut (*Arachis hypogaea* L.) + arhar (*Cajanus cajan* (L.) Millsp) (5:1)-wheat + sarson (*Brassica napus* L.) (9:1); S_9, cotton (*Gossypium hirsutum* L.) +

dhaincha (*Sesbania aculeate*)-radish (bed) + hayola transplanted (furrows); S_{10}, cotton + dhaincha-wheat+linseed (furrows); S_{11}, maize (cobs) + vegetable cowpea (*Vigna unguiculata* (L.) Walp) + dhaincha (BBF: 105 cm wide bed and 30 cm wide furrow, sowing of dhaincha in furrow and incorporation at 42 days after sowing. Two rows of maize on beds (70 × 25 cm) and row of cowpea for vegetable (fodder purpose) mustard sowing in furrow and gram on beds- 3 rows in rabi green gram (G+R in summer); S_{12}, sorghum (*Sorghum bicolor* Moench) + cowpeas (fodder)-wheat + mustard (9:1) – cowpeas (Vegetable) + fodder. A randomized block design was followed with four replications. For comparison between crop sequences, the yields of all the crops were converted into rice equivalent yield on price basis. The mean data of two years were analysed for computing stability indices as per the procedure described by Katyal *et al.* (1999). Mean of prevailing market rates during 2009-10 and 2010-11 were used for computing economic viability. The water use productivity of different cropping systems was calculated by dividing the rice grain equivalent yield of the system by the total of average water use by different crops in the cropping system. Similarly, the nutrient use productivity was calculated by dividing the grain equivalent yield of the system with the total quantity of nutrients (N-P-K) used in different crops in the system.

The farmyard manure @ 10 t ha^{-1} on air dry weight basis was applied to maize crops. The farmyard manure contains 0.75 % N, 0.34 % P, 0.71 % K, 56 ppm Zn, 14 ppm Cu, 478 ppm Fe and 116 ppm Mn. The soil samples, taken for analysis from 0-15 cm soil layer after summer season of 2009-10, were analyzed in the laboratory using standard procedures. Rapid titration method (wet digestion method) was used for organic carbon determination (Walkley and Black, 1934). Available nitrogen, phosphorus and potassium were determined by the methods described by Dalal *et al.* (1984); Subbiah and Asija (1956); Olsen *et al.* (1954), respectively. The micronutrients from soil samples were determined from 1:2, soil- extractant ratio using DTPA-TEA buffer (0.005 M DTPA + 0.001 M $CaCl_2$ + 0.1 M TEA, pH 7.3) as per method proposed by Lindsay and Norvell (1978). The uptake of available N, P and K by plants was determined by the procedures given by Jackson (1973). Serial dilution plates count method was followed for determining bacterial and fungal population using soil extract agar (Lochhaed and Chase, 1943) and Rose Bengal streptomycin agar medium (Martin, 1950), respectively.

RESULTS AND DISCUSSION

The results revealed that there is sufficient scope to replace rice-wheat system with other systems without any decline in economic yield rather it improved substantially (Table 1 and 2). The maize (furrow) + turmeric (bed) - barley + linseed (furrow), maize (furrow) + turmeric (bed) - wheat (bed) + linseed (furrow), maize- potato- spring maize, maize (furrow) + radish (bed) - wheat+ linseed (furrow)-summer moongbean, basmati rice-radish-spring maize, basmati rice-hyola (transplanted)-summer moongbean (G+R) gave rice equivalent yield as 25.7, 23.8, 20.3, 18.2, 17.1 and 16.8 t^{-1} ha $annum^{-1}$ as against 12.4 t^{-1} ha $annum^{-1}$ in rice-wheat system, which clearly illucidated the superiority of these systems over rice-wheat system. These systems also help to save substantial quantity of irrigation water. It is therefore, pertinent that shifting of small area under the systems discussed above related to crop diversification and intensification concept can help to conserve the resources and keep productivity level intact. In Trans-Gangetic plains, the system productivity of maize based cropping systems viz., 'maize-wheat-greengram', 'maize-potato-greengram' and 'maize-potato-onion' was remarkably higher over rice-wheat system. Further, the irrigation water productivity in maize based systems was more than double compared to rice-wheat system (Gill and Sharma, 2005). Singh (2006) reported that in peri-urban interface, high value cropping systems involving maize are more remunerative than the 'rice-wheat' cropping system. The maize-potato-onion; summer groundnut-potato-pearlmillet (f) and maize-potato-summer moong bean produced significantly higher rice equivalent yield as 22.5, 15.8 and 15.8 t^{-1} ha $annum^{-1}$ in rice-wheat system, which clearly elucidated the superiority of these systems over rice-wheat system (Walia *et al.,* 2010). Choudhary *et al.* (2001) also reported greater productivity by replacing wheat in rice-wheat system with vegetables crops like radish and potato. Sharma *et al.* (2004) have also reported that intensification through inclusion of vegetables and leguminous crops increase the production and land use efficiency.

Productivity and water saving

The cropping systems having **3**00 per cent cropping intensity viz., maize (furrow) + turmeric (bed) - barley (bed) + linseed (furrow) gave highest productivity (25.7 t^{-1} ha $annum^{-1}$) and used 132 cm less water than rice-wheat system with a productivity margin of 13.3 t^{-1} ha $annum^{-1}$ (Table 2). The second best cropping system proved as maize (furrow) + turmeric (bed) - wheat (bed) + linseed (furrow) showed an edge of 11.4 t ha^{-1} productivity and saved 132 cm of irrigation water. The maize-potato-spring maize cropping system produced 20.3 t^{-1} ha $annum^{-1}$ productivity and resulted in saving of 117 cm irrigation water. In basmati rice-hayola (transplanted)-summer moongbean cropping system in which the residues of summer moongbean were

Table 1. Economic yield of different cropping systems in 2009-10 and 2010-11

Cropping system	Economic yield (q ha^{-1})											
	2009-10						2010-11					
	Kharif		*Rabi*		Summer		*Kharif*		*Rabi*		Summer	
	Main	Inter-crop	Main	Inter-crop	Main	Inter-crop	Main	Inter-crop	Main	Inter-crop	Main	Inter-crop
Rice-Wheat	61.8		54.3				63.1		54.6			
Basmati rice- Hayola (transplanted) – Summer moongbean (G+R)	44.6		17.7		11.91		42.3		19.5		11.8	
Basmati rice- Radish- Spring maize	43.8		179.2		63.53		41.5		166.9		64.3	
Maize- Potato- Spring maize	42.0		225.0		65.38		51.4		216.9		64.7	
Maize (furrow) + Turmeric (bed) - Barley (bed) + Linseed (Furrow)	42.1	82.5	37.0	3.6			44.6	211.9	38.3	3.89		
Maize (furrow) + Turmeric (bed) - Wheat (bed) + Linseed (furrow)	42.0	81.7	36.9	4.3			46.7	219.4	39.2	4.86		
Maize (furrow) + Radish (bed) - Wheat (bed) + Linseed (furrow) – Summer moongbean	39.0	117.0	38.1	4.7	11.73		49.9	95.8	37.8	5.11	11.5	
Groundnut + Arhar (5:1) – Wheat + Sarson (9:1)	29.0	6.4	46.2	2.3			23.3	6.1	47.1	2.34		
Cotton + Sesbaina –Radish (bed) + Hayola transplanted (furrows)	12.7		14.5	176.8			14.2		16.1	129.28		
Cotton + Sesbaina –Wheat (bed) + Linseed (furrows)	15.2		35.8	4.2			15.8		36.9	4.10		
Maize (cobs) + Vegetable Cowpea + Sesbania - Mustard +Gram -Green gram	205.7	42.8	2.4	14.7	10.81		221.4	40.6	3.5	16.75	11.3	
Sorghum + Cowpeas (fodder)- Wheat + mustard (9:1) – Cowpeas (Vegetable) + Fodder			46.3	2.3	62.88	108.3		211.9	48.0	2.33	65.8	110.77

Table 2. Rice equivalent yield and economic analysis of different bio-intensive complementary cropping systems (Mean 2009-10 and 2010-11)

Cropping systems	*Kharif*		*Rabi*		Summer		Rice equivalent yield (q ha^{-1})	Production efficiency (kg day^{-1} ha^{-1})	Irrigation water (cm)	Irrigation water use efficiency (kg grain m^3 irrigation water)	Gross returns (Rs ha^{-1})	Input cost (Rs ha^{-1})	Net return (Rs ha^{-1})
	Main	Inter-crop	Main	Inter-crop	Main	Inter-crop							
Rice-wheat	124.9	0	108.9	0	0	0	124.30	34.1	230	0.540	128029	50425	77604
Basmati rice- Hayola (transplanted) - Summer moongbean (G+R)	86.9	0	37.2	0	23.71	0	167.99	46.0	210	0.800	173030	64533	108497
Basmati rice- Radish- Spring maize	85.3	0	346.1	0	127.83	0	171.02	46.9	225	0.760	176151	72406	103745
Maize- Potato- Spring maize	93.4	0	441.9	0	130.08	0	202.72	55.5	113	1.794	208802	86949	121853
Maize (furrow) + Turmeric (bed) - Barley (bed) + Linseed (furrow)	86.7	294.4	75.3	7.49	0	0	256.62	70.3	98	2.619	264319	72198	192121
Maize (furrow) + Turmeric (bed) - Wheat (Bed) + Linseed (furrow)	88.7	301.1	76.1	9.16	0	0	238.16	65.2	98	2.430	245305	72198	173107
Maize (furrow) + Radish (bed) - Wheat (bed) + Linseed (furrow) – Summer moongbean	88.9	212.8	75.9	9.81	23.23	0	182.43	50.0	120	1.520	187903	78320	109583
Groundnut + Arhar (5:1) – Wheat + Sarson (9:1)	52.3	12.5	93.3	4.64	0	0	134.98	37.0	83	1.626	139029	48675	90354
Cotton + Sesbaina –Radish (bed) + Hayola transplanted (furrows)	26.9	0	30.6	306.08	0	0	72.94	20.0	83	0.879	75128	56415	18713
Cotton + Sesbaina –Wheat (bed) + Linseed (furrows)	31	0	72.7	8.3	0	0	95.43	26.1	83	1.150	98293	61060	37233
Maize (cobs) + Vegetable Cowpea + sesbania - Mustard +Gram -Green gram	427.1	83.4	5.9	31.45	22.11	0	138.88	38.0	83	1.673	143046	73140	69906
Sorghum + Cowpeas (fodder)- Wheat + Mustard (9:1) – Cowpeas (Vegetable) + Fodder	0	211.9	94.3	4.63	128.68	219.07	126.18	34.6	98	1.288	129965	48985	80980

incorporated in the field (16.8 t^{-1} ha $annum^{-1}$) total irrigation water used as 210 cm; there by indicating the net saving of irrigation water to the extent of 20 cm. The maize (furrow) + radish (bed) - wheat (bed) + linseed (furrow) – summer moongbean another promising cropping system, gave 18.2 t^{-1} ha $annum^{-1}$ productivity with 120 cm of irrigation water leading to 110 cm saving of water. Water is the most crucial input and must be used rationally and these results consolidate the scope for immediate shift to the high productivity cropping systems as stated above. Similarly maize-potato-onion system gave the highest productivity (278.6 q^{-1} ha $annum^{-1}$) and used 82 cm less water than rice-wheat system with a productivity margin of 132.4 q^{-1} ha $annum^{-1}$. The summer groundnut-potato-bajra (fodder) system gave 233.0 q^{-1} ha $annum^{-1}$ productivity with 103 cm irrigation water leading to 109 cm saving of water. Maize-potato-summer moong cropping system gave 191.0 q^{-1} ha $annum^{-1}$ productivity with total irrigation water used as 92 cm, thereby indicating the net saving of irrigation water to the extent of 120 cm. The maize-wheat-summer moong produced 161.8 q^{-1} ha $annum^{-1}$ productivity and used only 68 cm irrigation water which was 68 per cent less than irrigation water used for rice-wheat system (Sharma *et al.,* 2004).

Economics

The net returns were maximum in maize (furrow) + turmeric (bed) - barley (bed) + linseed (furrow) followed by maize (furrow) + turmeric (bed) - wheat (bed) + linseed (furrow) i.e., Rs. 2,64,319 and Rs 2,45,305 ha^{-1} $annum^{-1}$. The maize-potato-spring maize and basmati rice-hayola (transplanted)- summer moongbean system gave 1.34 and 1.40 times more net returns over existing rice-wheat cropping system (Table 2). Similarly in experiment conducted by Sharma *et al.* (2004), net returns were maximum Rs. 1,25,023 ha^{-1} $annum^{-1}$ in maize-potato-onion system and it was 2.09 times more over rice-wheat system. The net returns in the other cropping systems like maize-wheat-moong, maize-potato-moong and summer groundnut-potato-bajra (fodder) were Rs. 72,797,78,588 and 1,11,839, respectively.

Irrigation water application efficiency

The maize (furrow) + turmeric (bed) - barley (bed) + linseed (furrow) and maize (furrow) + turmeric (bed) - barley(bed) + linseed (furrow) maize-potato-spring maize cropping system showed highest water productivity (2.619 and 2.430 kg grain m^3 irrigation water) followed by and groundnut + arhar (5:1) – wheat + sarson (9:1) . The lowest water productivity value of 0.540 kg grain m^3 irrigation water was observed with rice-wheat cropping system (Table 2). Low water use efficiency is apparently attributed to excessive use of water and non-adoption of appropriate cropping system. Due to continuous adoption of rice-wheat cropping system, indiscriminate exploitation of ground water has been observed, which has revised concerns about the longterm sustainability of rice-wheat cropping system besides in-efficient land use. Efficiency has to be improved by introducing diversified cropping system this may also help in improving in factor productivity and farm profitability.

Soil fertility status after *rabi* 2010-11

There was not much difference in the soil fertility status from the initial values as well as in between the treatments since the experiment was just started. The organic carbon values ranged from 0.39 - 0.45%, the nitrogen content ranged from 231.44 - 251.60 kg ha^{-1}, the phosphorus content from 46.5 - 50.25 kg ha^{-1} and potassium content from 98.5 - 120.35 kg ha^{-1}, respectively (Table 3). Optimum levels of soil organic matter should be managed through crop rotation, fertility maintenance including use of inorganic fertilizers and organic manures, tillage methods, and other cropping system components (Purakayastha *et al.,* 2008). Among these, management practices like proper cropping systems and balanced fertilization are believed to offer the greatest potential for increasing SOC (soil organic carbon) storage in agricultural soils (Lal, 2002). Pandey *et al.* (2006) reported that application of manures, irrespective of sources and rates recorded significantly higher soil organic carbon, N, P_2O_5 and K_2O compared to control. Increased sequestration of C in agricultural soils has the potential to mitigate the increase in atmospheric greenhouse gases (Sampson and Scholes, 2006).

Soil micro-fauna

The soil microbial population of different cropping systems showed a varied trend both for the systems and the type of micro-organisms. The microbial status of the soil under rice in bio-intensive complementary system is presented in Table 3. It is manifested from the data that the maize (furrow)+turmeric (bed)-barley (bed)+linseed (furrow) gave highest viable counts of bacteria 56.5 x 10^6, highest viable counts of actinomycetes 39.3 x 10^4 and gave the highest number of fungi (31.1 x 10^3 cfu/g).

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Table 3. Soil fertility status after rabi 2010-11 in 0-15 cm depth and microbial counts of soils for evaluation of bio-intensive complementary cropping system (2010-11)

Treatment	OC (%)	Available Nutrients (kg ha^{-1})			Viable count (cfu g^{-1})		
		N	P	K	Bacteria (× 10^6)	Actinomycetes (× 10^4)	Fungi (× 10^3)
Rice-wheat	0.41	243.7	47.13	108.86	19.4	25.3	19.4
Basmati rice- Hayola (transplanted) – Summer moongbean (G+R)	0.40	231.44	48.64	100.62	19.6	22.7	13.6
Basmati rice- Radish- Spring maize	0.43	246.85	49.25	101.03	17.8	25.5	22.6
Maize- Potato- Spring maize	0.45	251.10	50.25	120.35	18.2	21.8	16.9
Maize (furrow) + Turmeric (bed) - Barley (bed) + Linseed (furrow)	0.41	243.5	46.5	98.5	56.5	39.3	31.1
Maize (furrow) + Turmeric (bed) - Wheat (bed) + Linseed (furrow)	0.42	238.6	48.5	99.6	30.0	28.9	16.1
Maize (furrow) + Radish (bed) - Wheat (bed) + Linseed (furrow) – summer moongbean	0.41	234.6	47.5	102.5	27.1	23.6	29.2
Groundnut + Arhar (5:1) – Wheat + Sarson (9:1)	0.45	251.6	46.8	100.8	18.2	23.8	11.7
Cotton + Sesbaina –Radish (bed) + Hayola transplanted (furrows)	0.43	238.4	48.5	105.6	22.7	22.7	12.8
Cotton + Sesbaina –Wheat (bed) + Linseed (furrows)	0.39	238.6	46.5	117.5	22.3	24.0	13.8
Maize (cobs) + Vegetable Cowpea + sesbania - Mustard +Gram - Green gram	0.42	246.5	48.5	105.6	20.8	22.7	15.7
Sorghum + Cowpeas (fodder)- Wheat + mustard (9:1) – Cowpeas (Vegetable) + Fodder.	0.381	242.0	47.5	100.4	24.8	26.1	27.3
Initial status	0.381	242.0	47.5	100.4	20.2	22.6	18.4

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Composition and Assessment Potential of Wild Ginger Oil and its Fractions as Stored Grain Protectants

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Abstract: The wild ginger oil contained 36 compounds and out of which the major components were borneol (8.35%), limonene (7.12%), caryophyllene (2.83%), humulene (0.41%), myrtanol (0.82%) and geraniol (0.81%). Wild ginger oil and its fractions were tested for their bioefficacy against adults of *Tribolium castaneum* (Herbst). At 50 mg g^{-1} concentration, wild ginger oil and its non-polar fraction showed complete mortality on first day of exposure, whereas, the polar fraction showed complete mortality on sixth day of treatment. The results showed that wild ginger oil was more active followed by its non-polar and polar fractions and their effect increased with increase in concentration and time.

***Key Words*:** Bioefficacy, Column chromatography, GC-MS, *Tribolium castaneum, Zingiber zerumbet*

Essential oils are secondary metabolites produced by plants for their own needs other than for nutrition and as stored grain protectants (Kim *et al.,* 2003, Negahban and Moharramipour, 2007; Rajendran and Sriranjini, 2008). These are environmentally safe as compared to synthetic pesticides and easily degraded. The essential oils are rich in monoterpenes and cause death of insects by inhibiting acetylcholinesterase activity (Houghton *et al.,* 2006).

Zingiber zerumbet (L) Smith, a member of Zingiberaceae, native to southern Thailand is known to possess various types of biological activities. It possesses insecticidal, antinociceptive, anti-inflammatory, antiulcer, antihyperglycemic, antitumor, antiallergic and antiplatelet activities (Chung *et al.,* 2008, Sulaiman *et al.,* 2010 and Yob *et al.,* 2011). In the current scenario, there is an urgent need to develop safer, environmentally friendly and efficient alternatives that have potential to replace synthetic pesticides. The present investigation was undertaken to study the chemical composition of wild ginger oil and insecticidal potential of wild ginger oil and its fractions.

MATERIAL AND METHODS

Wild ginger oil was procured from laboratory stock and analyzed using the GC-MS (QP2010 Plus, Shimadzu, Japan), equipped with an Rtx-5 MS capillary column (30.0 m × 0.20-0.25 mm i.d., 0.25 µm film thickness). The GC injector was maintained at 250 °C and operated in split injection mode with the split valve closed for 1 min. Helium gas was used as the carrier gas at a constant pressure of 69kPa. The column oven was initially maintained at 50 °C for 2 min, raised to 180 °C at 3 °C min^{-1}, then to 280 °C at 10 °C min^{-1}. The interface temperature was 260 °C and the ionization mode was electron impact (70 eV). The mass selective detector was operated in the scan mode between 40 and 600 m/z. Data acquisition was started 3.0 min after injection. MS parameters were: Ionization Voltage (EI) 70 eV, peak width 2 s, mass range 40–600 amu and detector voltage 1.5 V. Peak identification was carried out by comparison of the mass spectra with mass spectra available on database of NIST08, WILEY8, Perfumery and Flavor and Fragrance libraries. The GC-MS data of the oil is given in Table 1.

The wild ginger oil was dissolved in petroleum ether and applied on the plate coated with silica gel G. The chromatographic plates were developed using benzene: ethyl acetate (95:5) as the solvent system, air dried, sprayed with sulfuric acid: methanol (95:5) and heated in an electric oven at 100° C for 5 min in order to reveal the spots. The R_f values and colour of the spots were noted. Wild ginger oil was subjected to column chromatography to fractionate it into non-polar and polar fractions. The column was packed with silica gel with 60-120 mesh size activated at 110° C for 1 h. The oil was adsorbed on silica gel for 5 min. Column was eluted with petroleum ether and dichloromethane as solvent to obtain its non-polar and polar fractions, respectively (Chahal *et al*., 2014)

Insecticidal activity: The wheat grains (*Triticum aestivum* variety PBW 343, moisture content 11.0 per cent) were obtained from Department of Plant Breeding and Genetics, PAU, Ludhiana. Adults of *Tribolium castaneum* were collected from the local grain market and released in glass jar containing wheat flour mixed with 5 per cent yeast powder. The culture jars were placed in incubators maintained at

30±1^{0}C and 70±1 per cent relative humidity.The stock solution **(500 mg ml^{-1})** of the oil was prepared by dissolving the wild ginger oil (5g) in acetone making its final volume to 10 ml. The stock solution was diluted for spiking wheat to have different concentrations viz. 10, 20, 40 and 50 mg g^{-1}. Similarly, the stock solutions for non-polar and polar fractions were also prepared. The wheat grains (10 g) were spiked at four different concentrations viz. 10, 20, 40 and 50 mg g^{-1} respectively. Each treatment was replicated thrice. Twenty adults of same age (1-2 weeks, F_1 generation) were released into each bottle and mouth of bottle was covered with muslin cloth. The observations of mortality of *T. castaneum* were taken after every 24 hrs till complete or constant mortality was obtained. The corrected per cent mortality was calculated.

RESULTS AND DISCUSSION

The wild ginger oil is yellow-coloured liquid with pH, specific gravity and refractive index of the oil of value 5.5, 0.887 and 1.50, respectively. The wild ginger oil was insoluble in water, sparingly soluble in hexane and soluble in acetone and ethanol. Thin layer chromatography of wild ginger oil revealed four spots indicating that it contained four major compounds with R_f value of 0.66, 0.77, 0.87 and 0.97. The essential oil was subjected to column chromatography to fractionate it into non-polar (petroleum ether) and polar (dichloromethane) fractions. The non-polar fraction showed one pinkish-brown spot having R_f value of 0.97. The polar fraction gave three pinkish-brown spots having R_f values of 0.77, 0.87 and 0.66. Gas chromatography- Mass spectrometry data of the wild ginger oil showed the presence of several compounds out of which caryophyllene, humulene, limonene, nerolidol, geraniol, borneol, myrtanol etc. were the major compounds. The retention time and percentage area for each compound are given in Table 1.

Insecticidal activity; The wild ginger oil showed complete per cent mortality at the concentration of 50 and 40 mg g^{-1} on first and tenth day, respectively. The lower concentrations of 10-20 mg g^{-1}, showed less mortality and increased slowly with time and complete mortality was not observed even after 30 days of application, which may be due to less concentration of toxic compounds present in the oil. The high mortality rate of wild ginger oil may be due to the presence of large number of both polar and non-polar toxic compounds present in the oil. Complete mortality at higher concentrations of 50 and 40 mg g^{-1} was achieved on first and second day respectively in case of non-polar fraction of wild ginger oil. The complete corrected per cent mortality at lower concentrations of 10 and 20 mg g^{-1} was not achieved in petroleum ether fraction. This may be attributed to the presence of less number of compounds and very low concentration of toxic compounds present at this concentration in the non-polar fraction. It was revealed that non-polar fraction was active at higher concentrations of 40 and 50 mg g^{-1} only, whereas, at low concentrations mortality rate was low. Polar dichloromethane fraction showed corrected per cent mortality of 51.67 and 91.65 on the first day of exposure at the concentrations of 40 and 50 mg g^{-1}, respectively, however complete mortality was

Table 1. GC-MS data of wild ginger oil

Name	Area (%)	Retention time (min)	Name	Area (%)	Retention time (min)
n-Octane	0.58	3.891	Bornyl acetate	0.84	23.181
Sabinene	0.38	9.256	n-Tridecane	2.11	23.799
Myrcene	1.52	9.992	Eicosane	0.71	26.521
Limonene	7.12	11.656	β-Bourbonene	0.33	27.424
Camphenilone	1.01	13.940	n-Tetradecane	1.62	28.092
n-Undecane	3.32	14.769	(E)-Caryophyllene	2.83	28.931
2-methyl-trans-Decalin	0.66	15.058	1,7,7-trimethyl-(1R)- Camphor	1.16	16.698
α-humulene	0.41	30.284	Cadina-1(6),4-diene	0.03	31.112
Borneol	8.35	17.841	γ.-Muurolene	0.17	31.245
n-Dodecane	3.17	19.333	Germacrene D	0.25	31.411
D-Verbenone	0.22	19.721	Cubebol	0.63	31.965
trans-Carveol	0.31	20.174	n-Pentadecane	1.08	32.162
Bornyl formate	0.75	20.552	β-Bisabolene	0.11	32.540
(-)-cis-Myrtanol	0.82	21.208	δ-Cadinene	1.06	33.145
Geraniol	0.81	21.807	Elemicin	3.87	34.641
Caryophyllene oxide	1.26	35.462	n-Hexadecane	0.52	36.024
Epicubenol	0.16	37.165	Guaiol	0.56	37.415
Hinesol	0.28	37.699	(E)-Nerolidol	0.07	50.487

not observed on the first day of treatment. On tenth day of experiment, complete corrected per cent mortality was observed at 40 mg g^{-1} concentration. After thirtieth day of application, the corrected percent mortality became constant. Complete mortality was not observed at lower concentration of 10 and 20 mg g^{-1} even after thirty days of exposure. The concentration of 50 mg g^{-1} was most effective, whereas, 10 mg g^{-1} were least effective (Table 2).

The data showed that the corrected per cent mortality increased with increase in concentration of wild ginger oil, its non-polar and polar fractions. The results were in consonance with earlier findings, which reported that corrected per cent mortality of *T. castaneum adult's increased* with increase in concentration and time of application at different concentrations of turmeric oil tested (Chahal *et al.,* 2009).

The statistical analysis of the parent oil and its non-polar and polar fractions were carried out. Mean values for compounds, concentration and days were worked out (Table 3). The critical difference values for compounds, concentration and days were 0.48, 0.84 and 0.56, respectively. The results showed that all the compounds, concentrations and days behaved significantly different. Mean values of compounds were found to be significantly

Table 2. Comparison of corrected per cent mortality of non-polar and polar fractions of wild ginger oil at four different concentrations and number of days

Days of application	Concentrations (mg g^{-1})	(Corrected percent mortality)		
		Wild ginger oil	Petroleum ether Fraction	Dichloromethane Fraction
1	10	4.35	0.00	0.00
	20	23.34	5.00	0.00
	40	91.65	93.35	51.67
	50	100.00	100.00	91.65
3	10	8.35	5.00	2.67
	20	28.35	23.00	26.67
	40	93.30	100.00	61.67
	50	100.00	100.00	98.50
6	10	15.00	5.00	3.67
	20	30.00	36.67	31.67
	40	95.00	100.00	96.67
	50	100.00	100.00	100.00
10	10	15.00	8.33	5.00
	20	33.35	36.67	35.00
	40	100.00	100.00	100.00
	50	100.00	100.00	100.00
15	10	20.00	8.33	5.00
	20	45.00	38.33	35.00
	40	100.00	100.00	100.00
	50	100.00	100.00	100.00
20	10	28.35	9.25	7.00
	20	51.65	38.33	35.00
	40	100.00	100.00	100.00
	50	100.00	100.00	100.00
25	10	33.35	10.00	8.33
	20	60.35	41.67	38.33
	40	100.00	100.00	100.00
	50	100.00	100.00	100.00
30	10	46.65	10.56	10.00
	20	66.50	41.67	40.00
	40	100.00	100.00	100.00
	50	100.00	100.00	100.00

Table 3. Effect of wild ginger oil and its fractions at their different concentrations against adults of *T. castaneum* at different time intervals

Compounds(A)	Days(C)	Concentration			
		10 mg g^{-1}	20 mg g^{-1}	40 mg g^{-1}	50 mg g^{-1}
Wild ginger oil	1	1±0	3.67±0.66	18.33±0.88	20±0
	3	1.67±0.33	5.67±0.66	18.67±0.66	20±0
	6	2.0±0.57	6.0±1.0	19.0±0.57	20±0
	10	3.0±0.57	6.67±1.66	20±0	20±0
	15	4.67±0.66	7.33±1.45	20±0	20±0
	20	5.67±0.87	10.33±2.40	20±0	20±0
	25	6.67±1.44	11.0±2.30	20±0	20±0
	30	9.33±1.85	13.33±1.33	20±0	20±0
	35	11.0±1.52	14.0±1.15	20±0	20±0
Non-polar fraction	1	0±0	1.0±0.57	18.67±0.88	20±0
	3	1.0±0.57	4.67±1.76	20±0	20±0
	6	1.0±0.57	7.33±2.60	20±0	20±0
	10	1.67±0.33	7.33±2.60	20±0	20±0
	15	1.67±0.33	7.67±2.91	20±0	20±0
	20	2.0±0	7.67±2.91	20±0	20±0
	25	2.0±0	8.33±2.60	20±0	20±0
	30	2.33±0.33	8.33±2.60	20±0	20±0
	35	2.33±0.33	8.67±2.91	20±0	20±0
Polar fraction	1	0±0	0±0	10.33±2.02	18.33±0.88
	3	0.33±0.33	5.33±1.44	12.33±2.18	19.67±0.33
	6	0.67±0.33	6.33±1.45	19.33±0.33	20±0
	10	1.0±0.57	7.0±1.15	20±0	20±0
	15	1.0±0.57	7.0±1.15	20±0	20±0
	20	1.33±0.33	7.0±1.15	20±0	20±0
	25	1.67±0.66	7.67±1.20	20±0	20±0
	30	1.67±0.66	7.67±1.20	20±0	20±0
	35	2.0±0.57	8.0±1.52	20±0	20±0

CD (0.05)		
	Compared	- 0.48
	Concentration	- 0.84
	Days	- 0.56
	Compared x Concentration	- 1.45
	Compared x Days	- 0.97
	Concentration x Days	- 1.68

different from each other and also the difference of mean values of the compounds is more than the critical difference calculated for the compounds. So the activity of compounds was found to be significant. As the mean value of wild ginger oil was more than the non-polar and polar fraction so the oil was found to be more potent at all the concentrations than its fractions. As per the mean values of concentrations and days are concerned, with the increase in the concentration and days, the mean values also increased, which proved that the effect of the compounds increased on the test insect with the increase in concentration and days of application. The interaction of the compound was statistically analysed with respect to concentration and number of days. The critical difference values of 1.45, 0.97 and 1.68 were obtained indicating that the interaction between the compounds and concentrations; compounds and days; concentrations and days is also significantly different.

It can be concluded that parent wild ginger oil was more effective in controlling the insects as compared to its non-polar and polar fractions separately due to the synergistic action of the compounds present in the wild ginger oil. Out of petroleum ether and dichloromethane fractions, petroleum ether fraction was most active in controlling the adult insects. Earlier studies on insecticidal

properties of *Tagetes erecta* against *T. castaneum* (Sharma and Chahal, 2012) and *Cedrus deodara* against *Lipaphis erysimi* (Sharma *et al.,* 2007) and comparison of the bioefficacy of the essential oil and its fractions showed that non-polar fraction was more effective as insecticide as compared to polar fraction. Similarly, the bioactive extract and fractions of essential oil of *T.erecta* flowers showed that hexane fraction was more active against *Spodoptera litura* (Ray *et al.,* 2010) as compared to polar fraction. All these results are in consonance with our studies confirming that non-polar fraction contained the effective toxic compounds responsible for the insecticidal activity. Further the activity increased with increase in concentration and time of application.

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Effect of Potassium Huamte in Conjugation with Inorganic Fertilizers on Different Forms of Carbon in Soil Under Rice Crop

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***Abstract*:** Pot experiments were conducted to study the effect of potassium humate and chemical fertilizers on different soil C fraction under rice crop. Hot water soluble carbon (HWSC), microbial biomass carbon (MBC), $KMnO_4$ oxidizable C and total organic carbon (TOC) increased significantly with increasing level of potassium humate. The highest value of HWS carbon, microbial biomass carbon, $KMnO_4$ oxidizable C and total carbon were with 10 mg kg^{-1} of potassium humate (PH_{10}) and the values were significantly higher than the corresponding values obtained with PH_5 and PH_0. Increment to the tune of 4.7% in WSC, 7.6% in MBC, 6.3% in $KMnO_4$–C and 3.4% in TOC were recorded with PH_{10} over PH_0.

***Key Words*:** HWS carbon, MBC, $KMnO_4$ oxidizable C, Potassium humate, Total carbon

Research work in the field of soil fertility in the country attained greater significance since the introduction of high yielding varieties in 1965 as a part of the strategy to boost up production to overcome the chronic food shortage. This was soon followed by the emphasis on multiple cropping with a view to have higher return from land per unit area per unit time instead of yield per unit area only (productivity rather than production) at minimum loss of resources. This has resulted in deterioration of soil quality, increase in soil erosion and pollution risks. Thus, the possible negative environmental impact of crop and enhancement in the cost of production are two important considerations, which necessitate judicious application of chemical fertilizers and carbon rich materials to the soil. Potassium humate is one such material, which has been reported recently (Turgay *et al.,* 2011) as a potential to improve soil properties and nutrient dynamics. Potassium humate is a very concentrated form of humus in the naturally occurring lignite, which is the brown coal that accompanies coal deposits. Humic acid (HA) consists of conglomerate chemically reactive functional groups, including carboxyls, phenolic, and alcoholic hydroxyls with pH dependent properties (Alvarez-Puebla *et al.,* 2005). Change in land use or agricultural management practices lead to changes in SOM content. Small changes in total soil organic carbon are difficult to be detected because of the generally high background levels and natural soil variability. For this reason, many attempts have been made to use sub-pools of soil organic carbon as more sensitive indicators of short term changes in carbon pool. The hot-water extractable pool of C (HWC) tends to relate well with microbial biomass-C (Sparling *et al.,* 1998). The measurement of C released by the oxidation of soil with 333 mM $KMnO_4$ is a rapid and an economical method to quantify labile SOC fraction (Weil *et al*., 2003). The $KMnO_4$–C is a sensitive indicator of changes in the SOC caused by different management practices (Weil *et al.*, 2003). Hence, present study, influence of potassium huamte in conjugation with inorganic fertilizers on different forms of carbon in soil was assessed after completion of two years experiment.

MATERIAL AND METHODS

A two year replicated experiment were conducted in net house of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India to evaluate the effect of potassium humate and chemical fertilizers on nutrient availability pattern in soil. A bulk surface (0–15 cm) soil was collected and the soil sample was air-dried under shade and crushed with a wooden roller and passed through sieve having openings of 2 mm diameter and 8 kg of soil filled in each polythene lined pot. Soil in each pot was puddled manually and 5 seedlings of rice (variety Malviya 36) transplanted. After establishment, four plants were maintained. The experiment was arranged in factorial completely randomized design with three replications. Potassium humate was applied in soil @ 0 (PH_0), 5 (PH_5) and 10 mg kg^{-1} soil (PH_{10}) mg kg^{-1} soil along with 100% and 75% recommended doses of fertilizers NPK (60, 30, 30 mg kg^{-1}) and 12.5 mg kg^{-1} zinc sulphate was also used. The recommended dose of fertilizers (N, P and K), Zn and potassium humate in mg kg^{-1}

soil were applied through stock solutions of urea, KH_2PO_4, KCl, Zinc sulphate and potassium humate, respectively. Potassium humate used for experimentation contained 70% humic acid, 49.5% total carbon and 10% potassium with 95% solubility. The pots were irrigated and 2cm of standing water was maintained by daily addition of water on the basis of evaporation rate. **After completion of two years experiment,** total organic carbon content was determined by Yeomas and Bremmer (1988), hot water soluble carbon content (HWC) by Ghani *et al*. (2003) microbial biomass carbon (MBC) by using the chloroform fumigation extraction methods of Vance *et al*. (1987). Blair *et al*. (1995) method was used for determination of $KMnO_4$ oxidizable carbon.

RESULT AND DISCUSSION

Hot water soluble (HWS) carbon: Application of potassium humate significantly affected the HWS carbon in soil. The highest HWS carbon (72.62 mg kg^{-1}) was recorded with 10 mg kg^{-1} of potassium humate (PH_{10}) and lowest value of WSC was obtained with PH_0 (Table 1). Similarly, PH_5 increased HWS carbon by 1.4% over PH_0 (Fig. 1). The hot water soluble C constituted 1.0% of total organic C content of the soil. Hot water is a weak extractant used for extraction of labile portion of soil organic matter. The increase in HWS carbon concentration by application of potassium humate is attributed to a higher plant biomass in soil. Hot water soluble C was considered useful index of easily mineralizable N and fertility status of the soil and is largely composed of carbohydrates (Ghani *et al.,* 2003) and N containing compounds such as amino-N species and amides in particular of microbial origin. It may also originate from root exudates and lysates, organic matter weakly adsorbed to soil minerals, that is bound to or trapped in humic molecules and that involved in bringing soil aggregates together (Haynes, 2005). Kumari *et al.* (2011) reported that continuous application of organic manure with 100% NPK increased the water soluble C when compared to control. Bueno and Ladha (2009) found that HWS carbon was 0.5 to 1.7% of TOC and was comparatively low in cultivated soils as compared to adjacent uncultivated soils.

Soil microbial biomass carbon (SMBC): The microbial biomass carbon was higher with $RDF_{100\%}$ as compared to $RDF_{75\%}$ but the difference between levels was non-significant. Increasing levels of potassium humate from 0 to 10 mg kg^{-1} exerted lucid improvement in microbial biomass carbon. The value of MBC was highest with the level PH_{10} followed by PH_5. The lowest value of MBC was recorded in case PH_0 (Table 1). PH_{10} increased MBC by 7.6% over PH_0 and PH_5 caused increment of 3.1% over PH_0 (Fig.1). This increment indicated the activation of microorganisms through carbon source inputs consisting of organic residues. The proportion of soil microbial biomass carbon to the total organic C pool was 3.3%. Increases in soil organic matter are usually associated with similar increases in microbial biomass because the SOM

Table 1. Effect of potassium humate and chemical fertilizers on the soil carbon in different fraction

Treatment	WSC (mg kg^{-1})	MBC (mg kg^{-1})	$KMnO_4$- C (mg kg^{-1})	TOC (mg kg^{-1})
RDF (%)				
$RDF_{75\ \%}$	74.34	245.57	312.95	7271
$RDF_{100\%}$	75.04	248.20	316.27	7422
CD(P = 0.05)	NS	NS	NS	NS
Potassium humate (mg kg^{-1})				
PH_0	73.20	238.34	306.51	7232
PH_5	74.25	245.79	311.59	7330
PH_{10}	76.62	256.51	325.73	7478
CD(P = 0.05)	2.52	6.24	10.61	186
Zinc sulphate (mg kg^{-1})				
Zn_0	74.31	244.41	312.23	7315
$Zn_{12.5}$	75.07	249.35	316.98	7378
CD(P = 0.05)	NS	NS	NS	NS
Interaction		NS		

RDF = Recommended dose of fertilizer (60:30:30 mg kg^{-1} corresponding to 120, 60, and 60 kg ha^{-1} of N, P_2O_5 & K_2O, respectively), PH = Potassium humate, WSC = Water soluble carbon, MBC = Microbial biomass carbon, $KMnO_4$-C = Potassium permanganate oxidizible carbon, TOC = Total organic carbon

provides principal substrates for the microorganisms (Melero *et al*., 2009). Nakhro and Dkhar (2010) reported that application of organic fertilizers increased the organic carbon content of the soil and microbial biomass carbon. Combined application of organic materials and fertilizers is more favourable for improving the fertility of soil. Use of potassium humate and chemical fertilizers provided a good environment and energies for soil microorganism during its decomposing process, and replenished an appropriate amount of available nitrogen and adjusted the soil C/N ratio, and then provide rich carbon and nitrogen sources to soil microorganisms to substantially enhance the activity of soil microbial biomass.

$KMnO_4$ oxidizable C: No significant difference was found in the C oxidized by $KMnO_4$ with $RDF_{100\%}$ and $RDF_{75\%}$. The values of $KMnO_4$ oxidizable C increased only slightly with increasing level of NPK fertilizers. Use of potassium humate affected significantly $KMnO_4$ oxidizable C of soil. The highest value of $KMnO_4$ oxidizable C was recorded with 10 mg kg^{-1} of potassium humate (PH_{10}), which was significantly higher than PH_0. Potassium humate applied at the rate of 10 mg kg^{-1} (PH_{10}) increased concentrations of $KMnO_4$ oxidizable C by 6.3% compared to PH_0 treatment (Fig. 1). The proportion of $KMnO_4$ oxidizable C to the total organic C pool was computed. It was found that this fraction constituted a very small fraction of the total C pool and varied between 4.2 to 4.4% among the treatments. The $KMnO_4$–C is a sensitive indicator of changes in the SOC caused by different management practices (Weil *et al*., 2003). Generally, inorganic fertilizers indirectly influenced SOC concentration by increasing crop yields and thereby increasing the return of crop residues to the soil. In the same context, application of inorganic fertilizers also enhances SOC sequestration (Manna *et al*., 2007; Gong *et al*., 2009). Enhanced crop production due to application of potassium humate might be responsible for increasing $KMnO_4$–C. Similarly, Gong *et al*. (2009) reported that application of organic material (FYM) was more effective in increasing $KMnO_4$–C compared to inorganic fertilizers. In general, application of organic fertilizers either alone or in combination with inorganic fertilizers, increases SOC concentration (Blair *et al*., 2006; Rudrappa *et al*., 2006).

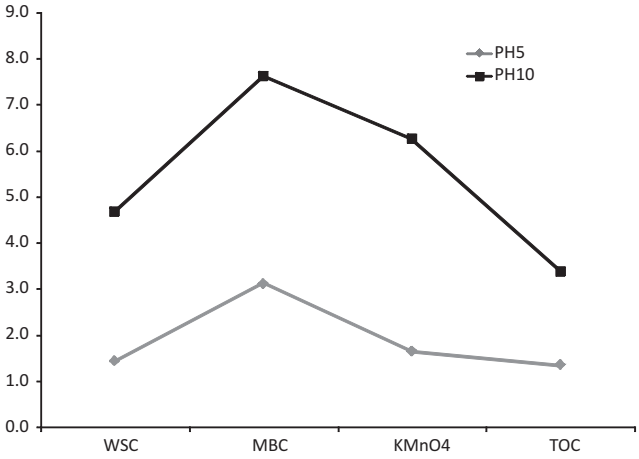

Fig. 1. Per cent increase of different carbon fractions in soil on application of potassium humate

Total organic carbon: Addition of potassium humate greatly influenced the total organic C content of soil. The highest total organic carbon (TOC) was observed with PH_{10}, which was significantly superior over PH_5 and PH_0 (Table 1). Application of 10 mg kg^{-1} of potassium humate (PH_{10}) increased TOC over PH_0 by 3.4% (Fig. 1). Conjoint use of inorganic fertilizer and organic amendments increased crop growth and root biomass, which raised the soil organic matter level. Talavia *et al.* (2007) reported that soil application of humic acid at 20 kg ha^{-1} + NP enhanced the residual status of organic carbon in soil. Higher soil organic carbon concentrations in the soil may be explained by the fact that it is strongly related to root C inputs and crop residues that are often accumulated in the surface soils.

Soil organic carbon is a nutrient governing factor during the crop growth. Increasing the labile pool of soil organic carbon enhanced the crop yield. In this experiment, addition of potassium humate positively affected the various pools of carbon. Application of 10 mg kg^{-1} of potassium humate significantly increased microbial biomass carbon, HWS carbon, potassium per magnate oxidizable carbon and total organic carbon in soil.

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Comparative Studies on Synthesis of Amides by Using Environmentally Benign Methods

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Abstract: Microwave and boric acid catalyzed methods were used for the synthesis of a series of acrylamides from prepared α, β- unsaturated acrylic acids and different amines having heterocyclic moiety i.e. 4-aminophenazone, 4-amino 1,2,4-triazole and morpholine. The increase in yield fluctuated between 11-42%. The time taken by microwave irradiation method was 7-21 minutes, which was 14 hours with conventional method.

Key Words: Acrylamides, Boric acid, Environmentally benign, Microwave, α, β- Unsaturated acids

Amide linkages are present in key natural products and in many biologically active molecules. Therefore, the formation of amide bonds is important to both synthetic chemists and biologists. Approximately 66% of all preliminary screening reactions in industrial medicinal chemistry laboratories involve amide formation (Glynn *et al*., 2008). A plethora of procedures for the formation of carboxamides is precedented in the literature. The most explored method incorporates acid chlorides as electrophiles that react with the amines in the presence of an acid scavenger. Despite its versatility, this method has limitations because there are many unstable acid chlorides and these also require hazardous reagents for their preparation (thionyl chloride, oxalyl chloride, phosgene, etc.). The concerned disadvantageous factors categorize these methods as uneco-friendly and warrant the development of a catalytic and mild process for amidation. First boron reagent based catalytic method that allows direct amide formation from free carboxylic acids and amines as the reaction partners was reported by Ishihara *et al*. (1996; 2001; 2004). A phenyl boronic acid derivative bearing electron-withdrawing substituents in the *m*- and *p*- positions was found to be the catalyst of choice for these kinds of transformations. Tang *et al*. (2005) featured the use of cheap, readily available, nontoxic and eco-friendly boric acid ($B(OH)_3$) as highly effective catalyst, which proved to be superior to other known catalysts involved in the amidation process.

Microwave irradiation is used for a variety of organic transformations where in chemical reactions are accelerated because of selective absorption of microwave energy by polar and non-polar molecules. An efficient and environmentally friendly synthetic method for the synthesis of primary amides under microwave irradiation was described, in which the primary amine was directly reacted with acid without any catalytic agents. The reaction completed in 8–12 minutes, which was much shorter than the conventional methods, with excellent yields (Wang *et al*., 2008). Despite the proven potential of boric acid as a catalyst, it has not been explored extensively for amidation. Herein, we report the application of a boric acid catalyzed and microwave amidation procedure for the synthesis of a series of amides having heteroatoms.

MATERIAL AND METHODS

Open capillaries method was used to determine the melting point and are uncorrected. The purity of compounds was checked on silica gel G coated TLC plates and the visualization was done in iodine chamber.

Boric acid catalysed method: To a solution of acrylic acid (0.03 mole) in toluene (80 ml) taken in a round bottomed flask was added boric acid (0.30 mmole) and was stirred at room temperature to make a clear solution. Amine (0.03 mole) was added to it in one installment and the reaction mixture was refluxed at 80^0 C for 14 hours in an oil bath. Approximately 0.5 ml water was trapped in Dean-Stark apparatus. The reaction mixture was cooled to room temperature and poured in hexane (400 ml) taken in a beaker. During pouring, the solution was stirred and precipitates separated out immediately. The stirring was continued for additional 30 minutes. The precipitates were filtered and then dried at room temperature to get amide. Thin layer chromatography technique was used to check the purity of amide.

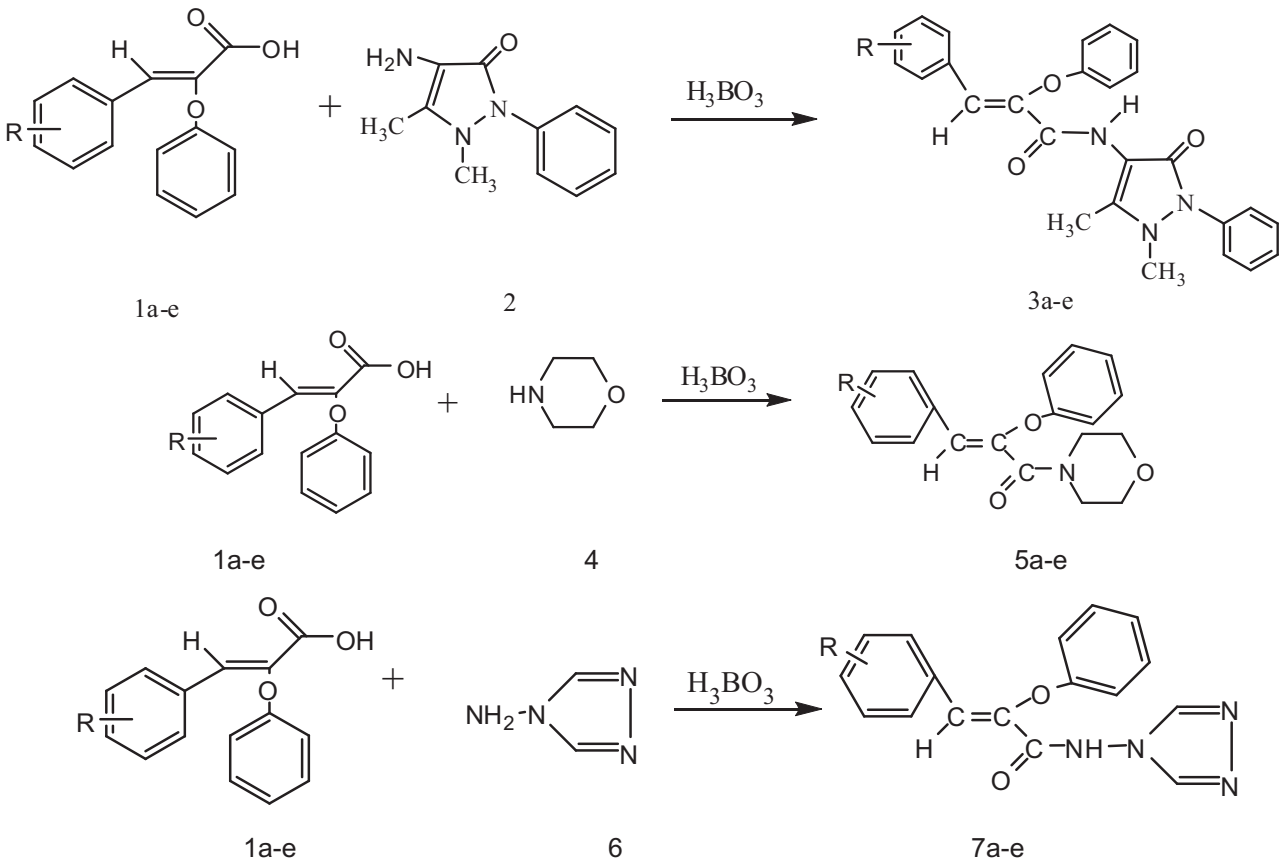
Microwave irradiation method: The conventionally prepared acrylic acid (0.01 mole) was taken in a 50 ml

beaker. Amine (0.01 mole) was added to it and mixed well. The mixture was irradiated in microwave oven at 180 W for different time intervals. The progress of reaction was monitored by thin layer chromatography at an interval of one minute. After the completion of reaction, the mixture was cooled to room temperature and was filtered-off. Finally, it was recrystalized from methanol to furnish corresponding acrylamide.

RESULTS AND DISCUSSION

The prepared α,β unsaturated acids (1a-e) (Kooner *et al*., 2014 and Bansal *et al*., 2015) were reacted with 4-aminophenazone (2), morpholine (4) and 4-amino 1, 2, 4 triazole (6) in the presence of boric acid (act as catalyst) to give corresponding amides (3a-e, 5a-e, 7a-e). These compounds were characterized by IR, ^{1}H NMR and ^{13}C NMR and mass spectra (Bansal *et al*., 2015). The highest increase in yield was 42 per cent in case of compound 3a having phenazone moiety with no substitution on phenyl ring followed by compound 5a with 38 per cent having morpholine moiety with no substitution on phenyl ring. In case of microwave irradiation method, the highest product yield was obtained in compound 5a with 90 per cent yield while for boric acid catalysed method, it was in case of compound 5b with 75 per cent yield. Even the reaction took only 7-21 minutes in microwave irradiation method that took 14 hours to complete in boric acid catalysed method (Table 2). Formation of amide is an exothermic reaction. So rather than providing energy in the form of heat, synthesis had been scaled up towards green chemistry domain by circumventing the use of boric acid as catalyst, toluene as solvent and microwave irradiations. Out of these adopoted greener methodologies, microwave irradiation was the indeed cheaper medium for the reactions. This solvent free microwave approach was not only environmentally benign but easy to handle and devoid of any corrosive and carcinogenic effect. Moreover, in this protocol, the products obtained were in high yield, pure and easily isolable. So it may be concluded that microwave irradiation method was better “green technique” for the synthesis of amides (powder form) and increase in yield was 11-42% as compared to boric acid catalysed reaction.

This study reports the synthesis of a new series of



Scheme 1

Table 1. Physical parameters of the compounds

Compound	Molecular formula	Color	Melting point(°C)	R_f value
3a	$C_{26}H_{23}N_3O_3$	Off-white	191-193	0.72
5a	$C_{19}H_{19}NO_3$	Off-white	119-121	0.70
7a	$C_{17}H_{14}N_4O_2$	Off-white	150-152	0.67
3b	$C_{26}H_{22}N_3O_3Cl$	Off-white	168-170	0.68
5b	$C_{19}H_{18}NO_3Cl$	Off-white	133-135	0.63
7b	$C_{17}H_{13}N_4O_2Cl$	Off-white	172-174	0.69
3c	$C_{26}H_{22}N_3O_3Cl$	Off-white	217-219	0.60
5c	$C_{19}H_{18}NO_3Cl$	Off-white	160-162	0.65
7c	$C_{17}H_{13}N_4O_2Cl$	White	145-147	0.60
3d	$C_{26}H_{22}N_4O_5$	Brown	205-207	0.65
5d	$C_{19}H_{18}N_2O_5$	Light Brown	209-211	0.60
7d	$C_{17}H_{13}N_5O_4$	Brown	182-184	0.70
3e	$C_{26}H_{22}N_4O_5$	Yellow	161-163	0.71
5e	$C_{19}H_{18}N_2O_5$	Light Brown	102-104	0.73
7e	$C_{17}H_{13}N_5O_4$	Off-white	117-119	0.60

Table 2. Comparison of conventional and microwave (MW) irradiation method

Compound	Molecular formula	Yield (%)			Time* taken in MW method
		Conventional Method	MW method	Increase in yield (%)	(min)
3a	$C_{26}H_{23}N_3O_3$	47	89	42	19
5a	$C_{19}H_{19}NO_3$	52	90	38	15
7a	$C_{17}H_{14}N_4O_2$	65	87	22	11
3b	$C_{26}H_{22}N_3O_3Cl$	48	82	36	13
5b	$C_{19}H_{18}NO_3Cl$	75	86	11	21
7b	$C_{17}H_{13}N_4O_2Cl$	70	86	16	7
3c	$C_{26}H_{22}N_3O_3Cl$	50	70	20	11
5c	$C_{19}H_{18}NO_3Cl$	70	84	14	7
7c	$C_{17}H_{13}N_4O_2Cl$	67	80	13	17
3d	$C_{26}H_{22}N_4O_5$	56	74	18	8
5d	$C_{19}H_{18}N_2O_5$	45	68	23	18
7d	$C_{17}H_{13}N_5O_4$	61	85	24	12
3e	$C_{26}H_{22}N_4O_5$	43	73	30	16
5e	$C_{19}H_{18}N_2O_5$	50	84	34	15
7e	$C_{17}H_{13}N_5O_4$	68	88	20	18

*The time taken for the synthesis of amides by conventional method was 14 hours

N-(1, 5-dimethyl-3-oxo-2-phenyl-2, 3-dihydro-1*H*-pyrazol-4-yl)-2-phenoxy-3-phenylacrylamide (3a-e), 1-morpholino-2-phenoxy-3-phenyl prop-2-ene-1-one (5a-e) and 2-phenoxy-3-phenyl-N-(4*H*-1, 2, 4 triazole-4-yl) acrylamide (7a-e) by two environmentally benign methods. Microwave irradiation method gave more yields in less time as compared to boric acid catalysed method.

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Effect of Temperature and Time of Incubation on Ammonical (NH_4^-), Nitrate (NO_3^-) and Mineral Nitrogen Accumulation in Soils Amended with FYM

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Abstract: Higher ammonical (NH_4^-) and nitrate (NO_3^-) nitrogen accumulation in soils receiving organic manures than integrated nutrient management, recommended fertilization and control treatment at all the temperatures (15, 25 and 35°C) of incubation were recorded. The NH_4-N concentration increased with the time of incubation up to about 56-70 days of incubation at all temperatures in all treatment, but decreased thereafter, whereas, NO_3-N release increased continuously with the increase in the time of incubation. The time course of mineralization showed that the mineral N accumulation increased with the increase in time of incubation at all the temperatures but was highest at 35°C in all the treated soils and decreased with decrease in temperature of incubation.

Key Words: FYM, Integrated nutrient management, Inorganic fertilizer, Nitrogen

Nitrogen is the key element in the crop production without which successful agricultural crop production is not possible, but most of this element is not available to plants for uptake. About 95-98% of nitrogen in soil is present in organic form unavailable to plants. The plants can take the nitrogen in only inorganic forms especially ammonical (NH_4^-) and nitrate (NO_3^-) nitrogen. Nitrogen mineralization, which involves conversion of organic nitrogen to plant usable inorganic forms NH_4-N and NO_3-N consists of essentially three steps aminization, amonification and nitrification mediated by microorganisms. The results from the incubation experiments have revealed that NH_4-N production is rapid initially in first few weeks then a slow rate (Broadbent, 1979). The net N mineralization has been found to increase exponentially with the temperature during the laboratory incubation experiments with optimum conditions being related to the soil water content and geographical origin of the soil (Dalias *et al.,* 2002 and Wang *et al.,* 2006). Although the considerable information is available on N mineralization kinetics in soils amended with different organic residues, but the information regarding the NH_4-N and NO_3-N accumulation in soils applied with FYM and chemical fertilizers is lacking. The present study was taken to study the NH_4-N, NO_3-N and mineral nitrogen release in soils receiving FYM alone or in combination with chemical fertilizers.

MATERIAL AND METHODS

For incubation study, surface soil samples (0-15cm) were collected before application of fertilizer treatments to wheat crop sown in November 2011 from five treatments: (i) Control (unfertilized); ii. Recommended fertilizers (RF); iii. INM2; iv. FYM 300 N;V. FYM 400 N, incubated at three temperatures (15, 25 and 35°C) for eleven times (0, 3, 5, 7, 14, 28, 42, 56, 70, 98 and 126 days) in three replications.

Mineralization of nitrogen was studied in laboratory by conducting aerobic incubation under controlled conditions. Ten gram of fresh soil was placed in plastic containers (120 ml capacity). The soils were wetted to field capacity (moisture held at 0.33 bars potential), the mouth of container was covered with perforated plastic to maintain a constant air supply. The soil moisture was maintained throughout the incubation period at field capacity by frequently weighing containers and adding water whenever necessary. Samples were analyzed for mineral N (NH_4-N + NO_3-N) at each incubation interval. To avoid soil disturbance due to sampling, independent sets were run concurrently for each incubation period. At the end of each incubation period, NH_4 and NO_3-N from soil samples were extracted with 2M KCl. The method involved shaking of incubated soil samples (10 g) with 50 ml of 2M KCl (ratio 1:5) for one hour. The NH_4-N and NO_3-N in the extract were analyzed by steam distillation method (Keeney, 1982). Ammonical, nitrate and mineral nitrogen data were analyzed statistically by analysis of variance technique (Narayanan and Adorisio, 1983) using randomized block design (at 5% level of probability).

RESULTS AND DISCUSSION

Ammonical, nitrate and mineral nitrogen at 15°C: At the

start of incubation NH_4-N concentration at 15°C ranged from 14.8 mg kg^{-1} to 42.4 mg kg^{-1} in different soils. At various incubation intervals in different treated soils, it ranged from 14.8 mg kg^{-1} to 82.1 mg kg^{-1} (Table 1). It was observed that NH_4-N release in control and recommended fertilizer treated soils increased up to 56 days of incubation and decreased thereafter. In case of soils receiving integrated nutrient management (INM2), 300 and 400 kg N ha^{-1} from FYM, it increased up to 70 days of incubation and decreased slowly thereafter.In control and recommended fertilizer treatments from 56th to 126th day of incubation NH_4-N release decreased from 49.9 to 40.5 mg kg^{-1} and 55.5 to 46.0 mg kg^{-1}, respectively and in INM2, 300 kg N ha^{-1} from FYM and 400 kg N ha^{-1} from FYM, it decreased from 68.0 to 61.2 mg kg^{-1}, 76.4 to 69.6 mg kg^{-1} and 82.1 to 76.5 mg kg^{-1}, respectively from 70th to 126th day.

The release of ammonical-N was faster during initial four weeks and then slow increase was observed followed by decrease in NH_4-N release. The decrease may be due to decrease in microbial activity as a result of decreased amount of easily decomposable organic matter. It was observed that release of ammonical-N was highest in 400 kg N ha^{-1} from FYM treated soil at all incubation intervals. The soils treated with organic manures alone or in combination with chemical fertilizers showed significantly higher release of ammonical-N as compared to control and the soil receiving recommended dose of fertilizers. It may be attributed to the fact that addition of organic manures led to increase in organic form of N resulting in higher microbial activity and increased mineralization of organic N. Higher mineralization of N in soils amended with N-rich plant residues had been observed by Seneviratne (2000); Eriksen and Jensen (2001).

The nitrate nitrogen ranged from 10.8- 38.3 mg kg^{-1} under different treatments at the start of incubation (0 day); being significantly higher (38.3 mg kg^{-1}) in soil receiving FYM to supply 400 kg N ha^{-1} than all other soils. The NO_3-N content of soils ranged from 10.8 mg kg^{-1} to 90.3 mg kg^{-1} under different treatments at different time intervals (Table 2). It was observed that there was continuous increase in the nitrate nitrogen content in all soils with the increase in incubation period as compared to ammonical nitrogen. This may be due to continuous oxidation of ammonical nitrogen to nitrate nitrogen. Nitrate-N release was significantly higher in the soils receiving 300 and 400 kg N ha^{-1} from FYM as compared to control and recommended fertilizer at all incubation intervals. It was observed that NO_3-N content in organic treatment soils was significantly higher than INM2 treatment soil at some incubation intervals, whereas, in others it could not reach the level of significance. It was noticed that NO_3-N

Table 1. Effect of incubation time on NH_4-N release (mg kg^{-1}) in different soils at 15°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	14.8	24.3	36.4	40.5	41.8	48.5	48.5	49.9	48.5	44.5	40.5
RF	21.7	31.1	39.3	40.6	43.3	48.7	52.8	55.5	52.7	48.7	46.0
INM2	28.6	39.4	46.2	51.1	52.3	55.7	61.2	65.3	68.0	63.9	61.2
300 kg N (FYM)	35.4	40.9	47.8	51.8	55.9	65.5	66.9	69.3	76.4	72.3	69.6
400 kg N (FYM)	42.4	50.6	53.3	55.3	57.4	75.2	73.9	78.0	82.1	79.3	76.5
CD (p=0.05)	5.62	6.57	5.37	5.1	4.10	8.06	7.12	8.42	11.81	10.12	10.6

Table 2. Effect of incubation time on NO_3-N release (mg kg^{-1}) in different soils at 15°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	10.8	18.9	33.7	35.1	40.8	45.9	47.2	51.2	58.0	62.0	64.7
RF	17.6	27.1	33.8	33.8	40.6	50.1	51.4	54.1	63.8	66.3	69.0
INM2	23.1	31.3	46.2	43.1	44.6	48.9	53.0	57.1	65.1	65.3	72.1
300 kg N (FYM)	31.3	36.8	47.7	43.7	46.4	57.3	60.0	62.8	73.8	75.0	81.9
400 kg N (FYM)	38.3	42.4	49.2	48.5	52.0	61.5	65.6	68.4	76.6	79.3	90.3
CD (p=0.05)	5.7	5.25	5.77	8.13	3.89	7.39	7.29	6.6	6.68	9.61	7.13

release was higher in FYM 400 N treated soils than FYM 300 N treated soil but the differences were non-significant.

The data regarding mineral nitrogen at 15°C showed that the mineral N release at the start of incubation i.e. on zero day ranged from 25.6 mg kg^{-1} to 80.7 mg kg^{-1} (Table 3). The mineral N release in soil receiving 400 kg N ha^{-1} from FYM was significantly higher than other treatments at the start of incubation. The mineral N accumulation increased with increase in time of incubation in all the treatments except control where a slight decrease in inorganic N was observed at 126th day. The mineral N release in soils treated with either organic manure alone or organic manures in combination with chemical fertilizers was significantly higher than control and recommended fertilizer treatments throughout the incubation. Mineral N accumulation at 126 days varied from 105.2 to 166.8 mg kg^{-1} in different soils. It was significantly greater in organic source than other treatments. It was found that inorganic N release in soil applied with recommended fertilizer was higher than control at all incubation intervals but the difference was significant only during initial three days. Highest mineral N accumulation throughout the incubation was observed in soil treated with N at 400 kg ha^{-1} from FYM and it followed the order, 400 kg N FYM > 300 kg N FYM > INM2 > RF > control. The higher mineral N accumulation in soils receiving organic manures alone or in conjunction with chemical fertilizer may be attributed to the continuous mineralization of organic N from organic matter rich materials as compared to control and recommended fertilizer alone. Azam *et al.* (1993) also observed higher mineralization of N in soils amended with N-rich organic materials.

Ammonical, nitrate and mineral nitrogen at 25°C: The results revealed that NH_4-N released at 25°C at different incubation times under different treatments varied from 14.8 mg kg^{-1} to 98.5 mg kg^{-1} (Table 4). The NH_4-N release at the start of incubation was same as that at 15°C. The ammonical-N release increased with the incubation time up to 56th day in control and recommended fertilizer treated soils and up to 70th day in integrated nutrient management (INM2) and soils treated with 300 and 400 kg N ha^{-1} from FYM and decreased thereafter till the end of incubation. Ammonical nitrogen release from 56th to 126th day of incubation decreased from 55.3 to 47.2 mg kg^{-1} in control and from 60.9 to 54.1 mg kg^{-1} in recommended fertilizer treated soil. The increase in incubation time from 70th to 126th day resulted in decrease of NH_4-N from 72.1 to 65.3 mg kg^{-1}, 87.3 to 72.3 mg kg^{-1} and 98.5 to 87.5 mg kg^{-1} in INM2, FYM 300 N and FYM 400 N treated soils, respectively. The decrease in the release of NH_4-N may be due to progressive mineralization of organic N leading to

Table 3. Effect of incubation time on mineral N release (mg kg^{-1}) in different soils at 15°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	25.6	43.1	70.1	75.5	82.6	94.3	95.7	101.1	106.5	106.5	105.2
RF	39.2	58.2	73.1	74.4	83.9	98.8	104.2	109.6	116.5	115.0	115.0
INM2	51.7	70.6	92.4	94.3	96.8	104.7	114.2	122.4	133.4	129.2	133.2
300 kg N (FYM)	66.7	77.8	95.5	95.5	102.3	122.8	126.9	132.0	150.2	147.3	151.4
400 kg N (FYM)	80.7	93.0	102.5	103.8	109.4	136.8	139.5	146.3	158.7	158.6	166.8
CD (p=0.05)	11.11	9.52	9.68	10.01	5.09	13.95	13.06	8.94	15.07	13.48	15.95

Table 4. Effect of incubation time on NH_4-N release (mg kg^{-1}) in different soils at 25°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	14.8	22.9	29.7	33.7	40.5	52.6	53.8	55.3	52.6	49.9	47.2
RF	21.7	33.9	29.8	32.5	41.9	55.5	58.1	60.9	59.5	56.8	54.1
INM2	28.6	36.7	51.7	55.7	58.5	69.3	69.3	69.3	72.1	68.0	65.3
300 kg N (FYM)	35.4	45.0	64.1	64.1	68.2	80.5	81.9	86.0	87.3	83.2	72.3
400 kg N (FYM)	42.4	54.7	65.6	68.4	75.2	83.4	86.2	91.6	98.5	93.0	87.5
CD (p=0.05)	5.62	8.12	9.64	8.49	5.78	6.09	6.84	7.15	9.84	9.68	10.24

reduction in easily available organic materials and thus decrease in the microbial activity. Isirimah and Keeney (1972) also reported rapid ammonium-N production in initial intervals of incubation followed by low NH_4-N release. Ammonical nitrogen release was significantly higher in soils where organic manures were used alone or in combination with chemical fertilizers at most of the time intervals than control and recommended fertilizer treated soils. This may be due to the mineralization of N from the organic N pools of organic sources. The order of NH_4-N release was, 400 kg N FYM > 300 kg N FYM > RF + INM2 > RF > control at all incubation periods. Vimlesh and Giri (2009) also observed an increase in the NH_4 and NO_3- N release with the increase in incubation time and organic manures at 30°C during their investigation on nitrogen mineralization in soil amended with crop residues. The ammonical nitrogen content in all the soils at all incubation intervals was higher at 25°C than 15°C temperature, it may be due to increase in rate of organic matter decomposition because of increased microbial activity with the increase in temperature from 15 to 25°C leading to increased mineralization of nitrogen.

The nitrate nitrogen ranged from 10.8 mg kg^{-1} to 132.7 mg kg^{-1} (Table 5) under different treatments at various incubation intervals. The NO_3-N concentration at the start of incubation was same as NO_3-N concentration at 15°C. It increased continuously with time of incubation and at the end of incubation it varied from 74.2-132.7 mg kg^{-1}. It was significantly higher in soil receiving 400 kg N ha^{-1} from FYM (132.7 mg kg^{-1}) than control (74.2 mg kg^{-1}) and the soils receiving 300 kg N ha^{-1} FYM (116.0 mg kg^{-1}), INM2 (96.5 mg kg^{-1}) and RF (83.9 mg kg^{-1}). Highest NO_3-N release was observed in 400 kg N ha^{-1} from FYM treated soil at all incubation intervals, being significantly higher than all other treatments except at few incubation intervals where the difference in NO_3-N between soils receiving FYM 400 N and FYM 300 N treatments was non-significant. It was noticed that the trend of NO_3-N release was same as observed at 15°C in different soils. Due to continuous oxidation of ammonical nitrogen there was a continuous increase in NO_3-N in all the soils, except a temporary decrease was observed in INM2 treated soil at 28th and 42nd day. The accumulation of NO_3-N increased with time of incubation and particularly it was higher after 8 weeks of incubation (Lodhi*et al* 2009). The results showed that at 25°C NO_3-N release was higher than NO_3-N at 15°C at all incubation intervals under all incubation time intervals in all soils, indicating higher nitrification at 25°C than 15°C.

Mineral N release at 25°C increased with the time of

Table 5. Effect of incubation time on NO_3-N release (mg kg^{-1}) in different soils at 25°C

Treatments	Incubation time (days)									
	0	3	5	7	14	28	42	56	70	98	126
Control	10.8	32.4	48.6	47.2	48.5	53.9	56.6	56.6	66.1	71.5	74.2
RF	17.6	41.9	55.5	52.8	54.1	58.2	59.6	61.0	77.4	81.2	83.9
INM2	23.1	50.3	65.3	72.1	76.1	73.4	73.4	76.1	84.3	89.7	96.5
300 kg N (FYM)	31.3	60.1	79.1	81.2	84.6	85.2	86.2	87.3	102.3	111.9	116.0
400 kg N (FYM)	38.3	68.4	84.8	90.3	91.6	97.1	98.7	95.7	112.1	123.1	132.7
CD (p=0.05)	5.7	5.56	7.22	8.32	9.8	6.95	8.64	8.49	8.96	9.61	9.12

incubation in all treatments except a slight decrease at 126th day was observed in soil receiving 300 kg N from FYM. The increase was more in first few days of incubation (Table 6). This may be due to initial rapid phase of mineralization. The mineral nitrogen accumulation was significantly higher in organically treated soils as compared to other treatments throughout the incubation time. The soil receiving N at 200 kg ha^{-1} from FYM along with recommended fertilizer (INM2) showed a significantly higher inorganic N release than control and RF alone at all incubation intervals. At the end of incubation, mineral N concentration ranged from 121.4 to 220.2 mg kg^{-1} under different treatments and followed the order of control < RF < RF+INM2 < 300 kg N FYM < 400 kg N FYM. It was lowest in control soil at 0 day (25.6 mg kg^{-1}) and highest in 400 kg N ha^{-1} from FYM treated soil (220.2 mg kg^{-1}) at 126th day. The higher mineral N release in organic treated soils may be due to higher microbial activity leading to higher mineralization (Pansu and Thuries, 2003). Mineral N accumulation was more at 25°C as compared to 15°C throughout the incubation time. It may be due to slower mineralization and N turnover from organic matter at low temperature (15°C) than at higher temperature (25°C).

Ammonical, nitrate and mineral nitrogen at 35°C: The NH_4-N release at 35°C increased with the increase in time of incubation up to 70 days in organically treated soils and up to 56 days in control, RF and INM2 treatment soil. It was found that NH_4-N release increased up to 70 days and attained a peak at 70th day in soils receiving N at 300 and 400 kg ha^{-1} from FYM and then decreased slowly till the end of incubation. However, in control, RF and INM2 treatment soils, the peak was observed at 56th day which may due to lesser organic N in these soils. The data showed that from 56 to 126th day of incubation, NH_4-N accumulation in control, RF and INM2 treated soils decreased from 62.1 to 52.6 mg kg^{-1}, 67.7 to 56.8 mg kg^{-1} and 81.6 to 69.3 mg kg^{-1}, respectively (Table 7). In soils receiving 300 and 400 kg N ha^{-1} from FYM from 70 to 126th, day NH_4-N decreased from 94.1 to 87.6 mg kg^{-1} and 102.6 to 93.0 mg kg^{-1}, respectively. The maximum NH_4-N release was observed in soil treated with 400 kg N ha^{-1} from FYM and it ranged from 42.4 mg kg^{-1} to 102.6 mg kg^{-1}. Higher ammonical-N accumulation was recorded throughout the incubation in integrated nutrient management (INM2) treated soil than soil receiving RF alone. The NH_4-N was higher at 35°C than at 15°C and 25°C in all the treatments. This could be attributed to the slower mineralization and turnover of N from organic matter pool at low temperatures, while at higher temperature, the organic matter has a very fast turn-over of N and hence more release of NH_4-N (Javier

Table 6. Effect incubation time on mineral N release (mg kg^{-1}) in different soils at 25°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	25.6	55.3	78.2	80.9	88.9	106.5	110.4	111.9	118.6	121.4	121.4
RF	39.2	75.8	85.3	85.3	96.1	113.6	117.6	121.9	136.9	138.0	138.0
INM2	51.7	87.0	116.9	127.8	134.6	142.8	142.8	145.5	156.4	157.7	161.8
300 kg N (FYM)	66.7	105.1	143.3	145.3	152.8	165.7	168.1	173.3	189.6	195.1	188.3
400 kg N (FYM)	80.7	123.1	150.4	158.6	166.9	180.5	184.9	187.4	210.6	216.1	220.2
CD (p=0.05)	11.11	11.72	9.62	13.99	11.27	12.51	15.40	14.86	17.29	18.27	17.03

Table 7. Effect of incubation time on NH_4-N release (mg kg^{-1}) in different soils at 35°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	14.8	29.7	30.0	29.7	41.8	56.8	59.3	62.0	59.3	55.2	52.6
RF	21.7	31.1	37.6	32.5	44.7	55.5	65.0	67.7	62.3	59.5	56.8
INM2	28.6	40.8	61.2	65.3	69.3	76.1	77.5	81.6	77.5	73.4	69.3
300 kg N (FYM)	35.4	51.8	69.6	73.7	77.8	88.4	90.0	91.4	94.1	90.0	87.6
400 kg N (FYM)	42.4	60.2	72.5	77.9	84.8	99.8	99.8	101.2	102.6	95.7	93.0
CD (p=0.05)	5.62	10.16	6.66	7.84	6.72	8.83	6.72	10.63	8.14	6.58	8.56

and Tabien, 2005).

The data showed that NO_3-N released from 0 to 126 days of incubation. The accumulation of NO_3-N increased from 10.8 to 85.0, 17.5 to 93.4, 23.1 to 102.0, 31.3 to 120.8 and 38.3-135.4 mg kg^{-1} in control, recommended fertilizer, INM2, FYM 300 N and FYM 400 N treated soils, respectively, at different incubation time intervals (Table 8). It was observed that NO_3-N release was significantly higher in soils treated with either organic manures alone or in combination with chemical fertilizers throughout the incubation period. The soil treated with N at 400 kg ha^{-1} from recorded highest NO_3-N release throughout the incubation study of 126 days. The release of NO_3-N accumulation at 35°C was greater than NO_3-N accumulation at 15 and 25° C indicating higher nitrification of N at 35°C. Meyers (1975) also observed highest accumulation of NO_3-N at 35°C than the temperatures lower than 35°C.

The soil receiving 400 kg N ha^{-1} from FYM showed significantly higher release of mineral nitrogen throughout the incubation time (Table 9). Mineral N concentration in soils receiving organic manures alone or in combination with chemical fertilizers showed significantly higher mineral nitrogen release than control and recommended fertilizer treatments. The mineral N accumulation increased with the incubation time in all the treatments, but the increase was higher in first few weeks. The mineral N content in soil receiving recommended fertilizer was significantly greater than control at most of the incubation time intervals. The higher mineral N release in organic as compared to other treatments may be due to mineralization of N from organic pool rich in organic nitrogen. The mineral N accumulation was higher at 35°C as compared to 15°C and 25°C at all incubation time periods. This is due to increase in microbial activity with the increase in temperature, which increase the nitrogen mineralization. Javier and Tabien (2005) also reported higher mineral N accumulation at 32°C than at 15°C.

Table 8. Effect of incubation time on NO_3-N release (mg kg^{-1}) in different soils at 35°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	10.8	41.8	56.6	58.0	59.3	68.8	68.8	70.1	75.5	79.6	85.0
RF	17.6	60.9	70.4	78.5	81.2	83.9	85.3	89.3	78.5	85.3	93.4
INM2	23.1	70.7	77.5	85.7	84.3	88.3	91.1	94.3	95.0	97.9	102.0
300 kg N (FYM)	31.3	80.4	94.1	102.3	112.6	113.2	114.6	116.0	116.0	118.7	120.8
400 kg N (FYM)	38.3	88.9	106.7	107.8	117.6	123.1	124.4	125.8	127.1	132.7	135.4
CD (p=0.05)	5.7	8.35	7.54	9.97	5.87	6.09	9.2	8.29	7.97	9.00	7.43

Table 9. Effect of incubation time on mineral N release (mg kg^{-1}) in different soils at 35°C

Treatments	Incubation time (days)										
	0	3	5	7	14	28	42	56	70	98	126
Control	25.6	71.5	86.5	87.7	101.2	125.6	128.1	132.2	134.8	134.8	137.6
RF	39.2	92.0	107.9	111.0	125.9	139.4	150.2	157.0	140.8	144.8	150.2
INM2	51.7	111.5	138.7	150.9	153.6	164.4	168.6	175.9	172.5	171.3	171.3
300 kg N (FYM)	66.7	132.3	163.7	176.0	190.3	201.7	204.6	207.4	210.1	208.7	208.4
400 kg N (FYM)	80.7	149.1	179.2	185.7	202.4	222.9	224.3	227.0	229.7	228.4	228.4
CD (p=0.05)	11.11	18.25	13.06	17.48	9.73	12.18	14.37	18.34	13.50	15.26	14.82

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Influence of Integrated Nutrient Management on Growth and Yield of Babycorn (*Zea mays* L.)

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Abstract: The Application of N-P_2O_5-K_2O; 75-15-11.3; kg/ha had significant effect on the plant height, dry matter accumulation, leaf area index and chlorophyll content which was at par with 15 kg N/ha (FYM) + 60 kg N/ha and N-P_2O_5-K_2O; 60-12-6; kg/ha. The minimum days taken to knee high, tasseling and silking was in N-P_2O_5-K_2O; 75-15-11.3; kg/ha. Baby corn yield and fodder yield was significantly increased with both organic and integrated nutrient treatments. The babycorn and green fodder yield 15.54 and 279.50 q/ha was recorded in N-P_2O_5-K_2O; 75-15-11.3; kg/ha which was statistically at par with 15 kg N/ha (FYM) + 60 kg N/ha and N-P_2O_5-K_2O; 60-12-6; kg/ha.

Key words: Baby corn, Growth, Nutrient management, Yield

Maize (*Zea mays* L.), as the third most important cereal crop in the world following wheat and rice, has been cultivated for centuries as a grain crop and more recently as a vegetable crop, such as babycorn and sweet maize (*Zea mays* var. saccharata). Babycorn cultivation being a relatively new practice in India, requires the development of suitable production technology in realizing higher baby corn yield and monetary returns before it could be popularized among maize growers. It is well established that the improvement of quality and productivity of crops could be made possible with combined application of organic manures and balanced chemical fertilizers. The concept of integrated nutrient management seeks to sustain soil fertility through an integration of different sources of nutrition that will produce maximum crop yield per unit input use (De Datta *et al.*1990). The present investigation was under taken to find out suitable integrated nutrient requirements for babycorn.

MATERIAL AND METHODS

The field experiment was conducted at Punjab Agricultural University, Ludhiana, during *kharif* 2013 which is situated at 30° 56' N latitude with 75° 52' E longitude with a mean height of 247 m above the mean sea level. The experimental field was sandy loam in texture with a pH 7.4 and EC 0.36 dSm^1. The soil was low in available nitrogen (134.1 kg/ha), medium in available phosphorus (19.46 kg /ha) and medium in potassium (132.3 kg/ha. There were 10 treatments including control (unfertilized) (Table1) The recommended dose of N 60 kg/ha was applied in two splits irrespective of treatments. Half of nitrogen (as per treatment level) and full doses of phosphorus and potassium was applied at the time of sowing in integrated nutrient management treatments and half the dose of nitrogen along with full dose of organic manures was applied at the time of sowing and remaining nitrogen was top dressed 25 days after sowing. The experiment was laid out in randomized complete block design with four replications. Nitrogen was given in the form of urea, phosphorus in the form of single super phosphate and potassium in muriate of potash. The variety 'Composite Kesri' was sown on 25th June 2013 at 30 x 20 cm spacing and immature cobs were harvested in end of August 2013. The crop was detasseled before pollen shed to prevent fertilization and also to divert nutrient flow to developing cob. Babycorns were dehusked manually and the yields of both babycorn and fodder are reported on a fresh weight basis.

RESULTS AND DISCUSSION

The plant height (Table 1) was significantly increased with the increase in the rates of application fertilizers but the tallest plant was recorded in T_7 (126.3 cm) which was at par with T_{10} (123.6 cm). Less growth in chemical fertilizer treatment may be due to the reason that surplus availability of nutrient for a limited period in the growth stage of crop. Similar observation was reported by Luikham *et al.* (2003). The leaf area index, dry matter accumulation and chlorophyll content was maximum in T_7 (N-P_2O_5-K_2O; 75-15-11.3; kg/ha) and this treatment was statistically at par with T_{10} (15 kg N/ha (FYM) + 60 kg N/ha) and (T_6) N-P_2O_5-K_2O; 60-12-6; kg/ha. The increased dry matter production might be due to better utilization of nutrient and phased released of nutrients as per requirement of maize. Similar results have been reported by Kumar *et al.* (2009) while studying the physiological basis of nitrogen use efficiency in maize at various rates of applied nitrogen. Each successive level of inorganic fertilizer and combination of both FYM and

Table 1. Effect of integrated nutrient management practices on growth attributes of babycorn

Treatment	Plant height (cm)	Leaf area index	Dry matter (qha^{-1})	Chlorophyll content	Days taken to Knee high	Days taken to Tasseling	Days taken to Silking
T_1 –Control	90.7	2.14	35.93	25.8	25.5	54.0	56.9
T_2 -Recommended N (60 kg/ha)	105.8	2.60	41.75	31.7	23.8	53.0	54.7
T_3 -N- K_2O; 60-6; kg/ha	110.4	2.88	44.28	31.9	23.6	52.6	54.6
T_4 -N- P_2O_5; 60-12; kg/ha	112.1	3.35	46.65	32.2	23.5	52.4	54.5
T_5 -N- P_2O_5-K_2O; 45-9-4.5; kg/ha	113.3	3.26	47.80	32.5	22.9	52.4	54.5
T_6 -N- P_2O_5-K_2O; 60-12-6; kg/ha	120.8	3.76	52.13	36.5	22.3	52.0	54.0
T_7 -N- P_2O_5-K_2O; 75-15-11.3; kg/ha	126.3	3.82	54.63	39.2	18.8	50.0	52.5
T_8 -30 kg N/ha (FYM) + 30 kg N/ha	115.2	3.45	49.40	34.5	22.5	52.5	54.4
T_9 -15 kg N/ha (FYM) + 45 kg N/ha	117.7	3.51	50.25	35.3	22.6	52.2	54.2
T_{10} -15 kg N/ha (FYM) + 60 kg N/ha	123.6	3.79	52.93	37.0	20.8	51.0	53.5
CD (p=0.05)	3.78	0.07	2.58	2.35	1.40	0.74	0.80

inorganic fertilizers advances the attainment of knee high, tasseling and siliking stages over the lower stages. The minimum days taken to knee high, tasseling, and siliking was taken by T_7. Eltelib *et al.* (2006) also observed that N fertilization induces tasseling early in maize crop. The length of ear however, tends to increase with increase in the rate of fertilizer application but the increase was significant upto T_5. The longest ear of baby corn (8.8 cm) was obtained with T_7 (Table 2). Application of different rates of integrated nutrient and alone chemical fertilizers did not have significant affect on the ear girth. The application T_7 recorded highest green cob weight (23.6g) which was statistically at par with 15 kg N/ha (FYM) + 60 kg N/ha (23.0g. The per cent increase in green cob weight of T_7 and T_{10} over recommended dose of fertilizer (T_2) was 17.44 and 14.42 (Table 2). The higher weight in these treatments was due to cumulative effect of elevated growth stature as well as yield structure. Similar results were also reported by Kumar *et al.* (2009). The cob weight without husk was maximum in T_7 treatment (6.20g) which was remain at par with T_{10} and T_6. The per cent increase in the babycorn weight was 18.54, 16.25 and11.47 in T_7, T_{10} and T_6 respectively over the control plot (T_1). The reason for higher cob weight without husk could be the better growth parameters of crop resulting from higher cob girth, length and weight (Table 2).The increased yield parameters were reflected from favourable growth crop promoted by the application of both organic and inorganic sources of nutrition (Table 1). The number cobs increased with increase in nutrition level but the difference was not quite significant. The maximum number of cobs were in N-P_2O_5-K_2O; 75-15-11.3; kg/ha (3.8/plant) and minimum in control (1.7/plant). The maximum number of harvest duration days was recorded inT_7 which was statistically at par with T_{10}, T_6 and T_9.

Babycorn can be marketed either as green ears (with husk) and dehusked ears. The yield of babycorn was significantly affected by both inorganic and INM treatments. The maximum babycorn yield was in T_7 which was statistically at par with T_{10} and T_6 and minimum babycorn yield was recorded in control plots. The per cent increases in the yield over recommended dose of fertilizer (N 60 kg/ha) in T_7, T_{10} and T_6 treatments were 26.4, 20.0 and 18.2 respectively. The integrated fertilization proven higher yield (T_8, T_9 and T_{10}) as compared to alone chemical fertilization (T_2, T_3, T_4 and T_5) might be due to high and sustained nutrient supply potential of the organic manure (FYM) in addition to supply of nitrogen from inorganic fertilizer (Table 2). The maximum green fodder was in T_7 (279.50 q/ha) which was statistically at par with T_{10},

Table 2. Effect of integrated nutrient management practices on yield and yield attributes of babycorn

Treatment	Babycorn length (cm)	Babycorn girth (cm)	Green cob weight (g)	Babycorn weight (g)	Cobs per plant	Harvest duration days	Babycorn yield (q ha^{-1})	Fodder yield (q ha^{-1})
T_1	6.3	2.7	16.6	3.83	1.7	10.0	8.15	163.75
T_2	7.6	3.1	20.1	5.23	2.7	11.8	12.29	218.40
T_3	7.9	3.2	22.0	5.25	2.8	12.0	12.82	224.98
T_4	8.1	3.2	22.2	5.30	2.8	12.3	12.94	229.80
T_5	8.1	3.2	22.3	5.30	2.9	12.8	12.99	234.75
T_6	8.4	3.3	22.9	5.83	3.3	13.4	14.56	263.25
T_7	8.8	3.4	23.6	6.20	3.8	14.3	15.54	279.50
T_8	8.2	3.2	22.5	5.33	3.0	13.3	13.26	237.10
T_9	8.3	3.3	22.7	5.35	3.1	13.2	13.48	243.25
T_{10}	8.4	3.3	23.0	6.08	3.5	13.5	14.75	269.30
CD (p=0.05)	0.6	NS	0.55	0.41	0.98	1.17	1.01	40.6

T_6 and T_9 The per cent increase in the green fodder yield over recommended dose of fertilizer (N 60 kg/ha) in T_7, T_{10} and T_6 treatments were 27.9, 23.3, 20.6 and 11.3. These findings are in agreement with Luikham *et al.* (2003).

It can be concluded that application of N-P_2O_5-K_2O; 75-15-11.3; kg/ha and 15 kg N/ha (FYM) + 60 kg N/ha significantly increased babycorn productivity over recommended N application (N 60 kg/ha).

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Influence of Integrated Nutrient Management Practices on Post Harvest Soil Properties in Sorghum-Barley Sequence

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***Abstract*:** Two levels of farmyard manure (FYM) (0 and 10 tonnes/ha), four fertility levels based on soil test recommendation (0%, 50%, 75% and 100% NPK) and four bio-fertilizers (No inoculation, *Azotobacte*r, *phosphate solubilizing bacteria* (PSB) and dual inoculation of *Azotobacter + PSB*) were compared for two years. Application of NPK at recommended rates significantly improved the organic carbon, EC and macronutrients (NPK) in soil after harvest of both crops as well as yields during both the years. Residual effect of FYM on sequence crop significantly improved the soil properties viz., organic carbon, nitrogen, phosphorus, potash as well as yields. Bio-inoculants improvement owing to appropriate combination of *Azotobacter* + PSB was observed.

Key Words: Bio fertilizers, Crop sequence, FYM, INM, NPK, Soil properties, Yields

In India, the area under sorghum is approximately 7.38 million ha with an annual production of about 7.0 million tonnes and an average productivity of 952 kg ha^{-1} (DAC, 2012). Since the possibility of horizontal expansion or putting more area under cultivation is difficult, future augmentation in yield should have to be harnessed vertically through increase in productivity by judicious management of all input especially nutrients. Similarly Barley (*Hordeum vulgare L.*) is an important cereal crop ranking just next to the rice, wheat, sorghum and maize in acreage and production. In India, the area under barley cultivation was approximately 0.70 million hectares with production of about 1.73 million tonnes (DAC, 2012). Although the balanced use of N, P and K fertilizers could maintain productivity, but in practice it has shown a declining trend in soil physical and biological qualities besides imbalance in micronutrients. In Zone IVA (Sub-humid Southern Plain and Aravali Hills) of Rajasthan, a fertilizer dose of 80 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} has been recommended for the cultivation of sorghum but the efficiency and productivity is low. The INM, however, helps in maintaining the productivity of soil and improves fertilizer-use efficiency. Application of FYM improves soil physical characteristics such as structures, porosity and water-holding capacity through increased organic matter content of soil and when applied in conjunction with bio-fertilizers, supplies energy to beneficial microorganisms including *Azotobacter* and PSB.

Further, bio-fertilizers offer a low cost, low capital intensive and ecofriendly route to boost the farm productivity depending upon their activity of mobilizing different nutrients. Use of bio-fertilizer in crop not only fixes the biological nitrogen but also solubilizes the insoluble phosphates in soil and thus improves fertilizers-use efficiency (Gogoi 2008). These microorganisms play an important role in increasing the availability of N, P and K in soil. The integrated approach of nutrient supply by inorganic fertilizers and organic manuring is gaining importance because this system not only reduces the use of costly inorganic fertilizers, but also an environment friendly approach. Organic manures and phosphatic fertilizers are known to have carry-over effect on succeeding crops. About less than 30 per cent of nitrogen and small fraction of phosphorus and potassium in organic manures become available to the immediate proceeding crop and rest to subsequent crops. Keeping this in view; present investigation was undertaken to find out influence of integrated nutrient management practices on post harvest soil properties in sorghum-barley sequence.

MATERIALS AND METHODS

A field experiment was conducted for two consecutive years during *Kharif* and *Rab*i season of 2010-2011 and 2011-2012 in Rajasthan College of Agriculture, Udaipur. The site was situated at 24°. 35' N latitude, 74°. 42' E longitude at an altitude of 579.5 m above mean sea-level. The region falls under agro-climatic zone IVA of Rajasthan. The soil was clay loam, medium in organic carbon (0.68 and 0.70%), low in available nitrogen (266.80 and 270.20 kg ha^{-1}) and medium in phosphorus (19.80 and 22.50 kg ha^{-1}) and high in potassium (358.50 and 365.80 kg ha^{-1}), with pH 7.98 and 8.10 in 2010 and 2011, respectively. The treatments comprised of two levels of farmyard manure (0 and 10 tonnes FYM ha^{-1}), four fertility levels (0%, 50%, 75% and 100% NPK)

based on soil test recommendation (STR) and four inoculations (no inoculation, *Azotobacter*, PSB and dual inoculation of *Azotobacter* + PSB). These treatments were evaluated in split-plot design, allocating organic manure and fertilizers in main plots and bio-fertilizers in subplots and replicated three times. Sorghum variety CSV 23 was sown in furrows at 45 cm row spacing using a seed rate of 10 kg ha^{-1}. Barley variety RD 2052 was sown at 22.5 cm row spacing to a depth of 5 cm. Based on soil test, recommended doses 51.98 kg N, 45.54 kg P_2O_5 and 15.60 kg K_2O ha^{-1} and 40.48 kg N, 25.03 kg P_2O_5, 10.20 kg K_2O ha^{-1} were applied to sorghum and barley crops, respectively.

Half dose of N and full dose of P and K applied at the time of sowing and remaining half dose of N at 30 days after sowing. FYM (N-0.47%, P_2O_5-0.25% and K_2O-0.54%) was mixed in soil at the time of field preparation as per treatment. Seeds were uniformly coated with *Azotobacter* inoculums using 500 g ha^{-1} and *Bacillus megatherium* var. *phosphaticum* @ 5 g kg^{-1} seed as per the treatments. Total amount of rainfall during the crop growth period was 580 mm and 630 mm in 2010 and 2011, respectively. The soil sample were collected after harvest of each crop and were analyzed for pH, EC, organic carbon, nitrogen, phosphorus and potash estimated by standard methods.

RESULTS AND DISCUSSION

Addition of 10 t FYM ha^{-1} and residual FYM significantly increased organic carbon, nitrogen, phosphorus and potash in soil after harvest of the crops in sequence (Table 1 and 3). The organic carbon content increased significantly with addition of FYM @ 10 t ha^{-1} at harvest of crops and was to the extent of 18.99 and 17.64 per cent in sorghum and barley, respectively with the incorporation of 10 t FYM ha^{-1} over no FYM. The beneficial effect of FYM application might be due to better root development and more plant residues left in FYM treated plots. Pathak *et al.* (2005) found that organic source performed well in improving soil physical properties. Further, with the addition of FYM significant improvement in N, P and K content of soil was also observed and the respective magnitude of increase was to the extent of 5.88, 5.44 and 2.15 per cent over control. Similar trend was also observed after harvesting of barley. This beneficial effect of FYM application might be due to increase in microbial activity and percent contribution of FYM to the pool of macro nutrients in soil.

The grain and straw yield of sorghum-barley cropping sequence increased significantly due to application of FYM (Table 2 and 4). Application of FYM @ 10 t ha^{-1} registered 4.05 t ha^{-1} grain and 14.90 t ha^{-1} straw yield of sorghum and 5.04 t/ha grain and 6.98 t ha^{-1} straw yield of barley. The increase in yields might be due to beneficial effect of FYM in improving the soil environment resulting in better absorption of moisture, nutrient and thus producing higher yields. Likewise, increase in harvest indices in respect of both the crops was also recorded with the application of FYM.

Fertility levels: Application of 100% NPK resulted in significant increase in EC, organic carbon as well as macronutrients (NPK) in soil after harvest of both the crops in

Table 1. Effect of FYM, fertility levels and biofertilizers on soil properties after harvest of sorghum (mean data of two years)

Treatment	pH_2	EC (dSm^{-1})	Organic carbon (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
FYM (t ha^{-1})						
0	8.08	0.337	0.674	278.38	26.29	325.49
10	7.98	0.336	0.802	294.75	27.72	332.50
CD (p = 0.05)	NS	NS	0.010	2.96	0.62	1.30
Fertility levels (based on STR)						
0% NPK	8.11	0.301	0.706	273.46	25.49	323.68
50% NPK	7.97	0.331	0.721	285.07	26.97	328.97
75% NPK	7.95	0.351	0.761	290.93	27.48	329.82
100% NPK	7.94	0.363	0.764	296.81	28.09	333.50
CD (p= 0.05)	NS	0.01	0.01	4.19	0.87	1.84
Biofertilizers						
No inoculation	8.03	0.332	0.728	279.26	25.85	329.23
Azotobacter	7.87	0.338	0.741	289.51	26.82	329.86
PSB	7.91	0.337	0.739	285.37	27.60	330.49
Azotobacter + PSB	7.99	0.339	0.744	292.14	28.28	331.19
CD (p= 0.05)	NS	NS	NS	1.95	0.83	NS

sequence. Application of increasing levels of chemical fertilizer from 0 to 100% NPK (based on STR) significantly increased the EC and organic carbon content of soil after harvesting of both the crops in the sequence *(Table 1 and 3)*. The increases in EC (20.60 and 34.62 %) and organic carbon content (8.21 and 8.45 %) of the soil over control with 100% NPK fertilizer application is probably due to enhanced root growth leading to accumulation of more organic residues in the post-harvest soil as also reported by Dhonde *and* Bhakare (2008). Application of increasing levels of chemical fertilizer from 0 to 100% significantly increased the nitrogen (8.54 and 8.48 %), phosphorus (10.20 and 10.21 %) and potash (3.04 and 3.03 %) content of soil after harvesting of both the crops. The NPK fertilizers improved the post-harvest

Table 2. Effect of FYM, fertility levels and biofertilizers on yields, harvest index and economics of sorghum (mean data of two years)

Treatment	Yields (tonnes ha^{-1})		Harvest index (%)	Net returns (X 10^3 Rs ha^{-1})	B:C ratio
	Grain	Stover			
FYM (t ha^{-1})					
0	3.16	13.29	19.09	29.9	1.70
10	4.05	14.90	21.19	37.9	1.93
CD (p= 0.05)	0.12	0.25	0.63	1.05	0.06
Fertility levels(based on STR)					
0% NPK	2.88	13.13	17.88	27.25	1.54
50% NPK	3.36	13.97	19.27	31.75	1.72
75% NPK	4.00	14.56	21.43	37.59	1.99
100% NPK	4.18	14.74	21.98	38.92	2.02
CD (p= 0.05)	0.17	0.35	0.89	1.48	0.08
Biofertilizers					
No inoculation	3.05	13.25	18.56	27.96	1.51
Azotobacter	3.83	14.30	20.95	36.04	1.93
PSB	3.65	13.94	20.61	34.01	1.83
Azotobacter + PSB	3.90	14.90	20.44	37.50	2.00
CD (p= 0.05)	0.16	0.28	0.85	1.34	0.07

Table 3. Effect of residual FYM, fertility levels and biofertilizers on soil properties after harvest of barley (mean data of two years)

Treatment	pH_2	EC (dSm^{-1})	Organic carbon (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
FYM (t ha^{-1})						
0	8.04	0.32	0.68	278.38	26.33	324.95
10	7.95	0.31	0.80	294.50	27.76	331.96
CD (p = 0.05)	NS	NS	0.01	3.00	0.62	1.30
Fertility levels (based on STR)						
0% NPK	8.13	0.26	0.71	273.46	25.56	323.14
50% NPK	8.03	0.31	0.72	285.07	26.96	328.43
75% NPK	8.02	0.34	0.76	290.57	27.49	329.28
100% NPK	8.00	0.35	0.77	296.66	28.17	332.96
CD (p = 0.05)	NS	0.01	0.01	4.25	0.874	1.84
Biofertilizers						
No inoculation	7.86	0.31	0.74	279.26	25.81	329.27
Azotobacter	7.87	0.32	0.74	289.51	26.79	329.86
PSB	7.91	0.32	0.74	285.37	28.40	330.28
Azotobacter + PSB	7.99	0.32	0.74	291.64	28.52	330.70
CD (p = 0.05)	NS	NS	NS	1.97	0.836	NS

Table 4. Effect of residual FYM, fertility levels and biofertilizers on yields, harvest index and economics of barley

Treatments	Yield (tonnesha^{-1})		Harvest index (%)	Net returns (X 10^3 Rs ha^{-1})	B:C ratio
	Grain	Stover			
FYM (t ha^{-1})					
0	4.33	5.82	42.56	35.50	1.95
10	5.04	6.98	41.78	42.74	2.11
CD (p= 0.05)	0.13	0.13	NS	1.42	0.07
Fertility levels (based on STR)					
0% NPK	4.14	5.99	40.79	33.49	1.80
50% NPK	4.60	6.21	42.61	37.96	1.99
75% NPK	4.90	6.61	42.54	41.42	2.13
100% NPK	5.11	6.78	42.73	43.60	2.20
CD (p= 0.05)	0.19	0.19	NS	2.01	0.10
Biofertilizers					
No inoculation	4.23	5.94	41.64	33.83	1.76
Azotobacter	4.78	6.50	42.26	40.21	2.09
PSB	4.66	6.30	42.35	38.68	2.00
Azotobacter + PSB	5.08	6.84	42.43	43.76	2.25
CD (p= 0.05)	0.16	0.12	NS	1.66	0.08

buildup of soil available N, P and K compared to control in both the crop. The significant increase in soil available N could be attributed to increased activity of nitrogen fixing bacteria there by higher accumulation of N in soil. The enhanced status of K could be attributed to the higher amount of potassium being added through muriate of potash besides that added by FYM.

Application of 100 % NPK remaining at par with 75% NPK increased grain, straw yield and harvest index of both the crops in sequence over the lower fertility levels. Application of 100% NPK (STR) recorded highest grain yield (4.18 t ha^{-1}), stover yield (14.74 t ha^{-1}) and harvest index (21.98%) of sorghum. Similar trend of 5.11 t ha^{-1} grain and 6.78 t ha^{-1} straw was observed in barley as compared to without NPK. Such improvement in yield with increasing levels of fertilizer application was supported by the findings of Jat *et al.* (2013).

Biofertilizers: The nitrogen and phosphorous content of soil significantly increased in *Azotobacter* and PSB over the no inoculation. However, inoculation with *Azotobacter* and PSB alone in combination in crops had no effect on pH, EC, OC and potash in soil after harvest of both the crops in sequence. Inoculation of bio-fertilizers significantly improved available N and P content of soil after harvest sorghum-barley sequence. Inoculation of Azotobacter + PSB was resulted in 4.61 % higher N and 9.40 % higher P status of soil after harvest of sorghum. Corresponding increase in N & P content of soil after barley harvest were 4.29 % and 10.49%, respectively. Increased P content in soil through bio-fertilizers may be due to increased solubility of unavailable native soil phosphate.

Co-inoculation of (*Azotobacter* + PSB) recorded highest grain yield (3.90 t/ha), stover yield (14.90 t ha^{-1}) and harvest index (20.44 %) of sorghum. Similar trend was observed in barley yield with the co-inoculation of (*Azotobacter* + PSB). Bio-fertilizers, the microbial inoculants which bring about fixation of atmospheric nitrogen either in free living N_2 fixer in the rhizosphere (*Azotobacter, PSB)* or transform native unavailable phosphorus into plant utilizable or improving germination, plant growth, plant stands and vegetative growth of plant, are low cost eco-friendly input for farmers. Bio-fertilizers on the other hand transform fixed and insoluble forms into soluble forms and make them readily available (Dadheech and Somani 2007). Among various treatments, highest net returns was recorded the treatment receiving combined use of 10 t FYM ha^{-1} with 100% NPK (based on STR) levels and dual inoculation of (*Azotobacter* + PSB) in sorghum – barley crop sequence. Beneficial effect of INM is visualized in first crop and residual effect of FYM in second crop of the sequence by way of sustaining the fertility status of soil as well as productivity.

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Isolation and Characterization of Antibiotic Producing Actinomycetes from Soil and Effect of Various Physical Parameters on Antibiotic Production

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Abstract: Total twenty three isolates of actinomyces were recovered from the soil of different region of Mohali and Bathinda region and screened for their antibacterial activity against test organisms *Kleibsella, Bacillus, Pseudomonas* and *Staphylococcus*. Four isolates were recorded to show antibiotic production, out of which two isolates named KA1 and KA2 were found most effective. The isolate KA2 showed maximum antibiotic production at neutral pH with 1% NaCl concentration at 30^0 C after 72 hours of incubation. Various biochemical and morphological tests along with some special tests were performed with KA1 and KA2 and results were confirmed with Bergay's manual for their belonging to sub-family streptomyces.

Key Words: Actenomycetes, Antibiotic production, Antibacterial activity, Streptomycetes

Soil is the primary and rich source of actinomyces. Within the bacterial domain actinomyces are one of the largest taxonomical unit and *Streptomyces* is the major dominant group among them. They have survival capability in different ecological environment with their bioactive potential. The suitable pH and presence of plenty of complex organic matter make their ecology suitable in soil. They also help in biological buffering of soil and organic matter decomposition. Actinomyces have unique metabolic diversity and enzymatic capability valuable for industrial and pharmaceutical purposes like enzyme, herbicides and pesticides production (Tokiwa and Buenaventurada, 2004). But most important among them is antibiotic as their secondary metabolites. At enzymatic level, the antibiotic production by them depend upon PPGPP level and SARP family (Pang *et al.*, 2004) of regulatory proteins, which exclusively belongs to actinomycetes. The other factors influence the antibiotic production are pH, temperature, precursors, inhibitors, carbonsource, nitrogen source, salt concentration, oxygentrace metal, etc. (Reddy *et al.*, 2011, Jaing *et al.,* 2013 and Mangamuri *et al.,* 2014). Today the over use of these antimicrobial substances increase the number of cases of multi drug resistance pathogen. Other consequences include side effect on host cell, adverse effect on normal micro flora of human body by broad spectrum antibiotics, high cost, difficult isolation and less or no effectiveness on some pathogens. These all factors lead to urgent need of today to find out their replacements with new one. Inspite of positive progress of *in vitro* chemical synthesis and bioengineered synthesis of antibacterial compounds, nature remain the primary and most versatile source of new antibiotics (Baskaran *et al.,* 2011). The present study was designed out for isolation and characterization of antibiotic producing actinomyces and checking effect of various physical parameters on antibiotic production by them.

MATERIALS AND METHOD

The various standard cultures used *viz. Staphylococcus aureus* (MTCC-3160), *Kleibsiella pneumonia* (MTCC-7407), *Bacillus subtilis* (MTCC-441) and *Pseudomonas aeruginosa* (MTCC-6458) were procured from IMTECH Chandigarh.

Sample collection and pretreatment: The soil samples for the experiment were collected from Mohali (30.68°N, 76.72°E) and Bathinda (30.20°N, 74.95°E). The soil samples were treated with $CaCO_3$ in the ratio of 1:1 to enrich soil with actinomyces and removal of other bacteria and fungi (Otoguro *et al.*, 2001) and incubated at 28^0C for 10 days.

Isolation and screening of cultures: The isolation was carried out by serial dilution agar plate method using 0.1 ml of 10^{-5}, $10^{-6.}$ 10^{-7}dilutions for spreading on AIA media for 3 to 4 days at 28^0 C. The media was added with rifampicin (5µl/ml) and Nystatin (25µl/ml) to totally inhibit bacterial and fungal contamination (Nanjwad *et al.*, 2010). After incubation, the colonies were further purified by multiple streaking methods and stored in glycerol based media at low temperature (Slavica *et al.*, 2005). Primary and secondary screening was done for the identification of antibiotic producing isolates. In primary screening (single line streak inoculation method), 24 hour old test cultures of *Kleibsella, Bacillus, Pseudomonas*

and *Staphylococcus* were spread over freshly prepared Muller Hinton Agar (MHA) plates. Then loopfulculture of actinomycete isolates were streak inoculated on the MHA plates and incubated at 37°C for 1-3 days. The plates were observed for zone of inhibition around the streak. The Isolates which show positive results were further proceeded by secondary screening (well diffusion method). The isolates were inoculated into nutrient broth and incubated at 150 rpm. After 72 hour, the culture was harvested into centrifuge tube at 8000 rpm for 20 minutes. The supernatant was filtered through 0.45 µm size membrane and added into wells dug on MHA plates previously swabbed with test organisms. These plates were then incubated at 37^{0}C for 1-3 days and zone of inhibition was observed around wells (Pandey *et al.*, 2004).

Effect of different physical and chemical parameters on antibiotic production by the isolates: The effect of change of various parameters *i.e.* pH, salt concentration, temperature and time of incubation on antibiotic production by the isolates was studied using well diffusion method with test microbes. For effect of change of pH on antibiotic production, the isolates were grown in 50 ml nutrient broth with different pH values viz. 5,6,7,8 and 9 and incubate at 27^{0}C for 2-3 days in a shaker at 180 rpm.To check the effect of various salt concentrations on antibiotic production, the isolates were inoculated in nutrient broth with different salt concentrations 1%, 2%, 3%, 4% and 5%, respectively. Similarly for checking the effect of change of temperature the isolates were inoculated at different temperature of 4^{0}C, 28^{0}C, 37^{0}C and 40^{0}C for 72 hour. Effect of incubation period was checked by taking the sample at regular intervals of 24 hours. Well diffusion method was used for checking the effect of these parameters and size of zone of inhibition were checked at different concentration of various parameters *i.e.* pH, temperature, salt concentration and incubation period. For the characterization of the potential isolates, these were subjected to various morphological and biochemical tests. Special tests for streptomyces genera like oxalate utilization test, salt tolerance test and lysozyme resistant test etc. were also performed.

RESULTS AND DISCUSSION

Total twenty three isolates were recovered from soil samples from the various regions of Mohali and Bathinda (Table 1). As organic matter play important role in microbiological diversity as well as physical and chemical properties of soil,organic field show greater diversity of microbes as compare to inorganic fertilized farms.

Antibacterial activity: Four isolates that showed positive results were designated as KA1, KA2, KA3 and KA4. These isolates were further preceded for the secondary screening by well diffusion method. In this method, out of four isolates, only two namely KA1 and KA2 showed the significant zone of inhibition against *Staphylococcus aureus* (18 mm and 21 mm, respectively) and *Bacillus subtitles* (14 mm and 18 mm) while KA3 and KA4 showed less zone of inhibition of 13 mm and 10 mm, respectively against *Staphylococcus aureus* and 11 mm and 7 mm against *Bacillus subtitles*. For *Pseudomonas*, all four isolates showed no inhibition zone for *Kleibsella*, KA1 and KA2 showed poor zone of inhibition of 8 mm and 12 mm but KA3 and KA4 showed no zone of inhibition (Table 2). The difference between sensitivity of gram positive and gram negative bacteria may be because of outer peptidoglycan (PG) layer in gram positive bacteria (Silhavy *et al.*, 2010), which is more susceptible to the antibiotics. They inhibit the enzyme (Transpeptidase) responsible for PG synthesis as a result the cell become permeable to the various lipophilic solutes, which lead to cell-lysis. On the other hand, gram negative bacteria have a prospective outer polysaccharide membrane carrying the structure lypopolysaccharide components that make their cell wall impermeable to the lipophillic solutes and thus prevent celllysis. The gram negative bacteria can also be inhibited by the antibiotic which inhibit their protein synthesis.

Effect of various physical and chemical parameters on antibiotic production of KA2 isolate: KA2 isolate that was found to be promising, was further checked for various physiological parameters. The optimal pH for antibiotic production of actenomyces varies between 6.0 to 8.08 (Fig. 1) a neutral pH, the isolate KA2 showed maximum antibacterial activity against both the pathogens (*S. aureus* and *Kleibsella*). The zone of inhibition was 19 mm and 16.5 mm, respectively for *S. aureus* and *Kleibsella.* Slight increase and decrease in pH adversely affected the antibiotic production and that was demonstrated by decrease in the

Table 1. Characteristics of soils and number of isolates recovered

	Location	Nature of soil	pH range	Dilution	No of isolates
1.Bathinda	Organic field soil	Sandy loam	7.8-8.5	10^{-6}	10
	Chemical fertilizer used field soil	Loamy sand	7.6-8.2	10^{-6}	4
2. Mohali	College campus soil	Loamy sand	6.8-7.7	10^{-6}	4
	Garden, park soil	Loamy sand	7.0-7.8	10^{-6}	5

zone of inhibition. Similar effects were observed by Reddy *et al.* (2011) and Sourav and Kannabiran (2010). They also observed maximum antimicrobial activity at pH 7.5 and 7.

Effect of salt concentration: NaCl 1% *(Fig. 2)* was optimum to induce the antibiotic production and showed 23 mm and 18 mm zone of inhibition against *S. aureus* and *Kleibsella* respectively. However, as the salt concentration was increased, there was significant decrease in the zone of inhibition that indicated the decrease in antibiotic production. Increase in salt concentration directly affect the cellular metabolism and other enzyme cascade and may result in decreased antibiotic production. Saha *et al.* (2010) recorded high antimicrobial potential at 5% NaCl with streptomyces MNK7, whereas, Singh *et al.* (2009) showed optimal potential at 2% NaCl by *Streptomyces tanashiensis*.

Effect of temperature: For the isolate KA2, the optimum temperature was 30^{0}C for maximum antibiotic production (Fig 3). The production of antibiotic is a temperature dependent phenomenon and mostly range between 28-37^0 C Ripa *et al.* (2009) reported 39^{O}C studied the optimum temperature for antimicrobial metabolites by *Streptomyces* sp. RUPA-08PR . Similarly Saha *et al.* (2010) found 35^{0}C as optimal temperature with *Streptomyces* sp. MNK7.

Effect of Incubation period: There was continuous increase in the antibiotic production as a function of incubation period (Fig. 4). Antibiotic production increased up to 72 hours of incubation and after 72 hours, it decreased probably due to exhaustion of nutrients and metabolic changes in the medium. Antibiotic production with the *KA2* isolates gave a maximum zone of inhibition of 22.3 mm against *S. aureus* and 18.3 mm against *Klebsiella* with a maximum biomass content of 6.45 g L^{-1}after 72 hours of incubation. Similarly, Osman *et al.* (2011) maximum antimicrobial compound production at 72 hours in *Streptomyces plicates*,

Characterization of the isolates: The results of various morphological, biological characterization tests along with special test for streptomyces sub class of the potential isolates

KA1 and KA2 are shown in Table 3.

Partial identification of the isolates was done tests and the results were compared with Bergey's Manual of Determinative Bacteriology, Volume-IV. The positive result conformed that the isolates KA1 and KA2 (mesophilic) belong to the sub-family Streptomyces (Family-Streptomycetes). The identification of the isolates up to the species level was not possible due to the lack of advance resources for the sophisticated tests. For the proper identification of genera and species of *actinomyces*, other biochemical properties such as cell wall chemo-type, whole cell sugar pattern, PG type, Phospholipid type and even G+C content of DNA and molecular characterization were investigated. Although the antibacterial agent obtained in this study cannot be declared as new antibiotic but there is the probability of finding new antibiotic from this region because its unexplored soil bio-diversity.

Soil is the main habitat of microbes, the present work was done for the isolation of various actinomycetes from unexplored regions of Bathinda and Mohali and were

Table 2: Antibacterial activity of various isolates

Test organisms	KA1	KA2	KA3	KA4
S. aureus	18mm	21mm	13mm	10mm
Pseudomonas	-	-	-	-
Kleibsella	8mm	12mm	-	-
Bacillus subtitles	14mm	18mm	11mm	7mm

Table 3. Various characteristics of the isolates

Biochemical test	
Catalase test	+
Oxidase test	-
Citrate utilization test	+
Starch hydrolysis	+
Nitrate reduction test	-For KA1 + for KA2
VP test	-
MR test	-
Indole test	-
Gelatineliquification	+
Casein hydrolysis	+
TSI	Alk/Acid
Urease test	+
Morphological test	
Gram staining	+
Sheath	-
Spores	-
Pigment	Non pigmented
Motility	Non motile
Colour of areal mycelium	Creamy white for KA1 Creamy for KA2
Specific test	
Oxalate utilization	+
Salt tolerance	+ (upto5% for KA1) + (upto 7% for KA2)
Lysozyme resistance	+

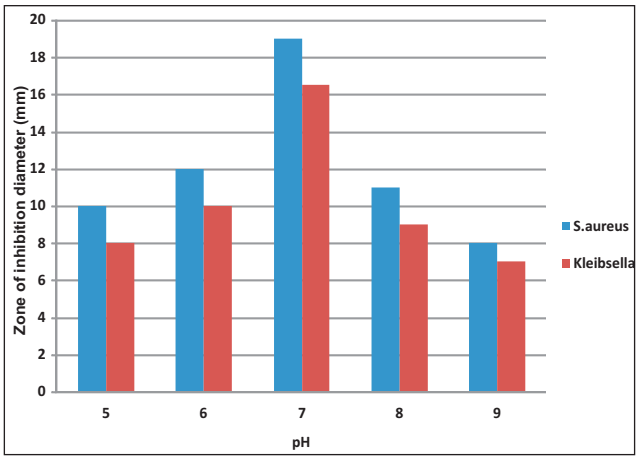

Fig. 1. Effect of pH on antibiotic production by Ka2

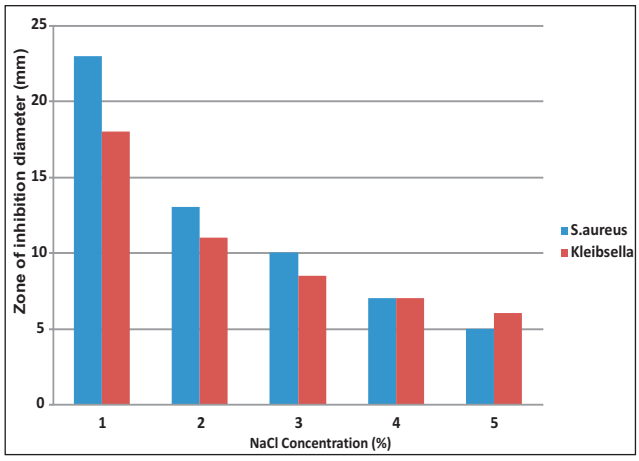

Fig. 2. Effect of different NaCl concentration on antibiotic production by Ka2

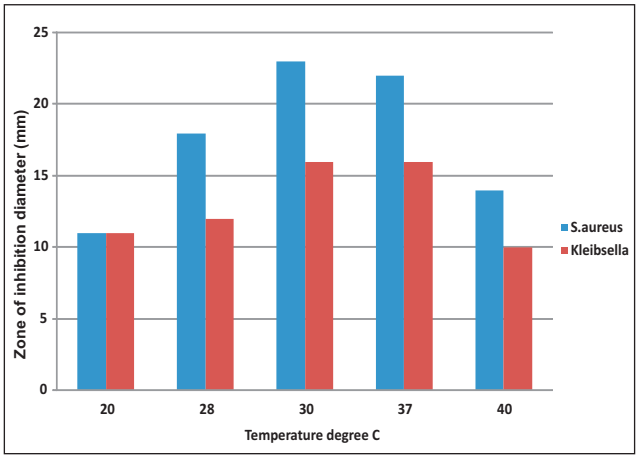

Fig. 3. Effect of different temperature on antibiotic production by Ka2

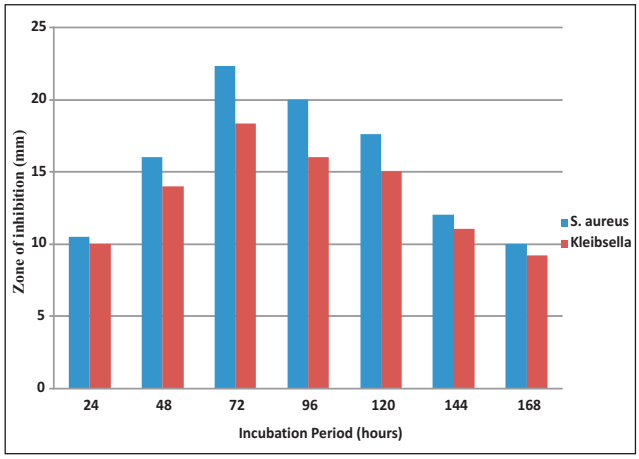

Fig. 4. Effect of different incubation periods on antibiotic production by Ka2

tested for their antimicrobial activity against four common test bacteria. Two isolates were studied in detail for variation in antibiotic production with change in different parameters and it was maximum at pH 7, 1% NaCl concentration, at 30^0 C temperature and after 72 hours of incubation periods.

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Effect of FYM Doses and Plant Spacing on Production of *Oenothera biennis* L.

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Abstract: FYM application of 45 t ha^{-1} at 45cm × 60cm spacing produced maximum plant spread, number of branches, number of flowers, number of capsules and seed yield plant^{-1}. Maximum value for plant height and seed yield ha^{-1} were recorded with 30cm × 30cm spacing with application of 45 t ha^{-1} FYM. The plant height and seed yield ha^{-1} decreased with the further increase in spacing.

Key Words: Evening primrose, FYM, Plant spacing, Seed yield, Seed oil

Oenothera biennis L. is a winter annual plant with bright yellow flowers commonly known as *evening primrose* because the flowers are partially close during the day and open in the evening (Pullaiah, 2006; Sekeroglu and Ozguven, 2006). Fever plant, sun drop, king's cureall, night willow herb, evening star, etc. are other common names and it belongs to the family Onagraceae. This plant is native to North America. In recent years, it has made the transition from being a wild flower and garden plant to an established agricultural crop. It is commercially cultivated for its seed oil, known as Evening Primrose Oil (Sekergolu and Ozguven, 2006), which is characterized by its content of gamma linolenic acid (7-10%), the precursor of prostaglandin E1 and its derivatives (Yunusova *et al.,*2007). The oil is used in preparation of medicines, nutrients, health products and cosmetics (Deng *et al*., 2001). Evening Primrose Oil (EPO) has been used for a wide range of conditions including premenstrual syndrome, mastalgia, atopic eczema, rheumatoid arthritis, neuro-dermatitis (Yunusova *et al*., 2007; Ghasemnezhad, 2007). EPO is available as a nutritional supplement in over 30 countries. It has been reported that during the year 2008, EPO was the 20th top selling botanical dietary supplement (Cavaliere *et al.,* 2009).

Presently, organic cultivation is attaining a priority in the crop production as it is not only supportive to the environment but also ensures quality of the material produced. Organic production of food crops aim at achieving agro-ecosystems, which are socially and ecologically sustainable. Different growing conditions and agricultural applications affect the plant development, yield and quality of the plants. In the wider spacing, plants have more nutrition, water and air, but at narrow spacing, they have restricted conditions for development, and competition is induced (Sekeroglu and Ozguven, 2006). In India, not much of the research work has been conducted on agrotechnology, processing and other aspects related to the medicinal properties of evening primrose.

MATERIALS AND METHODS

The study was carried out at Nauni, Solan (HP) located at 30°52'N latitude and 70°11'E longitude with an elevation of 1235m asl, which falls under mid-hill zone. The climate is sub-tropical to sub-temperate. The site is characterized by undulating topography and experimental area has been terraced. Soil is silty-loam with medium organic carbon content (0.92%), 6.74 pH and normal electrical conductivity (0.37 dS m^{-1}). Soil test values for available nutrient were medium for available nitrogen (321.51 kg ha^{-1}), high for available phosphorus (33.16 kg ha^{-1}) and medium for potassium (202.68 kg ha^{-1}).

The seeds were sown in nursery beds (1.8m × 1.8m size) and seeds germinated within 6 days. The seedlings were transplanted to the experimental area at four spacing (30cm × 30cm, 30cm × 45cm, 45cm × 45cm, 45cm × 60cm) and four FYM doses (control, no application, 15t ha^{-1}, 30t ha^{-1} and 45t ha^{-1}). The FYM was applied at the time of transplanting.

Capsules brownish in colour before their opening were harvested. The data on plant height (cm), plant spread (cm) and number of flowers plant^{-1}, were recorded at the stage of completion of anthesis, whereas, number of capsules plant^{-1} was recorded at fruit setting stage. Five representative plants from each plot were randomly selected for detailed observations on related parameter. After harvesting, number of seed capsule^{-1} and seed yield plant^{-1} (g) were also measured. Oil content in seed was determined by using Soxhlet method. Finely grinded seed samples were

placed in porous cellulose thimble and extracted with n-hexane with in a Soxhlet apparatus for eight hours at a constant temperature of 70° C. Mass of remaining lipid (oil) was measured.

$$\text{Volume of seed oil (ml)} = \frac{\text{Weight of seed oil (g)}}{\text{Density of seed oil (g cm}^{-3})}$$

$$\text{Oil (\%)} = \frac{\text{Volume of oil (ml)}}{\text{Weight of sample (g)}} \times 100$$

The production data were analyzed by analysis of variance (ANOVA) using statistical package (SYSTAT, Version13). The results have been interpreted on the basis of 'F' test and critical difference (CD) at 5 per cent level of significance.

RESULTS AND DISCUSSION

Growth parameters: The maximum average plant height (160.9 cm) was recorded in 45t ha^{-1} FYM, which was significantly higher than other treatments, whereas, minimum mean plant height (154.5 cm) was noticed in control(Table 1). Among different planting densities, maximum average plant height (166.1 cm) was observed in 30cm × 30cm, which was significantly higher than rest of the values. Minimum average plant height (148.7 cm) was observed in 45cm × 60cm. With the increase in spacing, there has been decrease in plant height (Table 1). Sekeroglu and Ozguven (2006) also reported that increase in plant height with the decrease in spacing. In their interaction effect, maximum plant height was recorded under 45 t/ha at 30cm × 30cm spacing (Fig. 1).

Maximum number of branches plant^{-1} (14.9) was observed with 45t ha^{-1} FYM application and minimum (11.2) noticed in control (Table 1). The wider growing area for plants promotes the production of more branches. The maximum number of branches plant^{-1} (17.5) was recorded in 45cm × 60cm, which was significantly higher from other spacing treatments. The number of branches plant^{-1} increased significantly with the increase in spacing. This can be attributed to the less competition for water, minerals, etc. and much space to grow. The number of branches depends mainly on the soil fertility, growing conditions and agronomical practices. In the optimum growing conditions, plants produce more branches. In nutshell, the higher numbers of branches were obtained in the 45cm × 60cm spacing with 45 t ha^{-1} FYM dose in their interaction effect (Fig.

Table 1. Effect of FYM and plant spacing on growth and yield parameters of evening primrose

Treatments	Plant height (cm)	Number of branches plant^{-1}	Plant spread (cm)	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Number of seeds capsule^{-1}	Seed yield plant^{-1} (g)	Seed yield ha^{-1} (Kg)	Seed oil (%)
Spacing (S)									
S1 (30cm × 30cm)	166.1	9.8	50.6	244	230.9	324.8	23	255.6 (2.41)	25.32 (5.03)
S2 (30cm × 45cm)	161.8	11.6	66.5	265.3	251.7	306.5	28.7	212.4 (2.33)	25.17 (5.02)
S3 (45cm × 45cm)	154.4	12.7	84.3	279.6	266.5	327.8	35.6	175.9 (2.25)	25.31 (5.03)
S4 (45cm × 60cm)	148.7	17.5	99.7	301.1	285.4	333.2	42.6	157.8 (2.20)	25.30 (5.03)
CD (p=0.05)	1.07	0.83	2.35	1.00	0.64	NS	0.85	0.01	NS
FYM doses									
Control	154.5	11.2	69.8	249.1	236.0	304.3	29.7	181.2 (2.25)	25.38 (5.04)
15 t ha^{-1}	156.5	12.3	74.0	262.0	248.3	326.8	31.6	194.6 (2.28)	25.16 (5.01)
30 t ha^{-1}	158.9	13.5	77.4	280.8	266.4	326.9	33.2	205.4 (2.31)	25.08 (5.00)
45 t ha^{-1}	160.9	14.9	80.2	297.4	283.8	334.3	35.4	220.4 (2.33)	25.47 (5.05)
CD (p=0.05)	1.07	0.83	2.35	1.00	0.64	NS	0.85	0.01	NS

*, **Figures in parentheses are log transformed and square root transformed values, respectively

1). The plant spread also followed the same trend.

Yield attributes: Maximum average number of flowers plant^{-1} was recorded with 45t ha^{-1} FYM, which was significantly higher than the rest of the treatments (Table 1). There has been a significant increase as the FYM doses increased. In case of spacing, the maximum average number of flowers per plant was recorded at 45cm × 60cm and minimum average number of flower plant^{-1} was obtained in 30cm × 30cm. Number of flowers per plant increased significantly with the increase in spacing. In their interaction, the maximum number of flowers plant^{-1} was recorded for 45t ha^{-1} FYM application for 45cm × 60cm plant spacing (Fig. 2).

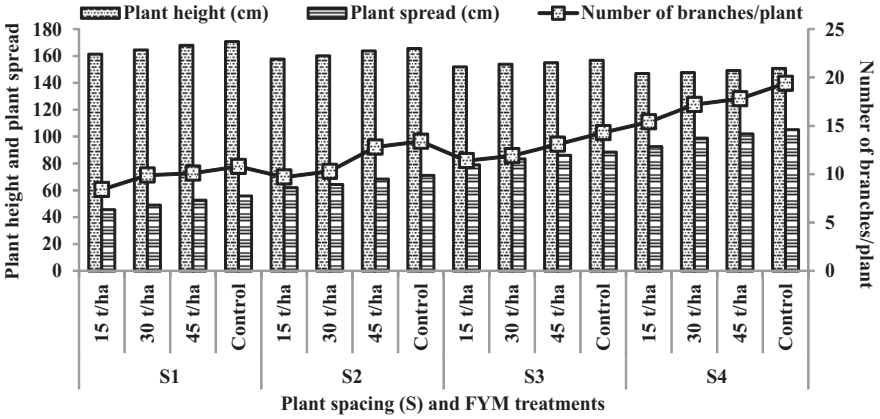

Fig. 1. Interaction of plant spacing and FYM application on growth of evening primrose

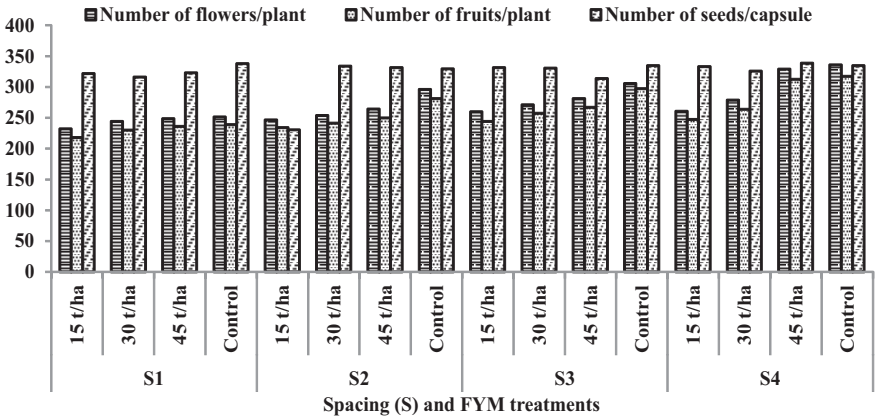

Fig. 2. Interaction of plant spacing and FYM application on yield attributes of evening primrose

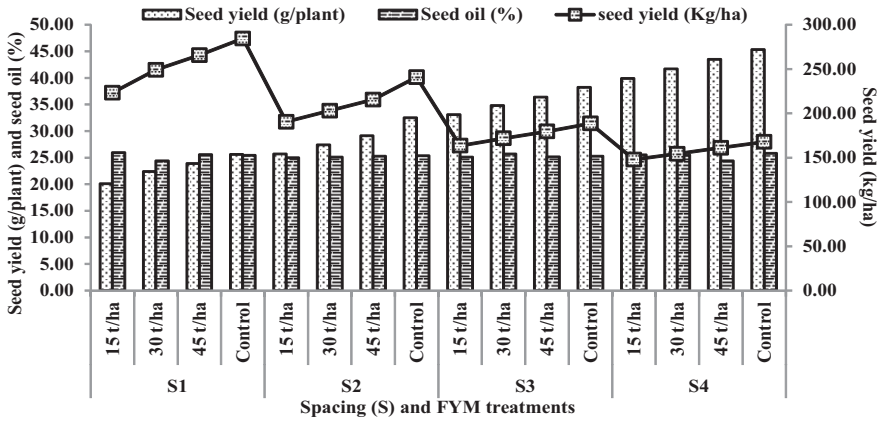

Fig. 3. Interaction of plant spacing and FYM application on yield of evening primrose

Number of capsules per plant followed the same trend of increase and decrease with different FYM doses and spacing. Non-significant effect was observed for all the treatments and their combinations for number of seeds capsule^{-1}.

Yield: Maximum average seed yield plant^{-1} was obtained with 45t ha^{-1} FYM application and the minimum average seed yield plant^{-1} was recorded for control. Seed yield per plant increased significantly with the increase in FYM doses (Table 1). Blaise *et al.* (2005) reported improvement in cotton seed yield with addition of FYM (5 t ha^{-1}). In planting densities, significantly maximum average seed yield per plant was obtained at 45cm × 60cm spacing. The beneficial effect of wider row spacing has been due to better light penetration and higher photosynthetic efficiency resulting in better development of plant canopy with more number of capsules per plant and seed yield per plant. Similar trend was obvious in seed yield on hectare basis. The crude oil contents varied from 24.38 to 25.97 per cent, which are in accordance with previous reportes i.e., 25.5-26.8% (Reiner *et al*., 1989); 21.5-25.0% (Roy *et al.,*1994) and 23.0-27.8% (Fieldsend and Morison, 2000), though the differences were non-significant.

The growth, yield attributes and yield parameters were improved at wider spacing of 45cm × 60cm. Overall, the application of 45t ha^{-1} FYM with wider plant spacing (45cm × 60cm) improved growth and yield of evening primrose.

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Impact of Cadmium on Feeding Response and Growth of *Filicaulis alte* Ferussac and *Macrochlamys indica* Godwin-Austen

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***Abstract*:** The bait was offered containing different concentration of cadmium (50 ppm, 100 ppm, 200 ppm, 400 ppm and 800 ppm) in no choice laboratory feeding tests, to study the effect on feeding responses and mortality of snail (*Macrochlamys indica*) and slug (*Filicaulis alte*). Presence of cadmium resulted in inhibition of feeding in dose dependant manner. Low mortality was recorded in treatments. Juvenile slugs when exposed to lowest concentration of cadmium showed a decrease in weight along with mortality, which suggests that slug was more sensitive to cadmium contaminated food and can be used as bio-indicator of cadmium laden sites.

***Key Words*:** Bioindicator, Cadmium, *Filicaulis alte, Macrochlamys indica*

Snails and slugs are prominent among the invertebrates as they are the most important terrestrial bio-indicators of metal pollution, because they are able to accumulate large quantities of metals in their tissues and play a major role in food chain transport of metals (Gomot and Pihan, 2000). Manzl *et al* (2004) has reported the toxic effect of Cadmium (Cd) on isolated hepatopancreatic cells from the Roman snail, *Helix pomatia.* Using snails in toxicity bioassays is an attractive method since they are easy to culture in the laboratory, and can be fed on artificial diets with the desired amounts of metals, and respond quickly to metal contamination (Swaileh and Ezzughayyar, 2000). The present study was conducted to investigate the effect of cadmium on feeding responses and mortality of snail, *M. indica* and slug, *F. alte.*

MATERIAL AND METHODS

Black slug (*F. alte*) and snail (*M. indica*) were acclimatized for a week in trays of 18 x 15 x 4 cm each covered by moist muslin cloth. Soil was kept moist throughout the experiment by sprinkling water after removal of feces of slugs and snails daily.

Feeding and mortality experiment was carried out in plastic trays by exposing 5 slugs (3-6 g body weight) and 5 snails (1.5-2 g body weight) in each tray to five concentrations of cadmium (50, 100, 200, 400 and 800 µg/ g bait) in three replications. Control experiment was run along with each test and offered 5g wheat bran per tray daily. Daily observations were made for their mortality during test period. After four days test period, they were offered plain wheat bran.

Young slug (0.2-1.5 g body weight) and snail (0.2-0.5 g body weight) collected from plant nurseries at P.A.U campus Ludhiana were acclimatized in laboratory cages for a week. The animals were provided with a plain wheat bran and moist damp soil in tray during this period. Growth testing was carried out by exposing these slugs and snails to Cd (50 ppm) for one month. Treatment was replicated 3 times. Control experiment was run along with this by providing untreated plain bait. Trays were kept neat and clean to provide hygienic conditions. Animals were weighed every week. Food was changed every 3rd day. Feeding responses were recorded at two days interval and growth at weekly interval in juvenile slugs and snails for one month.

RESULTS AND DISCUSSION

Feeding responses and mortality on cadmium mixed wheat bran bait: Exposure of slug and snail to different doses of cadmium resulted in significant decrease in mean bait consumption as compared to those fed on untreated bait. Dose dependent decrease in consumption was observed (Table 1, 2). Consumption of treated bait was nil at higher concentrations (400 ppm and 800 ppm) as a result of which no fecal matter was observed. Swaileh and Ezzughayyar (2000, 2001) also found significant reduction in food consumption with increase in concentration of heavy metals in diet of snail. Das and Khangrot (2010, 2011) observed that cadmium inhibited the feeding and growth in snails. Epiphragm formation in snail might due to stress induced by cadmium was observed. In this condition, snails draw their body reserve at much reduced rate, which implies an imminent reduction in weight (Abdussamad *et al.,* 2010). Low mortality rate was not found a sensitive parameter to check toxicity of Cd, it can be due to efficient mechanism of both slug and snail to repair damage. The most obvious of these is

Table 1. Effect of different concentrations of Cd mixed in wheat bran on feeding responses of the slug, *Filicaulis alte* (n=5) in no-choice laboratory feeding test

Treatment	Body weight of slug (g)		Percent increase (+) / decrease (-) in body weight	Overall bait intake (g/10g body weight)
	Before treatment	After treatment		
UT-1	3.76±0.97	4.17±0.33	10.90 (+)	1.54±0.08*
T-1 (50 ppm)	4.48±1.15	4.01±0.19	10.49 (-)	0.33±0.11
UT-2	4.0±1.03	4.23±0.24	5.43 (+)	1.31±0.07*
T-2 (100 ppm)	4.71±1.21	3.96±0.09	15.92 (-)	0.19±0.05
UT-3	4.50±1.16	4.87±0.52	7.59 (+)	1.45±0.06*
T-3 (200 ppm)	4.33±1.11	3.94±0.43	9.01 (-)	0.03±0.02
UT-4	5.05±1.30	5.34±0.58	5.61 (+)	1.36±0.07*
T-4 (400 ppm)	4.08±1.05	3.48±0.48	14.70 (-)	-
UT-5	6.33±0.09	6.47±0.26	2.16 (+)	1.16±0.21*
T-5 (800 ppm)	6.13±0.26	5.56±0.23	9.29 (-)	-

%(+) – increase in body weight, %(-) - decrease in body weight, UT – Untreated, T- Treated
* Differences between consumption of untreated and treated baits significant at $p < 0.05$

Table 2. Effect of different concentrations of Cd in wheat bran on feeding responses of the snail *Macrochlamys indica* (n=5) in no-choice laboratory feeding tests

Treatment	Body weight of snail (g)		Per cent Increase (+) / decrease (- in body weight	Overall bait intake (g/10g body weight)
	Before treatment	After treatment		
UT-1	1.29±0.33	1.36±0.03	5.14 (+)	1.11±0.11*
T-1 (50 ppm)	1.61±0.05	1.45±0.08	9.93 (-)	0.28±0.04
UT-2	1.17±0.30	1.53±0.08	23.5 (+)	1.27±0.06*
T-2 (100 ppm)	1.64±0.42	1.31±0.10	20.12 (-)	0.12±0.03
UT-3	1.23±0.31	1.57±0.03	21.65 (+)	1.24±0.05*
T-3 (200 ppm)	1.59±0.41	1.48±0.06	6.91 (-)	0.02±0.01
UT-4	1.72±0.44	1.76±0.06	2.27 (+)	1.09±0.12*
T-4 (400 ppm)	1.55±0.40	1.47±0.11	5.16 (-)	-
UT-5	1.47±0.08	1.72±0.06	14.53 (+)	1.21±0.10*
T-5 (800 ppm)	1.91±0.09	1.79±0.09	6.28 (-)	-

%(+) – increase in body weight, %(-) - decrease in body weight, UT – Untreated, T- Treated
* Differences between consumption of untreated and treated baits significant at $p < 0.05$

enhanced mucus secretion. High mucus secretion in both slug and snail was reported at higher concentrations of cadmium. Increased mucus production followed by increased mucus secretion is one of the first reactions of gastropods to many kinds of chemical stressors (Barker 2002). Deshmane (2012) revealed that mucus secretion in snail, *Viviparus bengalensis* increases is dose dependent. Similar behavioural changes were recorded by Compbell *et al* (2000) in *Lymnaea stagnalis* in aluminum and silicilic acid in environment.

Effect of cadmium (50 ppm) on the growth : Mean bait consumption and mean weight of slugs and snails fed on control and cadmium (50 ppm) treated bait was significantly ($P < 0.05$) different. Decrease in weight was observed from 0 day to 28th day in slugs fed on cadmium treated bait (Table 3). 65.30 per cent decrease in body weight was observed in case of juvenile slug (Table 3), but in snail no significant difference was evident in mean bait consumption and mean weight. Interaction between metal exposure and weight of snail was not significant. Treated juvenile snail increase (14th day) and then decrease (21st and 28th day) in consumption. Weight also first increased (7th day), remain constant for 2 weeks (14th and 21st day) and decreased at end of month (28th day). Only 3 per cent decrease in weight of juvenile snail was recorded. In case of untreated juvenile slug and snail body weight increased every week with increase in mean bait consumptions. Swaileh *et al* (2007) found that inhibitory effects of cadmium on juvenile snail (*Helix engaddensis*)

Table 3. Impact of Cd (50 ppm) on bait consumption and growth of juvenile slug and snail for one month laboratory feeding test

Treatments	Animal	Over all mean bait consumption(g)/10g body weight)				Body weight (g)				Percent increase (+)/decrease(-) body weight
		7th Day	14th Day	21st Day	28th Day	0 Day	7th Day	14th Day	21st Day	28th Day	
Control	Slug	9.13±0.20	10.19±0.6	15.14±0.09	20.33±0.21	0.44±0.08	0.53±0.08	0.62±0.09	0.72±0.09	0.79±0.09	44.30 (+)
Cd (50 ppm)		8.06±0.01	9.30±0.18	13.01±0.19	14.24±3.16	0.49±0.11	0.41±0.11	0.37±0.08	0.30±0.08	0.17±0.03	65.30 (-)
Control	Snail	9.32±2.18	9.81±0.50	10.14±0.51	11.18±0.42	0.24±0.01	0.41±0.03	0.46±0.02	0.59±0.04	0.71±0.03	66.20 (+)
Cd (50 ppm)		8.96±1.5	9.53±0.11	9.45±1.7	8.84±0.51	0.21±0.01	0.23±0.01	0.23±0.01	0.23±0.01	0.18±0.01	3 (-)

started from the third week of exposure, which was similar to present results. The reduced growth observed can be due to additional energy required in accumulation and detoxification of metals (Walker *et al* 2001). The growth can also be effected due to heavy metal stress, which further leads to change in activity of an organism resulting in utilisation of their biochemical energy to counteract the toxic stress, hence metabolic rate increases which affect growth (Mahajan and Zambare 2013).

Results of the present study indicate that slug was more sensitive as compared to snail as it shows early responses towards Cd contaminated food. This suggests that slug (*F. alte*) is good bio-indicator of cadmium toxicity as compared to snail (*M. indica*) and its presence and absence could be an indicator of the status of the soil health.

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Effect of Incorporation of Defatted Flaxseed Flour on Functional and Proximate Composition of Crackers

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Abstract: Incorporation of roasted and partially defatted flaxseed flour in refined wheat flour increased the water absorption capacity, foam capacity and foam stability from 1.48 to 2.57 g g^{-1}, 11.52 to 17.04 % and 83.65 to 89.56 %, respectively. Dough produced from such flour blends was non sticky. The highest mean moisture (4.48%) was recorded in 0% flaxseed flour, whereas, crude protein, crude fat, crude fibre and ash content of 15.31, 14.45, 4.56 and 2.25 per cent, respectively were observed with 30% flaxseed flour. There was an increase in moisture but decrease in crude protein, crude fat and crude fibre content during 90 days of storage.

Key Words: Crackers, Defatting, Foam capacity, Foam stability, Proximate composition, Roasting

Flaxseed contains valuable nutritional compounds such as alpha linolenic acid, lignin, and dietary fibre. It has also been reported to lower low density lipo-protein, cholesterol, which has been attributed to the high content of fibre components. Flaxseed is recognized as good source of soluble fibres that helps lower blood cholesterol, insoluble fibre that promote laxation, alpha linolenic acid and essential omega-3 fatty acids important for cardiovascular health and phytoestrogens beneficial in post menopausal women. Flaxseed is one of those healthy ingredients that is easy to sneak into foods as cookies, biscuits, etc. increasing the nutritional value. Flaxseed proteins have been assessed as techno-functional ingredients in many food formulations such as bakery products and pastries, meat emulsions, sauces and ice creams. Functional properties of flaxseed proteins including emulsifying and foaming ability and stability are comparable to those of other oilseed proteins. The advantage of flaxseed proteins compared to other vegetable proteins arises from their association with the mucilage, a co-product in flaxseed, which may enhance their properties in food formulation (Rabetafika *et al*., 2011). Therefore, the present study was carried out with the objective of using roasted defatted flaxseed flour as a functional ingredient in crackers and its effect on the functional and proximate constituents during storage.

MATERIALS AND METHODS

The flaxseed grains and refined wheat flour (*maida*) were procured from local market. The flaxseed grains were then roasted for 3 minutes in household microwave oven at 450 watts and then defatted in oil expeller to reduce oil. Finally cooled and milled into flour. For preparation of crackers refined wheat flour and roasted defatted flaxseed flour was blended in the ratios given below and were analyzed for different functional parameters viz., water absorption capacity, foam capacity, foam stability and dough handling: Crackers were prepared from blends of wheat-flaxseed flour and other ingredients (water, baking powder, shortening, cheese, salt and sugar) according to formulation described by Kohajdova *et al.* (2013). Fine wheat flour was used (as per flow chart, Fig.1) for preparation of control crackers.

Shortening + sugar + cheese + milk + salt

Cream

Sifted refined wheat flour, flaxseed flour and baking powder

Mixed cream with flour

Dough formation

10 minutes resting of dough

Sheeting and cutting of crackers

Baking (210°C for 8-10 minutes)

Fig. 1. Flow chart for preparation of crackers

The treatment combinations of refined wheat-flaxseed flour crackers were packed in aluminum laminate (150 gauge) and then stored for a period of 90 days at room temperature. The stored products were analyzed for proximate composition for an interval of 30 days.

Functional properties of blended flours: The determination of water absorption capacity was carried out

after following the method of Anderson *et al*. (1969). A 2.5 g sample was dispersed in 25 g distilled water, using a glass rod to break up any lumps. After stirring for 30 minutes, the dispersions were rinsed into centrifuge tubes, made up to 32.5 g and centrifuged at 5000 rpm for 10 minutes. The water absorption capacity is the weight of gel obtained per gram of dry ground sample. evaporated from the water absorption determination.

Foam capacity and Foam stability: Foam capacity and stability was determined by the procedure as mentioned by Baljeet *et al.* (2014). Fifty ml water was taken in a cylinder, one grams of flour samples was mixed keeping the temperature at 30± 2 ^{0}C. The suspension was properly shaken to foam and the volume of the foam after 30 seconds was recorded in per cent as foam capacity while the foam volume per cent recorded after one hour of whipping was recorded as foam stability.

Proximate composition of blended crackers: Moisture, ash, crude fibre and nitrogen free extract were determined according to AOAC (1995). Crude protein was estimated by using micro-kjeldahl method using the factor 6.25 for converting nitrogen content into crude protein. For fat content of noodles, 5 g sample was placed in Soxhlet extraction apparatus and subjected to extraction for six hours using petroleum ether as solvent and per cent fat content of cracker samples were calculated on weight basis.

RESULTS AND DISCUSSION

Functional properties of flour blends: The variations were significant among the treatments with respect to water absorption capacity, foam capacity and foam stability (Table 1). The highest water absorption capacity of 2.57 g per g, foam capacity of 17.04% and foam stability of 89.56% were observed in 30% flaxseed flour. Water absorption capacity increased with the incorporation of flaxseed flour. Flaxseed is high in mucilage (gum) that can increase the water absorption capacity of blended dough, which can impact mixing time and dough handling characteristics. The dough remained non-sticky in all the treatments with the incorporation of flaxseed flour. Protein can help the foam because of their surface active property (Baljeet *et al.,* 2014). Flaxseed is a rich source of protein thus with the incorporation of flaxseed foam capacity and stability increased.

Storage studies of refined wheat – flaxseed flour blended crackers: Proximate analysis of refined wheat-flaxseed flour blended crackers stored under ambient conditions was conducted at 30 days interval to find out the changes in storage.

Moisture: The moisture content of crackers differed significantly in all the treatments. At 0 day storage, the highest moisture content of 3.85 per cent was observed in 0% flaxseed flour and lowest of 3.31 per cent in 30% flaxseed flour (Table 2). As the storage period advances, there was increase in moisture content. The increase in moisture content of crackers might be due to hygroscopic nature of flaxseed flour and wheat flour. Increase in moisture content with storage period was also reported by Nagi *et al*. (2012) in cereal bran biscuits.

Crude protein: At 0 day, the increase in level of partially defatted roasted flaxseed flour supplementation in refined wheat flour improved the crude protein contents, from 9.80 per cent in 0% flaxseed flour to 15.52 per cent in 30% flaxseed flour (Table 2). The mean value of crude protein content decreased slightly during storage from 0 to 90 days of storage. The decrease in protein content during storage might be due to hydrolysis of peptide bonds with the help of protease enzyme that cause splitting of protein molecules during storage. Similar results were reported by Kanchana *et al*. (2008) in single cell protein biscuits.

Crude fat: The treatments significantly influenced crude fat content of crackers and fat content increased with the incorporation of flaxseed flour (Table 3). At 0 day of storage,

Table 1. Effect of treatment on functional properties of flour blends

Treatment*	Water absorption capacity (g g^{-1})	Foam capacity (%)	Foam stability (%)
100:00 :: RWF :PDRFF	1.48	11.52	83.65
95:05 :: RWF :PDRFF	1.56	12.40	84.82
90:10 :: RWF :PDRFF	1.70	13.27	85.54
85 :15 :: RWF :PDRFF	1.93	14.15	86.73
80 :20 :: RWF :PDRFF	2.18	15.19	87.49
75 :25 :: RWF :PDRFF	2.35	16.23	88.63
70 :30 :: RWF:PDRFF	2.57	17.04	89.56
Mean	1.96	14.25	86.63
CD (p=0.05)	0.07	0.10	0.07

*RWF : Refined wheat flour, and PDRFF: Partially defatted roasted flaxseed flour

30% flaxseed flour recorded highest fat content (14.92%) but after 90 days of storage 0% flaxseed flour recorded the lowest value. Storage period also significantly influenced fat content of crackers. The significant reduction of fat content during storage in crackers might be due to the activity of lipase enzyme leading to decreased fat content. These findings are in accordance with the findings of Singh *et al*. (2008).

Ash: During storage, a significant decrease in the ash content was observed from 1.93 (0 day) to 1.83% after 90 days (Table 3). With the incorporation of flaxseed flour, the ash content increased in all treatments. Similar results have been reported by Owusu *et al*. (2011) in crackers from cassava and sweet potato flour.

Crude fibre: The crude fibre content of all treatments increased significantly with the increase in the level of partially defatted roasted flaxseed flour incorporation in refined wheat flour (Table 4). At 0 day, the highest crude fibre content of 4.69 per cent was recorded in 30% flaxseed flour whereas, 0% flaxseed flour recorded the lowest crude fibre content of 2.72%. The mean value of crude fibre content decreased from 3.64% at 0 to 3.36% after 90 days of storage. Similar decline in crude fibre content during storage was reported by Mushtaq *et al*. (2010) in xylitol blended cookies.

Nitrogen free extract: Nitrogen free extract decreased with increase in proportion of flaxseed flour in various treatments (Table 4). At the beginning, the highest value of nitrogen free extract (71.69%) was recorded in 0% flaxseed flour. After 90 days of storage, 30% flaxseed flour recorded the lowest value of 59.95%, whereas, highest nitrogen free extract of 71.98% was in 0% flaxseed flour. The highest amount of nitrogen free extract was noted on 90 days interval whereas, the minimum nitrogen free extract was observed on 0 day storage.

The incorporation of roasted defatted flaxseed flour significantly increased the functional properties of flour blends. Further, the substitution of refined wheat flour with 0-30% roasted and defatted flaxseed flour decreased moisture content and nitrogen free extract however, crude protein, crude fat, ash and crude fibre content increased significantly. Great potential therefore, exists for incorporating roasted- defatted flaxseed flour in baked products as a protein supplement and functional ingredient.

Table 2. Effect of treatment and storage on moisture (%) and crude protein (%) content of flaxseed flour blended crackers at different storage period (days)

Treatment*	Moisture (%)					Crude protein (%)				
	0	30	60	90	Mean	0	30	60	90	Mean
100:00 :: RWF :PDRFF	3.85	4.24	4.70	5.13	4.48	9.80	9.72	9.64	9.41	9.64
95:05 :: RWF :PDRFF	3.73	4.10	4.58	5.02	4.35	10.73	10.64	10.56	10.33	10.56
90:10 :: RWF :PDRFF	3.67	3.99	4.42	4.89	4.24	11.86	11.76	11.68	11.42	11.68
85 :15 :: RWF :PDRFF	3.54	3.87	4.35	4.73	4.12	12.54	12.43	12.34	12.08	12.34
80 :20 :: RWF :PDRFF	3.43	3.76	4.20	4.67	4.01	13.41	13.34	13.25	13.02	13.25
75 :25 :: RWF :PDRFF	3.35	3.67	3.95	4.40	3.84	14.60	14.51	14.41	14.15	14.41
70 :30 :: RWF:PDRFF	3.31	3.59	3.80	4.26	3.73	15.52	15.40	15.29	15.03	15.31
Mean	3.55	3.88	4.28	4.72		12.63	12.54	12.45	12.20	
Effect	C.D. (P=0.05)					C.D. (P=0.05)				
Treatment	0.04					0.03				
Storage	0.03					0.02				
Treatment × Storage	0.08					0.06				

* RWF : Refined wheat flour, and PDRFF: Partially defatted roasted flaxseed flour

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Table 3. Effect of treatment and storage on crude fat (%) and ash (%) content of flaxseed flour blended crackers

Treatment*	Crude fat (%) Storage period (days)					Ash (%) Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
100:00 :: RWF :PDRFF	10.51	10.11	9.83	9.69	10.03	1.43	1.40	1.36	1.33	1.38
95:05 :: RWF :PDRFF	11.12	10.72	10.44	10.30	10.64	1.60	1.58	1.55	1.53	1.56
90:10 :: RWF :PDRFF	12.24	11.84	11.56	11.42	11.76	1.79	1.76	1.74	1.71	1.75
85 :15 :: RWF :PDRFF	13.10	12.71	12.43	12.28	12.63	1.94	1.91	1.87	1.83	1.88
80 :20 :: RWF :PDRFF	13.78	13.39	13.11	12.96	13.31	2.13	2.09	2.06	2.04	2.08
75 :25 :: RWF :PDRFF	14.47	14.08	13.80	13.65	14.00	2.28	2.25	2.21	2.18	2.23
70 :30 :: RWF:PDRFF	14.92	14.53	14.25	14.12	14.45	2.36	2.32	2.25	2.20	2.25
Mean	12.87	12.48	12.20	12.06		1.93	1.90	1.86	1.83	

Effect	C.D. (P=0.05)	C.D. (P=0.05)
Treatment	0.04	0.04
Storage	0.03	0.03
Treatment × Storage	0.09	0.08

* RWF : Refined wheat flour, and PDRFF: Partially defatted roasted flaxseed flour

Table 4. Effect of treatment and storage on crude fibre (%) and nitrogen free extract (%) of flaxseed flour blended crackers

Treatment*	Crude fibre (%) Storage period (days)					Nitrogen free extract (%) Storage period (days)				
	0	30	60	90	Mean	0	30	60	90	Mean
100:00 :: RWF :PDRFF	2.72	2.67	2.55	2.46	2.60	71.69	71.86	71.92	71.98	71.86
95:05 :: RWF :PDRFF	2.98	2.89	2.78	2.65	2.82	69.84	71.02	70.09	70.17	70.03
90:10 :: RWF :PDRFF	3.24	3.18	3.10	2.95	3.11	67.20	67.47	67.50	67.61	67.44
85 :15 :: RWF :PDRFF	3.63	3.57	3.49	3.37	3.51	65.25	65.51	65.52	65.71	65.49
80 :20 :: RWF :PDRFF	3.95	3.92	3.81	3.73	3.85	63.25	63.51	63.57	63.58	63.47
75 :25 :: RWF :PDRFF	4.27	4.20	4.11	3.98	4.14	60.99	61.29	61.52	61.61	61.35
70 :30 :: RWF:PDRFF	4.69	4.60	4.53	4.44	4.56	59.26	59.60	59.88	59.95	59.67
Mean	3.64	3.57	3.48	3.36		65.35	65.61	65.71	65.80	

Effect	C.D. (P=0.05)	C.D. (P=0.05)
Treatment	0.03	0.03
Storage	0.02	0.02
Treatment × Storage	0.06	0.06

*RWF : Refined wheat flour, and PDRFF: Partially defatted roasted flaxseed flour

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Assessment of Forced Genetic Divergence in a Collection of *Brassica Juncea* L. Germplasm Grown Under Varying Nitrogen Levels

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***Abstract*:** The amount of diversity available in the crop decides the success of any crop improvement programme with manifested objectives. Assemblage and assessment of divergence in the germplsm is essential to know the spectrum of diversity. In the present investigation, 34 *Brassica juncea* L. genotypes were considered for the assessment of genetic diversity at three nitrogen levels (N_0, N_{50} and N_{100}) and at two stages (Pre-anthesis and Post-anthesis) by multivariate analysis as per Mahalanobis concept of generalize distance (D^2) considering 19 biochemical and agronomical characters. Almost all the evaluated traits revealed significant variation in the germplasm. On subjecting these traits to D^2 analysis, genotypes were allowed to group into 6 clusters at both pre- and post-anthesis, indicating the presence of genetic diversity in the material. The inter-cluster distances were higher than the intra-cluster distances supporting the grouping of the genotypes. The presence of different genotypes in 6 clusters at different nitrogen levels, suggests that genetic variation is forced by nitrogen application. On the basis of mean performances of checks (PBR 210, PBR 91 and PBR 97), different promising genotypes have been selected with respect to different N-level, which may be beneficial in various breeding programmes.

***Key Words*:** *Brassica juncea* L., Clustering, D^2 analysis, Genetic divergence, Nitrogen levels

Indian mustard (*Brassica juncea* L., 2n=36) is the second most important oilseed crop of India after soybean, accounting nearly 30% of total oilseeds produced in the country. It is the pre-dominant cruciferous species in the Indian sub-continent. *B. juncea* has higher productivity, yield, high quality oil, high protein seed meal, more vigorous seedling growth, quicker ground covering ability, greater tolerance to heat and drought and enhanced resistance to insects, pests and diseases (Woods *et al.,* 1991). *Brassica juncea* predominate the commonly cultivated *Brassica* species. India needs to import more than 40% of its annual edible oils requirements to meet the demand of a growing economy and a burgeoning population. Nitrogen (N) is an important constituent of protein and is essential for the growth of the plants and hence influences yield as well as oil content. Nitrogen deficiency results in the yellowing or chlorosis of leaves and reduces the amount of protein in the seed as well as oil in the plant. *Brassica* has high efficiency to absorb mineral nitrogen from soil but low capacity to use it. Thus, high rates of N fertilizer are usually applied to oilseed rape in order to obtain high seed yield (Rossato *et al.,* 2001) and protein content (Sahoo *et al.,* 2000).

Genetic diversity plays an important role in plant breeding because hybrid between genotypes of diverged origin generally display a great heterosis than those between closely related strains (Khatun *et al.,* 2010), which permits to select the genetically divergent plants to obtain the desirable recombinants from the segregating generation. Multivariate analysis is a useful tool in quantifying the degree of divergence between biological population at genotypic level and to assess relative contribution of different components to the total divergence both at intra- and inter-cluster levels (Zahan *et al.,* 2008). Therefore, in the present study, the genetic divergence among *B. juncea* germplasm collections available at Punjab Agricultural University, Ludhiana was quantified by multivariate (D^2 analysis) with the objectives: to estimate the genetic variation among the genotypes and identify promising genotypes with respect to different nitrogen doses.

MATERIAL AND METHODS

A germplasm set comprising 34 genotypes of *Brassica juncea* were evaluated in the fields at Punjab Agricultural University, Ludhiana. Three treatments of nitrogen *viz;* 0 (N_0), 50 (N_{50}) and 100 (N_{100}) kg N ha^{-1} were applied. Experiment was conducted on loamy sandy soil having low organic carbon content (0.24%). Treatments were sown in split plot design, replicated twice with doses of N (N_0, N_{50} and N_{100}) in the main plots and genotypes in the sub plots. Each plot accommodated 5 rows each of 5 meter length with row spacing of 30 cm and plant to plant spacing of 10-12 cm. Nitrogen was applied in the form of urea in two equal splits at

sowing (basal dose) and after first irrigation (4 weeks after sowing). Standard agronomic package and practices were followed to raise a healthy crop (Bajwa, 2011).

Biochemical analysis: Plant tissues such as young leaves and seeds were collected and half sample of each tissue was used immediately for analysis of enzyme activity and remaining part of the samples was stored for estimation of total nitrogen, sugars, proteins and chlorophyll. For preparing enzyme extract for ammonium assimilation, leaves weighing 1g were macerated in 10ml of 0.1M phosphate buffer (pH 7.5) containing 5mM cysteine and 300mg polyvinyl pyrollidone. After centrifugation at 10,000 X g for 10 minutes, the proteins in the supernatant were precipitated using 70% ammonium sulphate concentration and aged overnight. Thereafter, centrifugation was done at 15,000 X g for 20 minutes. The pellet so obtained was dissolved in 0.1M phosphate buffer (pH 7.5) and dialysed for 36 h. This extract was then used for enzyme assays. Standard protocols were followed in the estimation of nitrate reductase activity (NR), nitrite reductase activity (NIR), glutamine synthetase activity (GS), glutamate dehydrogenase activity (GDH), glutamate synthase activity (GOGAT) (Daubresse *et al.,* 2010), nitrogen (McKenzie and Wallace, 1954), protein and sugar (Prakasha and Murthy 2012) and chlorophyll content (Johnston *et al.,* 1984) at pre-anthesis (green bud stage; the development stage code 3.3, flower buds present but enclosed by leaves) and post-anthesis (development stage code 5.9; all potential pods on raceme more than 2 cm long) (Sylvester-Bradley and Makepeace, 1984). Oil content in intact seeds was estimated by Nuclear Magnetic Resonance (NMR) spectrometer on dry weight basis (Alexander *et al*.. 1967).

Agronomic traits: Nitrogen use efficiency (NUE) was computed as the grain yield per unit of available/applied N (soil + fertilizer N or fertilizer N) (Novoa and Loomis, 1981). The apparent NUE was worked out as suggested by Chamorro *et al.* (2002). The apparent NUE indicates the increase in seed yield per kg of applied N.

Apparent NUE =

$$\frac{\text{N uptake at a given dose of N} - \text{N uptake under control}}{\text{N uptake under control}}$$

Nitrogen harvest index (NHI) is the N taken up by seed relative to total N taken up by the plant at harvest expressed in percentage.

$$\text{Nitrogen Harvest Index (NHI)} = \frac{\text{Seed nitrogen}}{\text{Total nitrogen}} \times 100$$

Genetic divergence studies: Genetic divergence among the germplasm collection was studied using the Mahalanobis generalized distance (D^2) statistics (1936). D^2 values were clustered using Tocher's method as detailed by Rao (1952). The intra and inter-cluster distances were calculated by the formula described by Singh and Chaudhary (1977).

RESULTS AND DISCUSSION

At all level of nitrogen application, D^2 analysis assigned 34 test genotypes into six major clusters having 1 to 10 genotypes per cluster in preanthesis and 1 to 14 genotypes in postanthesis, indicating the presence of enough genetic diversity in the material (Table 1).

In preanthesis, majority of the genotypes were grouped into cluster II, V and I at control nitrogen application, at $N_{50,}$ genotypes assembled in cluster II, V and VI; while at N_{100} level, cluster no. I and II consisted majority of genotypes (Table 1).

In postanthesis, majority of the genotypes were falling into cluster III followed by clusters V and I at control nitrogen application, at N_{50} genotypes groped in cluster VI, V and IV; while at N_{100} level, cluster IV, III and V comprises majority of genotypes; which itself indicates sufficient intra-species variability for biochemical and agronomic traits in *B. juncea* (Table 1). The constitution of genotypes in different clusters was not same in different nitrogen doses, which confirms that the grouping of genotypes is forced by nitrogen application.

Cluster distances: Euclidian cluster analysis was also used to identify diverse and desirable genotypes in terms of inter-cluster distance and mean performance of characters in each cluster, respectively. Analysis of genetic divergence has been used to select genotypes, (a) the genetic distance between the genotypes; choices of the clusters which are separated by maximum intercluster distance (b) identify promising types to utilize them in crossing programme: For this purpose intra and inter-cluster distances (Fig. 1-6) and character wise cluster means (Table 2 and 3) were considered at pre and post-anthesis, respectively.

In pre and postanthesis, and at all the three N doses, a wide range of intra-cluster distances indicated that genotypes in one cluster were more diverse in morphological features and performance than genotypes of other clusters. Hence, there is a lot of scope for exchange of genes among genotype within these clusters.

The inter-cluster distances were larger than the intra-cluster distances indicating wider genetic diversity between genotypes of the clusters with respect to the trait. Therefore, combinations with high heterotic response and superior recombinants may be obtained through hybridizations between genotypes across the clusters. It could be concluded that the genotypes present in combination of these clusters could be utilized for successful

Table 1. Grouping of germplasm collection based on different clusters of 34 *Brassica juncea* genotypes at pre-anthesis and post-anthesis

N-level	Cluster Number	Pre-anthesis		Post-anthesis	
		Number of genotypes in cluster	Genotypes	Number of genotypes in cluster	Genotypes
N_0	I	7	QLM-1,PLM-1, ISB-89, NLM-2, PLM-3, M,LM-40,ELM-0-79	7	MLM40, MLM45, MLM47, PLM3, PBR91, MLM19, NPJ89
	II	9	MLM-43,NPJ-79,NLM-20,MSC-5,RLM-619,PBR-210,MLM-38,NLM-8,NLM-38	1	NPJ79
	III	1	MLM48	14	MLM32, NLM32, MLM44, NLM20, PBR210, RLM619, MLM38, QLM1, MLM41, ELM079, NLM13, MLM46, MLM48, NLM38
	IV	5	MLM-39,MLM-32,NPJ-89,NLM-48,MLM-19	1	MLM39
	V	8	MLM-45,PBR-91,MLM-42,MLM-47,PBR-97,PLM-3,NLM-13,MLM-46	9	MLM42, PBR97, MLM43, MSC5, NLM2, ISB89, PLM3, NLM48, PLM1
	VI	4	MLM-44,NLM-32,PLM-4,MLM-41	2	PLM4, NLM8
N_{50}	I	6	MLM-38,MSC-5,NPJ-89,MLM-39,NLM-48,NLM-20	3	MLM38, NPJ79, MLM47
	II	10	MLM-42,NLM-38,MLM-40,MLM-43,RLM-619,ELM-0-79,PBR-210,NPJ-79,NLM-2,NLM-8	5	NLM38, PLM2, PLM1, PLM3, MLM39
	III	1	MLM-19	5	MLM40, MLM43, MLM42, MLM45, MSC5
	IV	5	ISB-89,PLM-3,QLM-1,PLM-1,MLM-48	6	PLM4, PLM1, MLM41, PBR210, NLM32, MLM32
	V	7	MLM-45,PBR-91,MLM-46,NLM-13,MLM-47,PLM-2,PBR-97	7	ISB89, MLM46, PBR91, PBR97, MLM19, NPJ89, QLM1
	VI	5	MLM-41,NLM-32,MLM-32,MLM-44,PLM-4	8	MLM44, NLM48, NLM2, NLM8, ELM079, NLM13, MLM48, NLM20
N_{100}	I	10	QLM1, NPJ-89, PBR-210, PLM-3, MLM-19, MSC-5, MLM-38, NLM-48, ELM-0-79, ISB-89	5	QLM1, MLM19, NLM20, NLM32, PBR91
	II	8	MLM-40,NLM-38,MLM-43,RLM-619,PBR-97,PLM-1,MLM-47,MLM-48	2	MLM43, NPJ89
	III	2	MLM-39,NLM-20	7	MLM38, MLM44, MLM39, MLM41, MLM42, RLM619, PLM3
	IV	5	MLM-44,NLM-32,MLM-41,PLM-4,MLM-32	14	MLM45, PLM2, ISB89, MLM46, PLM4, NPJ79, PBR210, NLM8, MLM48, PLM1, PBR97, NLM2, NLM38, NLM48
	V	5	MLM-42,PBR-91,NLM-2,NLM-8,NPJ-79	2	MLM40, MSC5
	VI	4	MLM-45,PLM-2,MLM-46,NLM-13	4	MLM32, ELM079, MLM47, NLM13

Table 2. Mean performances of different clusters for 9 evaluated traits of 34 *Brassica juncea* genotypes at pre-anthesis at N_0, N_{50} and N_{100} level

N-level	Cluster No.	NR	NIR	GS	GOGAT	GDH	CHL	N LEAF	SUG	PRO
N_0	ClusterI	0.121	0.138	14.545	0.529	0.509	2.090	2.689	36.564	16.804
	ClusterII	0.211	0.180	18.906	0.735	0.813	2.286	3.509	46.283	21.939
	Cluster III	0.114	0.115	12.505	0.617	0.371	2.021	0.563	45.500	3.500
	ClusterIV	0.251	0.203	26.755	0.806	1.063	2.564	3.860	56.140	24.128
	ClusterV	0.089	0.114	9.773	0.280	0.216	1.609	1.776	23.400	11.105
	ClusterVI	0.330	0.292	36.441	0.960	1.471	2.865	4.646	76.125	29.048
N_{50}	Cluster I	0.259	0.247	28.737	0.797	1.237	2.952	4.658	66.050	29.125
	Cluster II	0.257	0.227	24.189	0.669	0.810	2.659	3.672	49.950	22.959
	Cluster III	0.345	0.238	38.500	0.787	1.350	3.861	3.966	45.050	24.810
	Cluster IV	0.161	0.191	16.900	0.704	0.822	2.704	2.774	61.930	17.340
	Cluster V	0.171	0.160	13.295	0.426	0.402	2.425	2.579	36.586	16.117
	Cluster VI	0.366	0.352	39.405	1.044	1.855	3.405	4.955	85.220	30.964
N_{100}	Cluster I	0.285	0.309	27.073	0.774	1.398	3.163	4.788	77.520	29.927
	Cluster II	0.298	0.266	31.310	0.773	0.950	3.220	3.383	63.550	21.141
	Cluster III	0.385	0.251	31.310	0.882	1.602	2.931	7.573	64.750	47.315
	Cluster IV	0.434	0.419	44.671	1.211	2.087	3.889	4.950	89.190	30.940
	Cluster V	0.268	0.244	28.966	0.772	0.783	2.969	4.178	47.590	26.126
	Cluster VI	0.245	0.268	13.875	0.582	0.529	3.209	3.795	42.188	23.702

NR - Nitrate Reductase, NIR – Nitrite Reductase, GS – Glutamine Synthetase; GOGAT – Clutamate Synthase, GDH – Glutamate Dehydrogenase, CHL – Chlorophyll, NLEAF – Nitrogen content of leat, SUG – Sugar, PRO - Protein

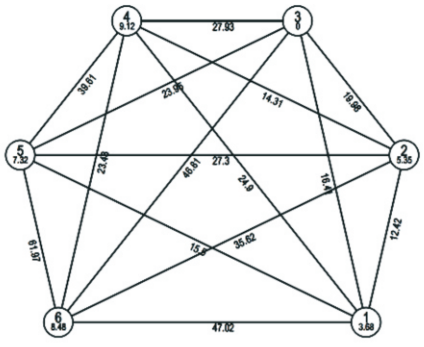

Fig. 1. Intercluster distances of *B. juncea* at pre-anthesis at N_0 Level.

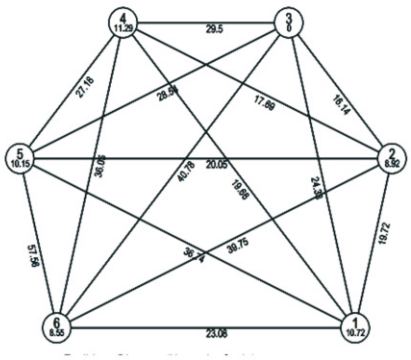

Fig. 2. Intercluster distances of *B. juncea* at pre-anthesis N_{50} Level.

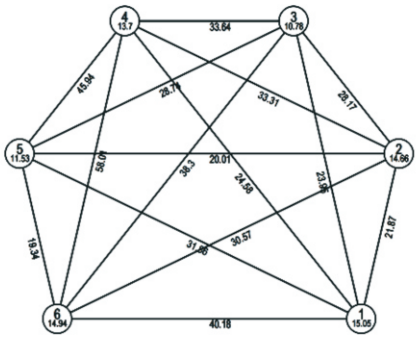

Fig. 3. Intercluster distances of *B. juncea* at pre-anthesis N_{100} Level.

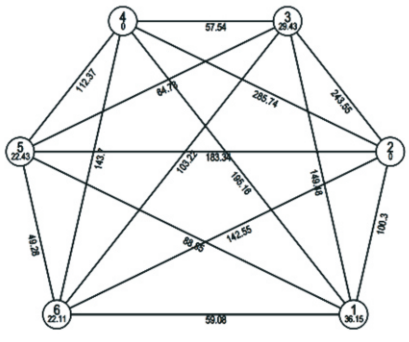

Fig. 4. Intercluster distances of *B. juncea* at post-anthesis at N_0 Level.

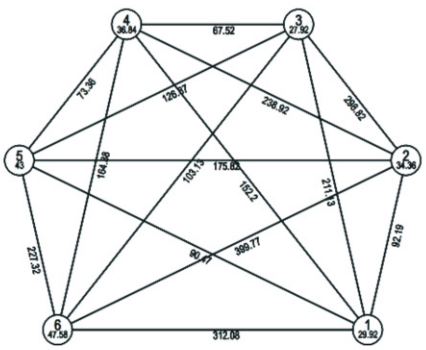

Fig. 5. Intercluster distances of *B. juncea* at post-anthesis N_{50} Level.

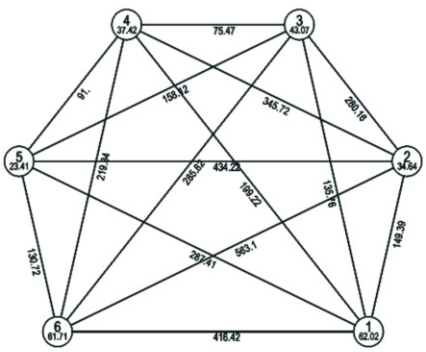

Fig. 6. Intercluster distances of *B. juncea* at post-anthesis N_{100} Level.

Table 3. Mean performances of different clusters for 19 evaluated traits of 34 *Brassica* juncea genotypes at post-anthesis at N_0, N_{50} and N_{100} level

N-level	Cluster No.	NR	NIR	GS	GOGAT	GDH	CHL	N LEAF	SUG	PRO	N CHAFF	N STEM	N SEED	TNU	NHI	SEED NUE	OIL	SEED YIELD	NUE	AppNUE
N_0	Cluster I	0.095	0.115	13.806	0.473	0.474	1.530	2.233	33.136	13.789	0.755	0.202	3.507	18.194	0.545	28.924	34.186	356.071	6.005	1.157
	Cluster II	0.203	0.184	21.325	0.79	0.928	2.125	3.912	50.700	24.440	0.906	0.267	4.143	27.260	0.449	24.150	36.200	451.500	7.555	1.725
	Cluster III	0.125	0.14	15.455	0.634	0.693	1.894	2.834	41.893	17.024	0.874	0.308	3.993	13.073	0.512	25.604	32.193	209.286	5.664	2.818
	Cluster IV	0.215	0.215	31.455	1.025	1.164	2.328	4.202	70.100	26.250	1.018	0.378	4.743	13.770	0.458	21.100	30.400	167.000	4.005	1.010
	Cluster V	0.099	0.118	11.767	0.527	0.493	1.702	2.401	34.211	15.008	0.843	0.212	3.645	15.129	0.518	27.814	34.239	270.111	4.752	1.512
	Cluster VI	0.207	0.202	26.033	0.814	0.957	2.125	4.105	53.200	25.660	0.973	0.441	4.590	21.850	0.454	21.980	34.400	309.250	4.105	2.652
N_{50}	Cluster I	0.153	0.191	17.657	0.585	0.628	2.219	3.318	40.367	20.730	0.921	0.314	4.016	42.770	0.47	25.490	35.383	708.333	7.547	1.707
	Cluster II	0.155	0.159	17.666	0.647	0.630	2.154	3.142	42.730	19.652	1.057	0.31	4.178	48.768	0.487	24.506	34.660	795.800	11.084	2.524
	Cluster III	0.128	0.162	16.441	0.603	0.534	2.116	2.781	39.550	17.514	0.941	0.283	4.021	31.210	0.505	24.926	34.100	498.600	3.556	0.83
	Cluster IV	0.225	0.235	25.907	0.871	1.144	2.429	3.898	55.333	24.667	1.225	0.494	4.894	43.125	0.462	20.858	36.142	559.000	6.575	1.762
	Cluster V	0.154	0.154	18.638	0.672	0.620	1.985	3.099	44.264	19.367	0.872	0.277	4.221	37.830	0.502	24.436	35.986	623.143	6.687	1.640
	Cluster VI	0.138	0.164	16.027	0.587	0.601	2.117	3.227	43.656	20.172	1.071	0.404	4.355	26.690	0.484	23.456	33.656	397.563	3.246	0.886
N_{100}	Cluster I	0.213	0.219	23.010	0.737	0.864	2.319	4.497	53.170	28.114	1.230	0.456	4.909	69.210	0.444	20.798	33.790	886.200	6.096	3.180
	Cluster II	0.244	0.252	28.202	0.889	0.933	2.698	3.746	59.600	24.345	1.490	0.568	5.441	91.470	0.478	18.545	34.025	1031.500	7.085	3.400
	Cluster III	0.202	0.227	28.566	0.877	1.113	2.791	3.971	52.929	25.884	1.327	0.585	5.520	68.250	0.477	18.830	33.971	753.929	5.337	3.946
	Cluster IV	0.192	0.216	22.287	0.730	0.676	2.394	4.048	45.814	25.792	1.171	0.411	4.548	49.243	0.448	22.374	33.821	689.536	4.102	2.464
	Cluster V	0.203	0.213	18.685	0.719	0.644	2.431	3.306	48.325	21.905	0.974	0.353	4.181	40.370	0.464	23.930	35.700	601.000	2.705	1.155
	Cluster VI	0.13	0.162	14.491	0.508	0.361	2.289	3.315	38.625	20.737	1.168	0.494	4.754	37.140	0.484	22.380	33.425	472.125	2.345	1.858

NR - Nitrate Reductase, NIR – Nitrite Reductase, GS – Glutamine Synthetase; GOGAT – Clutamate Synthase, GDH – Glutamate Dehydrogenase, CHL – Chlorophyll, NLEAF – Nitrogen content of leat, SUG – Sugar, PRO - Protein

breeding programme. Such information may be helpful to identify genetically diverse genotypes within species with contrasting traits, to develop mapping populations for genomic studies that involve wild *Brassica juncea.*

Mean performances of morpho-physiological traits in different clusters: The further choice of the genotypes could be made considering the mean performance of the genotypes in respect to various characters. For all nitrogen doses, the cluster means in respect to all nineteen characters (Tables 2 and 3) indicated considerable differences between clusters.

At preanthesis, at N_0, the genotypes of cluster VI exhibited the highest trait mean value for almost all the traits. Cluster II at N_{50} and cluster IV at N_{100}, whereas, cluster V had lowest trait mean values at N_0 and N_{50} and cluster VI had at N_{100} (Table 2). At postanthesis, cluster IV exhibited the highest trait mean value at both N_0 and N_{50}, whereas, it was cluster II at N_{100} (Table 3).

In the present study, the genotypes which were better or at least comparable in performance to the best check were deemed desirable. Some of the identified genotypes *viz;*MLM-44, MLM-32, MLM-41 and PLM-4 are desirable in evaluated traits at preanthesis at all N level, however MLM39 is desirable at N_0 and N_{50} level at post-anthesis stage (Table 4). The genotypes included in the same cluster are considered similar in respect to the aggregate effect of the characters examined; the hybridization between them is not expected to provide good scope for obtaining useful segregants.

Table 4. Identified promising genotypes for various evaluated traits

Stage	N-dose	Cluster no.	Promising genotypes
Pre-anthesis	N_0	VI	MLM-44,NLM-32,PLM-4,MLM-41
	N_{50}	VI	MLM-41,MLM-32,MLM-32,MLM-44,PLM-4
	N_{100}	IV	MLM-44,NLM-32,MLM-41,PLM-4,MLM-32
Post-anthesis	N_0	IV	MLM39
	N_{50}	II	NLM38, PLM2, PLM1, PLM3, MLM39
	N_{100}	II	MLM43, NPJ89

From the present study it is concluded that the grouping pattern of different *B. juncea* genotypes is affected by the doses of nitrogen application. Some nitrogen efficient genotypes have been identified at three applied levels of nitrogen. These genotypes might be useful for transferring this trait to existing cultivar or upcoming variety or can be used in various hybridization programmes.

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Combining Ability Studies in Bitter Gourd [*Momordica charantia* L.] in Relation to Line × Tester Crossing System

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Abstract: Combining ability studies in bitter gourd through line × tester analysis in which 19 lines (as females), three testers (as male) and 57 crosses were studied in randomized block design with two replications. Significant differences were observed among the genotypes indicating the existence of diversity for all traits. Non additive gene action was predominant for sex ratio, number of fruits per vine, number of branches, vine length, ascorbic acid, days to first harvest and average fruit weight. For fruit yield per plot and fruit length both additive and non-additive components of genetic variance are important, for fruit yield per vine additive gene action was predominant. The lines BGA-15, BGA-10, BGA-18 and BGA-6 were identified as the good general combiners for total fruit yield per vine and yield components. The cross BGA-15× PV was identified as the good specific combiner for total yield per vine and yield per plot.

Key Words: Additive/Non-additive component, Bitter gourd, GCA, SCA

Among widely cultivated cucurbits, bitter gourd (*Momordica charantia L.*) is one of most important vegetable crop extensively grow throughout the country for its nutritive value and medicinal properties. It is rich source of calcium, phosphorus, iron protein, vitamin A and vitamin C. It's juice consumption is also very useful for diabetic patient due to its potent oxygen free radicals scavenging activity of the fruit juice (Sreejayan and Rao, 1991). The bitter principle in bitter gourd is cucurbitacin (tetracycline triterpenes), a bitter glucoside which prevents the spoilage of cooked vegetables and keeps fit for consumption even two to three days. The exploitation of hybrid vigour in bitter gourd will provide quantum jump in boosting the yield and for development of promising varieties. Identification of genetically superior diverse parent is prerequisite for exploitation of hybrid vigour. Combining ability of the inbreed line is the ultimate factor determining usefulness of the lines for hybrids and synthetics. The present investigation was therefore, undertaken in a group of twenty two genetically diverse lines of bitter gourd to obtain information regarding the estimates of general and specific combining ability.

MATERIALS AND METHODS

An experiment was conducted during summer and *kharif*, 2011 at Vegetable Science Department, K. R. C. College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot on 22 parents *viz*., BGA-1, BGA-2, BGA-3, BGA-4, BGA-5, BGA-6, BGA-7, BGA-8, BGA-9, BGA-10, BGA-11, BGA-12, BGA-13, BGA-14, BGA-15, BGA-16, BGA-17, BGA-18 and BGA-19 as female parents and three testers viz., Arka Harit (AH), Pusa Vishesh (PV) and Coimbatore Long (COGL) as male parents. The experiment consists of twenty two parents and fifty seven hybrids and evaluated in randomized block design with two replications. A spacing of 1.2 m × 0.9 m was followed and other cultural practices were followed as per the package of practices of UAS, Dharwad. Observations on five randomly selected plants were recorded for various growth, earliness, yield and quality parameters. The combining ability analysis for different traits was carried out.

RESULT AND DISCUSSION

The analysis of variance (Table 1) for genotypes showed significant differences for all the characters. It indicates the existences of sufficient diversity in the material tested. The estimates of mean sum of squares due to lines showed significant differences for days to first harvest, average fruit weight and ascorbic acid, whereas, mean sum of squares of testers showed significant difference for fruit length and fruit yield per vine. Variance due to line × tester was significant for all the characters studied except days to first harvest and fruit length. This indicates enormous amount of variability present among the genotypes. The present results showed consistency in general combining ability (GCA) effects for female parents (lines) to most of the characters (Table 2), which indicated good general combining ability for most of the characters. Among 19 female lines BGA-15 (0.96), BGA-9 (0.48) and BGA-6 (0.45) showed significant positive GCA effects for vine length at 90 days after sowing. For number of branches, three lines

Table 1. Analysis of variance for combining ability for different characters of bitter gourd

Character	Crosses	Lines	Testers	Line × tester	Error
Degrees of freedom	56	18	2	36	78
Growth Parameters					
Vine length at 90 days afetr sowing (m)	1.00**	1.48*	0.92NS	0.76*	0.24
Number of branches per vine 90 days after sowing	17.97*	21.45NS	20.94NS	16.07*	6.46
Earliness Parameters					
Days to first harvest	50.85*	89.99**	13.89NS	33.33NS	22.69
Yield parameters					
Sex ratio	7.82*	25.27NS	6.19NS	14.74*	8.82
Fruit length (cm)	5.11*	5.30NS	27.94**	3.76NS	3.87
Average fruit weight (g)	538.74*	916.85**	705.02NS	340.45*	78.08
Number of fruits per vine	36.03*	53.87NS	8.09NS	28.66*	16.85
Fruit yield per vine (kg)	0.0624**	0.08NS	0.40**	0.050**	0.048
Fruit yield per plot (kg)	4.05*	6.80NS	5.92NS	2.56*	2.22
Quality parameters					
Ascorbic acid (mg)	318.91**	606.89**	229.60NS	179.88**	4.24

*and** indicate significance of values at p=0.05,p=0.01, respectively , NS= Non s

showed significant positive GCA effects. The highest and significantly positive GCA effects was observed in the line BGA-9 (3.55) followed by BGA-15 (3.02). In respect to earliness days to first harvesting, the significantly negative GCA effects was exhibited by the line BGA-3 and BGA-14 (-4.07). With respect to yield and quality related parameters for sex ratio, seven lines showed significantly negative GCA effect. Highest negative GCA effects was exhibited by the line BGA-4 (-3.79), which was followed by BGA-13 (-2.77). Five lines exhibited significant and positive GCA effects for fruit length and the highest and significantly positive GCA effects was exhibited by the line BGA-15 (1.57), which was followed by BGA-8 (1.56). For average fruit weight, four lines exhibited significant positive GCA effects and maximum was observed in the line BGA-8 (21.40) followed by BGA-15 (19.43). In respect to number of fruits per vine, four line exhibited significantly positive GCA effects. The highest and significantly positive GCA effects was exhibited by the line BGA-10 (5.35) followed by BGA-3 (3.84) as good combiners. On other hand for fruit yield per vine, five lines showed positive and significant GCA effects. The highest was observed in the line BGA-15 (0.25) followed by BGA-10 (0.21), BGA-18 (0.13) and BGA-6 (0.12). For fruit yield per plot, two lines showed positive and significant GCA effects, the highest and significant positive GCA being exhibited by the line BGA-15 (2.38) followed by BGA-18 (1.60). Eleven lines showed significantly positive GCA effects in ascorbic acid, highest being observed in the line BGA-12 (12.62) followed by BGA-8 (10.95). Sundharaiya and Venkateran (2007), Sundaram (2008) and Thangamani *et al.* (2011) also reported high GCA effects for yield and its related attributes. Thus, the parent showing good general combining ability could be used in identifying superior new heterotic combinations involving diallel crosses.

Out of three males (testers), the tester COGL was best general combiner (0.16, 0.75, and 2.00) showed significant GCA effects in positive direction for vine length, fruit length and ascorbic acid. For average fruit weight, PV (4.41) exhibited significantly positive GCA effects. So these parents can be used in breeding of these characters.

For specific combining ability effects, Table 3 indicated that out of 57 cross combinations, five crosses for vine length , three cross for number of branches, one cross for day to first harvesting, eleven crosses for sex ratio, four cross for fruit length, five for average fruit weight, four crosses for number of fruits per branches, one cross for fruit yield per vine and fruit yield per plot and 19 crosses for ascorbic acid showed significant and desirable SCA effects.

In the identification of good specific combiner for various traits, the cross BGA-16 X COGL and BGA-2 X PV (0.83) exhibited maximum and significant SCA effects for vine length and the cross BGA-18 × AH (4.67), BGA-16 × COGL (4.11) followed by BGA-2 × PV exhibited maximum and significant SCA effects for number of branches per vine at 90 DAS. The cross BGA-9 × AH exhibited maximum and significant SCA effects (-7.76) in desirable direction for number of days to first harvest. The highest and significantly negative SCA effects was exhibited by the cross BGA-16 × COGL (-4.61) followed by BGA-7 × PV for sex ratio. The cross BGA-19 × COGL (2.89) and BGA-12 × PV (2.67) exhibited maximum and significant SCA effects for fruit length. The highest positive SCA effects was exhibited by

Table 2. General combining ability effects for growth, earliness, yield and quality in bitter gourd

Parents	Vine length	Days to first harvesting	Sex ratio	Fruit length	Average fruit weight	Number of fruits per vine	Fruit yield/vine	Fruit yield/plot	Ascorbic acid
Lines									
BGA-1	0.36**	1.99	0.53	1.16**	5.8	-6.76**	-0.16**	-0.39	-9.60**
BGA-2	-0.25**	3.66	5.24**	-0.29	-3.26	3.01*	0.01	-1.07	10.40**
BGA-3	-0.26**	-4.07*	1.1	-0.81**	-12.05**	3.84**	0.08*	0.84	-15.16**
BGA-4	0.30**	-1.27	-3.79**	-0.59*	3.23	-1.97	-0.03	0.84	2.06*
BGA-5	-1.01**	-0.81	1.56**	0.28	-11.91**	-2.02	-0.21**	-1.06	8.17**
BGA-6	0.45**	-2.21	-1.15*	-0.22	16.44**	-2.12	0.12**	1.21	-6.66**
BGA-7	-0.48**	1.59	0.09	-0.27	0.22	0.69	-0.03	0.1	2.62**
BGA-8	0.30**	-0.34	0.61	1.56**	21.40**	-0.6	-0.04	0.18	10.95**
BGA-9	0.48**	3.93*	0.05	-1.51**	-12.83**	1.2	-0.01	0.11	-10.16**
BGA-10	-0.12**	12.09*	0.89	-0.03	-0.4	5.35**	0.21**	-0.62	-4.60**
BGA-11	0.33**	2.53	2.26**	0.19	-10.83**	-0.03	-0.01	-1.64**	-24.05**
BGA-12	0.28**	-2.67	-2.25**	1.43**	3.38	-0.08	0	0.49	12.62**
BGA-13	-0.66**	-2.21	-2.77**	-1.44**	-20.75**	-0.24	-0.10**	-1.18	-2.38*
BGA-14	-0.36**	-4.07*	-1.83**	0.16	0.22	-0.98	-0.15**	-1.01	6.45**
BGA-15	0.96**	-3.14	-1.18*	1.57**	19.43**	2.59*	0.25**	2.38**	7.62**
BGA-16	0.39**	-2.67	0.64	-0.48*	6.5	3.11*	0.04	-0.51	-6.82**
BGA-17	-0.48**	0.96	1.08	-0.99**	-9.28*	-3.92**	-0.12**	-0.77	8.73**
BGA-18	-0.44**	0.13	-1.73**	-0.42	17.16**	-1.92	0.13**	1.60*	2.62**
BGA-19	0.21**	-3.41	0.63	0.73**	-12.47**	0.85	0.02	0.52	7.17**
C.D. at 5%	0.08	3.87	1.11	0.46	7.18	2.48	0.07	1.21	1.67
C.D. at 1%	0.1	5.13	1.48	0.61	9.52	3.29	0.09	1.61	2.22
Testers									
AH	-0.01	0.7	0.46*	-0.93**	-4.20**	0.03	-0.04	-0.36	-2.75**
PV	-0.15	-0.31	-0.18	0.18	4.41**	-0.36	0.01	-0.06	0.75*
COGL	0.16*	-0.39	-0.28	0.75**	-0.21	0.33	0.02	0.42	2.00**
C.D at 5%	0.15	NS	0.36	0.38	2.85	NS	NS	NS	0.66
C.D at 1%	0.2	NS	0.48	0.5	3.78	NS	NS	NS	0.88

*and** indicate significance of values at p = 0.05 and p = 0.01, respectively. DAS = Days after sowing NS= non significant

the cross BGA-10 × COGL (29.81) followed by BGA-12 × PV for average fruit weight. The highest and significantly positive SCA effects was observed in the cross BGA-9 × PV (7.98) followed by BGA-18 × COGL for number of fruits per vine. The BGA-15 × PV (0.32) cross only exhibited significant positive SCA effects for fruit yield per vine and fruit yield per plot. The highest and significant positive SCA effects was observed in the cross BGA-9 × PV (24.26) followed by BGA-6 × AH for ascorbic acid. It is evident that SCA effects of certain crosses were related with GCA of their parent as the best cross combination for most of the characters involved at least one parent with high or average GCA effects for particular traits. Similar results have been reported by Mishra *et al.* (1994). The parents, BGA-15, BGA-10, BGA-18 and BGA-6 are the good general combiners for total yield per vine and can be used in identifying superior new heterotic combinations involving diallel crosses. The cross BGA-15 × PV (0.32) was identified as good specific combiner for fruit yield per vine, possessing significantly high SCA effects and also exhibited significant SCA effects in desirable direction for various characters. This cross can be further assessed for their yield stability to confirm their potentiality and also their adaptability to different agro-climatic conditions before exploiting them on commercial Scale.

GCA to SCA ratio (Table 4) was very low for sex ratio indicating preponderance of non-additive gene action and hence these traits can be improved through recurrent selection through specific combining ability or heterosis breeding. GCA to SCA ratio is near the unity for fruit yield per plot, fruit length indicating importance of both additive and

Table 3. Ten Specific combining ability effects for growth, earliness, yield and quality in bitter gourd

Characters	I	II	II	IV	V	VI	VII	VIII	IX	X	C.D at 5%	C.D at 1%
Vine length 90 DAS	BGA-4 × COGL (1.04**)	BGA-2 × PV(0.83*)	BGA-16 × COGL(0.83*)	BGA-14 × AH(0.72*)	BGA-9 × PV(0.71*)	BGA-10 × PV(0.69*)	BGA-17 × COGL(0.67)	BGA-12 × PV(0.55)	BGA-3 × AH(0.49)	BGA-11 × PV(0.42)	0.68	0.91
No. of branches per vine 90 DAS	BGA-18 × AH(4.67*)	BGA-16 × COGL(4.11*)	BGA-2 × PV(4.02*)	BGA-9 × PV(3.19)	BGA-17 × COGL(3.15)	BGA-1 × AH(3.1)	BGA-15 × AH(3.04)	BGA-12 × PV(3.02)	BGA-10 × PV(2.95)	BGA-4 × COGL(2.88)	3.58	4.74
Days to first harvesting	BGA-9 × AH(-7.76)	BGA-11 × PV(-5.36)	BGA-1 × COGL(-5.25)	BGA-2 × AH(-4.7)	BGA-7 × AH(-4.03)	BGA-4 × AH(-3.96)	BGA-11 × COGL(-3.88)	BGA-17 × COGL(-3.71)	BGA-5 × PV(-3.42)	BGA-13 × AH (-3.03)	6.7	8.89
Sex ratio	BGA-16 × COGL(-4.61**)	BGA-7 × PV(-4.14**)	BGA-9 × COGL(-3.38**)	BGA-13 × AH(-3.38)	BGA-12 × AH(-3.12**)	BGA-17 × PV(-2.97**)	BGA-2 × AH(-2.46*)	BGA-12 × PV(-2.40*)	BGA-18 × AH(-2.34*)	BGA-19 × COGL(-2.32*)	1.93	2.56
Fruit length	BGA-19 × COGL(2.89**)	BGA-12 × PV(2.67**)	BGA-8 × AH(1.85*)	BGA-1 × COGL(1.71*)	BGA-17 × PV(1.59)	BGA-4 × COGL(1.41)	BGA-6 × PV(1.17)	BGA-3 × AH(1.17)	BGA-15 × PV(1.08)	BGA-17 × AH(0.9)	1.66	2.2
Average fruit weight	BGA-10 × COGL(29.81**)	BGA-12 × PV(22.61**)	BGA-17 × PV(14.57*)	BGA-18 × AH(14.03*)	BGA-15 × PV(12.77*)	BGA-1 × COGL(12.21)	BGA-3 × AH(10.16)	BGA-4 × COGL(9.97)	BGA-6 × AH(9.96)	BGA-9 × PV(9.9)	12.43	16.5
Number of fruits per vine	BGA-9 × PV(7.98**)	BGA-18 × COGL(6.70**)	BGA-11 × COGL(4.58*)	BGA-14 × AH(4.33*)	BGA-16 × AH(4.08)	BGA-5 × PV(3.91)	BGA-17 × AH(3.42)	BGA-7 × AH(3.24)	BGA-8 × COGL(2.77)	BGA-3 × AH(2.71)	4.28	5.67
Fruit yield/vine	BGA-15 × PV(0.32*)	BGA-6 × PV(0.27)	BGA-9 × PV(0.26)	BGA-19 × COGL(0.21)	BGA-11 × AH(0.2)	BGA-3 × COGL(0.18)	BGA-18 × COGL(0.15)	BGA-12 × PV(0.13)	BGA-16 × AH(0.13)	BGA-14 × AH(0.11)	0.31	0.41
Fruit yield/plot	BGA-15 × PV(2.37*)	BGA-9 × PV(1.98)	BGA-6 × PV(1.72)	BGA-19 × COGL(1.69)	BGA-12 × PV(1.18)	BGA-1 × COGL(1.1)	BGA-11 × AH(1.08)	BGA-16 × COGL(0.95)	BGA-3 × AH(0.94)	BGA-3 × COGL(0.83)	2.1	2.78
Ascorbic acid	BGA-9 × PV(24.26**)	BGA-6 × AH(17.58**)	BGA-1 × COGL(10.78**)	BGA-2 × AH(10.53**)	BGA-13 × COGL(10.22**)	BGA-16 × COGL(9.66**)	BGA-4 × PV(8.70**)	BGA-19 × AH(7.08**)	BGA-15 × AH(6.63**)	BGA-16 × PV(5.92**)	2.9	3.84

Table 4. Variance due to general combining ability and specific combining ability for different characters in bitter gourd

Character	GCA	SCA	GCA:SCA
Vine length at 90 DAS	0.02	0.26	0.07
Number of branches per vine 90 DAS	0.23	5.04	0.05
Days to first harvest	0.85	6	0.14
Sex ratio	0.04	4.07	0.01
Fruit length	0.58	0.61	0.96
Average fruit weight	21.39	127.31	0.17
Number of fruits per vine	0.11	5.8	0.02
Fruit yield per vine	0.007	0.001	8.82
Fruit yield per plot	0.17	0.19	0.91
Ascorbic acid	10.83	87.78	0.12

GCA- Variance due to General combining ability
SCA- Variance due to Specific combining ability
DAS- Days after sowing

non-additive component of genetic variance. These traits can be improved through direct selection or by recurrent selection schemes. High GCA to SCA ratio is observed for fruit yield per vine indicating preponderance of additive gene action and hence these traits can be improved through direct selection.

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Combining ability studies in ridge gourd [*Luffa acutangula* (L.) Roxb.]

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Abstract: Fifty-one cross combinations were evaluated for 16 traits. The variance due to specific combining ability (SCA) was higher than the general combining ability (GCA) for all the characters, indicating the importance of non-additive gene action. Comprehensive assessment of parents by considering *gca* effects of 16 characters resulted into identification of lines, *viz.,* KRG-2, KRG-3, KRG-4, KRG-11, KRG-16 and tester ASM as good combiners and PN as average combiners over all characters. Maximum and positively significant *sca* effects was observed in the cross KRG-9 x ASJ followed by KRG-10 x PN, KRG-6 x ASM, KRG-5 x ASM and KRG-3 x ASJ for fruit yield per vine. KRG-9 × ASJ showed significant *sca* effects for earliness characters like days to first male and female flower appearance, node to first male and female flower appearance and days to first harvest.

Key Words: Combining ability, Earliness, *gca* effects, *Luffa acutangula,* Non-additive gene action

Ridge gourd (*Luffa acutangula* (L.) Roxb.) is an important cucurbitaceous vegetable crop widely grown in tropical and subtropical parts of the world. It belongs to genus *Luffa* of Cucurbitaceae and has a chromosome number 2n=26. Ridge gourd, being predominantly monoecious, is a cross pollinated crop and provides ample scope for utilization of the hybrid vigour. During recent years, the exploitation of hybrid vigour and selection of parents on the basis of combining ability have expanded a new alley in crop improvement. These studies are generally used to assess the performance of lines in hybridization programme and to understand the gene action involved in different characters.

MATERIALS AND METHODS

An experiment was carried out at Vegetable Science Department, K. R. C. College of Horticulture, Arabhavi, during summer season, 2011. Twenty parents and 51 hybrids were evaluated in randomized block design with two replications. A spacing of 1.2 m × 0.9 m was followed and other cultural practices were followed as per the package of practices of UAS, Dharwad (Anonymous, 2007). Observations on five randomly selected plants were recorded for various growth, earliness, yield and quality parameters. The Line × Tester analysis is one of the most appropriate methods in preliminary screening of the breeding material for combining ability and data were analyzed to determine general and specific combining ability.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) for genotypes showed significant differences for all the characters. It indicates the existences of sufficient diversity in the material. Variance due to Line × Tester was significant for all the characters except vine length at 90 days after sowing (DAS) and number of fruits per vine. This indicates enormous amount of variability present among the genotypes. The magnitude of variance due to sca was greater than gca (Table 2) for all the characters showing predominance of non-additive gene action. Among the 20 parents, seven parents showed significant and positive *gca* effects for fruit yield per vine, the highest was observed in the line KRG-3 (0.29) followed by KRG-11, KRG-10 and KRG-2 (Table 3). The parent KRG-3 was found to be good general combiner for all the character except number of leaves 90 DAS, days to first female flower appearance, node to first male and female flower appearance, sex ratio, per cent fruit set, average fruit weight and flesh thickness.

For days to first male flower appearance, maximum and significant negative *gca* effect was observed in the line KRG-2 (-2.64) followed by KRG-3 and KRG-1. The line KRG-5 (-2.99) and tester PN exhibited negative and significant *gca* effects for days to first female flower appearance. For node to first male flower appearance, the maximum and significant *gca* effects was observed in the line KRG-1 (-74.00) followed by KRG-9 and tester PN. For days to first harvest, significant and highest *gca* effects was observed in the parent KRG-5 (-5.62) followed by KRG-3 and PN. The parents *viz.* KRG-5 and PN exhibited the significant and negative *gca* effects for both days to first female flower appearance and days to first harvest so, these parents may be used in breeding programme for earliness. The female parent KRG-11 exhibited the maximum and significant *gca* effects for vine length at 90 DAS (0.71), number of leaves at 90 DAS (6.77) and number of branches at 90 DAS (2.09), whereas, the male

Table 1. Analysis of variance (mean sum of squares) of Line × Tester analysis for various characters in ridge gourd

Character	Replications	Genotypes	Parents	Parents vs Crosses	Crosses	Lines	Testers	Line × Tester	Error
Degree of freedom	1	70	19	1	50	16	2	32	70
Vine length (m) at 90 DAS	4.93	1.09**	1.31**	4.37**	0.94**	1.48**	3.04**	0.54	0.37
Number of leaves on 90 DAS	2992.11	2713.58**	2253.55**	2652.41**	2889.63**	4336.66	1707.65	2239.98**	159.91
Number of branches at 90 DAS	18.316	3.23**	3.25**	2.97**	3.23**	4.46	4.4.7	2.53**	0.163
Days to first male flowering	0.18	12.12**	19.57**	19.37**	9.14**	15.12*	6.29	6.25**	2.75
Days to first female flowering	43.94	47.98**	54.95**	6.92	46.15**	55.74	89.01	38.68**	11.57
Node to first male flower	7.21	7.60**	11.42**	0.68	6.29**	6.51	35.05**	4.37**	2.19
Node to first female flower	3.71	15.02*	12.73	2.08	16.15*	11.69	37.93	17.02*	9.40
Days to first harvest	156.34	39.32**	46.36**	0.88	35.99**	38.41	129.45*	28.93**	14.29
Sex ratio (%)	21.93	60.05**	68.32**	17.33	57.77**	42.18	259.45*	52.95*	30.66
Per cent fruit set	474.76	99.19*	93.23	62.95	102.19*	73.07	45.91	120.26*	62.94
Number of fruits per vine	12.30	1.23**	0.76	22.22**	0.98*	1.35*	3.54**	0.65	0.64
Average fruit weight (g)	108.86	4412.09**	3415.40**	35021.75**	29533.38**	4480.72	1076.19	4462.62**	285.14
Fruit length (cm)	5.70	40.10**	41.02**	358.34**	33.39**	46.25*	104.96*	22.49**	7.85
Fruit diameter (cm)	0.008	0.81**	0.98**	0.84	0.74**	0.76	1.87	0.67*	0.39
Fruit yield per vine (g)	0.003	0.054**	0.069	0.108**	0.108**	0.073*	0.037	0.035**	0.002
Flesh thickness (cm)	0.07	0.48**	0.53**	0.42	0.46**	0.56	1.13	0.37*	0.22

*and ** indicate significance of values at p=0.05 and p=0.01, respectively

Table 2. Variance due to general and specific combining ability for different characters in ridge gourd

Character	GCA	SCA	GCA:SCA
Vine length at 90 DAS	0.08	0.05	1.50
Number of leaves on 90 DAS	39.10	1025.02	0.03
Number of branches at 90 DAS	0.09	1.19	0.08
Days to first male flowering	0.24	1.71	0.13
Days to first female flowering	1.68	16.56	0.10
Node to first male flower	0.82	1.20	0.68
Node to first female flower	0.38	3.07	0.12
Days to first harvest	2.74	8.60	0.31
Sex ratio	4.89	9.99	0.48
Per cent fruit set	3.03	25.64	0.11
Number of fruits per vine	0.08	0.00	0.00
Average fruit weight (g)	84.20	2153.81	0.03
Fruit length (cm)	2.65	7.28	0.36
Fruit diameter (cm)	0.03	0.10	0.32
Fruit yield per vine (kg)	0.00	0.01	0.06
Flesh thickness (cm)	0.02	0.06	0.34

GCA: Variance due to general combining ability
SCA: Variance due to specific combining ability
DAS: Days after sowing

parent ASJ for number of leaves at 90 DAS (6.43) and number of branches at 90 DAS (0.37) exhibited positive and significant *gca* effects. None of the parents exhibited positive and significant *gca* effects for per cent fruit set. For average fruit weight, the line KRG-12(75.28) exhibited maximum and significant *gca* effects, whereas, KRG-1 (5.40) exhibited significant and maximum *gca* effects for fruit length. The line KRG-3 was the good general combiner for number of fruits per vine (1.20), fruit diameter (0.59), fruit yield per vine (0.29), whereas, KRG-2 exhibited the maximum and significant *gca* effects for flesh thickness (0.50).

Parents KRG-2, KRG-3, KRG-4, KRG-11, KRG-16, ASM and PN exhibited significant *gca* effects for the most of the traits. Due to predominant role of non-additive gene action for yield and its components, it is difficult to bring together desirable genes by pedigree method. In this situation formation of central gene pool by bringing together the multiple parents having the good *gca* might prove to be useful.

For days to first male flower appearance, maximum negative and significant *sca* effects was observed in the cross KRG-6 x ASM (-3.75) followed by KRG-9 x ASJ and KRG-3 x PN. For days to first female flower appearance, the cross KRG-15 x ASJ (-7.35) followed by KRG-15 x PN and KRG-11 x ASM exhibited maximum negative and significant *sca* effects. Maximum negative *sca* effects was observed in the cross KRG-11 x PN (-2.81) followed by KRG-9 x ASJ and KRG-8 x ASM for node to first male flower appearance. Among the different crosses, only cross KRG-9 x ASJ (-5.31) exhibited negative and significant *sca* effects for node to first female flower appearance, which is desirable. The highest *sca* effects was observed in the cross KRG-9 x ASJ (-8.64) followed by KRG-10 x PN days to first harvest. For vine length at 90 DAS, only cross KRG-6 x PN (1.10) showed positive and significant *sca* effects. The highest positive *sca* effects was exhibited by the cross KRG-11 x PN (90.46) followed by KRG-6 x PN for number of leaves per vine. For number of branches, significant *sca* effects and maximum *sca* effects were exhibited by KRG-3 x ASM (1.86) followed by KRG-11 x PN and KRG-15 x PN. For per cent fruit set, the cross KRG-16 x PN (12.38) exhibited positive and significant *sca* effects. For average fruit weight, maximum and significant *sca* effects was observed in KRG-6 x ASJ (75.70) followed by KRG-12 x PN and KRG-8 x ASJ, whereas, the highest positive and significant *sca* effects was exhibited by the cross KRG-1 x ASJ (8.20) followed by KRG-12 x PN and KRG-14 x ASM for fruit length. Maximum and significant *sca* effects was observed in the cross KRG-12 x PN for fruit diameter. Maximum and positively significant *sca* effects was observed in the cross KRG-9 x ASJ (0.24) followed by KRG-10 x PN, KRG-6 x ASM and KRG-3 x ASJ for fruit yield per vine.

Out of 51 crosses, five crosses were highly heterotic for different parameters. Among the five heterotic crosses, two crosses were the product of one parent having a high general combining ability, two crosses were one cross was the product of one parent having a low general combining ability and remaining one cross involved the both parents having high general combining ability. Similar results were also reported by Neeraja (2008) and Shaha *et al*. (2003) in ridge gourd. The crosses involving parents with good general combining ability effects can be exploited effectively by conventional breeding procedure like pedigree method. However, the crosses with one good combiner and other average or poor combiner could produce desirable transgressive segregators if additive genetic system was operative in good combining parents and epistatic effects also act in the same direction (Kantharaj, 2003).

The variance due to SCA was higher than the GCA for all the characters, indicating the importance of non-additive gene action. Similar results were also obtained for fruit yield and its component traits by Mole *et al*. (2001) and Purohit *et al*. (2007). There is a great scope for heterosis breeding to exploit non-additive variance observed for yield and yield components. Both additive and non-additive genetic variance was observed for node to first male flowering as the GCA to SCA ratio nearer unity. Hence, direct selection or recurrent selection can be employed for

Table 3. General combining ability effects of parents for growth, earliness, yield and quality parameters in ridge gourd

Parent	Vine length at 90 DAS	Number of leaves at 90 DAS	Number of branches at 90 DAS	Days to first male f lowering	Days to first female flowering	Node to first male flower	Node to first female flower	Days to first harvest	Sex ratio	Per cent fruit set	Number of fruit per vine	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield per vine (kg)	Flesh thickness cm)
Lines																
KRG-1	-0.27	-28.73**	-0.78**	-2.14**	-2.32	-74.00**	-1.41	-0.78	-0.87	2.92	-0.03	-10.18	5.40**	0.04	0.07**	-0.19
KRG-2	0.23	-7.60	0.55**	-2.64**	-1.82	-0.97	-2.11	-0.28	-0.91	-1.31	0.14	-35.10**	2.76*	0.56*	0.08**	0.50*
KRG-3	0.60*	2.37	1.29**	-2.30**	-2.49	0.03	-1.37	-4.28**	-3.33	4.37	1.20**	-12.76	2.56*	0.59*	0.29**	0.3
KRG-4	-0.04	-5.90	-0.15	1.03	-2.46	-0.37	-0.97	-0.78	0.33	-1.39	0.17	22.50**	1.80	0.33	0.01	0.01
KRG-5	-0.27	-17.70**	-0.71**	-0.64	-2.99*	-0.41	-0.67	-5.62**	-3.38	-0.31	0.34	-14.67*	-3.50**	-0.12	0.04	-0.13
KRG-6	-0.35	0.77	-0.85**	-0.80	2.68	-0.27	-0.01	0.55	2.29	1.33	-0.46	28.61**	-4.62**	-0.57*	-0.07**	0.21
KRG-7	0.70**	11.10*	-0.48*	0.70	0.34	0.73	1.13	0.05	0.60	3.49	-0.36	-39.86**	-4.20**	0.31	-0.02	0.31
KRG-8	0.22	5.24	-0.28	0.36	-2.16	-0.07	0.43	-1.28	0.48	-3.47	0.1	-11.31	-1.47	0.05	0.07**	0.21
KRG-9	-0.57*	-34.06**	-1.11**	-1.14	-0.99	-1.91**	2.79*	-0.55	2.25	1.48	-0.33	5.48	-1.70	-0.15	-0.08**	0.23
KRG-10	-0.45	-11.03*	0.09	-0.47	-2.82	-0.97	-1.94	-0.95	4.18	2.48	0.14	4.88	-1.00	0.00	0.08**	-0.06
KRG-11	0.71**	66.64**	2.09**	1.70*	6.18**	2.93**	2.13	2.55	1.33	4.57	0.70*	-12.62	0.26	0.26	0.12**	-0.04
KRG-12	-0.07	24.64**	0.99**	1.03	0.18	-0.01	1.03	-1.12	0.96	-8.15*	-0.3	75.28**	0.46	0.27	-0.08**	0.34
KRG-13	-0.84**	-31.90**	-0.15	-1.14	-2.49	0.19	-0.07	4.72**	-6.57**	-5.32	-0.66	17.18*	-1.70	-0.64*	-0.14**	-0.61
KRG-14	-0.52*	-23.06**	-0.35*	2.03**	4.51**	-0.01	0.73	3.88*	-1.59	1.94	-0.43	-22.24**	0.20	-0.33	-0.10**	-0.49*
KRG-15	0.45	4.64	1.02**	0.03	5.68**	-0.01	-0.87	0.55	3.2	-1.42	-0.03	3.15	-0.60	-0.16	-0.07**	-0.15
KRG-16	-0.23	-2.96	-0.11	1.70*	0.84	0.89	-0.07	1.38	1.11	1.27	-0.46	16.84*	3.50**	-0.26	-0.12**	-0.24
KRG-17	0.68**	47.67**	0.02	2.70**	0.18	0.99	1.26	0.88	-0.09	-2.49	0.27	-15.20*	1.96	-0.18	-0.09**	-0.20
CD at 5%	0.50	10.29	0.32	1.36	2.77	1.20	2.49	3.07	4.51	6.46	0.66	13.64	2.27	0.52	0.04	0.38
CD at 1%	0.66	13.66	0.42	1.8	3.68	1.59	NS	4.08	5.98	NS	0.87	18.11	3.02	NS	0.05	0.5
Testers																
ASJ	0.16	6.43**	0.37**	0.52	1.19*	1.04**	1.07*	2.14**	2.31*	0.94	-0.37*	4.6	1.93**	-0.08	-0.04**	0.02
ASM	0.19	1.17	-0.03	-0.25	0.66	-0.05	-0.03	-0.45	0.75	-1.3	0.15	1.68	-0.42	-0.19	0.01	-0.19*
PN	-0.35**	-7.60**	-0.35**	-0.27	-1.84**	-0.99**	-1.04	-1.69*	-3.06**	0.36	0.22	-6.27*	-1.51**	0.26*	0.03*	0.17*
CD (p=0.05)	0.20	4.33	0.14	NS	1.16	0.50	1.06	1.30	1.89	NS	0.28	5.78	0.96	0.22	0.02	0.16
CD (p=0.05)	0.26	5.75	0.19	NS	1.54	0.66	NS	1.72	2.52	NS	NS	NS	1.27	NS	0.03	NS

*and ** indicate significance of values at 5% and 1%, respectively

Table 4. Specific combining ability effects of selected hybrids for growth, earliness yield and quality parameters

Cross	Vine length 90 DAS	Number of leaves 90 DAS	Number of branches 90 DAS	Days to first male flowering	Days to first female flowering	Node to first male flower	Node to first female flower	Days to first harvest	Sex ratio	Per cent fruit set	Number of fruits per vine	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield per vine (kg)	Flesh thickness (cm)
KRG-1 × ASJ	0.36	5.30	0.53	-1.69	1.65	-0.27	0.19	-1.30	-0.07	2.95	0.07	19.57	8.20**	0.24	0.03	-0.18
KRG-1 × ASM	-0.45	2.87	-0.37	1.08	-1.82	0.81	-1.30	-3.72	1.81	3.45	0.05	-8.96	-5.75**	0.73	0.09**	0.69*
KRG-2 × ASJ	0.28	21.27*	0.39	-0.19	-0.85	-1.14	1.89	3.20	-2.44	-8.87	-0.4	-0.51	3.14	0.07	0.01	0.13
KRG-2 × ASM	0.28	-17.87*	-0.51	-0.92	1.18	0.25	-1.90	0.78	-1.4	4.04	0.78	-0.66	1.59	0.01	0.07*	-0.19
KRG-3 × ASJ	-0.06	-10.6	-1.74**	-0.02	2.81	1.26	1.36	4.70	0.75	-0.22	-0.46	-43.26**	-3.96*	0.28	0.14**	-0.08
KRG-3 × ASM	0.15	5.67	1.86**	3.25**	-0.66	-0.35	0.17	-1.22	3.83	-5.18	-0.29	11.95*	-0.61	-0.17	0.07*	0.00
KRG-3 × PN	-0.09	4.93	-0.12	-3.23**	-2.16	-0.96	-1.53	-3.48	-4.58	5.39	0.75	31.94**	4.58*	-0.11	0.03	0.08
KRG-4 × ASJ	-0.12	-1.73	1.39**	-0.35	-1.69	0.46	-3.04	-3.80	-2.47	8.13	0.47	-51.56**	1.6	-0.16	0.12**	0.07
KRG-4 × PN	-0.04	3.40	-1.18**	-0.56	4.34	0.29	2.57	2.52	7.91*	4.57	-0.62	-34.43**	-2.46	-0.24	-0.05	-0.15
KRG-5 × ASM	0.15	5.63	-0.14	-1.42	-1.16	-0.92	-3.23	1.12	-5.46	2.75	0.18	-15.72	-1.15	0.15	0.15**	0.24
KRG-5 × PN	-0.03	-1.30	1.38**	1.11	-1.16	0.93	1.67	1.35	6.51	-0.96	-0.08	4.04	2.74	0.13	0.00	0.07
KRG-6 × ASJ	-0.36	-33.10**	-0.01	1.98	0.65	-1.94	-1.81	3.86	3.00	2.97	-0.70	75.70**	-0.08	-0.79	-0.22**	0.85*
KRG-6 × ASM	-0.73	-37.53**	-1.21**	-3.75**	-3.32	-1.15	0.50	-2.55	-4.99	-1.11	-0.12	1.21	-1.63	-0.02	0.16**	-0.81
KRG-6 × PN	1.10*	70.63**	1.22**	1.77	2.68	3.09**	1.31	-1.31	1.99	-1.87	0.82	-76.90**	1.71	0.82	0.07*	-0.04
KRG-7 × ASM	0.61	35.33**	0.63*	0.25	2.01	0.15	1.97	0.45	-3.71	-10.89	0.28	4.28	-1.35	-0.07	0.03	0.03
KRG-8 × ASJ	0.56	-10.86	0.83**	0.81	1.48	1.56	4.46*	-0.80	4.06	-0.85	0.34	45.08**	1.37	0.51	0.10**	0.3
KRG-8 × ASM	-0.08	10.80	0.43	-0.92	-1.99	-2.15*	-2.43	1.78	-2.89	-2.12	0.21	-17.45	-0.48	0.03	0.01	-0.01
KRG-9 × ASJ	0.85	31.94**	0.36	-3.69**	-6.19*	-2.20*	-5.31*	-8.64**	1.37	-5.58	0.47	5.61	0.6	0.79	0.24**	0.43
KRG-9 × PN	0.03	-10.44	-0.12	0.61	2.84	0.63	-3.89	6.19*	-4.63	-3.79	-0.32	11.89	0.44	0.13	-0.12*	-0.36
KRG-10 × ASJ	-0.05	37.30**	0.76*	0.15	0.65	0.96	0.63	5.36*	-1.39	-3.52	0.00	11.67	-0.8	-0.63	-0.05	-0.57
KRG-10 × PN	0.09	-18.17*	0.18	-0.06	-2.32	0.19	0.94	-6.81*	-5.22	-2.48	0.72	-30.11*	-0.26	0.12	0.22**	0.19
KRG-11 × ASM	-0.36	-33.00**	-0.14	0.25	-6.32*	0.96	0.67	-2.05	-4.48	3.79	-0.39	27.06*	-0.71	-0.41	-0.11**	-0.11
KRG-11 × PN	0.81	90.46**	1.68**	0.27	2.18	-2.81**	2.77	-0.81	5.28	-6.95	-0.15	21.88	0.32	0.69	0.15**	0.42
KRG-12 × ASJ	-0.17	15.84	0.86**	0.65	3.65	0.90	2.06	4.03	4.00	2.77	-0.06	-45.17**	-7.06**	-1.17*	0.16**	-0.96
KRG-12 × ASM	0.01	18.80*	0.06	0.41	-0.82	0.28	-1.43	-0.88	4.68	7.89	-0.49	-3.01	1.59	0.07	-0.15**	0.03
KRG-12 × PN	0.16	-34.64**	-0.92**	-1.06	-2.82	-1.17	-0.63	-3.15	-8.67*	-10.66	0.55	48.18**	5.48**	1.10*	-0.01	0.93
KRG-13 × ASJ	-0.19	-15.03	1.29**	2.81*	4.82*	-0.70	0.96	-0.30	-5.88	-5.14	0.10	18.24	0.2	0.33	-0.01	-0.04
KRG-13 × ASM	-0.04	11.73	-0.61*	-2.42*	-4.66	0.88	-0.33	0.78	2.32	-3.28	0.58	-99.33**	-0.05	-0.23	0.09**	0.07
KRG-14 × ASM	0.58	8.20	0.59*	-0.09	1.84	0.88	2.27	-0.88	-0.26	-6.75	0.85	-54.55**	4.45*	-0.06	0.04	-0.18
KRG-14 × PN	0.02	3.26	0.72*	-0.06	-0.66	-0.17	-1.93	2.85	-3.36	7.99	-0.22	35.92**	-3.06	-0.17	0.04	0.01
KRG-15 × ASJ	0.56	35.24**	-0.37	1.15	-7.35**	-0.2	1.76	-2.64	-0.05	5.34	0.77	-43.26**	1.8	0.26	0.04	0.16
KRG-15 × PN	-0.57	-34.34**	1.45**	-1.56	-6.82**	-0.27	-1.93	2.69	0.65	-11.69*	-0.02	-16.78	-3.16	-0.50	0.05	-0.30
KRG-16 × ASM	0.54	36.90**	1.06**	0.25	0.51	0.18	-1.73	-0.88	2.60	-9.21	-0.42	25.26*	1.05	-0.24	0.04	-0.30
KRG-16 × PN	-0.45	-26.14**	-0.82**	0.27	0.01	-0.47	1.17	-2.15	4.87	12.38*	0.22	-51.12**	-0.36	-0.23	-0.08**	-0.10
KRG-17 × ASJ	0.17	32.10**	0.03	-0.52	-1.85	-0.2	0.33	-2.97	3.70	-3.54	-0.53	1.79	-3.00	-0.23	-0.03	-0.14
KRG-17 × PN	-0.23	-27.77**	-0.85**	0.77	3.18	1.07	-1.14	0.85	-7.83*	-4.07	0.28	14.63	2.14	-0.25	0.12**	0.13

*and ** indicate significance of values at 5% and 1%, respectively

improvement of these traits. Additive genetic variance was more than the non-additive genetic variance for the vine length at 90 DAS and hence these characters can be improved through simple selection. These results imply tat ridge gourd breeding programme should be formulated in such a way to exploit the non-additive variance.

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Genetic Architecture of Gladiolus (*Gladiolus Hybridus Hort.*) under Sub Tropical Condition of Punjab (India)

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***Abstract*:** Morphometric characterization of fifty seven gladiolus genotypes was undertaken to analyze the genetic variability, correlation and path coefficient analysis of yield and yield contributing traits during 2012-13 to 2013-14. High phenotypic and genotypic co-efficient of variation were recorded for weight of cormels plant^{-1}, durability of floret and equatorial corm diameter, moderate for leaf breadth, leaf length, plant height, rachis length, floret size, stem diameter, rachis diameter and number of florets spike^{-1} and low for leaf chlorophyll content and days taken to colour bud show. High values of heritability and genetic advance were observed for plant height, rachis length and days taken to colour bud show indicating that these traits were under additive gene control and selection for genetic improvement for these traits would be effective. High heritability and low genetic advance were observed for stem diameter, equatorial corm diameter and number of florets spike^{-1} which indicated the involvement of non-additive gene action for the expression of these characters. Genetic advance as per cent of mean was highest for weight of cormels plant^{-1} and equatorial corm diameter. The number of florets spike^{-1} showed positive correlation with leaf chlorophyll content, leaf breadth, days taken to colour bud show, durability of floret, plant height, rachis length, stem diameter, rachis diameter and equatorial corm diameter. Path coefficient analysis revealed that rachis length followed by plant height and equatorial corm diameter exhibited maximum positive association and direct contribution towards no. of florets spike^{-1}.

Key Words: Correlation and path coefficient analysis, Genetic components, Gladiolus

Gladiolus (*Gladiolus x hybridus Hort.*) is an important bulbous plant, belongs to family Iridaceae and is one of the leading cut-flower crops, known for its majestic spikes having attractive, elegant and delicate florets. A large number of varieties are available in gladiolus and every year there is addition of new varieties through breeding programmes. Huge quantum of variability exists in this crop with respect to shape, growth habit, flowering behaviour, vase life, etc. Inspite of such variability, very few have desirable characters in terms of yield and quality (Kumar *et al.,* 2011). Therefore, there is a need for genetic restructuring of gladiolus germplasm for increasing the productivity and quality of crop in accordance to preferences of the consumer. The estimation of heritability and genetic advance is essential for a breeder, which helps in understanding the magnitude, nature and interaction of genotype and environmental variation of the traits.

The present experiment was conducted to study the extent of genotypic and phenotypic variability among the genotypes to estimate genetic advance, correlation coefficient among the selected characters and direct and indirect effects of component characters on yield of gladiolus.

MATERIAL AND METHODS

The field trials were conducted in two consecutive years (2012-13 and 2013-14) at the Research Farm of Floriculture and Landscaping Department, PAU, Ludhiana. The plant material comprised of 57 genotypes of gladiolus *viz.,* 26 exotic, 22 Indian and 9 newly developed hybrids were assessed for their growth, flowering and yield contributing characters. All the genotypes were procured from the Department of Floriculture and Landscaping, PAU, Ludhiana. Uniform sized corms (4.0-5.0 cm diameter) were planted during 2nd week of October each year. The experiment was laid out in a randomized block design with three replications. Corms were planted at a plant spacing of 20 cm x 30 cm in 1.2 m^2 plot. Uniform package of practices were followed for all the genotypes throughout the experiment. Corms and cormels were harvested in the 3rd week of April and then shade-dried. The observations were recorded on randomly selected plants for various parameters. Chlorophyll content was measured by chlorophyll meter (SPAD-502 Minolta®), avoiding readings on midrib, collected at random positions from particular selected leaves on both side of the plant. Stem, rachis and equatorial corm diameter were measured with the help of digital vernier calliper. Equatorial corm diameter was measured by holding the corm across the position perpendicular to stem axis. Mean, range and coefficient of variation (CV) were also estimated. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated according to Burton (1952); heritability in broad sense (h^2bs)

as per Burton and De vane (1953); genetic advance (GA), genetic advance as per cent mean, correlation coefficients at phenotypic and genotypic levels were calculated as per Johnson *et al* (1955) and path coefficient analysis as per Dewey and Lu (1959). In the present study, path coefficient analysis was carried out by selecting number of florets as dependent variable and other traits as independent variables in each year and also for pooled data. All the genetic components were estimated on two year pooled data.

RESULTS AND DISCUSSION

Analysis of variance: Analysis of variance revealed significant differences among the genotypes for all the traits indicating the presence of sufficient genetic variability in the germplasm and considerable scope for their improvement. Sufficient genetic variability for many traits studied in gladiolus had also been reported by earlier workers (Lepcha *et al.,* 2007, Bhujbal *et al.,* 2013). The wide range in plant height (73.57 - 113.91 cm), days taken to colour bud show (77.78 - 106.7 days), rachis length (24.57 - 53.4 cm), leaf length (23.33 - 43.5 cm) and leaf chlorophyll content (35.95 - 54.15 mg/cm^2) (Table 1).

GCV and PCV: A perusal of the data (Table 1) revealed that the magnitude of PCV was higher than GCV for all the characters, thereby confirming the earlier findings of Mishra *et al.* (2014). Differences between PCV and GCV for the studied characters was very less indicating low sensitivity to environment and consequently greater role of genetic factors influencing the expression of these characters. Similar results were reported by Kumar *et al* (2011). The estimates of PCV and GCV were high for weight of cormels plant^{-1}, durability of floret and equatorial corm diameter, moderate for chlorophyll content, leaf breadth, leaf length, plant height, floret size, stem diameter, rachis diameter and number of florets spike^{-1} and low for days taken to colour bud show. Balaram and Janakiram (2009) obtained high PCV and GCV for weight of cormels plant^{-1}. Kumar *et al* (2011) also reported low phenotypic and genotypic coefficient of variations, for days to first floret show colour and plant height. High values of PCV and GCV indicated the existence of substantial variability, ensuring ample scope for their improvement through selection.

Heritability and genetic advance: Most of the traits studied had high heritability estimates though they were moderate for chlorophyll content, leaf breadth, durability of floret, floret size and rachis diameter. The heritability of the highest magnitude was noticed for weight of cormels plant^{-1} (97.98%) followed by plant height (97.15%), equatorial corm diameter (95.13%), leaf length (90.23%), days taken to colour bud show (88.37%), number of florets spike^{-1} (87.37) and stem diameter (84.52%). Therefore, it indicated that larger proportion of phenotypic variance has been attributed to genotypic variance and reliable selection could be made for most of these traits on the basis of phenotypic expression. High estimates of heritability in broad sense indicate that substantial improvement can be made using standard selection procedures. High estimates of heritability and genetic advance were observed for plant height (97.15 and 22.34%), rachis length (92.74 and 15.58%) and days taken to colour bud show (88.37 and 14.71%). This suggested the

Table 1. Genetic parameters of different character of gladiolus

Character	Range	Mean	Coefficient of variation		Heritability (BS %)	Genetic Advancement 5%	GA as a percent of mean
			GCV	PCV			
Leaf chlorophyll content (mg/cm^2)	35.95 - 54.15	46.61	8.90	11.06	64.77	6.88	14.76
Leaf breadth (cm)	1.54 - 3.04	2.12	15.33	17.75	74.57	0.57	27.27
Leaf length (cm)	23.33 - 43.5	35.86	14.33	15.08	90.23	10.05	28.03
Days taken to colour bud show	77.78 - 106.7	95.17	7.98	8.49	88.37	14.71	15.46
Durability of floret (day)	1.5 - 5.93	3.78	28.46	34.55	67.85	1.83	48.28
Plant height (cm)	73.57 - 113.91	92.59	11.88	12.05	97.15	22.34	24.13
Rachis length (cm)	24.57 - 53.4	42.02	19.01	19.74	92.74	15.58	37.27
Floret size (cm)	6.78 - 13.21	8.90	10.45	12.31	72.11	1.63	18.28
Stem diameter (mm)	9.53 - 16.35	13.30	13.10	14.25	84.52	3.30	24.81
Rachis diameter (mm)	4.31- 7.11	5.70	12.54	14.85	71.35	1.24	21.83
Equatorial corm diameter (cm)	3.73 - 8.88	6.01	25.78	26.44	95.13	3.12	51.81
Weight of cormels/plant (g)	8.53 - 26.5	15.49	34.66	35.01	97.98	10.94	70.67
No. of florets/spike	9.57 - 16.56	12.90	15.43	16.51	87.37	3.83	29.71

Table 2. Estimates of Phenotypic (P), genotypic (G) and Environmental (E) correlation coefficient among thirteen characters of gladiolus

Trait		Leaf chlorophyll content (mg/cm^2)	Leaf breadth (cm)	Leaf length (cm)	Days taken to colour bud show	Durability of floret (day)	Plant height (cm)	Rachis length (cm)	Floret size (cm)	Stem diameter (mm)	Rachis diameter (mm)	Equatorial corm diameter (cm)	Weight of cormels/plant (g)	No. of florets/spike
Leaf chlorophyll content (mg cm^2)	P		0.31**	0.34***	-0.10	0.42***	0.26**	0.34***	0.01	0.15	0.38***	0.29**	0.25**	0.18
	G		0.48***	0.45***	-0.11	0.62***	0.30**	0.40***	0.07	0.23*	0.51***	0.34***	0.31**	0.29**
	E		-0.08	-0.01	-0.09	0.03	0.23*	0.20*	-0.13	-0.10	0.12	0.17	0.08	-0.17
Leaf breadth (cm)	P			0.41***	0.16	0.31**	0.18	0.28**	0.22*	0.33**	0.36***	0.19*	0.18	0.24*
	G			0.42***	0.21*	0.37***	0.22*	0.35***	0.31**	0.41***	0.48***	0.23*	0.21*	0.31**
	E			0.38***	-0.08	0.16	-0.04	-0.09	-0.04	0.03	0.05	-0.05	-0.06	-0.07
Leaf length (cm)	P				0.26**	0.24*	0.36***	0.18	0.08	0.20*	0.23*	0.04	0.04	0.14
	G				0.28**	0.24*	0.37***	0.18	0.09	0.24*	0.35***	0.05	0.04	0.17
	E				0.12	0.26**	0.25**	0.21*	0.07	-0.07	-0.29**	-0.09	0.10	-0.04
Days taken to colour bud show	P					0.01	0.26**	0.18	0.04	0.14	0.12	0.02	-0.15	0.19
	G					0.05	0.28**	0.20*	0.06	0.19	0.17	0.03	-0.15	0.22
	E					-0.17	-0.01	-0.03	-0.06	-0.10	-0.06	-0.03	-0.15	-0.04
Durability of floret (day)	P						0.46***	0.46***	0.16	0.33**	0.37***	0.32**	0.14	0.34**
	G						0.56***	0.57***	0.17	0.47***	0.49***	0.45***	0.17z	0.44***
	E						-0.01	0.00	0.14	-0.11	0.08	-0.32**	0.22*	-0.02
Plant height (cm)	P							0.78***	0.28**	0.19	0.12	0.31**	0.52***	0.72***
	G							0.78***	0.35***	0.21	0.14	0.32**	0.53***	0.76***
	E							0.62***	-0.05	-0.01	-0.11	0.05	-0.04	0.33**
Rachis length (cm)	P								0.34***	0.14	0.13	0.33**	0.50***	0.85***
	G								0.44***	0.17	0.16	0.36***	0.52***	0.90***
	E								-0.17	-0.01	-0.17	0.07	0.04	0.42***
Floret size (cm)	P									0.23*	0.15	0.08	0.28**	0.18
	G									0.30**	0.12	0.14	0.31**	0.20
	E									-0.03	0.23*	-0.28**	0.22*	-0.17
Stem diameter (mm)	P										0.54***	0.51***	0.33**	0.47***
	G										0.62***	0.55***	0.36***	0.51***
	E										0.27**	0.24*	0.05	0.23*
Rachis diameter (mm)	P											0.38***	0.20*	0.34***
	G											0.43***	0.23*	0.42***
	E											0.22*	0.10	0.06
Equatorial corm diameter (cm)	P												0.49***	0.41***
	G												0.52***	0.45***
	E												-0.25**	0.07
Weight of cormels $^{-1}$ plant (g)	P													0.17
	G													0.20
	E													-0.14
No. of florets spike^{-1}	P													
	G													
	E													

***, **,* significant at p=0.001, 0.01and p=0.05, respectively

Table 3. Estimates of direct and indirect effect of different traits on yield at phenotypic (P) and genotypic (G) levels in gladiolus

Trait		Chlorophyll content (mg/cm^2)	Leaf breadth (cm)	Leaf length (cm)	Days to colour bud show	Floret durability (day)	Plant height (cm)	Rachis length (cm)	Floret size (cm)	Stem diameter (mm)	Rachis diameter (mm)	Equatorial corm diameter (cm)	Weight of cormels/ plant (g)	No. of florets/ spike
Chlorophyll content (mg/cm^2)	P	-0.14	0.01	-0.01	0.003	-0.03	0.06	0.26	0.00	-0.01	0.01	0.07	-0.05	0.18
	G	-0.02	0.03	-0.03	-0.00	-0.10	0.10	0.31	0.01	-0.04	-0.01	0.11	-0.07	0.29**
Leaf breadth (cm)	P	-0.04	0.04	-0.01	-0.01	-0.02	0.04	0.21	0.02	-0.02	0.01	0.05	-0.03	0.24*
	G	-0.01	0.07	-0.02	0.01	-0.06	0.07	0.27	0.04	-0.08	-0.01	0.08	-0.05	0.31**
Leaf length (cm)	P	-0.05	0.02	-0.03	-0.01	-0.02	0.08	0.14	0.01	-0.01	0.01	0.01	-0.01	0.14
	G	-0.01	0.03	-0.06	0.01	-0.04	0.13	0.14	0.01	-0.04	-0.01	0.02	-0.01	0.17
Days to colour bud show	P	0.01	0.01	-0.01	-0.03	-0.00	0.06	0.14	0.00	-0.03	0.00	0.01	0.03	0.19
	G	0.00	0.01	-0.02	0.03	-0.01	0.09	0.16	0.01	-0.10	-0.00	0.01	0.03	0.22
Durability of floret (day)	P	-0.06	0.01	-0.01	-0.00	-0.07	0.11	0.35	0.01	-0.02	0.01	0.08	-0.08	0.34**
	G	-0.01	0.03	-0.01	0.00	-0.16	0.19	0.44	0.02	-0.09	-0.01	0.15	-0.10	0.44***
Plant height (cm)	P	-0.04	0.0	-0.01	-0.01	-0.03	0.23	0.59	0.02	-0.04	0.01	0.08	-0.10	0.72***
	G	-0.01	0.02	-0.02	0.01	-0.09	0.34	0.61	0.04	-0.11	-0.01	0.11	-0.12	0.76***
Rachis length (cm)	P	-0.04	0.01	-0.01	-0.01	-0.03	0.18	0.76	0.03	-0.03	0.01	0.09	-0.10	0.85***
	G	-0.01	0.02	-0.01	0.01	-0.09	0.26	0.77	0.05	-0.10	-0.01	0.12	-0.12	0.90***
Floret size (cm)	P	-0.00	0.01	-0.00	-0.02	-0.02	0.07	0.16	0.05	-0.05	0.00	0.02	-0.05	0.18
	G	-0.01	0.02	-0.01	0.00	-0.03	0.12	0.17	0.08	-0.10	-0.02	0.07	-0.09	0.20
Stem diameter (mm)	P	-0.02	0.01	-0.01	-0.02	-0.02	0.12	0.37	0.02	-0.07	0.01	0.13	-0.06	0.47***
	G	-0.00	0.03	-0.01	0.02	-0.08	0.20	0.42	0.04	-0.19	-0.01	0.19	-0.08	0.51***
Rachis diameter (mm)	P	-0.05	0.02	-0.01	-0.00	-0.03	0.10	0.25	0.01	-0.04	0.02	0.10	-0.04	0.34***
	G	-0.01	0.03	-0.02	0.01	0.08	0.18	0.33	0.01	-0.12	-0.02	0.14	-0.05	0.42***
Equatorial corm diameter (cm)	P	-0.04	0.01	-0.00	-0.00	-0.02	0.07	0.25	0.01	-0.04	0.01	0.26	-0.10	0.41***
	G	-0.01	0.02	-0.00	0.00	-0.07	0.11	0.28	0.02	-0.10	-0.01	0.34	-0.12	0.45***
Weight of cormels/ plant (g)	P	-0.05	0.01	-0.03	0.00	-0.03	0.10	0.23	0.02	-0.02	0.00	0.13	-0.19	0.17
	G	-0.08	0.01	-0.06	-0.00	0.05	0.12	0.26	0.04	-0.07	-0.02	0.17	-0.22	0.20

***, **,* significant at p=0.001, 0.01and p=0.05, respectively. Residual effect P=0.1545, G=0.0922; Bold values indicate direct effects

presence of additive gene action and hence these characters are likely to respond better to selection. High heritability along with low genetic advance were observed for stem diameter (84.52 and 3.30%) equatorial corm diameter (95.13 and 3.12%) and number of florets spike^{-1} (87.37 and 3.83%), which may be attributed to the non-additive gene effects and these traits can be improved through hybridization and use of hybrid vigour. High heritability along with high genetic advance was observed for plant height, days to first floret show colour, weight of corm and cormel production (Kumar *et al.,* 2011). High heritability along with high genetic advance was also recorded for plant height and rachis length (Choudhary *et al.,* 2012). Genetic advance as per cent of mean was highest for weight of cormels plant^{-1} (70.67%) followed by equatorial corm diameter (51.81%) and lowest for chlorophyll content (14.76%).

Correlation coefficient of variation: The genotypic correlation coefficients were observed to be higher than the phenotypic correlation coefficient for most of the traits (Table 2). The yield i,e., the number of florets/spike had positive correlation with leaf chlorophyll content, leaf breadth and days taken to floral bud show at genotypic level. It also showed positive correlation with durability of floret, plant height, rachis length, stem diameter, rachis diameter and equatorial corm diameter both at phenotypic and genotypic level. However at environment level, it showed non-significant negative correlation with leaf chlorophyll content, leaf breadth and length, days to colour bud show, floret size and weight of cormels plant^{-1}. Choudhary *et al.* (2011a) reported positive correlation between number of florets and plant height. Similar findings were also reported by Sakkeerhussain *et al* (2001). Rachis length, which is an important trait for export depicted significant positive correlation with chlorophyll content, leaf breadth, durability of floret and stem length. Similarly, plant height also depicted significant positive relationship with chlorophyll content, leaf breadth and length, days taken to colour bud show and durability of floret. Choudhary *et al.* (2011a) reported positive correlation of plant height with rachis length, duration of flowering and number of florets. Equatorial corm diameter exhibited positive correlation with chlorophyll content, leaf breadth, plant height, rachis length, stem diameter and rachis diameter. This indicates the importance of photosynthetic area and translocation of photosynthetic assimilates towards corms. On the other hand, it depicted significant negative association with durability of floret and floret size at environment level.

Path analysis: At genotypic level, rachis length (0.77) had highest positive direct effect on number of florets spike^{-1} followed by plant height (0.34) and equatorial corm diameter (0.34), while high negative direct effect was observed for weight of cormels plant^{-1} (-0.22) followed by stem diameter (-0.19), durability of floret (-0.16), leaf length (-0.06) and chlorophyll content (-0.02). High direct and positive effect of rachis length and plant height on number of florets spike^{-1} in gladiolus has been reported by Choudhary *et al.* (2011b). The direct contribution of rachis length to number of florets spike^{-1} was supported by indirect effects of plant height, equatorial corm diameter, floret size and leaf breadth (Table 3). Similarly plant height also contributed to yield i,e. number of florets spike^{-1} via rachis length, equatorial corm diameter, floret size and leaf breadth. Rachis length, besides having positive direct effect and correlation coefficient of high magnitude, had also positive indirect effects of considerable magnitude via plant height and equatorial corm diameter. Similar findings have also been reported by Pal and Singh (2012). Low magnitude of residual effect (0.09) at genotypic level indicated that the traits included in the present investigation accounted for most of the variation present in the dependent variable (number of florets spike^{-1}).

In view of the direct and indirect contributions of component traits towards number of florets, selection on the basis of traits viz., rachis length and plant height would be a paying preposition in the genotypes included in the study.

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Effect of Pruning Intensity on Physiology and Quality of Red Globe Grapes in Summer Season

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Abstract: Maximum total chlorophyll (2.022 mg g^{-1}), total carbohydrate (15.88 %), petiole nitrogen (2.688%), phosphorus (0.864%) and potassium content (2.825 %) were recorded in vines pruned for 50 % of canes to 2 bud level and 50 % of canes to 6 bud level in summer seasons crop. The vines pruned at 2 bud level for summer season crop registered highest TSS (17.82 ^{0}Brix), TSS/acid ratio (35.95), lower titrable acidity (0.49%), whereas, the maximum reducing sugar (15.65%), total sugars (17.24%) and sugar-acid ratio (34.17) was observed in vines pruned to 50% of the canes for vegetative growth and 50% of the canes for crop yield in summer season and better performed among different pruning intensities.

***Key Words*:** Acidity, Carbohydrates, Chlorophyll, Grape, Pruning, Sugars, TSS

Grape (*Vitis vinifera* L.) is considered as one of the most important commercial fruit crops of temperate, tropical and sub-tropical regions of the world. In India, grape is grown over an area of 0.118 million hectares with annual production of 2.48 million MT (NHB, 2013) and production share of 3.1% among fruit crops. Recently, the exotic cv. Red Globe, introduced from University of California, USA which is popular in Australia, China and USA, is also slowly gaining importance in India among the grape growers and consumer's preference is also much higher for this exotic variety.

The vines of this cultivar are moderate in vigour but tend to produce more number of bunches with variable sizes. Hence, optimum canopy size and bunch number per vine are to be maintained for achieving better fruit quality, which calls for a proper balancing between vigour and capacity. Among different cultural practices, pruning is of immense importance to control the growth, crop load and also the quality of bunches. The time of pruning varies greatly with the variety and local climatic conditions in different grape-growing regions in India. Generally growers adopt a pruning level of 4-5 buds/cane for pruning of all matured canes in cv. Muscat, which results in more exploitation of reserved food materials leading to the loss of vigour, quality and early setting of senility in the vines, whereas in cv. Red Globe, pruning level was unknown. In the present investigation, attempts were made to aim the quality bunches exclusively for summer season by striking a balance between vigour and capacity through regulating the pruning intensities.

MATERIALS AND METHODS

The present investigation was undertaken at Horticulture Orchard, TNAU, Coimbatore on eight years old grapevines, which were trained on bower system spaced at 3.0 x 2.5 m apart. For summer season, crop vines were pruned on 2nd fortnight of December, 2012 and harvested during the months of May-June, 2013 with four pruning intensities replicated five times in a randomized block design. Four different pruning levels were adopted (Table 1). Four vines were observed in each replication under each treatment for the collection of data. The soil samples collected from the experimental plot were analysed for organic carbon (0.85%), available N (**390.67** kg ha^{-1}), P (**35.43** kg ha^{-1}), K (**809.13** kg ha^{-1}) before imposition of treatments. A nutrient dosage consisting of 5 kg FYM along with 0.75: 0.75: 0.50 kg NPK per vine was applied in 2 split doses, at vegetative and fruiting phase as recommended by NRC-Grapes, Pune, India. Proper plant protection measures and cultural practices were also followed whenever needed.

Physiological characteristics: Thirty petioles borne opposite to the inflorescence in each replication were collected at random during flowering phase, dried at constant 60^{0}C in hot air oven and used for analyzing leaf mineral content. Percentage of total nitrogen was estimated by Micro-Kjeldahl method and percentage of total phosphorus was estimated in triple acid extract by adopting Vanadomolybdate phosphoric yellow colour method. The total potassium was determined by reading the Flame Photometer values of triple acid extract. Chlorophyll 'a', 'b' content (mg g^{-1}) was calculated in the leaf, which was borne opposite to the inflorescence at flowering stage and estimated by following the method of Yoshida *et al*. (1971). Cane total carbohydrates content (%) was determined according to Somogyi (1952).

Quality characteristics: Randomly selected ten berries per

replication in each treatment were used for assessing quality parameters. Total soluble solids (T.S.S.) in berry juice were determined by means of digital hand refractometer (Atago, Japan) having a scale of 0-50^0 Brix and expressed as degrees Brix at 21 ^{0}C and titrable acidity was expressed as tartaric acid (%) according to AOAC (1998. TSS/acid ratio was calculated by dividing TSS (^{0}brix) by acidity (%). The total, reducing and non-reducing sugars were estimated as per the method suggested by Somogyi (1952) and expressed in percentage.

RESULTS AND DISCUSSION

Physiological characteristics: Among the pruning intensities, pruning 50% of the canes for vegetative growth and remaining 50% of the canes for crop load maintained better petiole nutrient status in respect of total nitrogen (2.69%), total phosphorus (0.86%) and total potassium (2.82%) (Table 1) at the time of flowering when compared to other pruning levels. Pruning 100% canes to 6 bud level exhibited lower level of nutrients in the petiole due to relatively more number of fruiting canes per vine, competing for drawing more nutrients for development of bunches. This finding was strongly supported by the results of Cangi and Kilic (2011) and Waqar Ahmad (2008) indicating higher depletion of nutrients due to heavy crop load. Among the treatments, the canes pruned to 50% for vegetative growth and remaining 50% for crop yield recorded the maximum chlorophyll a, chlorophyll b and total chlorophyll content (Table 1). The vegetative growth developed from 50% of shoots retained for two bud level might have produced sufficient photosynthates through enhanced chlorophyll content in these vines. The chlorophyll content during summer season crop was significantly higher due to the prevailing high temperature; more sunshine hours and less relative humidity, which might have favoured the synthesis of more chlorophyll. Availability of sufficient vegetative growth in these vines with enhanced chlorophyll content due to pruning of 50% of the shoots for vegetative growth and remaining 50% of the shoots for crop yield might have accelerated the photosynthetic efficiency of the crop, which was also reflected in terms of higher total carbohydrate content (15.88%).

Quality characteristics: Severely pruned vines *i.e*., pruning all the canes to 2 bud level produced higher TSS (17.82^{0}Brix), TSS/acid ratio (35.95) and lesser acidity (0.49%) than less severely pruned vines, followed by the vines which were pruned to equal number of canes to 2 bud and 6 bud level (Table 2). This clearly indicates that crop load has a negative effect on the quality of bunches and need to regulate the crop load in order to produce the quality bunches. The reason for high TSS, TSS/acid ratio in severely pruned vines might be due to lesser competition for metabolites, among the limited number of bunches per vine, availability of more photosynthates consequent to better vigour and physiological activities induced in them. The predominant acids found in grapes *viz*., malic and tartaric acid are synthesized in leaves, these acids are translocated from leaves to bunch. This higher quantum of acids might have deposited in bunch during development and resulted in higher acidity in less intensive pruning levels. These results are in conformity with earlier studies given of Chougule (2004); Somkuwar and Ramteke, (2007) and Ahmad (2008). Among the pruning intensities, the vines which were pruned 50% of canes for vegetative growth (2 bud level) and remaining 50% for crop yield (6 bud level) registered the maximum percentage of reducing sugars (15.65%), total sugars (17.24%) and sugar-acid ratio (34.17). The reason for accumulation of high reducing and total sugars in balanced pruning of vegetative and reproductive growth might be due to lesser competition of metabolites, limited number of bunches per vine, availability of more photosynthates consequent to better vigour and physiological activity

Table 1. Effect of pruning intensity on physiological characteristics of grapes cv. Red Globe in summer season

Treatments	Petiole nitrogen content (%)	Petiole phosphorus content (%)	Petiole potassium content (%)	Cholorophyll 'a' (mg g^{-1})	Cholorophyll 'b' (mg g^{-1})	Total chlorophyll content (mg g^{-1})	Cane total carbohydrate content (%)
T_1	2.240	0.768	2.162	0.872	0.514	1.386	14.91
T_2	2.284	0.794	2.724	0.978	0.534	1.511	15.65
T_3	2.607	0.854	2.347	0.990	0.551	1.541	15.09
T_4	2.688	0.864	2.825	1.375	0.647	2.022	15.88
CD (0.05%)	0.020	0.005	0.028	0.020	0.005	0.030	0.04

T_1: Pruning all the canes to 2 bud level (100 **%**) for vegetative growth; **T_2:** Pruning all the canes to 6 buds level (100 **%**) for crop load; **T_3:** Pruning 1/3rd or 33 **%** of the canes for vegetative growth (2 bud level) and 2/3rd or 67 **%** of the canes for crop load (6 bud level).; **T_4:** Pruning 50 **%** of the canes for vegetative growth (2 bud level) and 50 **%** of the canes for crop load (6 bud level).

Table 2. Effect of pruning intensity on quality characteristics of grapes cv. Red Globe in summer season

Treatments*	TSS (^{0}Brix)	Titrable acidity (%)	TSS/acid ratio	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sugar-acid ratio
T_1	17.55	0.56	31.16	14.85	1.43	16.28	28.90
T_2	17.82	0.49	35.95	15.05	1.40	16.45	33.60
T_3	17.58	0.52	33.47	14.97	1.91	16.88	32.12
T_4	17.67	0.50	35.03	15.65	1.59	17.24	34.17
CD (0.05%)	NS	NS	0.19	0.03	0.02	0.04	0.22

*See table 1 for treatment details

induced in them where source-sink relationship was well balanced. Among the different intensities of pruning level *i.e*., pruning 50% of the canes for vegetative growth and 50% of the canes for crop yield had better quality bunches.

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Formulation of Crop Weather Disease Calendars of Mustard Crop for Different Agroclimatic Zones of Punjab

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***Abstract*:** The phenological calendars for the crop were computed using the crop data generated during the field experiments. Crop-weather-disease calendars were formulated by combining the weekly climatic normals and phenological calendar for the crop along with optimum climatic normals needed for different phenological stages of the crop. The optimum climatic normals were worked out from actual meteorological data of high yield crop years over the past 10 years. The crop-weather-disease calendars also contain the climatic normals required for major diseases of the crop as well as susceptible crop phenological stages. The crop-weather-disease calendars can be used for agro-advisory services for timely disease management and for prediction of high crop yield.

***Key Words*:** Agro-advisory, Crop phenology, Crop weather calendar, Meteorological parameters, Mustard

Oilseed crops have an important role in agriculture and industrial economy of India. These crops occupy second major group amongst agricultural crops. Rapeseed-mustard forms an important group of oilseeds next to soybean. It is the second most important edible oilseeds after groundnut sharing 27.8 per cent in India's oilseed economy. It has lowest amount of harmful saturated fatty acids and is a good source of protein and nutrition. Weather is the major variable affecting crop production in climate smart agricultural system (Sharma, 2004). Weather interferes with the production by the amount of water and sunshine that are present for the plants, but also influences yields through certain extremes in the weather that can increase the chance of an outbreak of a certain disease (Norton and Turvey, 2008). Crop yields are highly dependent on the inter- and intra-seasonal changes in meteorological parameters during the crop growth period (Kaur and Hundal, 2009).

A crop yield loss constitutes 30-40 per cent due to the infestation of pests and diseases. Such losses can be reduced to a considerable extent if the factors for their occurrence are known in advance. Weather conditions are responsible for the infestation of pests and diseases in the crop (Laxmi and Kumar, 2011). Agro-meteorological Advisory Service (AAS) is a step to contribute to weather information based crop management strategies and operations dedicated to enhancing crop production and food security. The AAS has helped to develop and apply operational tools to manage weather related uncertainties through agro-meteorological applications for efficient agriculture in rapidly changing environments (Singh, 2011).

A crop weather calendar is an effective tool, which can be used in issuing value added weather based agromet advisory for crops (Kaur *et al.*, 2013). These calendars help the weather forecaster to see, at a glance, what warnings are to be issued for a particular area during a given weather situation at a particular phase of a crop. With proper guidance and services provided by agricultural meteorologists, these calendars can be of much interest to the agricultural profession and to the various government departments concerned with agriculture and food production (Anonymous, 2004). The present study was conducted to determine the influence of meteorological parameters on the mustard crop yield, to formulate crop-weather-disease calendars and their use in agro-advisory service in different agro-climatic zones of Punjab.

MATERIALS AND METHODS

The normal weather data on maximum and minimum temperature, rainfall, sunshine hours, relative humidity, etc. for Agroclimatic Zone II (BallowalSaunkhri), Agroclimatic Zone III (Amritsar, Ludhiana and Patiala) and Agroclimatic Zone IV (Bathinda) were collected from IMD, Chandigarh. The historical data on area, production and productivity of mustard were collected from Statistical Abstract, Punjab from 2003-13 for five representative locations of Punjab to find out the low, medium and high yield crop years. The data on different phenological growth

stages (sowing, anthesis, pod formation, pod filling and physiological maturity) for mustard crop were collected from the published reports operational in the Department of Agricultural Meteorology for formulating the crop-weather calendar for 5 locations in the state. The effect of inter- and intra- seasonal meteorological parameters on different growth stages and the final yield of mustard were established as per the three major categories (high, medium and low crop yield year) of crop years by calculating the deviation of different meteorological parameters. The weekly and monthly deviations from normal meteorological parameters during the mustard season were calculated to identify the influence of meteorological parameters on the mustard crop yield. The data were also used for working out the stage wise "critical limits" of different meteorological parameters, *i.e.*, temperature (maximum and minimum), rainfall, sunshine hours, relative humidity (maximum and minimum), etc. from the actual meteorological data of high yield crop year of last decade (2003-2013). Then the critical limit of various meteorological parameters were analyzed and tabulated for predicting the potential yield of mustard crop at 5 locations in the state.

Formulation of crop-weather-disease calendars: Crop-weather calendars have been formulated by combining the weekly climatic normals and phonological calendar for the crop along with optimum climatic normals needed for different phonological stages of the crop. The phenological calendars for mustard crop were computed using the crop data generated at Ludhiana. The climatic normals were worked out using the historical meteorological data respect to total weekly rainfall (mm), number of rainy days and evaporation (mm). Weekly normals were also worked out for maximum temperature (°C), minimum temperature (°C), mean temperature (°C), sunshine hours (hours), solar radiation (W m^{-2}), maximum relative humidity (%), minimum relative humidity (%), mean relative humidity (%), wind speed (km hr^{-1}) and wind direction (degree) as per availability of data. In addition to the above information, the crop-weather-disease calendars contain the climatic normals required for major diseases of the crop as well as susceptible crop phenological stages.

RESULTS AND DISCUSSION

The actual weather data for different locations were analyzed to work out the weekly climatic normals for entire mustard growth period from 43 - 13 Standard Meteorological Week (SMW). Further the entire growth period of mustard at different locations in the state was divided into five major phenological windows starting from sowing and emergence (43-48 SMW), anthesis (49-52 SMW), pod formation (1-3 SMW), pod filling (4-8 SMW) and physiological maturity (9-13 SMW). The information on range of actual normal meteorological parameters and therange needed for high productivity of mustard crop for various growth windows for the respective location is given in the calendar. For high mustard yield in Punjab, the maximum and minimum temperature from sowing to physiological maturity stage of mustard at Ballowal Saunkhri (Fig. 1) is required to be in the range of 18.9-35.7C (normal 17.6-31.7°C) and 3.7-16.4°C (normal 4.3-14.9°C), respectively. Likewise, these temperatures are required at Amritsar (Fig. 2) to be in the range of 11.9-34.9°C (normal 18.0-31.8°C) and 0.1-18.6°C (normal 6.1-15.2°C); at Ludhiana (Fig. 3) in the range of 14.2-30.8°C (normal 17.7-30.5°C) and 5.3-14.7°C (normal 5.3-14.4°C); at Patiala (Fig. 4) in the range of 11.2-36.4°C (normal 18.5-30.9°C) and 2.0-21.1°C (normal 6.1-15.7°C)and at Bathinda (Fig. 5)in the range of 9.4-35.7°C (normal 18.6-31.8°C) and 0.4-17.4°C (normal 4.4-14.6°C),respectively. The favourable range of a meteorological parameter varies from one location to another as in addition to weather, the soil type also plays a pivotal role in determining the growth and yield of a crop. The formulated calendar also contains information on incidence of important diseases and the favourable meteorological conditions for their incidence in mustard. If the meteorological conditions for disease incidence are favourable, then in mustard crop the incidence window for downy mildew is from December-February (from flowering-pod filling stage of mustard); for white rust in December (during flowering stage of mustard) and for alternaria blight from January to February (from pod formation to pod filling stage of mustard) (Fig. 1-5).

The crop-weather-disease calendars formulated for wheat crop for different growth stages can be used for agro-advisory services and for prediction of potential crop yield. Thus. if the climatic conditions are favourable and pathogen is present, there are chances of occurrence of the disease. The crop-weather-disease calendars can act as a guiding tool while issuing agro-advisory to the farmers of the region. The agromet advisory bulletin contains information on crop management which is based on weather forecast and gives warning to farmers much in advance regarding rainfall variation, its amount and other

Months	October		November				December				January			February				March					
STD. Weeks	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13
Rain (mm)	0.2	0	0.5	1.2	0.4	0.5	0.2	2.9	1.7	5.1	3.8	5.2	7.9	10	7.4	12.9	9.3	1.2	4	4.3	10.1	6.1	4.1
Evap (mm)	2.8	2.6	2.4	2	1.9	1.8	1.8	1.5	1.2	0.9	0.8	1	1.1	1.6	1.8	2.1	2.4	2.7	3.3	3.6	4	4.5	4.7
Max T (°C)	30.9	30.3	28.9	27.3	26.1	24.8	24.1	23.1	22.1	20	17.6	18.6	18.9	20.4	21.3	21.9	23.4	25	26.1	27.8	29.1	30.3	31.7
Min T (°C)	14.3	13.5	12.4	11.2	9.7	7.9	7.7	6.9	6.8	5.1	4.6	4.3	4.4	4.9	6.4	8	8.5	9.1	10.7	10.8	12.9	14.1	14.9
Mean T (°C)	22.6	21.9	20.7	19.3	17.9	16.4	15.9	15	14.4	12.5	11.1	11.5	11.7	12.6	13.9	14.9	16	17.1	18.4	19.3	21	22.2	23.3
RH 1 (%)	82	85	85	85	87	87	87	91	91	97	92	93	95	93	90	91	84	85	79	79	79	67	64
RH 2(%)	42	44	45	46	47	39	52	50	53	54	69	59	57	49	50	50	47	44	44	43	49	37	36
WS (km/hr)	2.3	2.2	2.3	2.5	2.4	2.3	2.1	2.4	2.5	2.1	1.9	2.2	2.6	2.4	3.0	3.4	3.9	3.8	4.0	3.9	3.5	3.6	3.3
SSh (hrs)	8.8	8.2	8.3	8.4	8.0	7.9	7.7	6.9	6.5	5.9	6.0	6.2	6.4	6.9	7.4	7.6	7.5	8.1	8.1	8.5	8.5	8.6	9.3

Phenological stages of mustard

Sowing and emergence	Flowering	Pod formation	Pod filling	Physiological maturity
Climatic normals for mustard				
Max Temp = 23.5-29.9 °C	Max Temp =18.9-26.6 °C	Max Temp =12.1-21.2 °C	Max Temp =20.5-30.5 °C	Max Temp =21.5-35.7 °C
Min Temp =6.8-14.7 °C	Min Temp =4.0-11.0 °C	Min Temp =3.7-10.1 °C	Min Temp =5.3-6.8 °C	Min Temp = 11.6-16.4 °C
Rainfall = 5.0mm	Rainfall =4.7 mm	Rainfall = 11.9 mm	Rainfall = 4.7 mm	Rainfall =5.4 mm
RH max =79-96%	RH max =94-95%	RH max = 90-95%	RH max =94-95%	RH max =72-90%
RH min =30-54%	RH min =48-56%	RH min =45-56%	RH min =48-56%	RH min =27-43%
SSh =7.7-8.8hrs	SSh =5.9-6.9hrs	SSh =6.4-8.5hrs	SSh =5.9-6.9hrs	SSh =8.5-9.8hrs
Evaporation =14.0 - 24.2 mm	Evaporation =10.5- 12.1 mm	Evaporation=11.3-24.8 mm	Evaporation =10.5-12.1 mm	Evaporation =25.9-46.4 mm

Climatic normals for mustard pest		
White rust		
Downey mildew	Temp=10-20°C, RH= 90-100%	
Alternaria blight		Temp=25°C, RH= ≥70%

Fig. 1. Crop weather disease calendar for Ballowal Saunkhri, SBS Nagar

Months	October		November				December				January			February				March				
STD. Weeks	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13
Rain(mm)	0.7	0.8	1.0	1.7	1.7	1.3	0.8	4.3	2.6	4.1	4.7	2.8	5.7	8.0	7.6	8.5	8.4	12.3	8.9	9.3	10.1	8.0	3.6
Rainy days	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.5	0.2	0.3	0.4	0.2	0.6	0.7	0.7	0.7	0.8	0.9	0.8	0.7	0.9	0.8	0.5
Max T (°C)	31.8	29.8	28.8	27.4	25.8	24.0	23.1	21.8	20.5	19.3	18.0	18.3	18.5	19.1	20.0	20.8	21.9	22.6	23.5	25.3	26.5	27.8	30.0
Min T (°C)	13.2	12.1	10.5	9.1	7.4	5.8	4.9	4.6	4.0	3.6	3.2	3.3	3.4	3.8	4.4	5.1	6.7	7.1	8.0	9.4	10.8	12.0	13.6
Mean T (°C)	22.5	20.9	19.7	18.3	16.6	14.9	14.0	13.2	12.3	11.5	10.6	10.8	11.0	11.5	12.2	13.0	14.3	14.9	15.8	17.4	18.7	19.9	21.8

Phenological stages of mustard

	Sowing and emergence	Flowering	Pod formation	Pod filling	Physiological maturity
Climatic normals for mustard					
	Max Temp =26.1-32.7 ℃	Max Temp = 15.9-24.1 ℃	Max Temp = 11.9-20.7 ℃	Max Temp = 15.0-25.0 ℃	Max temp =22.7-34.9 ℃
	Min Temp =4.1-16.7 ℃	Min Temp = 0.3-7.6 ℃	Min Temp = 0.1-8.0 ℃	Min Temp =1.1-12.9 ℃	Min Temp = 7.1-18.6 ℃
	Rainfall = 8.5 mm	Rainfall = 24.6 mm	Rainfall = 32.3 mm	Rainfall = 13.4 mm	Rainfall = 4.6 mm

Climatic normals for mustard pest	
White rust	Temp= 12-25°C, RH=≥70%
Downey mildew	Temp=10-20°C, RH= 90-100%
Alternaria blight	Temp=25°C, RH= ≥70%

Fig. 2. Crop weather disease calendar for Amritsar

Months	October		November			December					January			February				March				
STD. Weeks	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13
Rain(mm)	0.4	2.5	0.5	0.6	1.9	1.2	3.3	2.7	4.9	4.1	4.7	4.1	5.6	7.9	5.2	8.5	11.9	7.1	6.7	4.6	5.2	5.4	2.5
Evap(mm)	24.1	21.0	19.7	18.9	17.3	15.1	14.0	12.1	11.1	10.6	10.2	10.4	11.3	12.0	13.6	16.3	16.8	19.0	20.9	24.2	25.9	29.8	33.2
Max T (°C)	30.5	29.4	28.3	27.0	25.3	23.6	22.7	21.1	20.4	18.5	17.7	17.9	17.8	18.8	19.4	20.3	21.3	22.2	23.2	25.1	26.4	27.9	30.0
Min T (°C)	14.4	13.3	12.1	10.9	9.4	7.9	7.2	6.8	6.2	5.6	5.3	5.4	5.7	5.8	6.1	6.8	8.1	8.4	9.3	10.6	11.6	12.9	14.3
Mean T (°C)	22.5	21.4	20.2	18.9	17.4	15.8	15.0	14.0	13.3	12.0	11.5	11.7	11.8	12.3	12.8	13.5	14.7	15.3	16.2	17.8	19.0	20.4	22.1
RH 1 (%)	87.3	89	90	91	91	93	93	94	95	95	95	95	95	94	94	93	93	92	91	90	89	88	85
RH 2(%)	34.1	37	35	36	37	39	41	48	52	55	56	56	57	53	53	51	53	50	49	45	43	42	37
WS (km/hr)	2.8	2.6	2.7	2.7	2.8	2.9	2.9	3.2	3.3	3.4	3.5	3.8	4.1	4.1	3.6	4.5	4.5	4.7	4.7	4.7	4.2	4.9	4.7
SSh (hrs)	8.8	8.2	8.3	8.4	8.0	7.9	7.7	6.9	6.5	5.9	6.0	6.2	6.4	6.9	7.4	7.6	7.5	8.1	8.1	8.5	8.5	8.6	9.3

Phenological stages of mustard

Sowing and emergence	Flowering	Pod formation	Pod filling	Physiological maturity
Climatic normals for mustard				
Max Temp = 26.9-28.1 ℃	Max Temp =20.0-27.3 ℃	Max Temp =14.2-18.7 ℃	Max Temp =18.2-24.5 ℃	Max Temp =26.4-30.8 ℃
Min Temp =11.8-13.2℃	Min Temp =5.3-8.0 ℃	Min Temp =5.3-7.7 ℃	Min Temp = 8.1-9.4 ℃	Min Temp = 12.4-14.7 ℃
Rainfall =14.0 mm	Rainfall =17.7 mm	Rainfall =47.8 mm	Rainfall =94.8 mm	Rainfall =42.2 mm
RH max =91-94%	RH max =92-98%	RH max = 92-98%	RH max =92-96%	RH max =88-93%
RH min =32-45%	RH min =44-55%	RH min =50-79%	RH min =47-67%	RH min =37-55%
SSh =4.6-17.5hrs	SSh =0.4-8.7hrs	SSh =2.3-7.8hrs	SSh =3.2-10.3hrs	SSh =4.1-10.8hrs
Evaporation =14.1-16.3 mm	Evaporation =8.3-11.2 mm	Evaporation =6.7-11.9 mm	Evaporation =11.1-15.3 mm	Evaporation =20.0-30.5 mm

Climatic normals for mustard pest

White rust	Temp= 12-25°C, RH=≥70%			
Downey mildew		Temp=10-20°C, RH= 90-100%		
Alternaria blight			Temp=25℃, RH=≥70%	

Fig. 3. Crop weather disease calendar for Ludhiana

Months	October		November				December				January			February				March				
STD. Weeks	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13
Rain(mm)	0.1	2.1	0.8	1.0	3.2	0.8	2.1	2.7	3.5	8.1	7.1	4.8	4.2	9.3	4.7	7.1	7.4	7.6	8.8	5.8	5.2	6.0	3.7
Rainy days	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.5	0.2	0.3	0.4	0.2	0.6	0.7	0.7	0.7	0.8	0.9	0.8	0.7	0.9	0.8	0.5
Max T (°C)	30.9	30.0	28.9	27.8	26.1	24.5	23.7	22.1	20.9	19.6	18.5	18.8	19.1	19.5	20.1	21.0	22.1	23.0	24.0	26.1	27.1	28.6	30.6
Min T (°C)	15.2	13.9	12.6	11.5	10.0	8.4	8.0	7.7	7.3	6.8	6.1	6.3	6.6	6.9	7.2	7.8	9.4	9.7	10.7	11.9	13.2	14.6	15.7
Mean T (°C)	23.1	21.9	20.8	19.6	18.1	16.5	15.8	14.9	14.1	13.2	12.3	12.5	12.8	13.2	13.7	14.4	15.8	16.4	17.4	19.0	20.2	21.6	23.1

Phenological stages of mustard

Sowing and emergence	Flowering	Pod formation	Pod filling	Physiological maturity
Climatic normals for mustard				
Max Temp =20.9-32.4 °C	Max Temp = 13-26.1 °C	Max Temp = 11.2-27.8 °C	Max temp =17.5-27.8 °C	Max temp =21.7-36.4 °C
Min Temp = 2-11.7 °C	Min Temp = 5.6-14.2 °C	Min temp = 11-18.6 °C	Min Temp = 11.3-21.1 °C	Min Temp = 5.7-14.7 °C
Rainfall = 20.2mm	Rainfall =66.1mm	Rainfall =62.2mm	Rainfall = 53.0mm	Rainfall = 60.3mm

Climatic normals for mustard pest

White rust	Temp= 12-25°C, RH=≥70%
Downey mildew	Temp=10-20°C, RH= 90-100%
Alternaria blight	Temp=25°C, RH=≥70%

Fig. 4. Crop weather disease calendar for Patiala

Months	October		November					December			January				February				March				
STD. Weeks	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13
Rain(mm)	0.2	1.7	0.2	0.4	1.9	0.4	0.7	1.1	2.1	4.6	4.0	1.9	2.3	6.0	3.0	7.3	7.8	8.8	3.5	2.7	6.2	4.1	2.1
Evap(mm)	28.8	26.8	23.6	22.7	20.3	19.2	18.6	16.3	15.5	13.8	9.9	10.3	10.3	12.5	14.3	12.4	14.8	17.4	22.1	25.6	26.6	30.3	33.8
Max T (°C)	31.8	31.1	30.1	28.6	26.8	25.1	24.2	22.7	21.5	19.6	18.6	18.8	18.7	20.3	20.7	21.2	22.1	23.1	24.4	26.6	28.0	29.1	31.0
Min T (°C)	14.5	13.3	11.9	11.0	9.4	7.4	6.7	6.4	5.6	5.0	4.5	4.4	4.8	5.5	5.6	6.5	8.0	8.3	9.3	10.4	12.2	13.1	14.6
Mean T (°C)	23.2	22.2	21.0	19.8	18.1	16.3	15.5	14.6	13.6	12.3	11.5	11.6	11.7	12.9	13.1	13.8	15.1	15.7	16.9	18.5	20.1	21.1	22.8
RH max (%)	80.1	83.2	85.9	87.5	88.9	88.9	90.4	91.1	91.4	92.5	94.1	93.0	92.5	90.3	90.5	91.3	90.0	88.8	88.2	88.4	87.8	82.8	79.4
RH min (%)	31.6	33.3	34.3	35.5	34.6	33.6	33.5	38.9	41.7	50.5	60.9	53.1	58.5	51.0	49.5	53.9	51.5	49.5	47.7	43.9	42.7	37.4	33.0
WS (km/hr)	3.5	4.1	2.7	3.4	2.7	2.9	2.8	3.0	3.1	3.6	2.8	2.5	2.7	2.8	3.3	3.5	3.3	4.7	4.1	4.8	3.9	5.1	4.0
WD	224.0	259.5	240.7	252.6	266.5	246.7	247.2	250.0	262.3	257.2	252.1	264.7	238.2	256.5	247.0	210.0	234.7	241.5	248.4	216.3	231.1	232.2	237.2
Phenological stages of mustard																							
	Sowing and emergence							Flowering			Pod formation			Pod filling					Physiological maturity				
Climatic normals for mustard																							
	Max Temp =23-35.6 ℃							Max Temp =12.9-26.2 ℃			Max Temp =9.4-22.0 ℃			Max Temp =13.8-28.7 ℃					Max Temp =19.7-35.7 ℃				
	Min Temp =5.8-16.4 ℃							Min Temp =0.4-11.8 ℃			Min Temp =1.7-9.1 ℃			Min Temp = 1.1-10.6 ℃					Min Temp = 6.8-17.4 ℃				
	Rainfall =66.6mm							Rainfall =24.6 mm			Rainfall = 30 mm			Rainfall =25.4 mm					Rainfall =11.6 mm				
	RH max =68-99 %							RH max =83-99%			RH max = 80-100%			RH max =76-98%					RH max =63-97%				
	RH min =14-57%							RH min =22-69%			RH min =36-82%			RH min =32-74%					RH min =18-89%				
	Evaporation =9-34.9 mm							Evaporation =8.5-24.2 mm			Evaporation =1.4-15.6 mm			Evaporation =6.8-24.8 mm					Evaporation =9.7-44.1 mm				
Climatic normals for mustard pest																							
White rust								Temp= 12-25℃, RH=≥70%															
Downey mildew								Temp=10-20℃, RH= 90-100%															
Alternaria blight														Temp=25℃, RH= ≥70%									

Fig. 5. Crop weather disease calendar for Bathinda

weather variables including pest/disease problems, so that farmers can decide about their choice on practical crop management, application of nutrients and adopt strategies to overcome field problems.

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Growth and Productivity of Wheat Varieties under *Ceiba pentandra* (L) based Agri-silvicultural System

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Abstract: A field experiment was conducted at Indira Gandhi Agricultural University, Raipur Chattisgarh India to evaluate the growth and yield of wheat varieties under *Ceiba pentandra* (L.) Gaertn. based agri-silvicultural system. Growth of *Ceiba* tree and crop yield decreased significantly from the lower tree density to higher density. Shoot length in wheat decreased by 4.5-17.1%, while root length decreased by 29.8-35.9% at 60 days after sowing. The grain yield ranged from 24.0 to 29.1q ha^{-1}. Higher grain yield (28.7 q ha^{-1}) was obtained in 4x8 m tree spacing, while the grain yield was 25.40 q ha^{-1} in 4 x 6 m and 24.90 q ha^{-1} in 4x4 m spacing.

Key Words: Agri-silvicultural system, *Ceiba pentandra*, Leaf area index, Pruning, Wheat, Yield

Almost 175 mha of land is subjected to several land degradation processes in India. The productivity of many fertile lands has substantially declined during past few decades. Presently, almost 100 mha is lying as degraded wasteland, of which more than 70% is carbon degraded (Rastogi *et al.,* 2000). These soils have relatively high potential for accumulating organic carbon in vegetation and soil. There is need to integrate trees on marginal and fallow crop lands to ensure soil conservation, building organic matter, efficient nutrient cycling, etc. In the light of both economic and ecological problems, there is growing concern about the sustainability of woody perennial based land use practices. Agroforestry is a blend of a agriculture and forestry, with prime objective of yield optimization and environmental protection to maintain the ecological sustainability. Many different agroforestry practices have been identified world over and agri-silvicultural system is one such system where agricultural crops are grown in association with trees. Choice of tree species and management play an important role in success of agri-silvicultural system, where it is targeted to maximize complementary and minimize competitiveness interactions between trees and crops. Emphasis is given to use fast growing multipurpose trees with desirable growth characters that could be compatible with crops and provide maximum benefits in quickest possible time. *C. pentandra* is a fast growing multipurpose tree and proved as one among the promising species for agroforestry practices (Puri, *et al.,* 2001; Rajendran *et al.,* 2002). It is commonly known as silk cotton tree distributed in south and central India up to an elevation of 450 m. It is a moderate size deciduous tree and a fully grown tree of 15 years produce 2.7 to 4.0 kg $tree^{-1}$ floss. The tree has straight bole, acute branching and deciduous nature and potential to produce high quality floss and seeds at early age made the species an ideal choice of farmers in different parts of south and central India including Chhattisgarh state. Great thrust is given to intensively practice the species under agroforestry and farm forestry programs in Chhatisgarh state, where mono-cropping of rice is practiced in more than 80% area only in kharif and lands are kept fallow in rabi season. As part of crop diversification, the state government is encouraging farmers to adopt agroforestry practices in different agro-climatic zones of Chhattisgarh. Wheat crop is one of the most important cereal crops of India not only in term of acreage, but also in terms of its versatility for adoption under wide range of agro-climatic situations. The present study was carried out to know the yield potential of wheat varieties under *Ceiba pentandra* canopy.

MATERIALS AND METHODS

The experiment was conducted in the Department of Forestry, Indira Gandhi Agricultural University, Raipur Chattisgarh, India (21.76^{0}N latitude; 81.36^{0}E longitude; 289 amsl) on nine-year-old *Ceiba pentandra* (L.) Gaertn tree based system. Trees planted at three spacing, viz, 4x4 m, 4x6 m and 4x8 m. Four wheat varieties namely (Sujata, GW-173, GW-273 and HD-2004) were sown as intercrop in the first week of December. Before wheat sowing, half of the trees in all spacing were pruned up to 25% crown height, while reaming half were kept unpruned. Plots of the size 64 m^2 in 4x4 m, 4x6 m and 4x8 m spacing were demarcated with in agri-silvicultural system and in an area without trees, which served as control plots for growing sole wheat varieties. Wheat varieties were sown in these plots in a randomized

block design with four replications. Wheat varieties sown in plots without trees served as control plots. Seed rate of 125 kg ha^{-1} was applied by maintaining a distance of 25 cm between the rows and 5 cm from plant to plant. Recommended fertilizer dose of Nitrogen (urea) @120 kg ha^{-1}, phosphorus (SSP) @ 60 kg ha^{-1}, potassium (MOP) @ 40 kg ha^{-1} were applied for the wheat varieties. Urea was applied in two splits, half as basal dose at the time of sowing and remaining half 30 days after sowing in the form of top dressing. Observations were recorded at three distances from the tree base i.e., 0.5 to 1.0 m, 1.0 to 3.0 m and >3.0 m. In total, there were 76 treatments (3 tree spacing x 4 varieties x 2 pruning x 3 distances) and 4 control plots (for each wheat variety). Wheat population was recorded 30 days after sowing, plant height (shoot length) at 30 and 90 days of sowing and number of tillers at 60 days of sowing. Biomass (shoot and root) was measured at 30 and 90 days after sowing. Leaf area Index (LAI) and Photosynthetically active radiation (PAR) were measured using LII 2000 and Line quantum sensor (LI-191 SA LI-COR Inc, Lincoln, USA) at 60 and 90 days of sowing, respectively. The observations were done in each plot with in a quadrate randomly at three places in sole wheat. In agri-silviculture system, the three random observations with quadrate were taken at three distances ranging from 0.5 to 1 m, 1.0 to 3.0 m and >3.0 m. from the main trunk. Number of effective tillers, spike length, grains per spike, test weight (1000 grain dry weight), grain and straw yield were measured at the time of wheat harvesting (after 120 days). The harvest index was calculated for each treatment by dividing the grain yield with the respective biological yield (grain and straw) and converting in to percentage values. Before sowing of wheat crop, tree growth characters, viz., total height, clean bole height, diameter at breast height, crown length and width, LAI, PAR and at harvesting pod diameter, number of pod per tree, pod length, seed and floss yield of *C. pentandra* in different spacing were estimated. Crop parameters were analyzed statistically using analysis of variance for factorial randomized block design (three factor). Simple randomized block design was used for analysis of tree parameters. The significance was tested for all the parameters at 5% level. All statistical analysis were done using MSTATC programme (Version 1.41)

RESULTS AND DISCUSSION

Growth of wheat crop in agri-silvicultural system: In agri-silvicultural system the important factor that influences the crop productivity is the tree spacing. The population of wheat crop was significantly higher under wide spacing compared to narrow tree spacing. Sole wheat recorded the highest plant population in comparison to intercrop. The wheat population reduced by 23% in 4x4 m, 15% in 4x6 m and 2.5% in 4x8 m tree spacing when compared to sole crop (Table 1). A significantly higher population was observed under pruned as compared to unpruned stands of *C. pentandra*. Among four wheat varieties, the highest plant population was found in HD-2004 variety fallowed by GW-273, GW-173 and Sujata. All these varieties showed significantly higher population in sole crop as compared to agri-silviculture system. The population of wheat gradually increased with increase in distance from the tree bole. Wheat population was reduced by 9.9%, 14.3% and 17% at >3 m, 1 to 3 m and 0.5 to 1m distance, respectively from tree base compared to sole crop. Sharma *et al.* (2000) observed that the reduction in plant population of wheat crop due to poplar at 0–3 m distances from tree line was 34.2% over control and this reduction was less with increasing distances from the tree line. Similar decreasing yield trend was also recorded by Chauhan *et al.* (2012) in poplar with decreasing distance from the poplar trees.

Number of tiller of wheat was increased with an increase in tree spacing under agri-silvicultural system. The number of tillers was 402.2 m^2 in 4x8 m spacing, whereas, it was only 387m^2 under 4x6 m spacing (Table 1). Number of tillers decreased by 12.2% in unpruned and 6.8% in pruned tree in comparison to sole wheat. The HD-2004 variety of wheat produced higher number of tillers in agri-silvicultural system, whereas, other three varieties (GW-173, GW-273 and Sujata) did not show any significant variation. Higher shoot length and root length was observed in wheat grown under 4x8 m and lower under 4x4 m at all growth stages. Among four wheat varieties, the higher shoot length was recorded in Sujata, while lower in GW-173 on 30th and 90th days of sowing. The shoot length and root length increased with increase in distance from the tree base. Shoot/root biomass was significantly affected by tree spacing. Higher shoot and root biomass was recorded in wheat crop grown in open and also as intercrop under 4x8 m tree spacing. The among four wheat varieties, the higher shoot and root biomass was recorded in HD-2004 variety. Numerically a higher shoot and root biomass was recorded in wheat growing away from the tree bases.

Leaf area index and PAR significantly $p \leq 0.05$ influenced by tree spacing, varieties and distance from the tree base at 60 and 90 days interval, while pruning of trees did not show any significant effect. LAI and PAR of wheat crop was highest under sole crop than intercrop in all treatments. LAI of crop was significantly higher in wheat grown away from the trees in comparison to wheat in proximity to the trees. Under agri-silvicultural system, the maximum PAR (1467.5 µ mol m^2s^1) was intercepted by GW-273 and HD-2004 varieties

Table 1. Variation in morphological characters of wheat varieties grown under different spacing of *Ceiba pentandra*

Treatment	Plant populationm^{-2}	No. of tillers m^{-2}	Shoot length (cm)		Root length (cm)		Shoot biomass (g $plant^{-1}$)		Root Biomass (g $plant^{-1}$)		Leaf area index		PAR μ mol m^2s^1	
			30 DAS	90 DAS	30 DAS	90 DAS	30 DAS	90 DAS	30 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
Tree Spacing														
4x4m	198.3	362.6	36.4	82.0	5.6	7.0	0.428	3.8	0.034	0.65	1.93	1.97	1403.3	1105.3
4x6m	221.3	387.8	38.0	92.2	6.4	7.7	0.446	4.0	0.037	0.66	2.05	1.89	1403.3	1080.8
4x8m	254.1	402.2	40.2	92.9	6.5	8.1	0.449	4.2	0.038	0.67	1.90	1.83	1403.4	1140.2
Control	260.8	425.0	37.1	98.3	7.6	10.0	0.450	2.8	0.092	0.66	2.86	3.05	1449.3	1465.3
CD (p=0.05)	NS	NS	3.33	1.85	0.42	0.78	0.00	0.06	0.006	0.01	0.16	NS	64.46	75.52
Pruning regimes														
Pruned	197.3	372.8	38.2	87.8	5.9	7.2	0.441	4.05	0.036	0.66	1.97	1.96	1396.8	1068.9
Unprumed	251.8	395.6	38.3	90.3	6.5	8.0	0.441	4.07	0.037	0.66	1.95	1.83	1409.9	1148.6
CD (p=0.05)	17.69	55.37	NS	NS	0.49	2.13	NS	NS	NS	NS	NS	NS	NS	NS
Variety														
Sujata	219.2	381.6	40.9	106.3	5.2	6.7	0.445	4.12	0.038	0.68	1.86	1.76	1066.6	1066.6
GW-173	220.3	376.4	33.6	72.8	5.9	7.2	0.414	3.87	0.034	0.64	1.98	1.95	1113.0	1113.0
GW-273	229.0	379.6	38.0	76.2	7.2	8.8	0.417	3.85	0.035	0.62	2.13	2.06	1121.0	1121.0
HD-2004	229.6	399.3	40.3	100.8	6.6	7.7	0.488	4.38	0.039	0.64	1.87	1.81	1134.0	1134.0
CD (p=0.05)	3.50	10.86	8.41	1.85	0.11	0.20	NS	0.13	0.05	NS	0.10	0.94	16.41	16.41
Distance														
0.5 to 1 m	214.9	371.9	36.9	86.0	5.8	7.0	0.424	3.6	0.031	0.61	1.93	1.83	1106.5	1106.5
1to 3 m	223.8	384.9	38.0	89.2	6.2	7.5	0.452	4.1	0.037	.0.66	1.94	1.83	1109.6	1104.6
>3 m	234.9	396.4	39.8	91.9	6.6	6.3	0.447	4.3	0.041	0.70	2.02	2.95	1210.2	1210.2
CD (p=0.05)	3.42	9.40	1.15	1.73	0.09	0.17	NS	NS	0.005	NS	0.09	0.08	14.21	14.21

at 60 and 90 days, respectively. The PAR levels varied significantly in wheat plants at different distances from the tree trunk. Shading significantly reduced the amount of PAR intercepted by the crop and consequently crop yield. Similar results were observed by Thakur and Singh (2002) in the case of *Morus alba*, in which 75% canopy removal allowed more light transmission as compared to 0, 25 and 50% canopy removal. In another study, light intensity was minimum in *Acacia auriculiformis* without pruning, but the intensity underwent a sharp rise on pruning (Datta and Dhiman, 2001). Several studies have already proved that the light interception in tree-crop system is less as compared to open field (Hazra and Patil,1986; Devaranavadagi *et al.,* 2002). Photosynthetic active radiation in crop was gradually increased with increasing distances from tree base. Many other studies have revealed the adverse effect on growth and yield of crop by tree component in the tree-crop system under different level of stresses and caused by growth behavior and age of tree (Puri and Sharma, 2002; Chirwa *et al.,* 2003). Some previous studies showed that shading by Paulownia trees during reproductive growth of the wheat crop could significantly reduce the amount of incoming photo synthetically active radiation (PAR) available for the wheat crop from flowering to maturity, and possibly crop yield (Lu *et al.,* 1997).

Yield and its attributes of wheat crop in agri-silvicultural system: Tree spacing, variety and distance treatments had significantly influenced the effective tillers in the wheat, whereas, pruning did not show any significant effect on it. Except under 4x4 m tree spacing, the average number of effective tillers was significantly higher in intercrop than sole crop. Significantly a higher number of effective tillers (321.0 m^2) were obtained in HD-2004 variety and it was lowest (277.1 m^2) in GW-273, which was statistically at par with GW-173 variety. The distance from the tree base had a significant influence on effective tillers. Spike length was significantly higher in sole than intercrop (Table 2). In agri-silvicultural system, spike length was significantly higher (5.8 cm) in 4x8 m while it was lower (4.8 cm) in 4x4 m tree spacing. Spike length has reduced by 44.4 %, 41.8 % and 36.5 % in 4x4 m, 4x6 m and 4x8 m tree spacing, respectively, when compared with sole crop. The spike length was significantly lowered in wheat under unpruned compared to pruned trees. A higher spike length (5.2 cm) was observed in HD-2004 while it was lowest in GW-173 variety (4.7 cm). Spike length increased with increase in distance from the tree bases (48. 1 % at 0.5 to 1 m, 45.3% at 1 to 3 m and 34.5 % at > 3 m distances) when compared to sole crop. Both variety and distances

Table 2. Yield attributes of wheat varieties grown under *Ceiba pentandra* based agri-silvicultural system

Treatment	Number of effective tiller (m^2)	Length of spike^{-1} (cm)	Number of seed (spike^{-1})	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Tree Spacing							
4 x 4 m	266.0	4.8	22.7	29.1	24.9	39.1	36.6
4 x 6 m	292.4	5.2	23.3	29.7	25.4	40.0	38.8
4 x 8 m	314.0	5.8	24.2	29.7	28.7	43.5	39.0
Control	279.3	8.7	36.4	46.3	33.7	44.9	42.6
CD (p=0.05)	52.03	0.30	NS	NS	2.76	0.26	0.02
Pruning regimes							
Unpruned	286.6	4.5	22.3	28.9	24.8	38.2	39.5
Pruned	294.9	5.6	24.5	30.1	26.5	38.5	41.5
CD (p=0.05)	NS	1.05	NS	3.01	NS	NS	NS
Variety							
Sujata	289.8	5.0	23.3	29.6	26.4	41.5	38.5
GW-173	275.3	4.7	23.1	29.1	23.1	39.2	37.8
GW-273	277.1	4.9	22.4	28.9	24.0	39.7	37.6
HD-2004	321.0	5.2	24.9	30.4	29.1	44.5	39.4
CD (p=0.05)	2.39	0.24	0.93	0.76	0.66	0.65	0.95
Distance							
1 m	283.0	4.5	18.7	25.9	22.2	39.4	36.4
1to 3 m	239.5	4.7	23.9	28.3	25.7	40.5	38.7
>3 m	299.9	5.7	27.7	34.3	29.0	43.7	39.8
CD (p=0.05)	1.20	0.02	0.81	0.66	0.97	1.05	0.82

treatments significantly influenced the number of seed spike^{-1}, whereas, tree spacing and pruning treatments did not show any significant effect. Higher number seed spike^{-1} was found under sole wheat than intercrop. Number of seed spike^{-1} in the wheat ranged from 22.7 to 24.2 under different tree spacing. Among four wheat varieties HD-2004 recorded significantly higher number seed spike^{-1} in both sole and intercropping compared to other varieties. Significantly higher number of seed spike^{-1} (27.7) was found in wheat at > 3 m distance compared to 0.5 to 1 m distance from tree trunk (Table 2).

All treatments including tree spacing, variety and distance significantly influenced the grain yield of wheat, while tree pruning did not exert any significantly effect. Mean yield was significantly higher in sole crop 33.7 qha^{-1} compared to intercrop wheat. The grain yield increased with an increase in tree spacing. It ranged from 24.9 to 28.7 qha^{-1}. Grain yield has reduced by 26%, 24.6% and 14.8% in 4x4 m, 4x6 m and 4x8 m tree spacing, respectively, when compared to sole crop. Significantly a higher grain yield 29.1 qha^{-1} of wheat was observed in HD-2004 variety fallowed by Sujata (26.4 qha^{-1}), Gw-273 (24.1 qha^{-1}). The reduction of grain yield of wheat varieties in agri-silvicultural system compared to their sole crops was fallowed the order of 37% in Sujata, 18.3% in HD-2004, 14.9% in GW-173 and 14.3% in GW-273. Grain yield of wheat reduced near to tree bases and it gradually increased with an increase in distance from the trees. Grain yield had reduced by 34%, 23.7% and 13.9% at 0.5 to 1, 1 to 3 m and >3 m distance, respectively in comparison to sole crop. There was reduction in the agricultural yield in agri-silvicultural system due to competition for light water and nutrients among trees and agricultural crops. The study from Newaj *et al.* (2003), Sharma and Chauhan (2003), Chauhan *et al.* (2010 and 2011) showed that the grain yield of pure crop was higher than under the tree-crop intercropping systems. Overall the reduction in the yield of intercrops due to presence of trees may be attributed to differential patterns of canopy spread resulting in variation in light interception (shade effects) and competition of the tree roots for nutrients and moisture. Wheat grain yield of the four varieties tested revealed significant inter-varietal and intra-environmental differences. Variety HD-2004 performed the best followed by Sujata, GW-273 and GW-173 under *Ceiba* plantation. Variation in wheat yield under *Ceiba* may be attributed to inter-varietal differences (genetic) in respect of response variety to shade and stress of nutrient and moisture caused by trees. The straw yield followed the trend of grain yield. Harvest index was highest in sole crop compared to all treatments of intercrop. In agri-silvicultural, harvest index was highest 39.0 % in 4x8 m, whereas, it was lowest in 36.6 % in 4x4 m tree spacing. It reduced by 13 % in 4x4 m, 9.8 % 4x6 m and 9 % in 4x8 m when compared to sole crop. Among wheat varieties HD-2004 had highest harvest index 39.8%, while lowest in 37.6% GW-273 variety. Highest harvest index was found at > 3m distance and lowest 0.5 to 1 m distance from tree base.

Growth and yield *Ceiba pentandra*: In the present study, the three planting spacing of *C. pentandra* showed variability with respect to crown closure. The crown closure was seen in the 4x4 m spacing only, indicating that the initial rate of growth in trees was same. The narrow spacing is good in early stages because of high total volume accumulation, but narrow spacing usually restrains the growth of individual's trees. Also the narrow spacing leads to competition for resources (light, nutrients, and water). The above ground competition was not evident (as growth rate was same in three spacing), there seems to be below ground competition. Growth in the tree stands of *C. pentandra* revealed that tree height, crown length and crown width were significantly influenced by different tree densities of *C. pentandra* while none of the other tree growth parameters exhibited any significant variations (Table 3). Swamy *et al.* (2003a) also reported non-significant variation in growth character due to different tree densities in the four year old stands *Gmelina arborea.* Tree heights was higher in dense (4x4 m) compared to open 4x8 m stands. This may be due to less competition among the widely spaced tree especially for light, where inadequate lights conditions provide trees to grow taller in dense stands. The ability of tree to grow taller in dense stands was evident and confirmed with findings of Ajit *et al.* (2001), where the trees height was recorded significantly more in higher density (800 and 400 tree ha^{-1}) compared to low density (200 tree ha^{-1}) in agri-silvicultural stands of *Hardwickia binnata*. In contrary to height growth, diameter at breast height (DBH) was higher in tree growing under wider spacing, while it was lower in narrow tree spacing of *C. pentandra.* The other growth parameter like crown width and crown length were also higher in wider spaced trees. These findings are line with Puri *et al.* (1994), where tree spacing had significant affected both crown length and its width. However pruning treatments significantly influenced the crown length but it did not show any effect on the crown width. Both parameters were significantly higher at 4x8 m spacing compared to other tree spacing. Significantly higher crown length 4.9 cm was attained by unpruned stands, where it was almost reduced by 30% in pruned trees. Leaf area index was also significantly higher in narrow tree spacing to wide tree spacing. A reduction of 15% in LAI was observed at 4x6 m and 13.6% at 4x8 m spacing as compared to 4x4 m spacing.

Table 3. Growth and yield of *Ceiba pentandra* in different tree spacing and pruning regimes in agri-silvicultural system

Treatment	DBH (cm)	Height (m)	Crown length (m)	Crown width (m)	Leaf area index	PAR µ mol m^2s^1	No. of pod /tree	Pod diameter cm	Pod length cm	Seed yield q^{ha-1}	Floss yield q^{ha-1}
Tree Spacing											
4 x 4 m	16.56	8.29	4.18	3.54	3.36	1208.1	190.2	5.23	13.5	9.62	7.62
4 x 6 m	16.28	7.49	3.85	3.98	2.84	1224.6	157.0	5.01	15.2	7.62	3.59
4 x 8 m	17.04	7.55	4.63	5.22	2.90	1239.6	140.6	4.86	14.0	5.37	2.75
CD (p=0.05)	NS	0.762	0.74	0.45	0.36	NS	6.55	0.086	0.51	6.51	3.54
Pruning Regimes											
Unpruned	17.60	8.02	4.98	4.40	3.05	1173.0	181.9	5.41	13.6	9.91	6.98
Pruned	15.65	4.09	3.46	4.10	3.03	1275.2	143.3	4.67	14.8	6.63	3.59
CD (p=0.05)	1.27	0.42	0.61	NS	NS	45.38	5.35	0.072	0.42	5.32	4.07

PAR ranged from 1208 to 1239 µ mol m^2s^1 in different tree spacing. PAR reduced by 15% in 4x6 m and 13.6% 4x8 m spacing as compared to 4x4 m spacing. These findings are similar to earlier reports. Swamy *et al.* (2003b) reported significantly higher LAI in stands planted at closer spacing (2x2m and 2x3m) compared to stands at wide spacing (2x4 m and 2x5 m) in *Gmelina arborea,* whereas, PAR was higher at wide spacing. The study also confirmed the inverse relationship between LAI and PAR, which was also reported in the past by Puri *et al.* (2002). A pod $tree^{-1}$ was significantly higher at 4x4m spacing and it decreased with an increase in tree spacing. Due to pruning almost 21% of pods $tree^{-1}$ had reduced. Pod diameter was highest 5.2 cm in 4x4 m tree spacing, while pod length was maximum 15.2 cm in 4x6 m tree spacing. Pod diameter 5.4 cm was highest in unpruned plot, whereas, pod length was maximum 14.8 cm in pruned plot. Floss and seed yield ranged from 2.75 to 7.62 q ha^{-1} and seed yield 5.37 to 9.62 q ha^{-1} in different tree spacing of *Ceiba*. Highest floss and seed yield was obtained in 4x4 m while lowest in 4x8 m spacing. Seed yield reduced by 63% and 52%, and floss yield by 44% and 20 % in 4x8 m and 4x6 m tree spacing. This is evident from the fact that the trees growing under narrow spacing (4x4 m) flowered heavily, which ultimately produced more pods and floss. Floss and seed yield were significantly highest in 4x4 m spaced trees while lowest in 4x8 m spacing. Seed yield reduced by 63% and 52% and floss yield by 44% and 20% in 4x8 m and 4x6 m tree spacing, respectively compared to 4x4 m tree spacing. The lower floss yield may be attributed to lower age of the stand.

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Growth and Yield of Soybean (*Glycine max*) Varieties as Influenced by Sowing Time

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Abstract: Field experiments were conducted to study the influence of four sowing dates (June 5, June 20, July 5 and July 20) on the symbiotic efficiency, thermal requirement, growth, productivity and economics of three varieties (PS 1347, SL 525 and SL 744) of soybean. The seed yield was significantly higher in June 5 sowing (2244 kg ha^{-1}) than June 20 and July 5 and 20. The early sowing gave significantly higher gross returns, net returns and B:C ratio than the other sowing dates. Number of nodules and their dry weight, days to 50% flowering and maturity, accumulated growing degree days, heliothermal units and photothermal units decreased with each successive delay in sowing. The variety SL 744 recorded significantly higher seed yield (2050 kg ha^{-1}) than SL 525 and SL 1347 and provided higher net returns. SL 744 performed better in terms of accumulation of growing degree days, photothermal units and heliothermal units than SL 525 and PS 1347.

Key Words: Agroclimatic indices, Economics, Nodulation, Sowing dates, Soybean, Varieties

Soybean [*Glycine max* (L.) Merr.] was cultivated on an area of 10.59 million hectares, with a production of 12.95 million tonnes and productivity of 1192 kg ha^{-1} during 2012 (INDIASTAT, 2014). Sowing date, as environment, has a pronounced effect on the growth and development of plants. Optimum sowing date ensures optimal utilization of the climatic factors for the time of flowering, maturity and dry matter production. Different soybean genotypes may not require the same critical day length. Therefore, the effect of planting date on the number of days to flowering, maturity and dry matter production may be different for different genotypes. As it is a subtropical legume, root zone temperature of 25-30 °C is optimum for both nodulation and efficient nodule functioning. Several phenological models have been prepared to predict the duration required to attain different phenophases by using growing degree days (GDD), photothermal units (PTU) and other crop thermal units (Esfandiary *et al*., 2009). GDD and PTU are good estimators of growth stages in different crops and finally to predict the yield in view of different climatic changes. In order to overcome the detrimental effect of temperature as well as sunshine hours during reproductive development of crop, there is a need to choose a specific cultivar for a particular sowing time. This screening of cultivars is done by using phenological models, prepared from GDD and other thermal units. Therefore, the present investigation was carried out to study the influence of different sowing dates on symbiotic efficiency, thermal requirement, growth and yield of soybean varieties.

MATERIALS AND METHODS

Field experiment was conducted during *kharif* (rainy season) 2009, 2010 and 2011 at Punjab Agricultural University, Ludhiana (30° 54´N, 75° 48´E, altitude 247 m), India. The soil of the experimental site was low in organic carbon (0.24), low in available nitrogen, medium in available phosphorus (33.5 kg ha^{-1}) and potassium (222.5 kg ha^{-1}) with a pH of 8.4. Weekly weather data were recorded during the crop growth period (Fig. 1). A rainfall of 864.3 mm (28 rainy days), 608.7 mm (30 rainy days) and 1157.6 mm (34 rainy days) was received during *kharif* season in 2009, 2010 and 2011, respectively.

The experiment was laid out in split plot design with four replications. The treatments included four dates of sowing (June 5, June 20, July 5 and July 20) in main plots and three varieties (PS 1347, SL 525 and SL 744) in sub plots. Each sub plot measured 4.0 m × 2.7 m in 2009 and 5.0 m × 3.6 m in 2010 and 2011. The crop was raised with the recommended package of practices (PAU, 2009).

Days taken to 50% flowering and maturity were recorded for each variety sown under different dates. Growing degree days were determined as per Nuttonson (1955):

$$GDD = \frac{T_{max} + T_{min}}{2} - T_b$$

Where, Tmax, maximum temperature (°C) during a day

Tmin, minimum temperature (°C) during a day

T_b, base temperature of 10.0 °C

Heliothermal units (HTU), the product of GDD and

corresponding actual sunshine hours for that day. Photothermal units (PTU), the product of GDD and corresponding day length (maximum possible sun shine hours) for that day were computed on daily basis. Heat use efficiency was calculated by using the formula i.e.,

$$\text{Heat use efficiency (HUE)} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Accumulated heat units (}^{o}\text{C day)}}$$

Growing degree days, heliothermal units and photothermal units were accumulated from the date of sowing to 50% flowering and maturity to give accumulated indices. Heat use efficiency was calculated after harvesting of the crop.

Observations for number and dry weight of nodules were recorded at 80 days after sowing from five randomly selected plants. The nodules oven dried at 60°C for 2 days and their dry weight was recorded. Data on plant height and pods per plant were recorded at harvest from randomly selected five plants from each plot. Biological yield and seed yield was recorded on the plot basis. Straw yield was obtained by subtracting seed yield from biological yield. The data on 100-seed weight were recorded after taking 100 randomly selected seeds. Harvest index was calculated by dividing seed yield by biological yield and multiplied by 100. Gross returns, net returns as well as benefit : cost (B:C) ratio were also worked out using prevailing prices of inputs and output. The cost of cultivation (Rs16,695 ha^{-1}) was the same for all the treatments.

RESULTS AND DISCUSSION

Effect of date of sowing: Sowing date had substantial effect on days to 50% flowering and maturity of soybean (Table 1). Early planted (June 5) soybean took maximum days to 50% flowering and maturity. A steady decrease in number of days to 50% flowering and maturity was observed as the sowing was delayed. Lesser days to maturity with delay in sowing may be due to quick changes in photoperiod and temperature.

Early sown crop required higher agroclimatic indices as compared to late sown crop in all three years of the study (Table 1). The timely-sown crop used heat more efficiently than late-sown crop, resulting in highest seed yield under June 5 sowing and it showed a significant reduction with each delay in sowing from June 5 to July 20. It is also supported by the weather data of different years that during

Table 1. Effect of dates of sowing and varieties on different agroclimatic indices i.e. GDD, HTU, PTU (^{o}C day) and heat use efficiency (kg ha^{-1o}C^{-1} day) of soybean crop

Year	Treatment		50% flowering				Physiological maturity				
			DAS	AGDD	AHTU	APTU	DAS	AGDD	AHTU	APTU	HUE
2009	Date of sowing	June 5	78	1655	13584	22915	144	2772	22925	36478	0.71
		June 20	67	1419	11555	19453	130	2453	20214	31925	0.66
		July 5	57	1180	8461	15987	114	2109	16442	27111	0.64
		July 20	49	991	6647	13175	100	1806	13689	22844	0.30
	Variety	PS 1347	63	1303	10001	17763	122	2286	18330	29594	0.46
		SL 525	61	1275	9768	17422	121	2274	18217	29472	0.59
		SL 744	65	1356	10417	18463	123	2295	18405	29703	0.69
2010	Date of sowing	June 5	76	1590	9828	22041	145	2774	17058	36309	0.76
		June 20	66	1376	7149	18912	131	2463	13979	32089	0.79
		July 5	56	1125	5870	15257	119	2345	12221	27600	0.80
		July 20	48	976	5081	12981	119	2096	11972	25166	0.74
	Variety	PS 1347	65	1328	7336	18087	130	2363	13861	30399	0.64
		SL 525	60	1236	6805	16903	127	2334	13700	30076	0.77
		SL 744	60	1236	6805	16903	130	2363	13861	30399	0.91
2011	Date of sowing	June 5	72	1475	8618	20502	144	2711	17274	35609	0.97
		June 20	66	1320	6961	18140	129	2395	14502	31130	0.99
		July 5	58	1158	5941	15679	115	2210	12995	27074	0.99
		July 20	49	978	4291	13005	103	1839	11292	23170	0.74
	Variety	PS 1347	64	1274	6554	17353	123	2269	14063	29309	0.85
		SL 525	60	1208	6379	16515	122	2252	13922	29119	0.93
		SL 744	61	1217	6425	16627	123	2269	14063	29309	0.99

the month of June the maximum temperature and sunshine hours were higher as compared to July (Fig. 1) and early sown crop acquired more heat units as compared to late sown crop. Among four dates of sowing of the soybean crop, June 5, June 20 and July 5 sowings accumulated more heat units, resulting in more heat use efficiencies than July 20 sowing.

On the basis of pooled mean data, nodule number and their dry weight were significantly higher in June 5 and 20 sowings than in July 5 and 20 sowings (Table 2). The June 5 and 20 sowings were at par in number as well as dry weight of nodules. Plant height was significantly affected by the sowing dates; the June 5 sowing had the highest and July 20 the lowest plant height. It indicated that in early sowing there was sufficient time for the crop to exploit the soil and environmental resources for vegetative development compared to late sowing. Delay in sowing reduced the pods plant^{-1} significantly with higher values under June 5 sowing than the other sowing dates. Delay in sowing reduced the vegetative and reproductive period (Table 1), which might have caused the reduction in growth and development and ultimately reduced the number of pods plant^{-1}. Different sowing dates did not affect the 100-seed weight significantly.

The June 5 sowing produced the maximum seed yield (2244 kg ha^{-1}), which was significantly higher than the other sowing dates. The seed yield in June 20 and July 5

Table 2. Effect of date of sowing and varieties on nodulation (pooled mean of 2 years), plant characters, yield, harvest index and economics of soybean (pooled mean of 3 years)

Treatment	Number of nodules plant^{-1}	Dry weight of nodules (mg plant^{-1})	Plant height (cm)	Pods plant^{-1}	100-seed weight (g)	Straw yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Date of sowing											
June 5	35.3	173.2	62.0	57.5	10.55	3467	2244	38.9	49386	32691	2.95
June 20	35.3	171.1	53.1	46.9	10.88	2724	1976	41.0	43462	26767	2.60
July 5	30.2	160.3	50.6	42.7	10.92	2444	1812	42.3	39869	23174	2.39
July 20	27.1	151.7	36.7	27.5	10.73	1654	1153	40.5	25366	8672	1.52
CD (p=0.05)	2.9	5.9	3.4	2.3	NS	207	110	NS	2421	2421	0.14
Variety											
PS 1347	31.7	161.1	40.7	40.2	10.91	2241	1544	40.6	33962	17267	2.03
SL 525	33.1	166.4	52.9	44.1	10.42	2607	1795	39.8	39489	22794	2.36
SL 744	30.9	166.7	58.2	46.7	10.98	2869	2050	41.7	45110	28415	2.70
CD (p=0.05)	NS	NS	2.4	1.7	0.24	198	87	NS	1919	1919	0.11

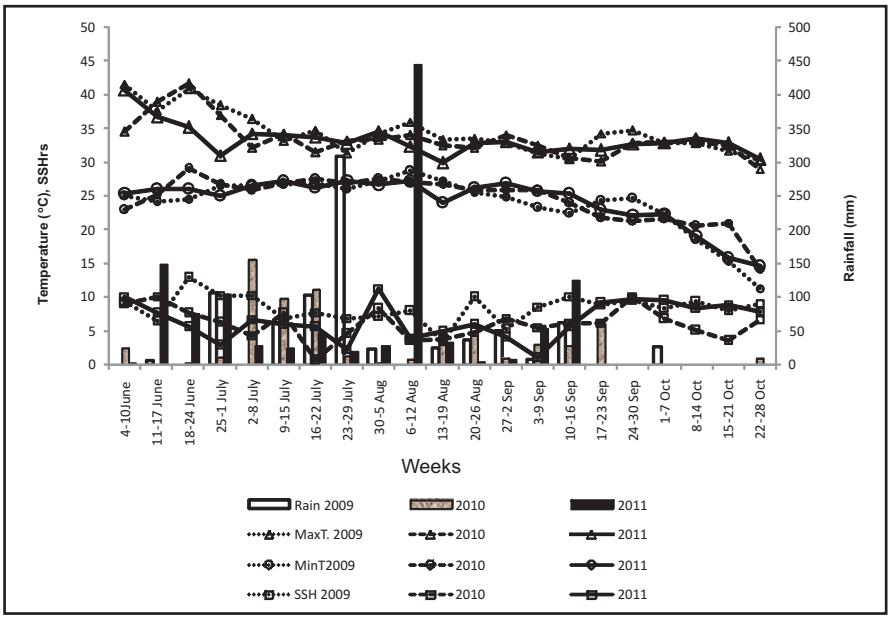

Fig. 1. Weekly mean weather conditions in 2009, 2010 and 2011 during the soybean crop season

sowing was at par and significantly higher than July 20 sowing. The June 5 sowing registered 13.6, 23.8 and 94.6 per cent higher seed yield over June 20, July 5 and 20 sowings, respectively. Early sowing (June 5) gave the highest seed yield possibly due to more pods plant^{-1}. Lower seed yield in delayed sowing could possibly be due to less time available for vegetative and reproductive development as the plant completed its life cycle in a short duration. Earlier researchers (Ahmed *et al*., 2010; Rekha and Dhurua, 2010; Moosavi *et al*., 2011; Ngalamu *et al*., 2012) have also pointed out that sowing date plays an important role in soybean productivity. The June 5 sowing had significantly higher gross returns, net returns and B:C ratio, whereas, July 20 sowing had the lowest (Table 2) due to higher seed yield. The June 5 sowing gave higher net returns.

Performance of varieties: SL 525 took less number of days to 50% flowering as compared to SL 744 and PS 1347 (Table 1). However, all varieties took almost the same number of days to maturity. During the three years of study, SL 744 performed better and can be considered as more thermo-tolerant than other varieties in terms of accumulated GDD, PTU and HTU and having highest HUE. On the other hand, PS 1347 can be considered as thermo-sensitive as it did not utilize heat units efficiently and showed lowest HUE. On the basis of pooled data, varieties did not differ significantly in nodule number and their dry weight (Table 2). SL 744 attained significantly higher plant height than SL 525 and PS 1347. The pods plant^{-1} was significantly affected by different varieties and it was significantly higher in SL 744 than SL 525 and PS 1347, which probably is due to genetic potential. The 100-seed weight of SL 744 was significantly higher than SL 525, which was, however, at par with PS 1347. The highest straw yield was recorded in variety SL 744, which was significantly higher than SL 525 and PS 1347 and directly related to plant height. The variety SL 744 recorded significantly higher seed yield than the other varieties. SL 744 gained 14.2 and 32.8% higher seed yield over SL 525 and SL 1347, respectively. The seed yield of SL 744 was higher due to higher pods plant^{-1} and 100-seed weight. Ram *et al.* (2011) also reported that the soybean variety SL 744 showed superiority over SL 525 in terms of yield attributing characters and seed yield. Genotypic differences in yield and other characters were also reported by other researchers (Billore *et al*., 2009 and Shegro *et al*., 2010). Harvest index differed non-significantly by different varieties. Any stress during anthesis and seed development is the major constraint of productivity so timely-sown and thermo tolerant varieties produced higher seed yield by using accumulated heat units efficiently. A significant polynomial relationship was also observed (Fig. 2) between seed yield and growing degree days (R^2 = 0.53) and a significant power function was observed (Fig. 3) between seed yield and heat use efficiency (R^2 = 0.91). Thus, these equations can be a useful tool in predicting growth behavior of soybean crop.

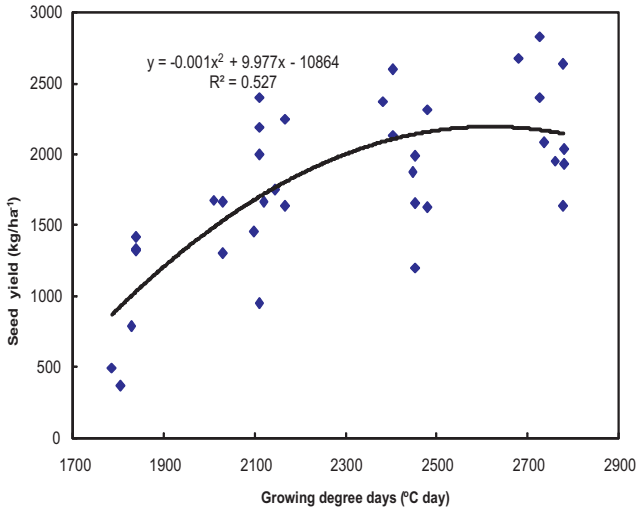

Fig. 2. Relationship between accumulated growing degree days and seed yield in soybean

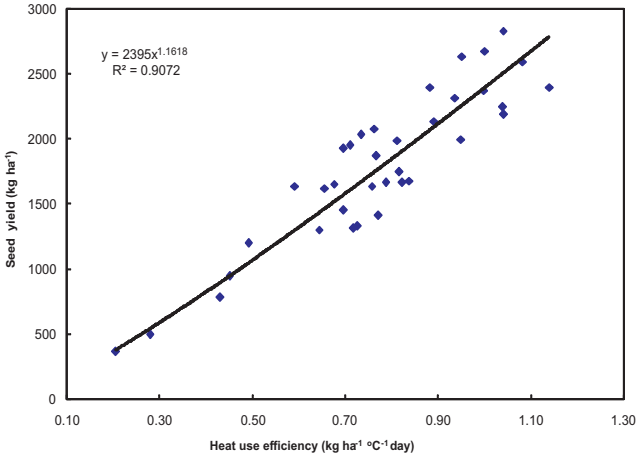

Fig. 3. Relationship between heat use efficiency and seed yield in soybean

Gross returns, net returns and B:C ratio were significantly higher in SL 744 than in SL 525 and PS 1347 (Table 2), which could be due to its higher seed yield. PS 1347 provided the least returns. June 5 is the optimum time of sowing of soybean and SL 744 is the most promising variety with respect to seed yield and economics.

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Performance of Spring Maize (*Zea mays* L.) under Different Drip Irrigation and Fertigation Levels

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Abstract: The field experiment was carried to study the effect of different drip irrigation and fertigation levels on water use efficiency and yield of PMH-1 var. of spring maize (*Zea Mays L.*). Drip irrigation with 0.80 times ET_{crop} and fertigation with 80% of recommended NPK gave higher yield (51.10 q ha^{-1}). There was 28.07 % increase in yield as compared to conventional method. The water use efficiency was 1.57 q ha^{-cm} as compared to 0.66 q ha^{-cm} in conventional method.

Key Words: Drip irrigation,Fertigation, Spring maize, Yield

Cereal grains are important sources of carbohydrates, protein, vitamins and minerals for an ever increasing world population. Maize, the queen of cereals occupies a pride place among cereal crops in India. It is a major crop for both direct and indirect human consumption and a cheap source of raw material for various agro-based industries and extensively used for preparation of corn starch. The maize crop has a wide adaptation and is able to grow in regions ranging from the semiarid, with an annual rainfall of 20 to 25 cm to those where annual rainfall may exceed 400 cm (Abuzar *et al*., 2011). It is one the most efficient crops, which can give high biological yield as well as grain yield in a short period of time due to its unique photosynthetic mechanism. It ranks after wheat and rice as the third most important cereal crop in the world considering total area and production. In Punjab, maize is grown mainly as a kharif crop and in some areas as winter crop. Its cultivation during spring has been exploited very recently. Sowing of maize in spring season is profitable as the yield in spring season is as high as in kharif season, there is limited proneness to disease during this season which otherwise reduces the yield, market price is generally higher for spring maize as compared to kharif crop (Verma and Mishra, 1998). Assured irrigation is very important during spring season as total water requirement is to be met only through irrigation in the absence of rains. Due to very high evaporative demand during the crop season (February to June) water stress even for a short period can adversely affect the growth and yield of maize. Wild flooding, furrow and raised bed methods of irrigation are commonly used for irrigation of spring maize crop. These methods of irrigation result in high water loss and lower irrigation efficiencies and thus creating the drainage and salinity problems. Optimizing rate of water application to the crop is important for conserving water (Ramulu *et al,* 2010). Drip irrigation is the most effective method in terms of both maximizing yield and water conservation as well as providing efficient use of limited water (Cetin and Bilgel, 2002). By introducing drip fertigation, it is possible to increase the yield of crops by three times from the same quantity of water (Viswantha *et al*., 2002). Maize responds well to the management practices like irrigation and nitrogen. However, poor water supply or excessive irrigation will result in unavailability or leaching of nitrogen resulting in its poor efficiency (Sridhar *et al.,* 1991). So, the present experiment was planned to study the effect of different drip irrigation and fertigation levels on yield, water use parameters, growth parameters and quality parameters of spring maize.

MATERIAL AND METHODS

A field experiment was carried out at the research farm of Department of Soil and Water Engineering, Punjab Agricultural University, Ludhiana, located at an altitude of 247 meters above sea level during spring season of the year 2012. The region is characterized by a sub tropical and semi-arid climate. Average annual rainfall is approximately 700 mm of which about 70% is received during monsoon. The experimental soil was sandy loam with pH 8.5, low in available nitrogen (124 kg per ha), organic matter (0.15%), medium in available phosphorus (16.75 kg per ha) and available potassium (307.50 kg per ha). The experiment was laid out in split plot design with three replications with plot size of 33.6m^2 with three drip irrigation levels (1.0, 0.8 and 0.6 times crop evapotranspiration (ET_{crop}) i.e. I1, I2 and I3, respectively) in the main plots and four fertigation levels

(120%, 100%, 80% and 60% of the recommended dose of N, P and K i.e. F1, F2, F3 and F4, respectively) in the sub plots. Furrow irrigation with manual application of fertilizer was considered as conventional treatment (CT). Paired row planting was used under drip irrigation treatments and single row planting was used under conventional treatment. The recommended dose of nitrogen (N), phosphorous (P_2O_5) and potassium (K_2O) were 125 kg, 60 kg and 20 kg per ha, respectively for spring maize. Irrigation to different drip treatments was given every 2nd day for the whole season using inline drippers. The daily ET values for the crop season were calculated using Modified Penman method based upon daily meteorological data collected from the School of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. Fertigation was done with every 3rd irrigation throughout the crop season. N fertilizer was applied in the form of Urea, P_2O_5 in the form of Mono Ammonium Phosphate (MAP) and K_2O in the form of Muriate of Potash (MOP, white) by using fertilizer tank. The PMH-1 variety of spring season was sown on 10th February, 2012 at inter row of 60 cm and plant to plant spacing of 30 cm and harvested on 2nd June 2012. The observations on plant height, leaf area index (LAI) and percentage ground cover were recorded in the field at different intervals of time upto harvesting. Grain yield, stover yield, harvest index and water use efficiency were also recorded at the time of harvest. The quality parameters i.e. protein, starch and oil content of grains were estimated. Total monthly rainfall and mean temperature data during the spring maize growing period are presented in Table 1. The total rainfall from February to May was 41.4 mm, which corresponds to about 8% of the annual rainfall of year 2012, which is insufficient for spring maize production as expected.

Table 1. Mean air temperature and total monthly rainfall during spring maize crop growing season (2012)

Month	Mean air temperature°(C)	Monthly rainfall (mm)
February	13.75	1.2
March	19.35	0
April	25.95	38.6
May	31.10	1.6
Total		41.4

RESULTS AND DISCUSSION

Plant height of spring maize at harvest exhibited non-significant effect due to interaction of irrigation and fertigation treatments (Table 2). Also the correlation analysis values showed a strong and positive relation between plant height at harvest and grain yield. Such association is further supported by regression model, which showed dependence of grain yield on plant height (Fig. 1). The leaf area index attained the highest value at around 75 days after sowing (DAS). The highest mean leaf area index (4.72) was recorded with the I2F3 treatment. This was closely followed by I1F3, I2F2. The increased plant height in the above mentioned treatments provided more space for formation of new leaves, which in turn increased leaf area index. Fig. 2 indicates that there is a positive linear relationship between the leaf area index at harvest and the grain yield of spring maize crop. The percentage ground cover increased till 75 DAS for all the treatments with different rates and after that it decreased marginally. This decrease was because of lesser number of green leaves at maturity causing reduction in leaf area and subsequently percentage ground cover. The highest percentage ground cover (92.23) after 75 DAS was recorded for the treatment I2F3, which was followed by I1F3 (Table 2).

Yield: The grain yield and stover yield varied significantly due to irrigation, fertigation and their interaction. Of all the drip irrigated treatments, the grain yield of 51.10 q ha^{-1} was found higher in I2F3 treatment. This might be due to moisture at optimum level enhanced the cell metabolism resulting in better yield. The fulfillment of crop nutrient requirements at various stages with minimum leaching of fertilizers in the root zone might had resulted in maximum yield. Increased stover yield of 128.85 q ha^{-1} in I2F3 treatment might be due to the sufficient plant water content that helped the plants to accumulate higher dry matter due to higher growth parameters. The grain yield (32.0 q ha^{-1}) and stover yield (98.10 q ha^{-1}) under conventional treatment was found less than all the treatments under drip irrigation and fertigation treatments. Harvest index did not vary significantly in different treatments.

Water use parameters: The total depth of irrigation water applied was 37.99 cm in I3 treatment, which was less than I2 (50.65 cm) and I1 (63.31 cm). In conventional treatment, the depth of irrigation water applied was 84.47 cm. This results in water saving over conventional irrigation i.e. in I3 treatment (55.03%) followed by I2 (40.04%) and I1 (25.05%). The higher water use efficiency in I3F1 could be attributed to relatively higher yield and lower depth of irrigation water applied. Similarly, the reason for higher water use efficiency in I2F3 was due to higher grain yield and relatively lower irrigation water applied. The water use efficiency (0.38 q/ha-cm) under conventional treatment was found less than all the treatments under drip irrigation and fertigation.

Quality parameters: The starch and oil content almost increased with decrease in fertigation levels and were highest in I3F4 (74.10% and 4.8%, respectively). The inverse

Table 2. Effect of different drip irrigation and fertigation levels on growth parameters of spring maize at the time of harvest

Treatments	Plant height (cm)				Leaf area index				Percentage ground cover (%)			
	45	60	75	At harvest	45	60	75	At harvest	45	60	75	At harvest
I1	58.45	90.52	149.48	184.75	0.79	2.78	4.57	2.73	36.85	75.01	82.23	70.05
I2	60.00	93.17	151.62	191.43	0.85	2.85	4.63	2.81	38.46	79.13	88.07	73.55
I3	54.23	87.99	143.10	177.29	0.68	2.66	4.46	2.59	31.88	67.29	76.17	64.59
CD (p=0.05)	3.83	2.25	2.05	6.29	0.05	0.03	0.07	0.08	3.23	4.82	3.89	5.72
F1	57.60	90.53	148.17	184.82	0.78	2.74	4.57	2.67	35.61	74.86	81.80	68.69
F2	58.27	90.93	148.72	185.43	0.78	2.78	4.61	2.72	36.29	75.71	83.52	72.12
F3	59.59	92.60	150.92	188.45	0.83	2.83	4.61	2.81	38.78	76.12	85.92	72.88
F4	54.78	88.18	144.46	179.26	0.71	2.70	4.42	2.65	32.24	68.54	77.37	63.89
CD (p=0.05)	NS	2.22	2.70	5.02	0.06	0.07	0.08	0.08	NS	5.89	5.66	6.11
I1F1	57.90	90.20	151.60	182.33	0.78	2.76	4.56	2.63	39.68	74.36	82.65	69.65
I1F2	58.03	90.90	148.79	185.90	0.79	2.77	4.55	2.68	34.90	75.57	83.09	72.98
I1F3	61.79	93.26	153.86	193.80	0.91	2.92	4.7	2.9	41.34	81.34	88.01	76.87
I1F4	56.08	87.73	143.67	176.97	0.68	2.67	4.45	2.72	31.48	68.78	75.17	60.68
I2F1	58.45	92.00	146.96	190.12	0.83	2.78	4.63	2.77	34.07	77.47	86.98	70.56
I2F2	60.09	92.80	151.93	190.50	0.85	2.87	4.67	2.86	40.00	80.64	88.00	75.23
I2F3	63.24	96.07	156.57	196.00	0.92	2.95	4.72	2.93	44.02	83.57	92.23	78.04
I2F4	58.23	91.80	151.02	189.10	0.8	2.81	4.5	2.69	35.73	74.85	85.06	70.36
I3F1	56.46	89.40	145.95	182.00	0.72	2.69	4.53	2.61	33.07	72.75	75.78	65.86
I3F2	56.68	89.10	145.45	179.90	0.69	2.71	4.6	2.62	33.97	70.93	79.47	68.14
I3F3	53.75	88.47	142.32	175.54	0.65	2.63	4.40	2.59	30.98	63.46	77.52	63.72
I3F4	50.02	85.00	138.69	171.70	0.65	2.62	4.32	2.53	29.50	62.00	71.89	60.64
CD (p=0.05)	NS	NS	4.68	NS	NS	NS	0.14	0.13	NS	NS	NS	NS
Conventional method	44.39	73.96	120.46	153.00	0.65	2.12	3.96	2.09	25.05	58.49	72.23	57.00

Table 3. Effect of different drip irrigation and fertigation levels on grain yield and water use efficiency of spring maize

Parameters	Treatments*	I1	I2	I3	Mean	Conventional method
Grain yield (qha^{-1})	F1	40.20	44.30	38.40	40.97	
	F2	41.29	48.59	36.80	42.23	
	F3	50.50	51.10	34.11	45.24	32.00
	F4	35.69	43.90	34.10	37.90	
	Mean	41.92	46.97	35.85		
	CD (p=0.05)	I= 1.78	F= 1.71	I × F= 2.97		
Stover yield(q ha^{-1})	F1	117.98	120.97	109.29	116.08	
	F2	118.32	125.46	105.67	116.48	
	F3	127.76	128.85	102.34	119.32	98.10
	F4	104.56	118.84	100.02	107.80	
	Mean	116.91	123.53	104.33		
	CD (p=0.05)	I= 8.71	F= 4.88	I × F= 8.46		
Harvest index (%)	F1	25.46	26.81	25.99	26.09	
	F2	25.90	27.92	25.84	26.55	
	F3	28.37	28.39	25.01	27.29	24.6
	F4	25.45	27.00	25.45	25.97	
	Mean	26.32	27.53	25.57		
	CD (p=0.05)	I= 0.66	F= NS	I × F= NS		
WUE (qha^{-cm})	F1	0.63	0.87	1.01	0.84	
	F2	0.65	0.96	0.97	0.86	
	F3	0.80	1.01	0.90	0.90	0.38
	F4	0.56	0.87	0.90	0.78	
	Mean	0.66	0.93	0.95		
	CD (p=0.05)	I= 0.04	F= 0.04	I × F= 0.06		

*I, I2, I3 are drip irrigation levels (1.0, 0.8 and 0.6 times crop evapotronspiration; F1, F2, F3 and F4 are fertigating levels (120, 100, 80 and 60 per cent of recommended dose of N P & K)

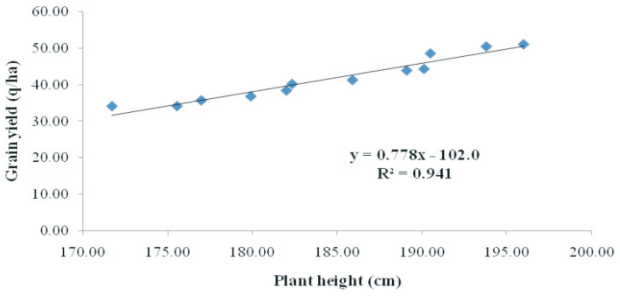

Fig. 1. Relationship between plant height at harvest stage and grain yield (q ha^{-1}) in maize

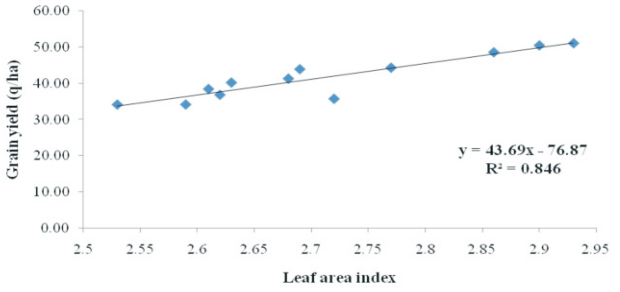

Fig. 2. Relationship between leaf area index at harvest stage and grain yield (q ha^{-1}) in maize

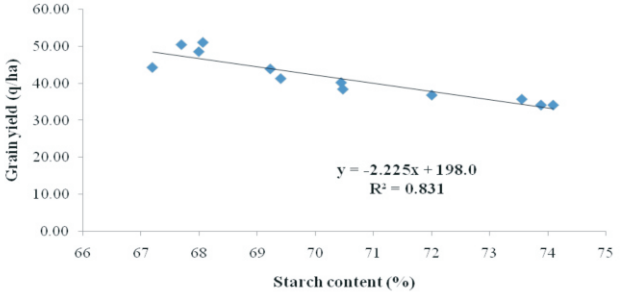

Fig. 3. Relationship between starch content and grain yield (q ha^{-1}) in maize

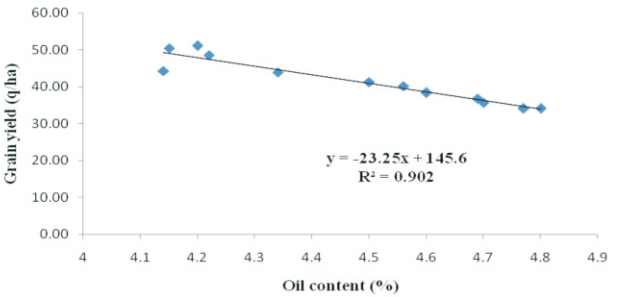

Fig. 4. Relationship between oil content and grain yield (q ha^{-1}) in maize

Table 4. Effect of different drip irrigation and fertigation levels on quality parameters of spring maize

Parameters	Treatments	I1	I2	I3	Mean	Conventional method
Starch content (%)	F1	70.45	67.20	70.48	69.38	
	F2	69.41	68.00	72.01	69.81	
	F3	67.70	68.07	73.89	69.89	60.03
	F4	73.56	69.23	74.10	72.30	
	Mean	7.028	68.13	72.62		
	CD (p=0.05)	I= 1.92	F= 1.22	I × F= 2.12		
Oil content (%)	F1	4.56	4.14	4.60	4.43	
	F2	4.5	4.22	4.69	4.47	
	F3	4.15	4.20	4.77	4.38	3.96
	F4	4.7	4.34	4.80	4.61	
	Mean	4.48	4.23	4.72		
	CD (p=0.05)	I= 0.20	F= 0.16	I × F= NS		
Protein content (%)	F1	8.3	9.12	7.9	8.44	
	F2	8.25	9.1	7.7	8.35	
	F3	9	8.98	7.23	8.40	7.02
	F4	7.48	8.6	7.21	7.76	
	Mean	8.26	8.95	7.51		
	CD (p=0.05)	I= 0.11	F= 0.28	I × F= 0.48		

relationship exists for starch content and oil content with fertilizer application. This decrease in starch content in grains with increasing nitrogen was due to more biosynthesis of carbohydrates into protein content and thus decreasing starch content. The decrease in oil content in grains may be due to better supply of nitrogen which increases the formation of N containing protein and this protein formation competes strongly for photosynthates. A negative relation was noted for both starch and oil content with grain yield (Fig. 3 and 4). Protein content increased with increase in fertigation levels. This might be due to higher nitrogen uptake by the plants in plots receiving more nitrogen and higher translocation of photosynthates to the grains. It was noticed that in the I2F1 treatment protein content was highest (9.12%). The association between protein content and grain yield was found to be positive with $R^2 = 0.891$ (Fig. 5).

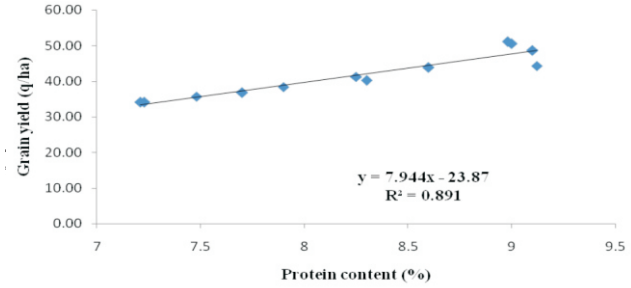

Fig. 5. Relationship between protein content and grain yield (q ha^{-1}) in maize

The results indicate that the growth parameters i.e. plant height, leaf area index and percentage ground cover were found maximum in I2F3 (I2 is 0.8 ET_{crop} and F3 is 80% of recommended dose of fertilizer). Number of grains per cob, grain weight per cob, 1000 grain weight, grain yield, stover yield, water use efficiency (WUE) was also found maximum in the same treatment.

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Impact of Joint Forest Management (JFM) Programme on Equality in Income Distribution in Nainital District, Uttarakhand

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Abstract: The inequality in income distribution decreased after implementation of Joint Forest Management programme in the study area. But the inequality persistent in the beneficiaries' income was due to presence of large number of low income individuals both before JFM and after JFM programme. To establish equality among users, the income that should be transferred from high income to low income group decreased after JFM programme. The JFM is a potent source for bringing income equality hence it needs to be strengthened for overall socio-economic development of the society.

Key Words: Equality, Income Groups, Joint Forest Management

Forest and tree cover in India is 78.91 m ha, which is 24.01 per cent of the geographical area of the country. India has only 1.8% per cent of the global forest area but has to support 17 per cent of the world's human population. Using forest products to satisfy basic needs such as food, fuel and fodder for sustenance in an unchecked manner often lead to deforestation and forest degradation. The forest policy, formulated in 1988 gave priority to the needs of the forest dependent communities and subsequently on June 1, 1990 Government of India issued the guidelines for implementation of Joint Forest Management (JFM) programme (Choudhary and Srivastava, 2014). The Joint Forest Management (JFM) program is described as a forest management strategy under which the government represented by the Forest Department and the village community enter into an agreement to jointly protect and manage forestlands adjoining villages and to share responsibilities and benefits (Government of India, 2002). In Uttarakhand, JFM started in 1992 and there are 10,107 JFM committees managing about 0.86 m ha of forest, which is about 27 per cent of the forest area of the Uttarakhand. Around 0.6 million families of Uttarakhand are involved in the JFM programme, of which around 15,000 families belongs to scheduled tribes (Ojha and Mukherji, 2009).

Nainital, where present study was conducted is the first district in implementation of JFM programme in Uttarakhand (Sarin *et al.,* 2008). But no assessment study has been conducted regarding JFM in the district. About 9 per cent of total forest area of the district comes under the programme (Ojha, 2009). Previous studies from different parts of the country show that the programme is focussed more on forest management rather than another important aspect i.e. livelihood of forest dependent people. JFM is not gaining sufficient acceptance as intended. Income generated from the programme is not equally distributed among different strata of society. The present study aims to measure income inequality among different groups of beneficiaries.

MATERIAL AND METHODS

Sampling framework: The study area was confined to Bhimtal block of Nainital district of Uttarakhand. Bhaktura and Junestate village were selected randomly and from each village, the sample beneficiaries were categorized into two income groups (low income and high income) based on their annual family income within a year (2011) by dividing the difference of two extreme incomes (highest and lowest annual family income) in two equal parts. The investigation on different aspects of selected sample was conducted for two separate years, one just before establishment of JFM programme (2001) in the villages and another after JFM programme in the year 2011.

The primary data were collected from the sample beneficiaries on pre-structured schedule. The data were collected related to family size, land holding, livestock holding, sources and amount of family income, expenditure pattern, employment activities of family members, number and type of livestock reared, amount of feed, fodder and medical expenses of livestock, cropped area, cropping pattern, manure and fertilizer, seeds etc. for both the periods i.e. before and after implementation of JFM programme.

Analytical framework: To measure the inequality in the distribution of income, Gini coefficient, Lorenz asymmetry coefficient, Robin Hood index and Herfindahl index were estimated for different income groups for both the periods.

Rangachari and Dagum (2004) formula was used to estimate Gini coefficient i.e.,

$$G \quad 1 \quad \frac{1}{n} \quad \frac{1}{n^2 Y} \; y_1 \quad 2y_2 \quad 3y_3 \quad \ldots\ldots\ldots\ldots ny_n$$

Where, G = Gini coefficient

n = Sample size

Y = Average annual income of the sample beneficiaries

$y_1, y_2 \ldots\ldots, y_n$ are Individual income of the beneficiaries in decreasing order of size.

The Lorenz asymmetry coefficient (S) calculated from the n ordered data ($X_1 \ldots\ldots\ldots X_m, X_{m+1} \ldots\ldots X_n$) of annual family income using the following equations.

$$S \quad \frac{m}{n} \quad \frac{l_m \quad X_{m\,1}}{l_n} \qquad = \frac{X_m}{X_{m\,1} \quad X_m}$$

Where,

S = Lorenz asymmetry coefficient

μ= Mean income level of the beneficiaries

m = Number of individuals with an income less than μ

l_m = Cumulative income of individuals with an income less than μ

l_m = Cumulative income of individuals with an income less than μ

l_n = Cumulative income of all the individuals

X_m = Highest income of the individual with an income less than μ

X_{m+1} = Lowest income of the individual with an income more than μ

When S = 1, the Lorenz curve of the income is symmetric. When S > 1, most of the inequality within the income is due to the high income individuals and if S < 1, it indicates that the inequality in income is due to relatively large number of low income individuals. The Herfindahl index is constructed as (Acharya, 2005)

$$\text{Value of index (D)} = \sum_{k=1}^{n60} P_k^{\,2}$$

$$P_k \quad \frac{Y_k}{\sum_{k\,1}^{60} Y_k}$$

Where,

P_k = Proportion of income for k^{th} beneficiaries

Y_k = Net annual family income income of k^{th} beneficiarie

k = Number of beneficiaries (1, 2, 3 ……., 60)

The Robin Hood index has been measured as the maximum vertical distance between the Loren curve and the line of equality.

RESULTS AND DISCUSSION

Lorenz curve: The Lorenz curve for annual family income of the beneficiaries after implementation of JFM programme was nearer to line of equality than Lorenz curve before JFM programme (Fig. 1). This shows that the inequality in the income distribution decreased after JFM programme due to increase in level of income after implementation of JFM programme. The Lorenz curve of beneficiaries' household income for low income group signifies that the equality among the beneficiaries in the study area has been increased after implementation of JFM programme (Fig. 2). This is evident from the figure as the Lorenz curve has been shifted towards line of equality after JFM programme. This shows that inequality was less after implementation of JFM programme in the study area for low income group.

In case of high income group, the Lorenz curve of the beneficiaries' household income before and after JFM programme crossed at a point in between two extremes (Fig 3).

But Lorenz curve of beneficiaries' household income before JFM was below the Lorenz curve of beneficiaries' household income after JFM programme, in larger part of the curve. So, the inequality in income decreased after implementation of JFM in the study area for high income group also.

Gini coefficient: Gini coefficient of annual family income decreased from 0.61 before JFM to 0.57 after implementation of JFM (Table 1). This signifies that the inequality in overall income group of beneficiaries after JFM programme has been decreased in the study area.

The intra-group inequality across different income groups also decreased after implementation of JFM programme. In case of low income group and high income group, the Gini coefficient was 0.34 and 0.40 before JFM, which decreased after JFM to 0.28 and 0.37. It is revealed from the table that the inequality decreased to higher extent in low income group compared to the high income group.

Lorenz asymmetry coefficient (LAC): Lorenz curve for income was asymmetric in both periods (i.e. before and after JFM). The value of LAC is less than one (S<1) for the sample in both cases, before JFM (S= 0.65) and after JFM (S= 0.91). This indicates that the inequality persistent in the beneficiaries' income is due to presence of large number of low income individuals (Table 1). In case of high income group, the LAC is less than one (S=0.85) before JFM period. Thus, the inequality in the beneficiaries' household income is due to presence of large number of low income individuals in the study area before JFM programme.

But LAC is more than one (S= 1.34) for beneficiaries' household income after JFM programme signifying that inequality in the beneficiaries is due to presence of large number of high income individuals in the

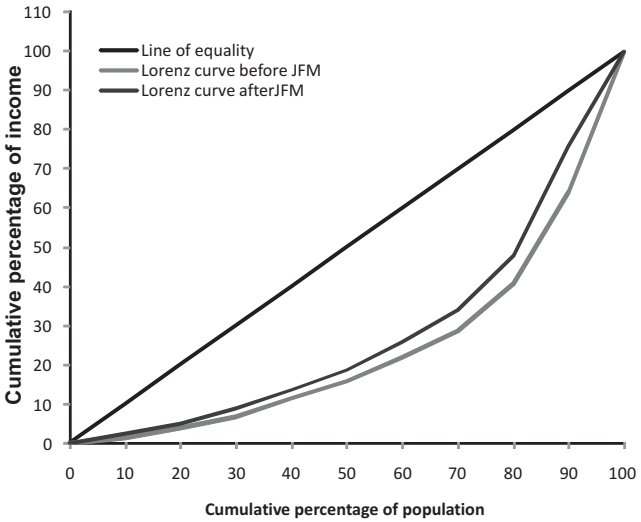

Fig. . Lorenz curve of annual family income of overall beneficiaries

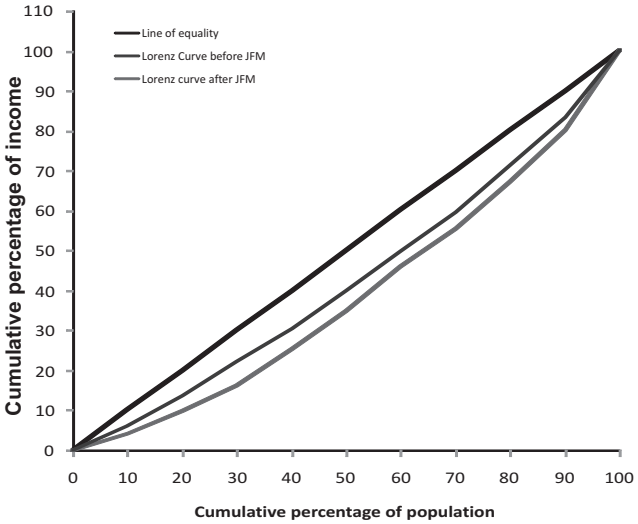

Fig. . Lorenz curve of annual family income for low income group of beneficiaries

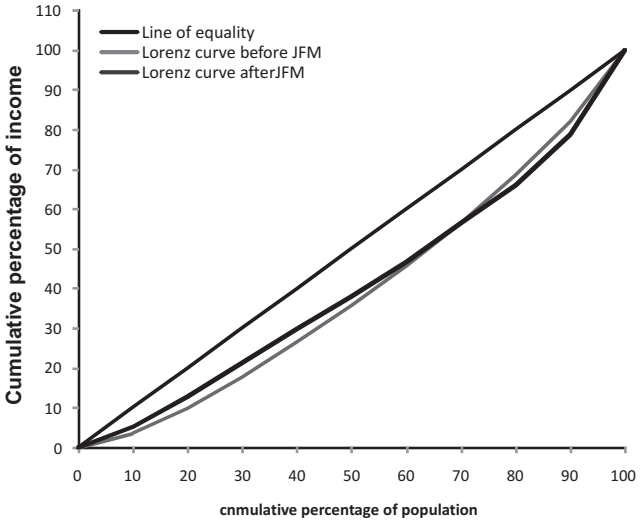

Fig. . Lorenz curve of annual family income for high income group of beneficiaries

study area. Similarly, the inequality of annual family income of beneficiaries among low income group before and after JFM is due to large number of low income individuals because LAC is less than one in both the periods (S = 0.93 before JFM programme and S = 0.89 after JFM programme).

Herfindahl index: The Herfindahl index for annual family income of the overall sample beneficiaries decreased after implementation of JFM. It is 0.021 before JFM, which decreased to 0.018 after JFM programme (Table 1). This implies that the concentration of income decreased resulting in decreased income inequality among beneficiaries. In case of high income group and low income group, the Herfindahl index for beneficiaries' household income is 0.050 and 0.048 before JFM programme, which decreased to 0.048 and 0.044 after JFM programme, respectively. It indicates that concentration of income decreased by lower extent in high income group of beneficiaries in comparison to low income group of beneficiaries after implementation of JFM programme. The results of the study shows that the inequality in the income distribution decreased after implementation of JFM programme in the study area for overall beneficiaries and across the income groups of beneficiaries as well but the inequality decreased to higher extent in low income group compared to the high income group of beneficiaries. The inequality in the beneficiaries' household income of high income group is due to presence of large number of low income individuals before JFM programme and due to presence of large number of high income individuals after JFM programme. The need of intra – group transfer of income to achieve equality is more in low income group in comparison to high income group of beneficiaries. The results from Herfindahl index indicates that concentration of income decreased by lower extent in high income group of beneficiaries in comparison to low income group of beneficiaries after implementation of JFM programme.

Robin-Hood index: For the overall sample, the Robin-Hood index decreased after implementation of JFM (Table 1). It signifies that before JFM, it was possible to make equality among beneficiaries by transferring 34.6 per cent of income of those who were earning more than average income to those who were earning below than overall average. But after implementation of JFM, it decreased to 32.1 per cent.

At individual income group level, the Robin-Hood index also decreased after implementation of JFM programme. Within high income group, the Robin-Hood

Table 1. Inequality measures before (B) and after (A) implementation of JFM programme

	Ginni coefficient		Lorenz Asymmetry coefficient		Herfindhal index		Robin-Hood index	
	B	A	B	A	B	A	B	A
Low Income Group	0.34	0.28	0.93	0.89	0.048	0.044	27.6	24.9
High Income group	0.40	0.37	0.85	1.34	0.050	0.048	25.6	21.2
Overall	0.61	0.57	0.65	0.91	0.021	0.018	34.6	32.1

index is 25.6 per cent before JFM that decreased to 21.2 per cent after JFM programme. It implies that within high income group, the need for intra group transfer of income from higher earning people to lower earning people for equality decreased after JFM programme.

Similar result has been obtained for low income groups. The Robin-Hood index is 27.6 before JFM and 24.9 after JFM in case of low income groups. So, the intra-group transfer of income from higher earning people to lower earning people decreased after JFM programme but need of intra – group transfer of income to achieve equality was found to be more in low income group of beneficiaries in comparison to high income group of beneficiaries in the study area.

The findings of the study suggest that Joint Forest Management (JFM) programme is a potent source, which can bridge income inequality hence it needs to be strengthened and there is need to focus more on low income group for better performance of the programme.

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Dietary and Physical Activity Pattern of Post Menopausal Women Belonging to Different Categories of Body Mass Index

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***Abstract*:** The present study was conducted to assess dietary and physical activity pattern of postmenopausal women in the age group of 45-60 years selected randomly from Ludhiana city of Punjab. The subjects were categorized into three groups i.e. normal (18.50-24.99 kg m^{-2}), overweight (25.00-29.99 kg m^{-2}) and obese ($\geq$30 kg m^{-2}) based on body mass index. The intake of energy, protein, carbohydrates and total fat increased significantly with the increase in body mass index from normal to overweight to obese postmenopausal. Waist hip ratio and fat also increased significantly with the increase in body mass index (BMI). All the subjects were falling in sedentary life style (physical activity level, 1.40-1.69).

Key Words: Dietary intake, Physical activity, Postmenopausal women, Risk factors

Menopause is a natural event in the ageing process, which signifies the end of reproductive years with cessation of cyclic menstruation. Menopause is associated with a wide variety of biological, physical and psychological symptoms. Physiological withdrawal of estrogen in postmenopausal women brings about changes in fat distribution (Dubnov *et al.,* 2007) from a gynoid to an android pattern, reduce glucose tolerance, increase blood pressure, sympathetic tone, endothelial dysfunction and vascular inflammation (Izumi *et al.,* 2007) leading to increased rates of hypertension, diabetes mellitus, coronary artery disease and mortality. In menopause women's metabolism slows down, vitamin requirements increase but calorie requirements decrease. So the diet needs to be modified by including more of whole and fresh food rich in vitamins but, poor in calories and reduced intake of sugar and fat. Exercise and physical activity provide a wide range of health benefits for postmenopausal women, a sustained weight loss of 5-10 per cent in obese postmenopausal women confers marked health benefits (Caroll *et al.,* 2007). Moreover, there is irrefutable evidence of the effectiveness of regular physical activity in the primary and secondary prevention of several chronic diseases (e.g., cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis), premature death (Sharma, *et. al.* 2008) and improvement of psychological health by reducing levels of stress, anxiety and depression. Since nutrition intervention and physical activity is of utmost importance in postmenopausal years so the study was undertaken to assess dietary and physical activity pattern of post menopausal women in Punjab.

MATERIAL AND METHODS

A sample of 300 postmenopausal women was randomly selected i.e., female who were not having their menstrual periods for last 1 year, age between 45-60 years and women who had not undergone hysterectomy or taken Hormone Replacement Therapy (HRT). Height and weight of all the subjects was recorded and Body Mass Index (BMI) was calculated as weight (Kg)/height (m^2). A sub sample of ninety postmenopausal women was randomly selected having thirty subjects in each of normal (18.50-24.99 Kg/m^2), overweight (25.00-29.99 Kg/m^2**)** and obese ($\geq$ 30 Kg/m^2**)** category of body mass index (WHO, 2004).

The data were collected from ninety postmenopausal women using pretested specially structured interview schedule. The data pertaining to age, caste, family type and educational level, religion and socioeconomic status of the subjects and the family were collected. The 24 hour food recall method for 3 consecutive days was used to assess the dietary intake. The food consumed was converted into their raw equivalents and the average daily intake of nutrients was calculated using the Indian Nutrition Software (Diet soft). The food and nutrient intake was compared with the suggested dietary intakes for balanced diet and recommended dietary allowances (ICMR, 2010). Height, weight, waist and hip circumference was recorded using standard methods (Jellife, 1966).

Body composition assessment: Bioelectric impedance using TANITA Body Composition Analyzer BC-420MA was employed to assess body composition of the subjects and body fat percentage, lean body mass comprised of muscle, bone, tissue, water and all other fat free mass in the body,

muscle mass which represents bone free lean tissue mass were studied. The muscle mass includes skeletal muscles, smooth muscles (such as cardiac and digestive muscles) and water contained in the muscles, bone mass and total body water.

Physical activity pattern: PADM (Physical Activity Diary Method) was used to record the time spent on different activities for the days during which dietary survey was carried out for three days. Physical Activity Ratios (PAR) given by FAO/WHO/UNU (2004) was used to calculate Physical Activity Level (PAL) of the subjects. The mean PAL was calculated using the following formula:

PAL=Σ [time spent on each activity (min) × energy cost of each activity (kcal)] / 1440 min

The life style of the subjects was determined on the basis of physical activity level (PAL) values. FAO/WHO/UNU (2004) classification was used to categorize the subjects of different age groups into three lifestyle categories of sedentary or light active lifestyle (1.40-1.69), active or moderately active lifestyle (1.70-1.99) and vigorous or vigorously active lifestyle (2.00-2.40).

RESULTS AND DISCUSSION

The age wise distribution of the subjects revealed that 60, 56 and 53 per cent of normal, overweight and obese subjects, respectively were in the age group of 45 to 50 years followed by 27, 30 and 33 per cent subjects in the age group of 50 to 55 years and 13 per cent of normal, overweight and obese subjects in the age group of 55 to 60 years. Majority of the subjects of the three groups were observed in the age group of 45-50 years. Majority of overweight subjects (90 %) followed by obese (67 %) and normal (60 %) were of general category remaining subjects were of backward class. Most of the subjects belonged to average family size of 4 to 5 members. Twenty seven per cent of normal and overweight and 30 per cent of obese subjects were illiterate. The subjects belonged mainly to two religions i.e., Hinduism and Sikhism.

Food intake: The daily intake of cereals, roots and tubers, milk/milk products and fats/oils was significantly ($p \leq 0.05$) higher in obese as compared to overweight and normal subjects. A non- significant difference was observed in intake of pulses and legumes, green leafy vegetables, other vegetables, fruits and sugar among normal, overweight and obese subjects (Table 1). The per cent adequacy in the intake of cereals, milk and milk products were observed adequate in normal, overweight and obese subjects, respectively. On the other hand, the consumption of legumes and pulses, green leafy vegetables, roots and tubers, other vegetables and fruits among the subjects was inadequate. The intake of sugar and fat was observed higher in all the three groups following increasing trend from normal to overweight to obese (Fig. 1).

Nutrient intake: The nutrient intake of selected postmenopausal women revealed that obese subjects had significantly ($p \leq 0.05$) higher intake of energy, protein,

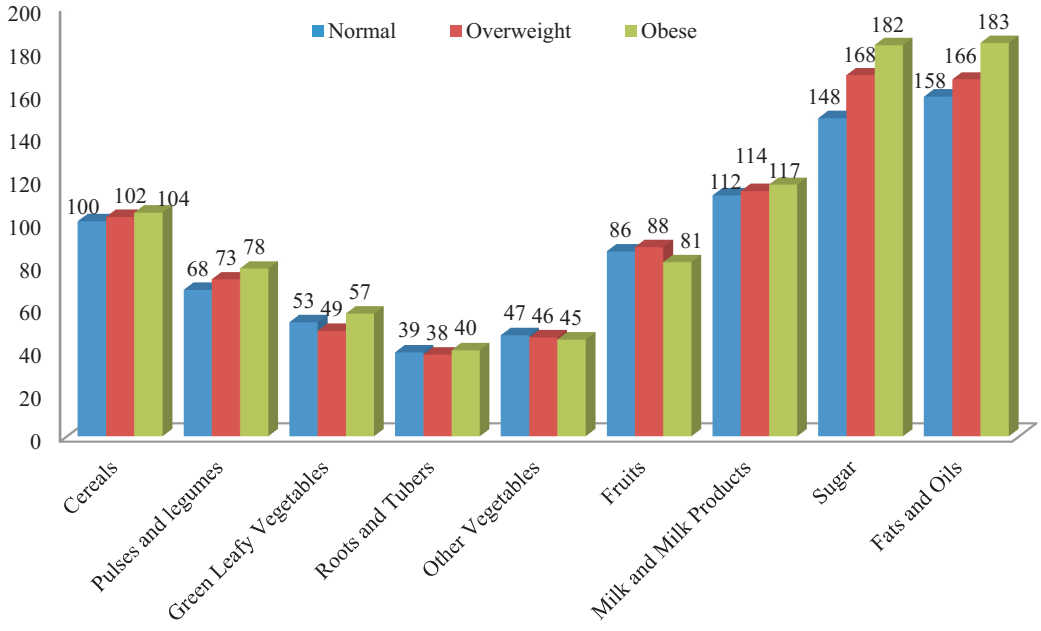

Fig. 1. Percent adequacy of food intake by selected post menopausal women

Table 1. Daily food and nutrient intake of selected post menopausal women

Food and Nutrients	Normal	Overweight	Obese	CD (p=0.05)
Food (g day^{-1})				
Cereals	270.32	276.00	281.21	2.75
Pulses and legumes	41.10	44.08	47.22	NS
Green leafy vegetables	53.15	49.21	57.48	NS
Roots and tubers	79.80	78.01	80.14	0.85
Other vegetables	94.07	92.05	91.13	NS
Fruits	86.31	88.11	81.15	NS
Milk and milk products	336.43	341.34	351.04	3.41
Sugar	30.30	34.22	36.04	NS
Fats and oils	31.11	33.32	37.14	2.30
Nutrients				
Energy (kcal)	1694.0	1835.0	1983.0	19.45
Protein (g)	51.0	55.0	59.0	3.61
Carbohydrates (g)	260.0	268.0	296.0	20.23
Total fat (g)	50.0	58.0	63.0	4.43
Fibre (g)	11.0	13.0	14.0	NS
Thiamine (mg)	1.5	1.3	1.6	0.12
Riboflavin (mg)	0.7	0.9	1.0	0.75
Niacin (mg)	10.0	11.0	12.0	0.79
Folic acid (µg)	191.0	188.0	183.0	NS
Ascorbic acid (mg)	51.0	57.0	54.0	NS
Calcium (mg)	834.0	841.0	906.0	NS
Magnesium (mg)	347.0	332.0	370.0	NS
Iron (mg)	14.0	16.0	17.0	0.22

carbohydrates, total fat, riboflavin and niacin as compared to overweight and normal subjects. Non-significant differences were observed in the intake of fibre, folic acid, ascorbic acid, calcium, magnesium and iron among normal, overweight and obese subjects (Table 1). Sowmya and Puttaraj (2007) indicated higher intake of energy and protein intake in women in the age group of 20 to 60 years. Studies have demonstrated higher daily intakes of energy, protein and fat in north Indian women aged 45-70 years (Kumar *et al.,* 2009) and lower fiber and calcium intake in postmenopausal women (Lovejoy *et al.,* 2001). The intake of energy was adequate in obese (104 %) as compared to overweight (97 %) and normal (89 %) subjects, whereas, the protein intake was adequate in obese and overweight subjects (107 % and 100 %) as compared to normal (93 %) subjects. The intake of total fat and thiamine was much higher in all the subjects of three groups when compared to RDA. Further the per cent adequacy of niacin was adequate in obese (100 %) as compared to overweight and normal subjects, whereas, riboflavin, folic acid and iron was inadequate. Per cent adequacy of calcium intake among subjects was adequate (Fig. 2).

Body composition: The mean body mass index was observed 22.72 kg m^{-2} in normal as compared to 27.44 kg m^{-2} in overweight and 32.31 kg m^{-2} in obese subjects. The waist hip ratio was observed significantly higher ($p \leq 0.05$) in obese (0.95) as compared to overweight (0.89) and normal (0.85) subjects. The observed waist hip ratio in all the subjects of the three groups was higher when compared to standard (0.8). The fat percentage was observed highest in obese (43.13 %) followed by overweight and normal subjects with significant difference. Significantly higher fat free mass (lean body mass) was observed in obese (45.38 kg) and overweight (40.77 kg) as compared to normal subjects (36.16 kg). Muscle mass was found highest in obese subjects (42.87 kg) followed by overweight and normal with significant difference among the three groups. Significantly different values of bone mass and total body water was observed in normal, overweight and obese subjects (Table 2).

Physical activity pattern: Physical activity pattern of the selected postmenopausal women revealed that time spent on sleeping was higher in normal as compared to overweight and obese subjects with significant difference. The time

spent on personal care was 53.23 minutes in normal, against 52.67 and 48.50 minutes in overweight and obese postmenopausal women. The time spent on light activities while sitting was significantly higher in obese (211.46 minutes) as compared to overweight and normal subjects. Time spent on cooking, other general household work and TV watching was higher by normal subjects. The time spent on walking at various paces without load was observed highest in overweight subjects (Table 3). All of the obese subjects against 97 and 80 per cent of overweight and normal subjects were involved in sedentary life style. Only 3 per cent of overweight and 20 per cent of normal subjects were involved in moderately active life style. All of the normal, overweight and obese subjects were in the sedentary or light activity group (PAL value 1.40-1.69) with a non-significant difference (Table 4).

The present study concluded that the intake of energy, protein, carbohydrates and total fat increased significantly

Table 2. Body composition of selected post menopausal women

Particulars	Normal	Overweight	Obese	CD (p=0.05)
Body mass index (Kg m^{-2})	22.72	27.44	32.31	0.82
Waist hip ratio (WHR)	0.85	0.89	0.95	0.62
Body fat (%)	31.16	36.74	43.13	0.79
Fat free mass (FFM)	36.16	40.77	45.38	0.72
Muscle mass (MM)	34.18	38.41	42.87	0.72
Bone mass	1.83	2.12	2.24	0.54
Total body water (TBW)	26.47	28.71	32.11	0.58

Table 3. Physical activity pattern of selected post menopausal women

Activities (PAR)	Normal	Overweight	Obese	CD (p=0.05)
Sleeping (1.0)	549.65	539.05	525.48	12.56
Personal care (2.3)	54.23	53.67	49.50	NS
Light activities while sitting (1.5)	157.28	169.62	211.46	23.55
Watching TV (1.4)	148.32	139.50	126.72	12.2
Sitting idle and chatting (1.5)	91.43	93.60	95.16	NS
Preparing meals (2.1)	192.06	179.56	183.22	NS
Other general household work (2.8)	221.55	225.72	215.40	NS
Walking at various paces without load (3.2)	35.69	43.30	35.43	NS

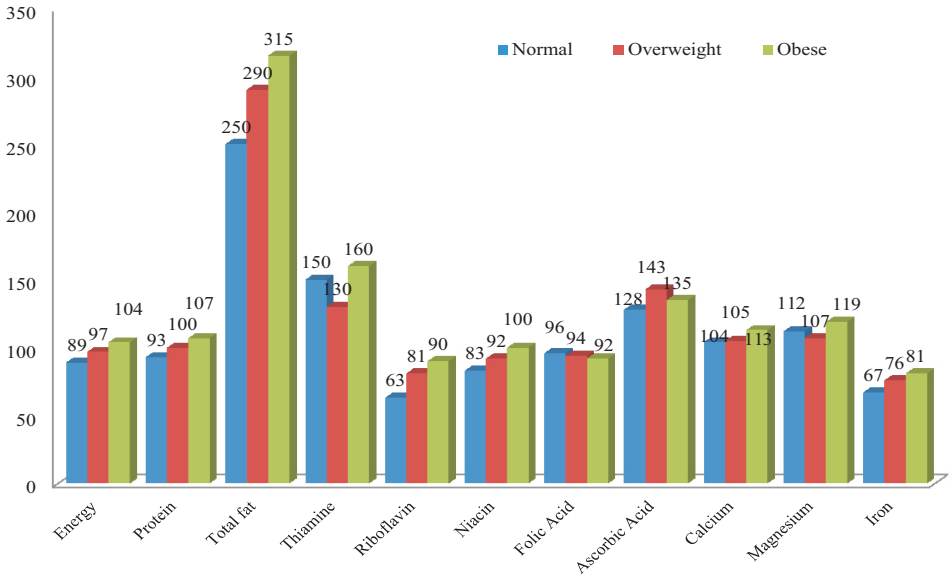

Fig. 2. Percent adequacy of nutrient intake by selected post menopausal women

Table 4. Physical activity level of selected post menopausal women

Physical activity level (PAL)	Normal (n=30)	Overweight (n=30)	Obese (n=30)
Sedentary or light activity lifestyle	24 (80.00)	29 (96.67)	30 (100.00)
Active or moderately active lifestyle	6 (20.00)	1 (3.33)	0 (0.00)
Vigorous or vigorously active lifestyle	0 (0.00)	0 (0.00)	0 (0.00)
Mean	1.61	1.62	1.61

Figures in parenthesis indicate percentage

with the increase in body mass index from normal to overweight to obese postmenopausal women. The intake of fruits and vegetables in the postmenopausal women was inadequate, which lead to low intake of micronutrients. Although all of the subjects were falling in sedentary life style yet less number of obese postmenopausal women were involved in regular physical exercise. Hence, there is a need for nutrition intervention, regular physical exercise and modification of life style pattern for postmenopausal women to stay healthy and risk free from of various chronic diseases.

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Assessment of Food and Nutrient Intake of University Resident Girls

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Abstract: Fifty undergraduate volunteer girls in the age group of 19-22 years were selected for the study. The total consumption of energy and protein by the hostel girls was 1856 Kcal and 52.6 g day^{-1} with nutritional adequacy 98 and 96%. The maximum consumption of energy was derived during breakfast (627 Kcal) followed by the dinner and then by lunch. The mean daily intake of fat was three times higher than that of RDA of 20 g $day^{-1}$of visible fat for a sedentary adult woman. The nutritional adequacy of ß-carotene**,** vitamin C, folacin, iron and calcium by subjects was 37, 138,133, 85 and 121%, respectively. The overview of nutrient intake suggested that out of the eight nutrients studied, vitamin C, calcium, folacin and fat was adequate while energy, protein and iron were marginally adequate with NAR values varying between 85 and 98%.

***Key Words*:** Hostel girls, Fast food consumption, Food intake, Nutrient intake

Iron deficiency is the most common deficiency worldwide defined as decreased total body iron content and it occurs when iron deficiency is severe enough to diminish erythropoiesis and cause of anemia. The main reasons for iron deficiency anaemia have been determined to be inadequate intake of iron, low bioavailability (1-6%) of dietary iron from plant foods due to inhibitory factors, low levels of absorption enhancers in the diet, repeated pregnancies, increased needs during growth and development among children and adolescents, parasitic infestations and chronic blood loss. However, anemia is wide spread in India in spite of diversity in food habits, particularly in the consumption of cereal based diet. Globally, there has been increased intake of energy dense foods that are high in fat, salt and sugar but low in vitamins, minerals and other micro nutrients (WHO 2011). The prevalence of underweight is higher among female students than male students (Gan e*t al.,* 2011; Huda and Ruzita, 2011). Most university students did not meet the recommended intakes for most of the macro and micronutrient (Sanlier and Unusan, 2011). Meal and snacking pattern have been shown to give effects on body weight (Song *et al.,* 2005). College students tend to practice poor eating habits for instance skipping meals, low frequency of vegetables and fruits prefer fatty food and poor physical activity (Abolfotouh *et al.,* 2007). Balanced and adequate nutrition is important to maintain good health and quality of life (Memis and Sanlier, 2010). University students may face difficulty in regulating eating behavior. Students living away from family home tend to develop poor eating habits compared to students who live at the family home (Angeliki *et al.,* 2007). The present study was carried out to assess the food and nutrient intake of the hostel girls.

MATERIAL AND METHODS

A total of 50 undergraduate volunteer girls in the age group of 19-22 years were selected from PAU girls' hostel of Punjab Agricultural University, Ludhiana. A prior written consent of the subjects to participate in the study was obtained. A questionnaire was developed to collect the information regarding food habits, fasting trends, and frequency of consumption of fast food by the subjects, meal pattern and food intake.

Information regarding weekly set menu was collected from the hostel mess. Food intake of girls was assessed by using '24 hour recall method' for 3 consecutive days The major nutrients were calculated using MSU Nutriguide Computer Program (Song *et al.,* 1992). The intake of nutrients i.e. energy, protein, β-carotene, folacin, vitamin C, iron and calcium in each meal was assessed. The food and nutrient intake was compared with the suggested dietary intake (SDI) and recommended dietary allowances (RDA) given by ICMR (2010), respectively. In order to determine the nutrient adequacy of diet, the nutrient adequacy ratios (NAR) were calculated for energy and protein along with micro-nutrients (β-carotene, vitamin C, folacin, iron and calcium).

Nutrient adequacy ratios (NAR %) were categorized as per Jood *et al.* (1999) as adequate (100% and above), marginally adequate (75 to 99.9%), marginally inadequate (50 to 74.9%) and inadequate (below 50%). The data was collected in March and April, 2014.

RESULTS AND DISCUSSION

Dietary pattern and fast food consumption pattern: Data

depicted that majority of the girls (46%) were vegetarian, while 38% were non-vegetarian and 16% were ova vegetarian. Majority of the subjects (72%) had more than three meals per day, but 42% of the subjects were skipping their meals due to various reasons. Among them, 48% of the subjects skipped their breakfast, 14% skipped their lunch and 38% skipped their dinner. Fasting was observed by 32% of the girls. Augustine and Poojara (2003) in urban college girls (17-18 years) observed that 41% of the subjects missed their breakfast on week days and it resulted to impaired cognitive ability, whereas, 20% skipped other meals. Majority of the subjects (84%) consumed fast foods. Among them, 9% had fast food thrice in a week, while 31% had twice in a week. But majority of the subjects (52%) were taking fast food only once in a week and only 8% had once in a month. Main choice in fast foods were sandwich (45%), burger (26%) and patty (17%). All other fast food consumed were mainly noodles, pizza, manchurian, French fries etc.

Meal pattern: The subjects followed a weekly set menu pattern as they were residing in the hostel and had food in the hostel mess (Table 1). All the subjects used to take three main meals as breakfast, lunch and dinner. Some of the girl students used to take milk or tea at the bed time. The breakfast of the hostel mess comprised mainly parantha, bread with curd or butter, milk or tea. Lunch of the hostel was mainly comprised of chapati, rice, vegetable, curd/raita/Kadhi, salad (onion, carrot, chilli). The dinner included chapati, dal, vegetable, any sweet dish (kheer/custard/gulabjamun/seviyan/banana/jalebi or halwa) and salad as onion and chilli. They were served rice once in a week in a dinner. Snacks items as pakoda, patties, sandwich and tea was taken by only some girls as these were not included in the hostel menu. These items could be taken by paying extra amounts by the hostellers. They were taking milk or tea at the bed time as optional. The description of Punjabi recipes consumed by the subjects has been given in Table 2.

Food intake: The mean daily intake of cereals was reported to be less than recommended intake range of 270 g with the per cent adequacy of 97 (Table 3 and Fig 1). It was observed that consumption of cereals was significantly ($p<0.01$) higher in breakfast as compared to lunch and dinner. Intake of cereals was maximum in the form of wheat (210 ± 14.6 g day^{-1}) as parantha, chapati and as the snack items burger, patties and sandwiches. Rice was taken at the lunch time mainly. A very small amount of cereals were taken in the form of sandwich, patties, samosa, etc. as all the subjects were not used to take snacks or in between meals every day. Although intake of pulses and legumes during breakfast and in between meals was very less but the percentage adequacy of pulses was found to be 74%. Consumption of pulses and legumes was significantly ($p<0.01$) higher in lunch as compared to dinner. The consumption of green leafy vegetable among the hostellers was less (15g day^{-1}) and its adequacy was only 15%. No significant difference was found in consumption of green leafy vegetables. The reason of low consumption of green leafy vegetable was inadequate availability of green leafy vegetable during survey period, its high cost, and required more time for preparation.

The mean daily intake of roots and tubers was 111g day^{-1}and its adequacy was 111%. The girls consumed significantly ($p<0.01$) higher amount of roots and tubers during dinner time as compared to lunch and breakfast. Consumption of roots and tubers in in-between meals was

Table 1. Weekly menu of the selected hostel mess

Day	Breakfast	Lunch	Dinner
Sunday	Dal parantha, bread, butter/jam, milk/tea	Rice, chapati, white channe , curd/raita salad(onion, carrot, chilli)	Chapati , rice, dal (rajmah + mah), halwa, salad (onion, chilli)
Monday	Potato parantha, butter/curd, milk/tea, bread, butter/jam	Rice, chapati , white channe, curd/raita, salad(onion, carrot, chilli)	Chapati, mah channe ki dal, mix vegetable (gajar matar aaloo mix), kheer, salad (onion, chilli)
Tuesday	Plain parantha, paneer bhurji, bread, butter/jam, milk/tea	Rice, chapati, Rajmah, curd, salad (onion, chilli)	Chapati , dal (moong-masoor), Gobi aaloo mixed vegetable, custard, salad (onion, chilli)
Wednesday	Gobi parantha, bread, butter/jam, milk/tea	Rice, chapati, pakoda kadhi, nutri aaloo sabji, curd/raita, salad (onion, carrot, chilli)	Chapati, dal (moong sabut), chilly paneer, gulab jamun, salad (onion, chilli)
Thursday	Methi parantha, bread, butter/jam, milk/tea	Rice, chapati , kale channe, curd/raita salad(onion, carrot, chilli)	Chapati, dal (masoor), Gajar Gobi aaloo mixed vegetable, seviyan , salad (onion, chilli)
Friday	Plain parantha, kale channe, bread, butter/jam, milk/tea	Rice, chapati , dal makhni (maa ki dal), curd/raita salad(onion, carrot, chilli)	Chapati, dal (channa dal), aaloo Sabji, jalebi, salad (onion, chilli)
Saturday	Bread, tikki/ omelette, milk/tea	Rice, chapati , h are matar aaloo mix, curd/raita salad(onion, carrot, chilli)	Chapati, dal (dhuli masoor), patta gobi Sabji, banana, salad (onion, chilli)

Table 2. Description of Punjabi recipes consumed by the subjects

Recipe	Description
Dal parantha	Wheat flour dough prepared by using dehusked legume, rolled and shallow fried.
Chapati	Wheat flour dough, rolled and baked on griddle.
White channe	Chickpea preparation in curry form
Raita	Curd with added vegetables and spices
Dal (rajmah + mah)	A black gram and kidney bean curry preparation
Halwa	Semolina, roasted with fat and cooked in water with sugar
Potato parantha	Wheat flour dough, stuffed with potato, rolled and shallow fried
Mah channe ki dal	Black gram and dehusked Bengal gram preparation
Mix vegetable (gajar matar aaloo mix)	Mixed vegetable preparation using carrots, peas and potatoes
Kheer	Rice cooked with milk and sugar
Plain parantha	Wheat flour dough, rolled and shallow fried
Paneer bhurji	Cottage cheese scrambled
Gobi parantha	Wheat flour dough, stuffed with cauliflower, rolled and shallow fried
Methi parantha	Wheat flour dough prepared by using fenugreek leaves, rolled and shallow fried
Kale channe	Bengal gram preparation in curry form
Tikki	Potatoes, boiled, mixed with spices, given shape of cutlet and shallow fried
Rajmah	Kidney bean preparation in curry form
Pakoda kadhi	A preparation from Bengal gram flour and curd
Nutri aaloo sabji	A curry preparation using Soybean nuggets and potatoes
Dal makhni (maa ki dal)	Black gram curry preparation with added cream
Hare matar aaloo mix	Green pea and potato curry preparation
Dal (moong-masoor)	Dehusked green gram and lentil curry preparation
Gobi aaloo mixed vegetable	Mixed vegetable preparation using cauliflower and potatoes
Dal (moong sabut)	Whole green gram curry preparation
Dal (masoor)	Lentil curry preparation
Gajar–Gobi-aaloo mixed vegetable	Mixed vegetable preparation using carrots, cauliflower and potatoes
Seviyan	Vermicelli cooked in milk with sugar
Dal (channa dal)	Dehusked Bengal gram curry preparation
Aaloo Sabji	Potato vegetable preparation
Jalebi	Refined flour, fermented, fried and dipped in sugar syrup
Dal (dhuli masoor)	Dehusked lentil preparation
Patta gobi Sabji	Cabbage vegetable preparation
Chilly paneer	Cottage cheese with capsicum preparation
Gulab jamun	Concentrated milk with refined flour, fried and dipped in sugar syrup

very small as it was only in the form of potato patties, bread pakoda, potato sandwich, burger etc. The daily intake of fruits was 25g day^{-1} which was grossly inadequate as compared to suggested intake of 100g. In hostel mess, only banana was given as fruit so all other fruits consumption was in between meals. No significant difference was observed in the consumption of fruits by the subjects. NFHS (2000) reported that fruits were daily consumed by only 8% of women and only one third of women consumed fruits at least once in a week.

Daily consumption of milk and milk products was 267g day^{-1}, while its adequacy was 89% in the diets of the hostel girls. The subjects consumed significantly ($p<0.01$) higher amount of milk in breakfast time in the form of milk or tea (132g day^{-1}) as compared to lunch (58g day^{-1}) as curd or raita. Tea and badam milk or milk shake was major source of milk during in between meals or at the snacks time. Only negligible amount of non-vegetarian foods (16g day^{-1}) were consumed by the subjects as it was not included in the menu of hostel mess. Egg was the major form of non vegetarian food included in the hostel diet as these were provided by mess on demand. Meat or poultry were consumed either outside or at home in the weekend. Adequacy of meat and meat products was low and this could be the major cause of

Table 3. Mean daily food intake (g) of the subjects (N=50)

Food group	Breakfast	Lunch	Snacks	Dinner	Total	P value	Critical difference	Suggested Intake (g)*
Cereals	88±19.3	86±13	13±6.7	74±11.2	261±50.2	≤0.01	9	270
Pulses	-	23.45±6.7		21±3.8	44.45±10.5	≤0.01	1.6	60
Green leafy vegetables	2.0±0.0	-	-	13±17.3	15±7.3	NS	-	100
Root and tubers	16±5.4	37±12.7	5±6.3	53±24.5	111±48.9	≤0.01	8	100
Other vegetables	-	-	-	65±27.4	65±27.4	≤0.01	11	100
Fruits	-	-	3±9.2	14±13.3	25±33.8	NS	-	100
Milk and milk products	132±34.62	58±19.5	43±21.1	34±9.4	267±84.6	≤0.01	26	300
Meat and meat products	3±8.54	-	-	13±0.0	16±8.54	NS	-	60
Fats and oils	22±10.7	15±7.1	4±5.2	17±8.7	58±31.7	≤0.01	1.5	20
Sugar and jaggery	11.8±10.0	10.3±5.9		6.9±3.5	29.1±19.4	NS	-	20

Values were Mean ± SD
* Suggested intake for sedentary adult women (ICMR, 2010)

their low iron status as meat and meat products were high in haem iron, which can be easily and maximum absorbable up to 15-35% (Hurrel and Egli 2010). On the contrary, Batra (2009) reported that consumption of egg, meat and poultry was 88 per cent among adolescent girls of Ludhiana. Daily consumption of sugar was 29.1g day^{-1}, which was higher than the suggested intake of 20 g day^{-1}. Most of the sugar (11.8g day^{-1}) was consumed at breakfast time with tea or milk followed by lunch with curd and in addition to this. It was also consumed in the form of biscuits, cakes, chocolates, ice cream, shakes, soft drinks, sweets, etc. There was no jaggery consumption by the subjects.

The daily consumption of fats and oils was 58 g day^{-1}, which was 2.9 times higher than that of suggested intake. The subjects consumed significantly ($p<0.01$) higher amount of fats and oils during breakfast (22g day^{-1}) in the form of butter or in parantha as compared to dinner (17 g day^{-1}) and lunch (15 g day^{-1}) as fried rice and poori was served in the menu of hostel mess. Intake of fats was less in in-between meals as every subject were not used to take snacks or in between meals.

Nutrient intake: The nutrient intake by the subject and per cent adequacy of nutrients has been shown in table 4 and fig 2. The average daily intake of energy, protein and fat by the hostel girls was 1856 Kcal, 52.65 g and 60.95g day^{-1}and per cent adequacy was 97.7%, 95.7% and 304 %. The energy intake was slightly lower than the RDA of 1900 Kcal (ICMR, 2010). The maximum consumption of energy was derived during breakfast (627 Kcal) followed by the dinner and then by lunch. This might be due to consumption of paranthas (shallow fried) with butter and milk/tea. There was a significant ($p<0.01$) difference in energy intake during breakfast, lunch and dinner. The nutrient adequacy ratio for protein was found to be marginally adequate. The subjects had significantly ($p<0.01$) higher protein intake in lunch (19.45 g day^{-1}), which might be due to inclusion of pulses/legumes and curd in the hostel mess menu as compared to dinner and breakfast. There was little contribution of snacks to the total protein intake.

The average daily intake of ß-carotene and vitamin C was 1788.2ug and 55.35mg with per cent adequacy of 37.2 and 138.3%. The ß-carotene intake was less than half of the RDA of 4800ug day^{-1}, whereas, vitamin C intake was higher than that of RDA of 40 mg day^{-1} for a sedentary adult woman (ICMR, 2010). No significant differences were found in ß-carotene content present in three meals. ß-carotene was found to be inadequate. This might be due to less consumption of green leafy vegetables and fruits. The nutrient adequacy ratio for vitamin C was found to be

Table 4. Daily nutrient intake of the subjects

Nutrient	Breakfast	Lunch	Dinner	Snacks	Total	P Value	Critical Difference	RDA*
Energy (Kcal)	626.6±95.8	566±86.01	578.7±151.8	85±43.7	1856±394.91	≤0.01	67	1900
Protein (g)	15.6±1.21	19.45±2.69	16.4±6.16	1.2±0.6	52.65±13.46	≤0.01	4	55
Fat (g)	32.8±12.17	8.45±0.93	11.7±3.19	4.5±5.2	60.95±23.63	≤0.01	56	20
Carotene (µg)	487±115.2	668±448.2	269.2±147.4	567±276.1	1788.2±1089.5	NS	-	4800
Vitamin C (mg)	17.2±23.5	7.45±2.06	24.71±22.89	2.3±3.54	55.35±51.99	≤0.01	39	40
Iron (mg)	5.03±0.05	6±1.41	5.14±1.77	0.765±1.11	17.83±5.57	≤0.01	1.8	21
Calcium (mg)	260±50.8	245.7±72.61	201±103.49	21.8±9.65	728.5±236.55	≤0.01	34	600
Folacin (µg)	32±4.1	120.54±52.3	111.85±15.5	0.6±1.45	265±73.38	≤0.01	6	200

P values were for three major meals i.e. breakfast, lunch and dinner only
*RDA - Recommended Dietary Allowances for sedentary adult woman (ICMR, 2010)

adequate. The subjects had significantly ($p<0.01$) higher vitamin C intake in dinner as compared to breakfast and lunch. Chacko and Begum (2007) reported the average daily intake of ß-carotene was low compared to recommended allowances. The total consumption of folacin by the hosteller was 265 ug day^{-1} and nutritional adequacy was 132.4%. The folacin intake was higher than the RDA of 200 ug day^{-1} for a sedentary adult woman (ICMR, 2010), this might be due to adequate intake of cereals, pulses and roots and tubers. The subjects had significantly ($p<0.01$) higher folacin intake in lunch as compared to dinner and breakfast. The nutrient adequacy ratio for folacin was found to be adequate. Pathak *et al.* (2004) also reported that 7.8 per cent of the young women of Haryana had adequate folic acid intake.

The daily intake of iron and calcium by the subjects was 17.8 and 728.5mg day^{-1}. Intake of iron was significantly lower than that of RDA of 21 mg day^{-1} with per cent adequacy of 84.76%, whereas, calcium intake was higher than the RDA of 600 mg day^{-1} with per cent adequacy 121.4%. Iron

Fig.1. Per cent adequacy of food groups among hosteller girls
A-adequate, MA-Marginally adequate, MI-Marginally inadequate and I–Inadequate

Fig. 2. Per cent adequacy of nutrient among young adult hostellers
A-adequate, MA-Marginally adequate MI-Marginally inadequate and I–Inadequate

contributed through breakfast, lunch, dinner and snacks was 5.0, 6.0, 5.0, 0.76 mg day^{-1}, respectively. The consumption of iron was significantly ($p<0.01$) higher in lunch followed by the dinner while the consumption of calcium was significantly ($p<0.01$) higher during breakfast as compared to lunch and dinner. The nutrient adequacy ratio for iron was found to be marginally adequate but for calcium, it was found to be adequate. Pathak *et al.* (2004) and Shukla *et al.* (2006) also reported low iron intake in women of Bihar, Haryana and Mumbai, respectively.

The study concluded that the consumption of cereals, pulses, milk and milk products was nearly adequate while consumption of green leafy vegetables, other vegetables, fruits, meat and meat products was inadequate as compared to suggested intake. The consumption of roots and tubers, fats and oils and sugar was much higher than suggested intake. The overview of nutrient intake suggested that out of the eight nutrients studied, vitamin C, calcium, folacin and fat was adequate while energy, protein and iron were marginally adequate. Though the recent trend of unhealthy eating among youngsters has been reported previously, the study indicates that hostel diets were optimally planned in terms of nutrition.

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Nutritional Inputs and Awareness to Manage Seasonal Variation in Iron Status of Adolescent Girls

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***Abstract*:** The iron status of the adolescent girls was assessed by dietary, anthropometric and hematological parameters. The dietary and nutrient adequacy was higher in winter season. Subjects recorded higher mean hemoglobin level during winter season compared to summer. For the management of seasonality, value added traditional recipes using dehydrated Bengal gram (*Cicer arietinum*), fenugreek (*Trigonella corniculata*) and spinach (*Spinacia oleracea*) leaves powder were developed for iron security. All the products with dehydrated *Bengal gram,* fenugreek and spinach leaves received higher scores on nine point hedonic scales, indicating the acceptable utilization of dehydrated green leafy vegetables in traditional products. All the selected value added traditional recipes showed higher iron content as compared to control (without supplementation). Nutrition intervention attains iron security, and significant improvement of 6.87 per cent over the initial hemoglobin level.

Key Word: Adolescent girls, Iron status, Nutritional inputs, Seasonal variation

Iron deficiency continues to be the leading single nutritional deficiency in the world, despite considerable efforts over the past three decades to decrease its prevalence (WHO, 2013). The prevalence of anemia in India is 55.6 per cent and in Punjab, the situation is worrisome, 80.2 per cent of the children in the age group of 6 month to 3 years, 38.4 per cent among young women in the age group of 15-49 years and 41.6 per cent pregnant women are suffering from anemia (NFHS-III, 2005-06).

Nutrition education, which is practical and adopted to suit the socioeconomic conditions, food habits and local food resources, can tackle the problem to a great extent. There is need to promote nutritional education on anemia and has come to put the array of iron rich foods like green leafy vegetables (GLVs) to effective use not just for combating anemia but for achieving all round improvement in health of adolescents. Hence, the present study was undertaken to examine the nutritional inputs and awareness to manage seasonal variation in iron status of adolescent girls of Ludhiana District of Punjab for dietary adequacy, prevalence of under nutrition and iron status. Also attempts to dehydrate the commonly consumed GLVs and to extend the utility of dehydrated vegetables in traditional recipes for iron security have and decide the right period of interventions to attain iron security have been made.

MATERIAL AND METHODS

Seasonal variability in nutritional status: The present study was conducted in Government Senior Secondary School of Ludhiana district of Punjab. A statistically adequate sample of 120 adolescent girls (13-15 years) was selected during May to July 2011 for summer season and December 2011 to February 2012 for winter season. A well- structured questionnaire-cum-interview schedule was developed to elicit the information of adolescent girls in both summer and winter seasons. Twenty four hour recall method was used for three consecutive days to assess the dietary intake. The food intake was compared with the suggested dietary intake (ICMR 2010).

Body Mass Index (BMI): The height and weight of all the adolescent girls was measured by using standard method (WHO, 2004) and calculated by using the formula i.e.,

Body Mass Index (Kg/m^2) = Weight (kg)/Height (m^2)

Measurement of hematological parameters: Blood samples were collected and analyzed for the hematological parameters. Hemoglobin level was measured by using cyanmethemoglobin method of Dacie and Lewis (1974) of all the 120 subjects in both the seasons and a sub-sample of one- third (40) subjects in both the seasons were randomly selected for the analysis of the following hematological parameters: red blood cell (RBC) count (Hunter and Bomford, 1947)), packed cell volume (PCV) (Raghuramulu *et al*., 1983), mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular volume (MCV) of subjects in both summer and winter seasons.

Development of products: Three green leafy vegetable (GLVs) i.e. Bengal gram leaves (*Cicer arietinum*), fenugreek leaves (*Trigonella corniculata*) and spinach leaves (*Spinacia oleracea*) were selected for dehydration and procured from the local market. Leaves were blanched (enclosed in muslin

cloth) in a stainless steel pan for 2 minutes at 80^{0}C and dried in a cabinet (tray) dryer at 50±5^{0}C for 8 hour. Various traditional preparations of cereal, pulses and vegetables namely *chapatti* (unleavened breads made by whole wheat dough), *poori (*unleavened flat rounded breads made by deep frying whole wheat dough)*, paratha* (unleavened flat breads made by pan frying of whole wheat dough)*,* moong dal *(green gram),* chana dal *(brown chickpeas),*kabuli chana *(white chickpeas),* aloo bhurji *(potato vegetable)* and gobhi sabji *(*cauliflower vegetable*)* were standardized in the laboratory. These were prepared using standardized recipes with supplementation of three dehydrated leaves at 5, 7.5 and 10.0 % level. Each product was tested thrice and mean scores were calculated. Judges were asked to score the samples for color, appearance, flavor, texture, taste and overall acceptability using a score card of 9 point Hedonic Rating Scale. The control and accepted products were used for estimation of iron.

Estimation of iron: Total and soluble iron were estimated using atomic absorption spectrophotometer (Piper, 1950). *In vitro* availability of iron (Rao and Prabhabati, 1978) was also estimated.

Ionizable iron: Free form of iron in the filtrate, which reacts with alpha- alpha- dipridyl to yield colour, obtained after incubation of the samples with pepsin- HCl at 1.35 and 7.5 as described by AOAC (1985). This form of iron corresponds to the ionizable iron. The percentage of iron absorption was determined by regression equation of Rao and Prabhavati (1978) as given below:

$Y = 0.4827 + 0.4707X$

Where, Y = % Fe absorption in adult, X = ionizable Fe at pH 7.5

Effectiveness of nutrition intervention: A statistically adequate sample of 60 adolescent girls aged 13- 15 years were selected randomly from Senior Secondary School, Ludhiana districts. Out of total 30 were in control group and the remaining 30 in experimental group.

Development of education material: Nutrition intervention including lecture cum demonstration for the period of three months at an interval of 15 days was imparted to the subjects of experimental group in the form of modules, as well as lectures, visual aids like charts and posters, booklet and leaflets. Demonstrations of developed and standardized traditional recipes using dehydrated green leafy vegetables (GLVs) were conducted to selected adolescent girls of experimental group. After pre-testing, the subjects were imparted nutrition education supplemented with printed material and demonstration of developed products from dried green leafy vegetables (GLVs). Knowledge, attitude and practice (KAP) and food frequency questionnaire was developed to obtain the desired information.

Frequency of food consumption: Information regarding the frequency of consumption of foods rich in blood forming nutrients for the last one month was collected by administering food frequency questionnaire. The frequency of food consumption was quantified by a score system i.e. 10- thrice in a day, 9- twice in a day, 8- daily, 7- thrice in a week, 6- twice in a week, 5-weekly, 4- thrice in a month, 3- twice in a month, 2- monthly, 1- occasionally and 0- never. The mean frequency was calculated for each food item consumed by each one.

Effectiveness of nutrition intervention: The pre and post intervention was done to evaluate the impact of intervention in terms of pre and post KAP (knowledge, attitude and practice) scores, food frequency scores and hemoglobin level of subjects.

RESULTS AND DISCUSSION

Seasonal variation on iron status

Food intake: The seasonal variation in consumption of cereals and pulses among the selected adolescent girls as 237.35 and 277.39 g and 25.38 g and 39.62g in summer and winter season, respectively which was significantly ($p \leq 0.01$) higher in winter season (Table 1). The per cent adequacy of cereals and pulses consumption was observed as 71.93 and 84.06, and 42.30 and 66.03 for summer and winter season, respectively. The cereal intake was observed in the form of chapattis and paratha. Zanvar and Devi (2007) reported that mean daily consumption of cereals among adolescent girls (13-18 years) ranged between 245.13 to 277.92g, which was lesser as compared to Indian Council of Medical Research recommendations.

The mean intake of green leafy vegetables was reported as 21.97 and 50.07g during summer and winter season, respectively depicting a significant ($p \leq 0.01$) difference in both the seasons. The per cent adequacy of green leafy vegetables was found to be only 21.97 in summer and 50.07 in winter season when compared with suggested dietary intake. Sajjan (2008) also found prevalence of anemia among adolescent girls due to fewer intakes of green leafy vegetables. Majority of the girls were not using at all because they were unaware of the nutritive value of these green leafy vegetables and consume very less quantity of GLVs, which was not sufficient to meet the daily recommendation of green leafy vegetables.

The average fruit intake was 24.00 and 76.16g in summer and winter respectively among selected adolescent girls. A significantly ($p \leq 0.01$) higher consumption of fruits was

observed in winter season. The per cent adequacy of consumption of fruits by selected adolescent girls in summer and winter was 24.00 and 76.16, respectively. Fruits are seasonal and available in huge amount during its peak season at low price that's why during winter season the consumption was higher, whereas, due to inadequate availability of fruits like grapes, orange, Indian gooseberry, etc. during summer the intakes of fruits among adolescents in the present study was less. The average intake of milk and milk products was 140.52 and 217.67g in summer and winter season respectively. The adequacy of milk and milk products was 28.10 and 43.53 per cent in summer and winter season respectively. Videon and Manning (2003) also reported the inadequate consumption of milk and milk products among adolescents. The mean intake of cereal and millets, pulses and legumes, green leafy vegetables, roots and tuber and milk and milk products was found significantly higher in winter as compared to summer season but their intake was lower as compared to recommended dietary allowances for Indians.

Biochemical assessment: The hemoglobin (Hb) levels of girls in summer and winter season was as 10.61and 10.85g/dl, respectively (Table 2) implying that a majority of the girls suffered from a mild degree of anemia (10-11.9g/dl). Increase in blood hemoglobin (Hb) levels in winter season was statistically significant ($p \leq 0.001$). Deepa *et al.* (2004a) reported that among the rural adolescent girls, hemoglobin level showed seasonal variation with higher values during winter (9.54 g/dl) compared to summer (9.21 g/dl) and rainy season (9.47 g/dl). On the contrary, hemoglobin level was higher during rainy season (10.26 g/dl) followed by winter (10.21 g/ dl) and summer (10.05 g/dl) among urban subjects.

The 90.84 per cent adolescent girls were affected with various grades of anemia i.e., 77.06 per cent were mildly anemic, 21.10 per cent were moderately anemic and 1.83 per cent were severely anemic in summer season. However, in winter season, the prevalence of anemia was 78.33 per cent (Table 3). The prevalence of various category of anemia among adolescent girls was lower in (84.04 per cent mild and 15.96 per cent moderately anemic) but a common problem and the rate of prevalence was low due to increased consumption of blood forming foods such as green leafy vegetables, fruits and other protective foods in their diet during winter season. Deepa *et al.* (2004b) reported that slightly more than 12 per cent of rural respondents were normal in rainy and winter seasons, but only 7.5 per cent were normal in summer.

Development of products: On hedonic scale, the mean scores for overall acceptability of supplemented value added

Table 1. Seasonal variation in mean food intake of selected adolescent girls

Food groups	Daily food intakes		t- test**
	Summer (n=120)	Winter (n=120)	
Cereals and millets	237.35	277.39	8.52
Pulses and legumes	25.38	39.62	19.10
Green leafy vegetables	21.97	50.07	20.81
Roots and tubers	47.46	64.84	24.07
Other vegetables	38.43	47.89	6.97
Fruits	24	76.16	19.44
Milk and milk products	140.52	217.67	18.81
Fat and oils	34.58	44.38	107.29
Sugar and jaggery	20.23	25.8	15.03

**significant at 0.01% level of significance

Table 2. Seasonal variation in hematological profile of adolescent girls

Hematological parameters	Standard value	Summer	Winter	t- test**
Hb (g/dl)	≥12@	10.61	10.85	8.92512
PCV (%)	32-48^	31.7	32.84	8.67412
RBC (million/m^3)	4.0-5.5^	3.38	3.71	7.32347
MCHC (%)	32-48^	34.17	35.03	5.64574
MCV (fl)	78-94^	94.25	95.35	5.40386

**significant at 1%
@ WHO (2001)
^ Hunter and Bomford (1967)

Table 3. Seasonal variation in prevalence of anemia among selected adolescent girls

Category of Anemia	Summer (n=120)	Winter (n=120)
Non Anemic (≥12 mg/dl)	11 (9.16)	26(21.67)
Anemic ((<12 mg/dl)	109 (90.84)	94(78.33)
Mild (11.9-10 mg/dl)	84 (77.06)	79(84.04)
Moderate (9.9-7.0 mg/dl)	23 (21.10)	15(15.96)
Severe (<7.0 mg/dl)	2 (1.83)	-

#Figure in parentheses represents percentage

chapati, *poori* and *paratha* with Bengal gram (BLP), fenugreek (FLP) and spinach leaves powder (SLP) at 7.5 per cent level obtained significantly highest scores for all the sensory attributes. The mean scores of supplemented value added *moong dal, channa dal* and *kabuli channa* with Bengal gram, fenugreek and spinach leaves powder at 5.0 per cent level obtained significantly highest scores for all the sensory attributes. The mean scores of supplemented value added *aloo bhurji* and *gobhi sabji* with Bengal gram, fenugreek and spinach leaves powder at 7.5 per cent level obtained significantly highest scores for all the sensory attributes. All cereal, pulses and vegetable based value added recipes were accepted at 7.5, 5.0 and 7.5 per cent level of supplementation.

Total and soluble iron: The total iron content of the treatment I (control) of various products ranged from 3.03 mg/100g in *potato vegetable* to 34.97 mg/100g in *gobhi sabji*. In *chapatti,* poori *and paratha* of treatment I was estimated at 7.37, 6.67 and 6.23 mg/100g respectively. The total iron content of treatment II (Bengal gram leaf powder), III (fenugreek leaf powder) and IV (spinach leaf powder) in all value added products was observed to be higher as compared to the control (Table 5).

It may be attributed to the high quantity of iron in dehydrated leaves powder of Bengal gram, fenugreek and spinach. Among these, three dehydrated samples, Bengal gram contain highest amount of iron. Punia *et al.* (2004) found 3.23 and 4.03 mg/100g of iron in khondhra leaves supplemented Bengal gram dhal and green gram dhal, whereas, 6.32 mg/100g of iron in amaranths leaves supplemented *paratha,* at different levels of supplementation. All value added product had higher ionizable iron content that in the control; which may be attributed to replacement of basic constituents of recipes by leaves powder with higher iron content. An increase in per cent bioavailability in treatment I, II and III of all the prepared products was found than to the control. This is due to the addition of leaves powder.

Frequency of different food groups consumption: The frequency of consumption of amaranth leaves (2.00), chenopodium leaves (2.43) and Bengal gram leaves (2.07) were in between monthly to twice a month in experimental group before nutrition intervention, which improved to 3.00, 3.20 and 3.40 after nutrition intervention, respectively.

Perusal of the data (Table 5) indicated that nutrition education positively improved the consumption scores of the entire blood forming food items among selected adolescent girls of experimental group. Therefore, there is a need to educate the people to increase the consumption of green leafy vegetables and help themselves in combating micronutrient deficiencies.

The mean KAP scores (Table 6) obtained in pre-test by selected adolescent girls of control group were 17.8 and of experimental group were 18.97, and corresponding mean scores in post test were 17.3 and 29.43, respectively. Gain in scores was found negative (-0.57) in control group, whereas, in experimental group it was 10.82. Quantum of improvement was 0.97 and 1.56 times in the adolescent girls of control and experimental group respectively, thereby indicating an improvement in knowledge scores of adolescent girls of experimental group.

The mean initial level of hemoglobin in experimental group was 10.48g/dl, which increased significantly ($p \leq 0.01$) to 11.20 g/dl, whereas, the mean initial level of hemoglobin increased non significantly from 10.80 in control group after the three months of nutrition intervention. There was a significant increment of 0.72 g/dl in experimental group (Table 7) and a non-significant increment was assessed in the control group. The student 't' test indicated that significant differences existed between the groups (experimental Vs. control group). The prevalence of anemia in experimental group before nutrition intervention were 86.7 per cent, which include 73.08 per cent mild, 23.08 per cent moderate and 3.84 per cent severe anemia. Prevalence of anemia in present study was 73.3 per cent in control group, which include 68.18 per cent mild, 31.82 per cent moderate and the percentage of severe anemia in control group was found to be negligible. After nutrition intervention, the prevalence of anemia was reduced to 73.3 per cent, which comprise 77.27 per cent mild, 22.73 per cent were moderately anemic and the prevalence of severe anemia was reduced to nil in experimental group. The present study observed that the prevalence of anemia may be due to inadequate consumption of green leafy vegetables and other blood forming foods in their dietaries was observed.

The results of the study revealed that there is considerable seasonal variation in food intake and the iron status of adolescent girls. The prevalence of under nutrition was observed higher in summer season. Correspondingly, the adolescent girls recorded higher mean hemoglobin level

Table 4. Total, soluble and ionisable iron content and bioavailability of iron value added accepted product (mg/100g DM basis)

Value added products	Total iron	Soluble iron	Ionisable iron	Bio-availability(%)
Chapati				
T 0	7.37	4.89	0.5	3.68
T I	14.7	5.98	2.5	8.49
T II	11.7	8.27	1.5	6.52
T III	10.27	5.11	2.5	11.94
Poori				
T 0	6.67	4.98	0.5	4.01
T I	12.87	5.94	2	7.8
T II	10.67	5.28	1.5	7.1
T III	9.37	7.42	2.3	12.04
Parantha				
T 0	6.23	4.06	0.6	5.02
T I	13.33	4.52	2.65	9.84
T II	11.1	2.66	1.65	7.48
T III	10.97	5.93	2.1	9.49
Moong dal				
T 0	4.27	3.53	0.57	6.77
T I	17.8	9.85	4.6	12.65
T II	15.4	8.1	3.85	12.25
T III	11.63	7.78	2.8	11.82
Chana dal				
T 0	6.07	3.1	0.50	4.4
T I	18.73	11.29	4.45	11.67
T II	13.33	10.77	3.02	11.16
T III	10.63	7.6	2.87	13.21
Kabuli chana				
T 0	4.67	4.28	0.7	7.54
T I	16.93	8.34	4.25	12.3
T II	13.3	5.39	3.94	14.43
T III	12.43	4.5	3.55	13.93
Aloo bhurji				
T 0	3.03	1.35	0.5	8.25
T I	10.2	4.49	3.3	15.71
T II	6.67	1.91	3.4	24.48
T III	4.23	7.41	3	33.87
Gobhi abji				
T 0	3.97	4.41	0.6	7.6
T I	7.77	5.34	7.3	44.71
T II	6.3	3.59	5.05	38.21
T III	4.5	5.07	6.5	68.47

T0= Control (without any supplementation)
T I= Accepted value added products supplemented with Bengal gram leaves powder (BLP)
T II= Accepted value added products supplemented with fenugreek leaves powder (FLP)
T III= Accepted value added products supplemented with spinach leaves powder (SLP)

Table 5. Effectiveness of intervention on mean food (rich in blood forming) frequency consumption scores of selected adolescent girls (n=60)

Fruits and vegetables	Group C		Group E	
	Pre	Post	Pre	Post
Green leafy vegetables				
Amaranth (*chauli*) leaves	0.20	0.37	2.00	3.00
Bathua leaves	1.07	1.17	2.43	3.20
Bengal gram leaves	0.97	1.10	2.07	3.40
Cabbage	0.30	0.30	3.80	4.20
Carrot leaves	0.83	0.83	2.63	3.37
Cauliflower greens	1.40	1.40	2.33	3.97
Coriander leaves	0.33	0.40	2.63	3.40
Curry leaves	0.60	0.60	1.20	2.73
Drum stick leaves	0.80	0.90	2.27	3.20
Fenugreek leaves	0.00	0.13	0.90	2.47
Mint	0.77	0.93	1.43	2.83
Mustard leaves	0.47	0.63	1.97	4.03
Onion stalks	0.00	0.10	1.37	4.43
Radish leaves	1.33	1.33	1.47	3.57
Spinach	3.97	3.97	4.00	5.90
Turnip greens	0.80	0.97	0.73	3.27
GLV alone	4.00	4.00	4.20	4.63
GLV with cereal/millet	2.50	2.67	3.10	3.83
GLV with pulse/Other vegetables	0.00	0.13	1.37	4.17
Fruits				
Amla	0.70	0.87	2.37	3.63
Apple	1.60	1.60	2.10	3.80
Banana	4.70	4.70	5.67	6.43
Grapes	1.33	1.43	2.73	4.77
Guava	2.70	2.80	4.33	4.90
Lemon	4.40	4.40	6.00	7.13
Orange	2.33	2.43	2.93	4.03
Papaya	0.73	0.83	1.80	3.30
Pineapple	0.50	0.63	1.60	2.97
Pomogranate	0.23	0.23	1.73	3.03
Raw mango	0.50	0.50	2.77	4.40
Ripe mango	2.87	2.87	2.57	3.33
Tamarind	0.50	0.63	0.63	3.13
Totmato (ripe)	5.30	5.40	8.00	8.23
Zizypus (Ber)	0.0	4.19	0.0	0.00

Note: 10- thrice in a day, 9- twice in a day, 8- daily, 7- thrice in a week, 6- twice in a week, 5-weekly, 4- thrice in a month, 3- twice in a month, 2- monthly, 1- occasionally and 0- never. The mean frequency was calculated for each food item consumed by each subject

Table 6. Impact of nutrition intervention on KAP scores of selected adolescent girls (n=60)

Parameters	Before	After	t value	Gain in scores	Quantum of improvement (x times)
			Group E (n=30)		
Knowledge	20.56	42.76	26.03	22.20	2.19
Attitude	1.47	5.14	91.91	3.67	3.55
Practice	12.83	18.76	17.51	5.93	1.48
Over all	11.62	22.23	32.94	10.61	1.91
			Group C (n=30)		
Knowledge	17.86	18.16	1.17^{NS}	0.30	1.02
Attitude	1.44	1.49	1.37^{NS}	0.06	1.05
Practice	12.66	12.86	1.79^{NS}	0.20	1.02
Over all	10.65	10.84	1.66^{NS}	0.19	1.01

Table 7. Impact of nutrition intervention on prevalence of anemia among* selected adolescent girls (n=60)

Hb level (g/dl)	Experimental group		Control group	
	Pre test	Post test	Pre test	Post test
Non anemic (≥12)	4 (13.3)	8 (26.7)	8 (26.7)	7 (23.3)
Anemic (<12)	26 (86.7)	22 (73.3)	22 (73.3)	23 (76.7)
Mild anemia (10-11.9)	19 (73.08)	17 (77.27)	15 (68.18)	16 (69.56)
Moderate anemia (7-9.9)	6 (23.08)	5 (22.73)	7 (31.82)	7 (30.44)
Severe anemia (<7)	1 (3.84)	-	-	-

* Figure in parentheses represents percentage

during winter season compared to summer. Season specific nutrition intervention including lecture cum demonstration improve the frequency of consumption of foods rich in blood forming nutrients by adolescents. The nutrition intervention during summer was found to be the most sustainable approach to overcome the seasonal variation and improve the iron status of adolescent girls.

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MATLAB Toolbox for Mathematical Modelling of Drying Kinetics of Tomato

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Abstract: The present study aimed to evaluate the drying quality of underripe, ripe and overripe tomato using various known semi-theoretical models. To estimate and select the appropriate drying curve equation semi-theoretical and/or empirical models i.e. Exponential equation, Page's model, Power equation, 2nd Order Polynomial equation and Handerson were fitted using cftool of MATLAB TOOLBOX to the data and compared according to coefficients of determination (R^2 and χ^2). Effects of drying air temperature, sample size and ripening stage on model constants and coefficients were studied by multiple regression analysis. Of all drying models, the semi-theoretical Midilli-Kucuk model was selected as best one, according to R^2, SSE, RMSE and χ^2 of 0.998, 0.0036, 0.0124 and 0.0026, respectively. Analysis of a fully factorial experimental design indicated that temperature had more effect on drying kinetics than did size. A constant rate period was not observed in the drying of tomato rather all the drying process occurred in falling rate period.

Key Words: Drying quality, Midilli–Kucuk model, Ripening stage, Temperature

Drying of moist materials is a complicated process involving simultaneous, coupled heat and mass transfer phenomena, which occur inside the material being dried (Yilbas *et al.,* 2003). Thin layer drying, dries a single layer of sample as slices. Thin layer drying models describing drying phenomenon of agricultural materials fall into theoretical, semi-theoretical and empirical categories (Midilli *et al.,* 2002; Panchariya *et al.,* 2002). The first takes into account only internal resistance to moisture transfer, the others consider only external resistance to moisture transfer between product and air. Semi-theoretical models offer a compromise between theory and ease of use. They are only valid within the temperature, relative humidity, airflow velocity and moisture content range for which they were developed. Among semi-theoretical thin layer drying models- Newton, Page, modified Page, Henderson and Pabis, logarithmic, two-term model, two-term exponential, diffusion approach model, modified Henderson and Pabis model, and the Midilli–Kucuk model are widely used. On the other hand, empirical models derive a direct relationship between average moisture content and drying time. The primary objective of drying is to extend shelf-life by reducing water content. Removal of moisture may deactivate enzymes or microorganisms that can cause undesired chemical reactions and lead to quality deterioration (Jayaraman *et al.,* 2006). In addition to preservation, drying is used to reduce cost or difficulty of packaging, handling, storage and transportation, by converting raw food into a dry product.

The drying rates of food materials are usually determined experimentally, since it is very difficult to predict accurately the heat and mass transport rates theoretically. Drying tests are carried out on a layer of material, placed in an experimental dryer, which is operated under controlled conditions of temperature, air velocity and humidity. Short constant drying rate periods are observed in air-drying of high moisture content. However, most food materials do not show constant rate periods and they dry entirely in the falling rate period, during which mass transfer is controlled by the transport of water (mostly molecular diffusion) through the material to the surface of evaporation.

MATERIAL AND METHODS

Under-ripe, ripe and over-ripe tomatoes purchased locally near Tezpur University, Assam, India were used for drying kinetics study. Before drying, tomatoes were washed to remove dirt, cut in cubes of 0.5×0.5×0.5, 1×1×1, 1.5×1.5×1.5 cm (width × thickness × length), weighed and kept on glass petriplates. For determination of initial moisture content, samples were dried in hot oven dried and weighed after 24hrs of drying and based on the initial weights, moisture content were calculated in triplicates.

A tray dryer (model-UOP8, Armfield) of duct dimension 262 × 28 × 28 cm was used for drying by passing a stream of hot air over trays of wet material in a uniform flow direction. The unit consists of a floor standing tunnel in one end of which is mounted an axial flow fan. Downstream of the fan a bank of electrically heated elements, heats air flowing to the drying chamber. The chamber with a transparent access door, contains a rack of trays suspended from a balance mounted on top of the drier. The total capacity of the trays is

approximately 3kg of solids. Ducting upstream and downstream of the drier is designed to provide a uniform airflow over the trays. Measurements of temperature and humidity (with an aspirated wet and dry bulb psychrometer) may be made before and after the drier chamber.

The petriplates holding samples were loaded as thin layer in ARMFIELD tray dryer. Drying kinetics of three ripening stages of tomato with varying cube sizes (0.5×0.5×0.5, 1×1×1, 1.5×1.5×1.5 cm) were studied at three different temperatures (45, 55 and 65ºC) at a constant air flow rate of 1m/s. Sample weight was taken after 15 minutes and the experimental drying process of tomato cubes were stopped after no further change in weight was observed. Moisture content data were converted to moisture ratio and then fitted to the six drying models. During the experiments, ambient temperature and relative humidity, inlet and outlet temperatures of drying air in the duct and dryer chamber were recorded. Samples were dried in a uniform flow. An initial moisture content of tomatoes were determined using hot-air oven at 130°C for 24hrs.

Mathematical modeling of drying curves: The semi-theoritical and empirical models, which derive a direct relationship between average moisture content and drying time. Theoretical and empirical models have been developed for various agro-based products (Basunia and Abe, 2001). The models selected for comparison were: Exponential equation, Page's model, Power equation, 2nd Order Polynomial equation, Handerson and Pabis model and the Midilli-Kucuk model (Table 1). Various model parameters like are used for prediction of drying behaviour.The moisture ratio (MR) of tomato during drying experiments was calculated using the formulae of Aghbashlo *et al.* (2008).

$$MR \quad ^{2} \frac{M_d - M_e}{M_0 - M_e}$$

(where MR – moisture ratio, M_d – Moisture at particular drying time and M_e – Equilibrium moisture content). However, the moisture ratio (MR) was simplified by modifying the above equation to M_d/M_o (Shanmugam and Natarajan, 2006).

After determination of the moisture ratio, fitting of models was done using the "cftool" in MATLAB (ver 7.6.0.324; 2008 made). Cftool is a curve fitting procedure with an initial data set containing the X and Y data, which must be numeric having the same length. The R^2, SSE, RMSE and chi-square (χ^2) values where determined. Design expert (ver 8.0.7.1) was used as an optimization tool and full factorial design was used for establishing numbers of experiments using temperature, time and ripeness stage as independent variables and drying constant as output.

RESULTS AND DISCUSSION

Average moisture content of under-ripe, ripe and over-ripe samples was 94.90, 95.01 and 94.39 per cent. The TSS of under-ripe, ripe and over-ripe samples was 2.203, 2.937 and 3.103, respectively. There was slight variation of moisture content, due to higher dry matter content in over-ripe samples. TSS of the over-ripe samples was higher followed by ripe and under-ripe.

The appropriate model for the description of the drying kinetics of tomato samples was chosen according to the criteria of Zhu and Shen (2014). The highest coefficient of determination (R^2), least reduced Chi-square (^{2}), low sum of squares (SSE) and low Root mean square error (RMSE) were used as the indicator of goodness of fits. Based on least ^{2} values, SSE, RSME and high R^2 values, Midilli-Kucuk model were selected to be the best model for the present study with R^2, SSE, RMSE and χ^2 of 0.9983, 0.0036, 0.0124 and 0.0026, respectively. Midili-Kucuk model constants *A, B, K, N* can be used to calculated predicted moisture ratio and a graph was plotted between actual and predicted moisture ratio for best fit model, fig. 1-3 shows the fitting of model. Value of constant *A* lies between 0.9 to 1.014, which indicates that most of the drying takes place in falling rate of drying period (Table 2).

Midlli-Kucuk model constant K was regressed against those of size, drying air temperature and ripening stage using design expert 8.0.7.1. General factorial experimental design with 3 factors (size, temperature and ripening stages) and 3 levels for each factor and 1 response

Table 1. Drying models used in examination of the data

Model Code	Model name and year	Model Equation
M1	Exponential Equation	$MR = \exp(-Kt)$
M2	Page's model	$MR = \exp(-Kt^N)$
M3	Power equation	$MR = 1 + At^N$
M4	Polynomial equation (2nd Order)	$MR = 1 + At + Bt^2$
M5	Henderson and Pabis model	MR = Aexp[(-Kt)
M6	Midilli-Kucuk model	$MR = A\exp(-Kt^N) + Bt$

where *K* is the empirical coefficient, *N is* no. of constants, *A* and *B* are empirical constants in the drying models

Table 2. Midilli-Kucuk model parameters for samples

Sample no.	Model parameters*				Statistical parameters for Model			
	A	B (min^{-1})	K (min^{-1})	n	SSE	R^2	RMSE	^{2}
1	0.9888	-0.0548	0.441	0.9817	0.0039	0.9974	0.018	0.00033
2	0.9855	-0.0248	0.5212	1.042	0.0047	0.9971	0.0183	0.00033
3	0.976	-0.0209	0.4395	1.145	0.0057	0.9968	0.0195	0.00038
4	0.9815	-0.0377	0.3746	0.9796	0.0055	0.9971	0.0179	0.00032
5	0.9786	-0.0203	0.3642	1.078	0.0038	0.9981	0.0141	0.0002
6	0.9781	-0.0056	0.2958	1.29	0.0025	0.9988	0.0114	0.00013
7	0.9779	-0.021	0.2571	1.053	0.0063	0.9967	0.0187	0.00035
8	0.986	-0.0394	0.2151	0.9739	0.0024	0.999	0.0102	0.0001
9	0.9904	-0.053	0.1622	0.9511	0.0019	0.999	0.0093	0.00009
10	1.001	-0.0358	0.3857	1.103	0.0017	0.999	0.011	0.00012
11	0.9801	-0.0118	0.3578	1.334	0.0033	0.9984	0.014	0.0002
12	0.9904	-0.053	0.3022	0.9511	0.0019	0.999	0.0093	0.05658
13	0.9934	-0.0271	0.3215	1.081	0.0029	0.9987	0.0123	0.00015
14	0.9971	-0.0425	0.3155	0.8609	0.0026	0.9987	0.0114	0.00013
15	0.994	-0.0302	0.2649	0.978	0.0061	0.9974	0.0162	0.00026
16	1.014	-0.0239	0.4044	0.8396	0.0053	0.9974	0.0155	0.00024
17	0.9971	-0.0238	0.3445	0.9098	0.0021	0.999	0.0097	0.00009
18	0.9984	-0.0126	0.3192	0.8862	0.0042	0.9982	0.012	0.00014
19	0.9929	-0.185	0.0321	1.294	0.0019	0.9994	0.0074	0.00005
20	0.9776	-0.016	0.0957	1.296	0.0029	0.9991	0.0094	0.00009
21	0.9894	-0.0638	0.0712	0.8443	0.004	0.9986	0.0109	0.00012
22	0.9692	-0.0152	0.1284	1.182	0.0065	0.998	0.0138	0.00018
23	0.9848	-0.0109	0.1661	1.065	0.0014	0.9996	0.0061	0.00003
24	0.9883	-0.0221	0.1428	0.9752	0.0009	0.9997	0.005	0.00002
25	0.9711	-0.0169	0.1293	1.162	0.0063	0.9978	0.0141	0.01102
26	0.9953	-0.0097	0.1994	1.048	0.0032	0.9991	0.0092	0.00008
27	0.9813	-0.0098	0.1678	1.104	0.0044	0.9987	0.0108	0.00011

*where K is the empirical coefficient, N is no. of constants, A and B are empirical constants in the drying models.

Table 3. Anova for two factor interaction model (2FI Model

Response I :Drying Constant (k)					
Source	Sum of squares	df	Mean Square	F value	p value Prob > F
Model	0.3907	8	0.0488	32.3375	< 0.0001*
Size	0.0113	2	0.0056	3.7407	0.0438
Temperature	0.2705	2	0.1353	89.5696	< 0.0001
Size x temperature	0.1088	4	0.0272	18.0198	< 0.0001
Residual	0.0272	18	0.0015		< 0.0001
Cor. Total	0.4178	26			
* significant					

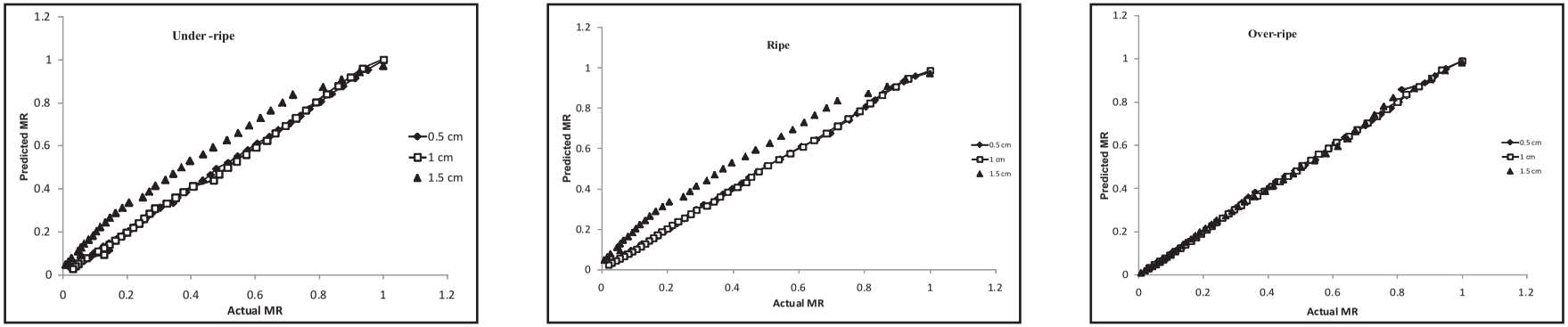

Fig 1. Midilli-kucuk model curves showing actual MR and predicted MR at 45ºC

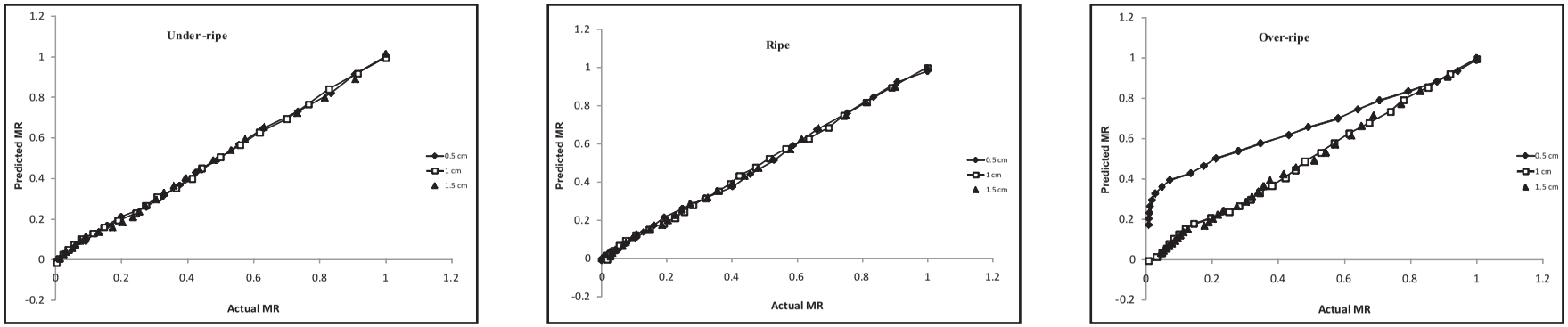

Fig 2. Midilli-Kucuk model curves showing actual MR and predicted MR at 55ºC

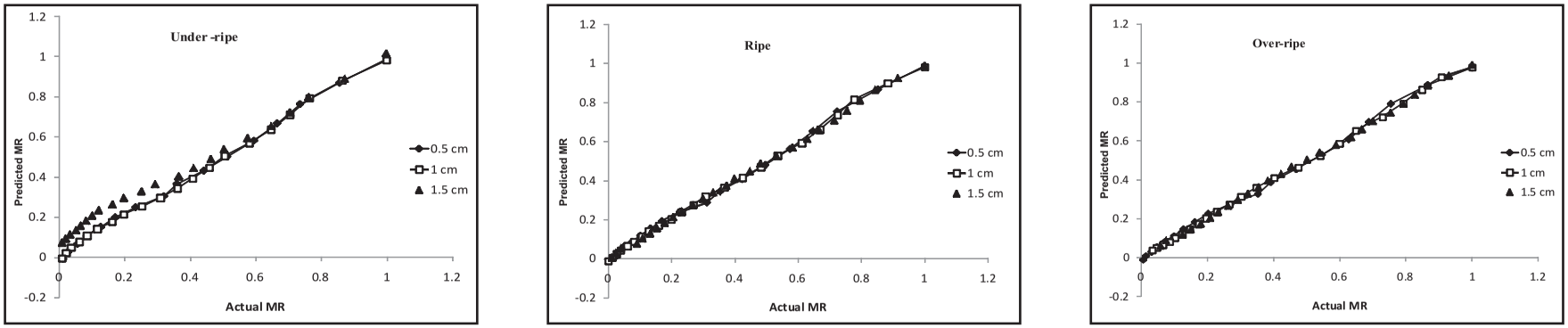

Fig 3. Midilli-Kucuk model curves showing actual MR and predicted MR at 65ºC

(drying constant-K) was chosen. Two factor interaction model (2FI model) provided the best fit with R^2 of 0.9349. F- value for temperature and size (89.569 and 3.7407, respectively) indicates that temperature has highest effect on drying kinetics (Table 3).

It can be concluded therefore that there is a significant influence of the drying air temperature on drying of tomatoes. These results were highlighted also by Kouhila *et al.* (2001) for different agricultural products where the temperature is the most important factor influencing drying kinetics Midilli-Kucuk model was selected to be the best model for the present study with highest R^2 and least SSE, RMSE and χ^2, for explaining the drying rate of tomato cubes of various size, temperature and ripeness. Under-ripe samples dried in less time followed by ripe tomatoes, whereas, higher drying time was required for drying of over-ripe tomatoes, this can be related to the presence of less bound water in under-ripe tomatoes. Least drying time of 3.5hrs was achieved in drying under-ripe tomatoes at 65°C of 5×5×5 cube size. It was also concluded that temperature had highest effect on drying of tomatoes, whereas size had least effect.

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Simulating Phenology, Growth Parameters and Yield of Aerobic Rice Using ORYZA2000 Model

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***Abstract*:** ORYZA2000 was calibrated and evaluated using data from field experiment at college farm, college of agriculture, Rajendranagar, Hyderabad during *Kharif*- 2012 to simulating phenology, growth parameters and yield of aerobic rice using ORYZA2000 model. Crop growth parameters were generated and calibrated at variable nitrogen conditions using ORYZA2000 rice model and was evaluated by root mean square error (RMSE), normalized RMSE and correlation coefficient. The experiment was carried out with BPT5204 cultivar growing under aerobic condition.

***Key Words*:** Calibration, Model, Normalized RMSE, Overestimation, Simulation

Aerobic rice (*Oryza sativa* L.) is water saving production system in which potentially high yielding, fertilizer responsive adapted rice varieties are grown in fertile aerobic soils that are non-puddled and have no standing water. However, supplementary irrigation can be provided in the same way as to any other upland cereal crop (Bouman *et al.,* 2005). The main driving force behind aerobic rice is the increasing water scarcity, which threatens the sustainability of lowland rice production.

Simulation modeling is one of the most powerful tools for analyzing interactions among the soil, plant and atmosphere systems. The models can help to compare experimental research finding across sites, extrapolate field data to wider environments, develop management recommendations and explore effects of climate change and make yield predictions (Jones *et al*., 2003). The first model was ORYZA1 for potential production (Kropff *et al.,* 1994), followed by ORYZA_W for water-limited production and by ORYZA-N and ORYZA1N (Aggarwal *et al.,* 1997) for nitrogen-limited production. In 2001, a new version of the ORYZA model was released, which improved and integrated all previous versions into one model, called ORYZA2000 (Bouman *et al.,* 2001). Hence, the study was carried out to investigate phenological development, yield and calibrate and validate the ORYZA2000 model based on the experimental data.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2012 (July to December)at Acharya N.G. Ranga Agricultural University Rajendranagar, Hyderabad. The site is geographically situated at $17^0$19' N Latitude, 78^0 23' E Longitude at an altitude of 542.6 m above sea level. It falls under Southern Telangana agro climatic zone of Andhra Pradesh. The soil of the experimental field was sandy loam in texture with 75.44 % sand, 11.54 % clay and 13.02 % silt. The nutrient status of the soil was neutral in reaction (7.42 pH), low in organic matter (0.31 %), low in available nitrogen (209 kg ha^{-1}), medium in available P_2O_5 (49 kg ha^{-1}) and medium in available K_2O (220 kg ha^{-1}).

Field experiment was conducted with long duration rice variety BPT5204 dwarf to medium tall, erect, medium tillering, green foliage, non-lodging open type of canopy. The field experiment was laid out in a randomized block design with four replication and six treatments. The treatments are 90 kg N ha^{-1}, 120 kg N ha^{-1}, 150 kg N ha^{-1}, 180 kg N ha^{-1}, 210 kg N ha^{-1} and 240 kg N ha^{-1}. As the paddy field was conducted under potential production conditions that exclude any water or nutrient limitations, disease and pest or weed infestation. Consequently, the data sets required for calibration were variety characteristics. The dates of sowing, emergence, panicle initiation, flowering and physiological maturity were reordered. For each plot during the growing season, plant samples were taken to measure leaf area index (LAI), chlorophyll reading and dry biomass. At maturity, plants were harvested to determine grain yield at 14% moisture content. Throughout the growing season, daily maximum and minimum temperature, sunshine hours, wind speed and rainfall were collected from the meteorological department located at about 150 m away from the experimental field plot.

Rice model ORYZA2000: ORYZA2000 model is an eco-physiological crop model to simulate the growth and development of a rice crop in situations of potential production, water limitation and nitrogen limitations. In

ORYZA2000, the rice crop has four phenological phases, viz., juvenile phase from emergence [development stage (DVS)=0] to start of photoperiod-sensitive phase (DVS=0.4), photoperiod-sensitive phase from DVS = 0.4 until panicle initiation (DVS=0.65), panicle development phase from DVS = 0.65 until 50% of flowering (DVS=1.0), and grain-fill phase from DVS = 1.0 until physiological maturity (DVS=2.0). Each of these four phases has variety-specific development rate constants (DRC).

The basic input requirements of the model are daily weather data (sunshine hours, minimum/maximum temperature, mean wind speed and precipitation), experimental data (dates of sowing, crop emergence, panicle initiation, flowering, maturity and plant density) and crop data (cultivar specific, morpho-physiologic character of plant species). Most of the crop parameters are generic and can be used for all varieties. However, some parameters and functions are best calibrated specifically for the variety and environment under consideration, namely development rates, partitioning factors, relative leaf growth rate, specific leaf area and fraction of stem reserves. The life cycle of rice crop is divided into four main phenological phases. Hence, rice variety specific development rates have to be estimated for the effect of temperature in the different stages. This model generates two output files one contains day wise simulation (run.dat) and other file contains simulation values of the last day of simulation (op.dat).

Two sub programs help to derive these parameters: DRATES for development rates and PARAM for others. The dates of sowing, transplanting, panicle initiation, flowering and maturity for each genotype in each experiment are used to determine the specific pre and post-flowering development rates using program DRATES (Kropff *et al.,* 1994). The special programme is available to compute the development rate parameters from the observed phenological data in the experimental data file: DRATES.EXE, though this programme uses the same input files as ORYZA2000, it does not run under the FSEWin shell. The minimum data required for crop variety calibration in direct sown (rainfed crop) is sowing date and duration of entire crop growth period. Finally development stages are calculated by integrating the development rates and expresses in degree days.

Input and output files: Input data was entered into three file i.e. weather, experimental and crop data file. Day wise weather data, such as maximum and minimum temperature, sunshine hours, rainfall, vapour pressure and wind speed were collected from Agricultural Research Institute, Rajendranagar, Hyderabad and entered into weather file of the ORYZA2000 model. Besides the weather variables, the weather data file also contains information on longitude (LONG; decimal degree), latitude (LAT; decimal degree) and elevation (ELEV; m) of the weather station. The crop data file contains all the parameter values that characterize the rice crop. The physiological and phenological characteristics of the crop needed to simulate potential yield were taken from the Crop data file IR72 (Bouman *et al.,* 2001). The IR 72 values (Bouman *et al.,* 2007) were used with some modifications for development rates of BPT-5204.

The complete experiment data presenting potential production conditions were used to parameterize the model. The calibrated parameters were used to parameterize the model for validation and application (Li *et al.,* 2009). The simulation was run in the N balance mode using six fertilization rates (90, 120, 150, 180, 210 and 240 kg ha^{-1}). The effects of nitrogen fertilization on grain yield, as well as water limited condition on potential yields were analyzed.

Model evaluation: In the process of model evaluation, four statistical methods were selected to compare the results from simulation and observation.

Model performance evaluation was presented by the absolute Root Mean Square Error (RMSE) and Root Mean Square Error normalized (RMSEn) (Kobayashi and Salam, 2000; Gauch *et al.,* 2003). Both characteristics are common tools to test the goodness of fit of simulation models (Larijani *et al.,* 2011).

Where P_i and O_i is the model simulated and experimental measured points, respectively. The 'n' observed data points may be from one treatment or multiple treatments.

RESULTS AND DISCUSSION

The observed and simulated LAI from 15 DAS to the harvest in all nitrogen levels of crop at 15 days interval is depicted in Table 1 and Figure 1. The results indicated that the LAI was overestimated at all stages of crop growth by ORYZA2000 model, though they were highly correlated. These results corroborate with Shailaja *et al.* (2009). The LAI was increased with increase of nitrogen levels up to 60 DAS both simulated and observed value. Bouman (2006) opined that the simulation of LAI was relatively poor and LAI values were overestimated by the model. The RMSE of LAI ranged between 0.96 to 1.71 in aerobic rice.

Dry biomass production (kg ha^{-1}): The results revealed that the dry biomass was overestimated at initial stage of crop growth to maturity. At all the levels of N, similar trend was observed. The RMSE ranged between 930 to 1129 with correlation coefficient 0.90 to 0.98. The high 'r' value suggested that the observed value were in agreement with simulated value. The RMSEn was 16.56 to 22.70, which suggests that the model is fairly well fitted. The data pertaining to observed and simulated dry biomass of aerobic

Table 1. Evaluation results of ORYZA2000 simulation of leaf area index for the validation in aerobic rice (N=8)

Treatments	X_{obs}	X_{sim}	R^2	RMSE absolute	RMSEn (%)
90 kg N ha^{-1}	2.79	5.53	0.83	0.96	34.72
120 kg N ha^{-1}	3.02	6.22	0.83	1.12	36.92
150 kg N ha^{-1}	3.55	6.78	0.74	1.71	48.29
180 kg N ha^{-1}	3.73	7.30	0.72	1.26	33.83
210 kg N ha^{-1}	3.83	7.70	0.77	1.36	35.72
240 kg N ha^{-1}	3.95	8.03	0.78	1.44	36.51

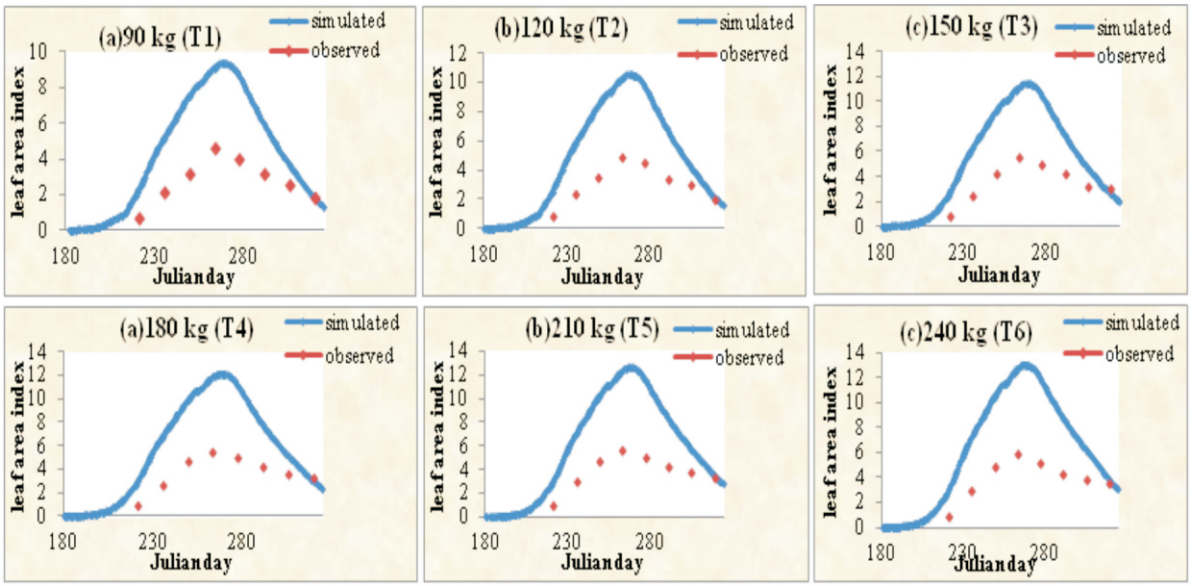

Fig. 1. Simulated and observed leaf area index of aerobic rice at variable nitrogen

rice is presented in Table 2 and Figure 2.

Straw yield (kg ha^{-1}): The results showed that simulated and observed straw yield increased with successive increase with N levels from 90 kg N ha^{-1} to 240 kg N ha^{-1} and the straw yield was also overestimated by this model (Table 3).

The over estimation was increased with increase of N levels. The RMSE and RMSEn of straw yield was 3650 and 64.43%, respectively. Hence, the model was not well predicting the straw yield of aerobic rice due to greater value of R^2 (Table 4). However, the high correlation was observed between simulated and observed straw yield of aerobic rice (R^2=0.96).

Grain yield (kg ha^{-1}): The simulated and observed grain yield of crop was presented in Table 5 and depicted in Figure 3. The data revealed significant differences between observed and simulated grain yield in aerobic rice. However, RMSE, normalized RMSE were 316 and 10.54 %, respectively. From the RMSEn and RMSE values, it can be conclude that the model was good in predicting grain yield even in aerobic rice.

No absolute value for goodness of fit parameter was defined to evaluate weather model is 'good' or 'bad'. Mitchell (1997) demonstrated that even achievement of close-to-ideal goodness-of-fit parameters such as in linear regression does not proved that a model in theoretically correct. Nonetheless, repeated and well documented comparison between model simulations and real world measurement for a certain purpose.

ORYZA2000 model was validated for aerobic rice in southern Telangana region. The model was good for prediction of grain yield and straw yield with RMSEn value 10.54 and 64.43%, respectively. The validity of model was also adjudged by non-significant 't' value in paired 't' test. ORYZA2000 model overestimated leaf area. The crop growth simulation model ORYZA2000 can replace the need for year of costly multi-location, on station, and on farms trial to select rice variety and management practices. The results of validation of the model suggested that there is ample scope for application of the calibrated model to identify better cultivar and management practices for irrigated and unirrigated conditions. The model was predicted well the dry biomass at all stages of crop.

Table 2. Evaluation results of ORYZA2000 simulation of dry biomass for the validation in aerobic rice (N=8)

Treatments	X_{obs}	X_{sim}	R^2	RMSE absolute	RMSEn (%)
90 kg N ha^{-1}	6267	6900	0.98	930	21.81
120 kg N ha^{-1}	4761	7819	0.97	1081	22.70
150 kg N ha^{-1}	5343	8538	0.93	1129	21.14
180 kg N ha^{-1}	5909	9084	0.93	1122	18.99
210 kg N ha^{-1}	6314	9468	0.90	1115	17.66
240 kg N ha^{-1}	6587	9673	0.90	1091	16.56

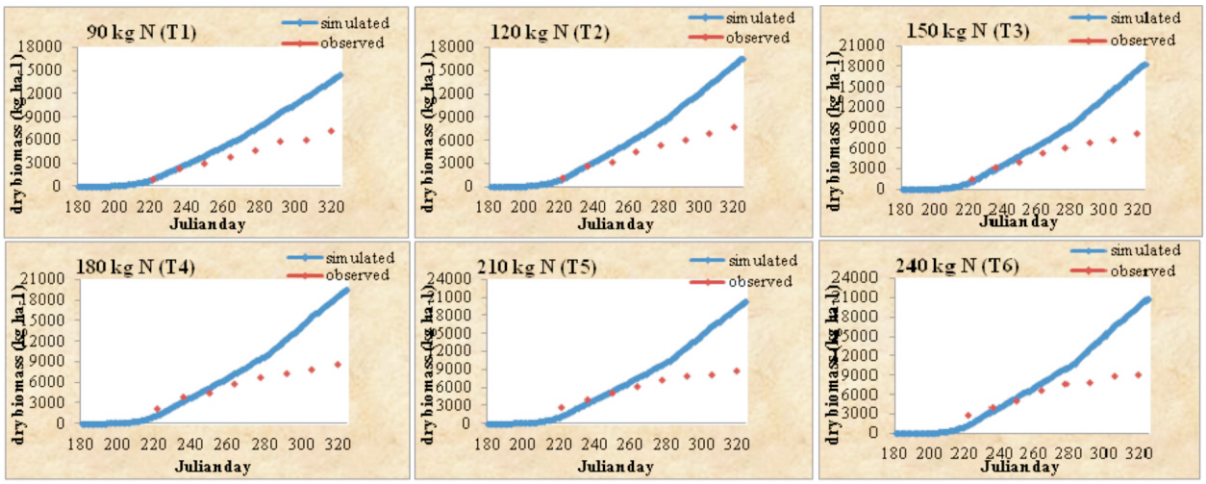

Fig. 2. Simulated and observed dry biomass of aerobic rice at variable nitrogen

Table 3. Simulated and observed straw yield of aerobic rice

Treatments	Simulated straw yield (kg ha^{-1})	Observed straw yield (kg ha^{-1})
90 kg N ha^{-1}	11249	5141
120 kg N ha^{-1}	13119	5303
150 kg N ha^{-1}	14623	5588
180 kg N ha^{-1}	15603	5866
210 kg N ha^{-1}	16364	5984
240 kg N ha^{-1}	16699	6116

Table 4. Evaluation results of ORYZA2000 simulation of straw and grain yield of aerobic rice parameters for validation (N=6)

Crop variables	X_{obs} (SD)	X_{sim} (SD)	R^2	RMSE absolute	RMSEn (%) normalized	t value
Straw yield	5666 (389)	14609 (2095)	0.96	3650	64.43	12.77
Grain yield	3005 (227)	3781 (367)	0.69	316	10.54	8.68

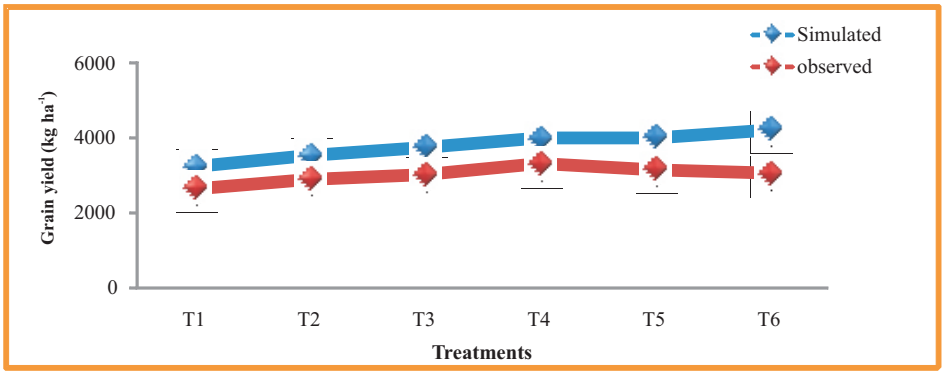

Fig. 3. Simulated and observed grain yield of aerobic rice at variable nitrogen

Table 5. Simulated and observed grain yield of aerobic rice

Treatments	Simulated grain yield (kg ha^{-1})	Observed grain yield (kg ha^{-1})
90 kg N ha^{-1}	3214	2644
120 kg N ha^{-1}	3521	2886
150 kg N ha^{-1}	3741	3006
180 kg N ha^{-1}	3985	3306
210 kg N ha^{-1}	4015	3152
240 kg N ha^{-1}	4215	3041

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Evaluation of Turmeric (*Curcuma Longa* L.) Cultivars for Growth and Yield in Southern Dry Zone of Karnataka

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***Abstract*:** Among the sixteen cultivars of turmeric for commercial production in southern dry zone of Karnataka. Cultivar (Cv.) Salem recorded higher plant height and number of tillers, Cv. CLT-325 recorded highest number of leaves, the Cv. Cuddapah recorded highest leaf area and leaf area index at 180 DAP. Maximum yield components were recorded in Salem, Rajapuri, Prathibha, CLT-325 and Cuddapah. Maximum fresh rhizomes yield was observed in Salem followed by Rajapuri, Prathibha and CLT-325. Thus should be recommended for commercial production of turmeric in southern dry zone of Karnataka.

Key Words: Evaluation, Dry zone, Growth, Turmeric, Yield

Turmeric (*Curcuma longa* L.) is one of the important spice crops grown in India. It is grown in Karnataka state on 15,320 ha area and producing about 93,817 million tonnes of cured turmeric per year (Anonymous, 2009). In Mysore (southern dry zone), the turmeric crop is mainly cultivated as an intercrop in coconut plantation and also as sole crop under protective irrigated conditions, taking the advantage of monsoon rains. The protective irrigation is necessary to get higher yield and income, by adopting suitable high yielding cultivars. The performance of any crop or variety largely depends upon its genetic make up. and climatic conditions of the region under which they are grown. As a result, cultivars which perform well in one region may not do well in other regions of varying climatic conditions. Hence, it is necessary to evaluate all the available cultivars in order to select suitable and high yielding cultivars in a particular region.

Sixteen turmeric cultivars were evaluated for their performance in RCBD with three replications (Table 1) at College of Horticulture, Mysore (Karnataka) during 2012-13. Recommended package of practices and plant protection measures were followed to raise a healthy crop (Anusuya, 2004). The observations were recorded for various growth parameters (Table 1 and 2).

The significant differences in growth parameters of

Table 1. Different growth parameters in turmeric cultivars

Cultivar	Plant height (cm)	Number of tillers per plant	Number of leaves per plant	Leaf area (dm^2)	Leaf area index
Co-1	33.73	3.00	12.73	48.80	6.47
Salem	37.07	3.80	16.70	55.80	7.40
Prabha	30.87	2.57	9.20	47.67	6.30
Krishna	31.53	2.43	11.60	39.97	5.30
Rajapuri	36.40	3.53	16.53	48.73	6.47
Prathibha	36.53	3.77	16.60	48.40	6.43
PTS-24	32.33	2.67	13.00	50.87	6.70
Cuddapah	35.73	2.87	15.67	55.83	7.40
Alleppey	33.13	2.97	10.93	55.17	7.33
Bidar-1	34.00	2.70	16.73	44.77	5.90
Bidar-4	31.14	2.73	14.73	48.67	6.43
CLI-327	35.67	2.73	14.20	44.93	5.97
CLI-14	30.60	2.90	13.00	41.84	5.53
CLT-325	36.93	3.63	17.67	51.63	6.83
Belgaum local	31.20	2.63	13.00	54.74	7.23
Erode local	33.09	2.73	14.13	44.77	5.93
C D (0.05)	0.91	0.35	1.11	5.13	0.68

Table 2. Different yield and yield components of turmeric cultivars

Cultivar	No. of mother rhizome	Wt. of mother rhizome	No.of primary fingers plant^{-1}	Wt. of Primary fingers plant^{-1}	No. of secondary fingers plant^{-1}	Wt. of secondary fingers plant^{-1}	Fresh weight of rhizomes (g plant^{-1})	Fresh rhizome yield (t ha^{-1})
Co-1	1.87	75.37	8.33	136.74	15.87	95.29	262.00	30.54
Salem	2.63	88.56	9.67	183.61	17.27	107.57	517.28	33.67
Prabha	1.91	62.27	8.67	128.41	16.13	58.92	507.64	21.54
Krishna	1.62	58.13	6.73	83.13	15.75	48.93	195.69	16.75
Rajapuri	2.80	84.13	9.10	179.93	16.56	105.73	511.67	32.67
Prathibha	2.47	83.73	9.13	181.27	16.28	103.04	510.06	32.56
PTS-24	2.31	81.49	8.67	176.37	15.80	93.53	464.00	26.65
Cuddapah	1.79	82.56	7.47	177.46	13.03	75.06	507.00	29.95
Alleppey	2.02	77.47	7.13	171.86	11.00	47.43	386.99	26.20
Bidar-1	1.96	69.03	7.73	151.44	9.60	49.76	322.31	28.19
Bidar-4	1.60	67.53	7.54	165.07	13.67	92.40	500.00	27.72
CLI-327	1.80	57.45	7.81	113.49	12.60	65.44	470.67	25.96
CLI-14	1.70	48.85	5.60	94.72	8.13	69.83	361.67	19.22
CLT-325	2.57	86.80	9.03	178.33	16.47	104.13	513.64	32.49
Belgaum Local	1.67	80.47	6.97	122.67	12.00	68.10	424.67	25.04
Erode local	1.49	71.10	7.20	135.20	13.87	73.64	492.71	28.93
C D (0.05)	0.23	4.93	0.61	6.24	1.03	5.68	8.83	1.50

different cultivars of turmeric were observed (Table 1). At 180 DAP, plant height ranged from 37.03 (Salem) -30.60 (CLI 14) cm. Salem recorded highest number of tillers (3.80) followed by Co-1 (3.00). Cultivar CLT-325 showed higher number of leaves per plant (17.67), Salem and Cuddapah recorded maximum leaf area (55.80 and 55.87 dm^2) and leaf area index (7.80) followed by Belgaum Local and Alleppey. Such variations in growth among different cultivars of turmeric were reported by several workers in turmeric grown under different agro-climatic regions (Kumar and Yadav, 2001; Anusuya, 2004 and Hanchinamani 2012).

Significant differences were observed in number of mother rhizomes per plant, number of primary fingers per plant and number of secondary fingers per plant (Table 2). Maximum number of mother rhizomes were recorded in Rajapuri (2.80), primary and secondary fingers in Salem (9.67 and 17.27 respectively). Fresh weight of mother rhizomes was recorded maximum in cultivar Salem (88.56 g).

The fresh rhizomes yield per hectare differed significantly among different turmeric cultivars. Cultivar Salem (33.67 t ha^{-1}) registered maximum fresh rhizomes yield, which was at par with, Rajapuri, Prathibha. Highest fresh rhizomes yield of these cultivars could be attributed to the maximum plant height, number of tillers, leaves and LAI, which are the important components of growth and had a positive and significant correlation with yield. Further, maximum rhizome yield from these cultivars may also relate to weight of mother rhizomes, primary and secondary fingers as they had positive and significant correlation with yield. Yield of rhizome is mainly dependent on vigour of the plants and yield components. Cultivars Salem, Rajapuri, CLT-325 and Prathibha were found suitable for commercial production in southern dry zone of Karnataka state.

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Assessment of Ground Water Quality in Different Cropping Systems of Varanasi District, Uttar Pradesh, India

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Abstract: Eighty four ground water samples were collected from different cropping systems (i.e. rice-wheat, rice-vegetable, vegetable-vegetable, pulse-pulse, orchard and sugarcane) to assess the groundwater quality. The analysed parameters of the groundwater in the study area had high RSC and Na^+ in few locations to restrict its suitability for agricultural activities. It was observed that ground water of this area is suitable for domestic purposes except for a few locations where high HCO_3^-, NO_3^- ions make it unsafe for drinking purpose.

Key Words: Contamination,Drinking water, Ground water quality

Water quality plays an important role in improving agricultural production and standard of human health. The overexploitation of groundwater has detrimentally affected ground water in terms of the quality and quantity. The chemical alteration of the rain water depends on several factors such as soil water interaction, dissolution of mineral species and anthropogenic activities (Umar and Ahmed, 2007). Apart from this, human activities such as contamination due to industrial effluents, landfills, application of fertilizers, etc., may also play a role in in?uencing the ground water composition (Vijay *et al.,* 2011; Brindha and Elango, 2012). Knowledge on groundwater quality of any area is essential for managing and sustaining the resource for various uses. With this motive, several researchers around the globe have given importance to groundwater quality (Belkhiri *et al.*, 2010; Dar *et al.,* 2011). Knowledge on hydrochemistry is important to assess the quality of ground water for understanding its suitability for domestic, irrigation and industrial needs.

Geographically the Varanasi is situated at 25°18' of Northern latitude, 83° 36' of Eastern longitude and at an altitude of 80.71 m above the mean sea level in the Indo-Gangatic plain of eastern Uttar Pradesh. The district Varanasi having alluvial soil lies in semi arid region to sub humid belt of Northern India.

A total of 84 ground water samples from bore wells in the different cropping systems (rice-wheat, rice-vegetable, vegetable-vegetable, pulse-pulse, orchard and sugarcane) of the study area were collected in the month of March-April, 2013 and analyzed to understand the quality of the groundwater (Table 1). For collecting the samples, pre-cleaned polyethylene containers of one litre capacity were used. The pH and electrical conductivity (EC) of the water samples were measured by using digital pH and EC meter, respectively. Cation and anion concentrations in ground water samples were determined by standard protocols (APHA, 1995).

The complied data of chemical parameters in groundwater of different cropping systems are presented in Tables 1 and Figure 1 and 2.

The ground water samples collected from different cropping systems had pH ranging from 8.0 to 8.1. The EC of the ground water ranged from 0.570 to 0.665 dSm^{-1} with mean value 0.62 dSm^{-1}. According to the quality of ground water, the ground waters in Varanasi district are slightly alkaline.

The HCO_3^-, SO_4^{2-}, PO_4^{3-} and NO_3^- were found in all the water samples but $CO_3^=$ was below the detectable levels

Table 1. Electro-chemical properties of ground water in different cropping systems of Varanasi district

Cropping system	pH	EC (dSm^{-1})
Rice-wheat	8.0±0.20	0.665±0.18
Rice-vegetable	8.0±0.20	0.662±0.25
Vegetable-vegetable	8.0±0.20	0.605±0.13
Pulse-pulse	8.1±0.23	0.570±0.15
Orchard	8.1±0.26	0.570±0.10
Sugarcane	8.0±0.21	0.659±0.15
Range	8.0-8.1	0.570-0.665
Mean	8.05	0.62
±S.D.	0.04	0.04
C.V.	0.46	7.15

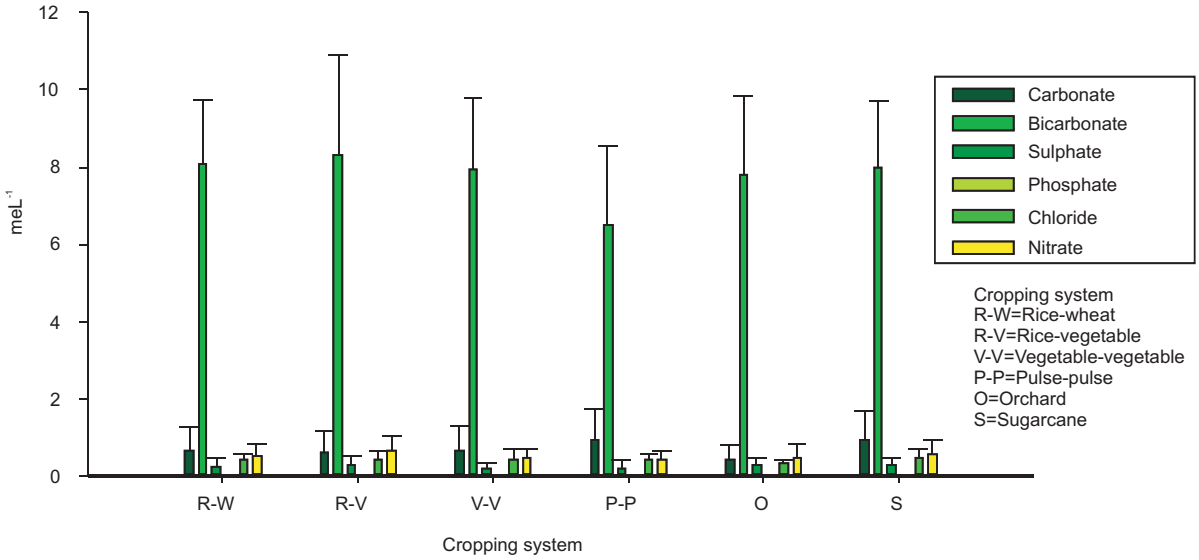

Fig. 1. Concentration of anions in ground water of different cropping system of Varanasi district

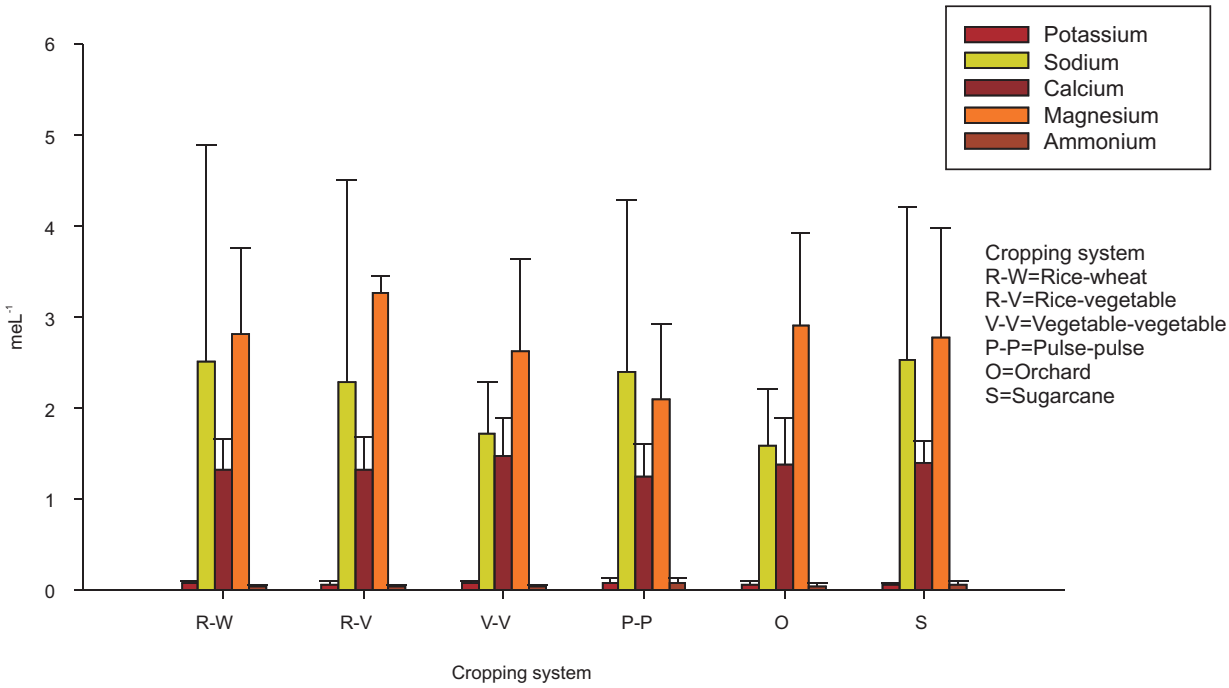

Fig. 2. Concentration of cations in ground water of different cropping systems of Varanasi district

in some locations. The average order of acidic anions in ground water of different cropping systems was as follows: NO_3^->Cl^->$SO_4^{=}$ > $PO_4\equiv$, whereas, the order of basic anions was HCO_3^-> $CO_3^{=}$ (Fig. 1). The study shows that groundwater is partially suitable for drinking purposes and public health, because all ground water samples were contaminated with nitrate but 26.9%, 33.3%, 5.5%, 10.0% and 18.2% samples in the cultivated areas of rice-wheat, rice-vegetable, vegetable-vegetable, orchard and sugarcane cropping system crossed the permissible limit of WHO (>45 ppm NO_3^--N) for drinking water purpose. Higher concentration of nitrate in groundwater of rice-vegetable and rice-wheat cropping systems was through anthropogenic pollutant contributed by use of nitrogenous fertilizers, human and animal waste. The other parameters were within permissible limits.

The range of alkaline cations in ground water of different cropping systems were in the range of 1.59 -2.54 me L^{-1} of Na^+, 0.07- 0.08 me L^{-1} of K^+, 1.24-1.48 me L^{-1} of Ca^{2+} and

2.09-3.27 meL^{-1} of Mg^{2+}. Thus, on an average Ca^{2+} + Mg^{2+} concentration in ground water was comparatively higher than Na^{+} (Fig.2). The sodicity hazards of ground water were further evaluated by calculating Sodium Adsorption Ratio (SAR). SAR values of ground water in different cropping systems varied from 1.10-1.84. SAR values were <10 and RSC were > 4.0 me L^{-1} in all the samples of the ground water.

The salinity is not a serious problem in this region, but alkalinity hazard due to application of irrigation water should not be ignored. High RSC and Na^{+} in few locations restrict its suitability for agricultural activities. The ground water of this area is suitable for domestic purposes except for a few locations where high HCO_3^-, NO_3^- ions make it unsafe for drinking purpose.

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Biology and Host Preference of Lemon Butterfly, *Papilio demoleus* Linnaeus on Citrus

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***Abstract*:** The mean developmental period in days for the different life stages (egg to adult) of the lemon butterfly on *kagzi* lime were 4.5 (egg), 13.52 (larval), 10.17 (pupal), 5.13 (adult male) and 6.86 (adult female). The total life cycle was completed in 30.85 days for males and 33.25 days for female. There were more males than females with a sex ratio of 1: 0.75. The morphometric variations of different life stages of the lemon butterfly have been recorded. The *kagzi* lime was the most preferred host/ food plant as larval development could be completed in minimum period of 13.15 days together with the maximum growth index value of 7.6.

Key Word: Biology, Food plant preference, Lemon butterfly

Citrus is cultivated world over. Early records indicate that the citrus fruits such as orange (*Citrus reliculata* Blanco), lime (*C. aurantifolia* Swingle) and lemon (*C. limonica* Burn) were cultivated in South China, Malaya and Sub-Himalayan parts of Assam; later on their cultivation spread to the tropical and sub-tropical parts of the world. Citrus trees are infested by a wide variety of pests. Ebeling (1959) reported that 823 species of insects cause damage to citrus in various countries and 175 of them occur in India. Among these, the lemon butter fly (*Papilio demoleus* L.) is an important pest of citrus causing severe damage to saplings in the nurseries and the young leaves in orchards. From the available literature it is evident that studies on the bio-ecology of lemon butterfly on orange, sweet orange and lemon have been often quoted, but similar work on *kagzi* lime is scanty. Hence, keeping in view the economic importance of *kagzi* lime, the present investigation was conducted.

Studies on the biology of lemon butterfly on *kagzi* lime and its host preference were carried out in the laboratory of Department of Agricultural Entomology, C.P. College of Agriculture, S.D. Agricultural University, SardarKrushinagar. The initial culture of lemon butterfly was raised by collecting larvae from 1 to 2 year old *kagzi* lime trees.

The larvae were reared on fresh tender and medium sized leaves of *kagzi* lime, in iron cages (21cm × 21cm × 30cm). Twigs of lime were kept in the cage before pupation. Newly emerged adult were paired and transferred to individual cages and 5 per cent honey solution tender twigs with 3 to 5 leaves were also placed within the cage to facilitate egg laying. Daily observations were made to record the egg laying. The eggs were collected gently with the help of a soft camel hair brush (№ 1) and were transferred singly on to a *kagzi* lime leaf in petri-dish (10cm diameter) placed on a wet cotton swab to avoid desiccation of the eggs. The different larval instars were identified by the cast exuviae and head capsule. The pre-pupal stage was considered when the last larval instar stopped feeding, which later on developed into a chrysalis. The male: female sex ratio was also worked out observations on the morphometric parameters were recorded as given by Veereshkumar *et al*. (2013).

Host preference studies: Five food plants *viz., kagzi* lime (*Citrus aurantifolia*); *bael* (*Aegle marmelos*); sweet orange (*Citurs sinensis*); *bijora*/ citron (*Citrus medica*) and rough lemon (*Citurs limonica* var. Jamuri) were evaluated for their preference by the lemon butterfly for egg laying. Equal sized tender twigs (15cm) containing 3 to 5 leaves of were placed individually inside separate wooden cages (45cm × 45cm × 60 cm) and one pair of the lemon butterfly was released. The experiment was replicated 5 times. Observations were recorded on egg hatching and growth indices on different food/ host plants were calculated:

The length of freshly laid egg was 1.21 mm and the breadth 1.35 mm (Table 1). Hatching percentage was 84.27 and incubation period lasted from 3 to 6 days with an average of 4.5 days.

Larval instars: The length and breadth of first instar larvae was 3.27 ± 0.0.83 x 0.83 ± 0.20 mm with average of 2.56 days. The length of second instar varied from 3.56 to 9.30 mm with an average of 6.97 mm, while breadth varied from 0.79 to 1.69 mm with an average of 1.31 mm. Duration of second instar larva varied from 1 to 2 days with an average of 1.53 ± 0.50 days (Table 1). T**he** third instar larvae differed

from the previous instars in having the spiracles clearly visible. The body length varied from 5.54 to 11.22mm with an average of 8.53 mm and body width varied from 1.45 to 2.50mm with an average 1.93 mm. The third instar larval duration varied from 1 to 2 days with an average of 1.44.

The fourth instar larva was similar to the previous instar except for the white stripes on the dorsum becoming light green in colour. Body length varied from 12.00 to 18.66mm with an average of 15.48 ± 2.19mm and body width varied from 3.07 to 4.52mm with an average of 3.83 ± 0.49mm; the larval duration ranged from 2 to 4 days with an average 2.79 ± 0.74 days (Table 1). **F**ifth instar larva was green in colour with brown head, the thorax and abdomen had black dots and stripes. There was no hair like structure on the body. The fifth instar larval length varied from 25.80 to 40.68mm with an average of 32.27 ± 5.19mm, while the breadth ranged from 4.75 to 10.17mm with an average of 7.67 ± 1.92mm; the larval duration varied from 4 to 6 days with an average of 5.18 ± 0.73 days. The total larval period of *P. demoleus* varied from 11 to 15 days with an average of 13.52 ± 1.13 days when reared at an average temperature of 27.47 ± 1.39° C and relative humidity 51.73 ± 8.52 per cent (Table 1).

Table 1. Development period of various life stages of the lemon butterfly reared on Kagzi lime (Mean ± S.D)

Life stage	Length (mm)	Breadth (mm)	Life stage
Egg	1.21 ± 0.028	1.35 ± 0.025	4.5 ± 1.15
Larva			
I instar	3.27 ± 0.83	0.83 ± 0.20	2.56 ± 050
II instar	6.97 ± 1.96	1.31 ± 0.37	1.53 ± 0.50
III instar	8.53 ± 1.95	1.93 ±0.43	1.44 ± 0.50
IV instar	15.48 ± 2.19	3.83 ± 0.49	2.79 ± 0.74
V instar	32.27 ± 5.19	7.67 ± 1.92	5.18 ± 0.73
Total larval			13.52 ± 1.13
Pre-Pupal	23.26 ± 4.30	6.64 ± 1.91	1.23 ± 0.42
Pupa			10.17 ± 0.91
Male	28.5±3.80	10.24±1.53	
Female	28.02±4.44	10.80±1.67	
Adult			
Male	32.54±4.42	81.95±4.50	5.13 ± 1.50
Female	32.90±5.30	85.65±5.53	6.86 ± 1.76
Total Life cycle (Egg to Adult)			
Male			30.85 ± 2.99
Female			33.25 ± 3.89
Pre-oviposition period			3.2±1.74
Oviposition period			2.26±1.16
Post-oviposition period			1.4±1.29
Longevity			
Male	3	7	5.13±1.50
Female	4	10	6.86±1.76
Fecundity	75	120	97.06±16.59
Sex ratio (Female and Male)			1 : 0.75

Pre-pupa: Pre-pupal stage was characterized by shortening of larva in length suspended feeding and movement. Colour of larva in pre-pupal stage was deep green. Length of pre-pupal stage varied from 18.00 to 30.02mm with an average of 23.26 ± 4.30mm, while breadth ranged from 3.25 to 9.68mm with an average of 6.64 ± 1.91mm (Table 1). The pre-pupal stage lasted from 1 to 2 days with an average of 1.23 ± 0.42 days.

Pupa: The freshly formed pupa was soft and green to brown in colour, which later turned dark green with white and yellow dots. The length of male pupae varied from 23.00 to 35.00mm (average 28.56 ± 3.80mm) and the female pupae from 22.00 to 35.00mm (average 28.02 ± 4.44mm). The breadth of male pupae ranged from 8.00 to 12.50mm (average 10.24 ± 1.53 mm) and that of the female pupae from 8.50 to 13.00mm (average 10.80 ± 1.67mm). The duration of pupal stage varied from 8 to 12 days with an average of 10.17 ± 0.91 days at an average room temperature 27.47 ± 1.39° C and relative humidity 51.73 ± 8.52 per cent (Table 1).

Adult: The length of female varied from 25.0 to 40.0mm (average 32.90 ± 5.30mm) and wing expansion from 78.0 to 94.00mm (average 85.65 ± 5.53mm). The length of male ranged from 26.00 to 38.00mm (average 32.54 ± 4.42mm) and wing expansion varied from 75.0 to 90.0mm average 81.95 ± 4.50mm (Table 1). Pre-oviposition period 3.2 ± 1.74, days, oviposition period 2.26 ± 1.16 days and post-oviposition periods: 1.40 ± 1.29 days.

Sex ratio: The sex ratio of female and male 1: 0.75 under laboratory and field condition. Total life period (from egg to adult of 30.85 ± 2.99 and 33.25 ± 3.89 days was recorded for male and females, respectively. Similar studies on the biology of the lemon butterfly were earlier carried out by various workers on different citrus host plants (Bhan and Singh, 1997; Phatiyal *et al.,* 2012; Radke and Khandalkar, 1988; Sharifi and Zarea, 1970) however, the data on life stages and the development periods varied according to the host/ food plant, temperature and humidity conditions.

Host preference studies: on *kagzi* lime followed rough lemon (22.0) and bijora (19.6). **T**he larval development was shorter (13.15 days) on *kagzi* lime. The growth index for the five food plants varied from 5.95 to 7.60 (Table 2). The highest growth index (7.60) was observed when reared on *kagzi* lime. Thus, the *kagzi* lime was most favourable host for the development of larvae. Rather and Fatima (2011)

Table 2. Growth and development of lemon butterfly on different food/ host plants

Host/Food plants	Mean eggs (No/leaf)	Mean hatching(%)	Mean larval period (days)	Growth index
Kagzi lime (*Citrus aurantifolia*)	24.0	24.09	13.15	7.60
Bel (*Aegle mormelos*)	16.0	16.06	14.60	6.84
Sweet orange (*Citrus sinensis*)	18.0	18.07	15.30	6.53
Bijora or citron (*Citrus medica*)	19.6	19.67	16.80	5.95
Rough lemon (*Citrus limonica*)	22.0	22.08	14.67	6.81

recorded highest net productive rate on lime than sweet orange and bawachi. Purohit *et al.* (1996) reported that the growth index of *P. demoleus* was 4.27 when reared on lemon.

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Biology of Leaf Eating Caterpillar, *Noorda blitealis* Walker on Drumstick

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Abstract: The life cycle of drumstick leaf eating caterpillar from egg to adult emergence was completed in 18.3 days. The eggs were laid either singly or in groups on ventral surface of the tender leaves. Incubation period, larval period, male and female pupal period were 2.8, 11.27, 6.95 and 7.50 days respectively. The average fecundity was 89.6 (82 to 102 eggs). The male moths lived for 6.25 days and female for 11.70 days.

Key Words: Biology, Drumstick, *Noorda blitealis*

Moringa (*Moringa oleifera* Lam.) is one of the most popular vegetables in South India. The cultivation of drumstick var. Bhagya is taken up on a commercial scale in Bagalkot district and spread over the Karnataka and also neighboring states in recent years. Moringa moth, *Noorda blitealis* Walker has become an important pest on drumstick and considered to be the most serious pests of annual moringa as it occurs throughout the year and causes serious damage to the crop.

The biology of drumstick leaf eating caterpillar was carried out in the Department of Entomology, College of Horticulture, UHS, Bagalkot during 2014 under laboratory conditions. The weather parameters *viz.,* temperature and relative humidity were recorded daily during the study period (April to May, 2014).

Development and maintenance of stock culture: The culture of leaf eating caterpillar was developed by collecting the late instar larvae from moringa field and rearing them in plastic cages of 28 x 21 x 12 cm. The pupae were sexed based on presence of slit on either eighth or ninth abdominal sternite. Immediately after emergence ten pairs of moths that emerged on the same day were enclosed in rearing cages for oviposition. A cotton swab dipped in ten per cent honey solution was provided as food for moths and tender drumstick branches were also provided for oviposition.

The tender leaves containing eggs laid on the same day were transferred to petriplates (20 x 5 cm, sterilized with 4 per cent formalin). On hatching, the larvae were transferred with the help of a soft camel hair brush to tender leaves. The food was changed whenever necessary.

Egg: For study of incubation, 50 eggs were examined for emergence of larvae. Out of these 20 larvae were reared for determining the duration of larval stage. Similarly, the pupal period was calculated from 20 pupae. The food was changed as and when required. General morphological features associated with different stadia of larva were recorded.

Adult: The longevity of adults was calculated from five pairs released singly in jar. Tender drumstick leaves were provided as oviposition substratum for studying the pre-oviposition, oviposition, fecundity, post- oviposition periods and adult longevity.

The freshly laid eggs are round, white or light yellowish in colour measuring about 0.65 ± 0.09 mm (0.5-0.73) in length and 0.24 ± 0.06 mm (0.2- 0.35) in width (Table 1). Eggs were laid either singly or in groups on ventral surface of the tender leaves (Plate 1). Oviposition was observed during the late evening hours 7.30 pm onwards. The average incubation period was 2.8 ± 0.83 days (2-4 days). The eggs were spherical in shape, transparent and were laid on ventral surface of leaves. Eggs were laid either singly or in clusters on under surface of the tender leaves and occupied the incubation period 2.5 to 3.5 days.

Larva: The larval eclosion took place during either morning hours (6.30 am) or evening hours (7.00 pm). There were five larval instars and the total larval period was 11.27 ± 2.36 days (9.50- 13.5 days) (Table 1 & Plate 2). Larva developed through five instars, which confirms the earlier reports of Honnalingappa (2001) and Selvi and Muthukrishnan (2011).

The newly hatched larva was pale green in colour. The head capsule was reddish and prothoracic shield was absent. The body was covered with minute whitish hairs. The larva measured 1.73 ± 0.23 mm (1.4- 1.9) in length and 0.21 ± 0.047 mm (0.28- 0.35) in width and head capsule measured 0.25 ± 0.07 mm in width (Table 1). On an average, the first instar occupied 1.45 days ± 0.47 (Table 1).The newly hatched second instar larva was also pale green in colour. It

Table 1. Morphometric parameters and duration of different stages of leaf eating caterpillar, *Noorda blitealis* under laboratory condition

Stage of insect	Duration (days) Mean ± SD	Body length (mm) Mean ± SD	Body width (mm) Mean ± SD	Head capsule (mm) Mean ± SD
Egg	2.8 ± 0.83	0.65 ± 0.09	0.24 ± 0.06	-
1st instar larva	1.45 ± 0.47	1.73 ± 0.23	0.21 ± 0.04	0.25 ± 0.07
2nd instar larva	2.3 ± 0.47	3.5 ± 0.81	0.52 ± 0.12	0.3 ± 0.018
3rd instar larva	2.42 ± 0.65	9.30 ± 1.16	1.70 ± 0.085	0.93 ± 0.16
4th instar larva	1.95 ± 0.66	11.52 ± 0.04	2.03 ± 0.07	1.23 ± 0.16
5th instar larva	2.02 ± 0.73	19.6 ± 2.25	19.6 ± 2.25	1.88 ± 0.18
Total larval period	11.27 ± 2.36	-	-	-
Pre pupal period	2.32 ± 0.73	10.82 ± 1.32	3.05 ± 0.23	-
Male pupal period	6.95 ± 1.09	7.15 ± 0.40	0.86 ± 0.10	-
Female pupal period	7.5 ± 1.00	7.9 ± 0.71	1.75 ± 0.09	-
Male adult longevity	6.25 ± 1.93	7.5 ± 0.45	16.0 ± 0.8 [wing expanse]	-
Female adult longevity	11.70 ± 3.35	8.75 ± 0.80	17.5 ± 1.33 [wing expanse]	-
Sex ratio (M:F)	1: 1.28	-	-	-
Pre- oviposition period	2.5 ± 0.51	-	-	-
Oviposition	5.9 ± 1.02	-	-	-
Post- oviposition period	3.6 ± 1.39	-	-	-
Total No. of eggs/females	89.6 (82-102)	-	-	-
Per cent egg hatch	87.37	-	-	-

Mean temperature and relative humidity recorded during April to May was 32.8° C (26.8- 32.8°C) and 56 % (47- 57%)

Plate 1. Eggs of *Noorda blitealis* laid on drumstick leaves

Plate 2. Different instars of *Noorda blitealis*

measured 3.5 ± 0.81 mm in length and 0.52 ± 0.21 mm in width. The third instar larva was pale yellowish with red tinge. The head capsule was yellowish. The third instar larva on an average occupied 2.42 ± 0.65 days (1.5- 3.0 days). The larva was pale green with reddish head capsule. The average duration of fourth instar larva was 1.95 ± 0.66 days (1- 3 days). The fifth and last instar larva was yellowish green with yellowish red head capsule. The duration occupied by fifth instar was 2.02 ± 0.54 days (1.5- 3.0 days). The grown up larva measured 19.6± 2.25 mm (13- 21) in length, 2.69± 0.30 mm (2.2- 3.0) in width and 1.88 ± 0.18 mm (1.6- 2.1) in head capsule width (Table 1).

Prepupa: The fully grown larva became sluggish and stopped feeding. The colour of larva turned to pinkish and started shedding hairs (Plate 3). As soon as hair shedding started, it gradually shrunk in size and remained straight with

Plate 3. Prepupa of *Noorda blitealis*

the legs stretched forward. It started to spin transparent silken loose web and constructed spindle shaped cocoon also by using the parts of eaten leaves provided for feeding. The prepupa measured 10.82 ± 1.32 mm (8- 12.5) in length and 3.05 ± 0.23 mm (2.6- 3.3) in width (Table 1). The prepupal duration was 2.32 ± 0.73 days (1- 3 days). The prepupal period lasted for 1 to 3 days during April to May, which is also in agreement with the findings of Munj *et al.* (1998) and Honnalingappa (2001), who reported a prepupal period of 2 to 3 days and 1.5 to 2.5 days, respectively.

Pupa: The last larval exuvium and head capsule remained inside the cocoon constructed by the last instar larva. The pupa inside was obtect type, the freshly formed pupa was brown in colour and later turned to deep brown colour just before the adult emergence (Plate 4). The male pupa measured 7.15 ± 0.40 mm (8- 12.5) in length and 0.86 ± 0.10 mm (0.7- 1.0 mm) in width. The female pupa measured 7.9 ± 0.71 mm (8- 9) in length and 1.75 ± 0.09 mm (1.8- 2.1) in width

Plate 4. Pupae of *Noorda blitealis*

(Table 1). In the case of female pupa, the genital opening was silt like and was situated on the posterior margin of the eighth abdominal sternite and in the case of male pupa the genital opening located on the posterior margin of ninth abdominal sternite just infront of the ninth and tenth abdominal sternite. The duration of the male pupa was 6.95 ± 1.09 days (5- 8 days) and female pupa was 7.5 ± 1.00 days (6-9 days).

Adult emergence: Emergence of adult from the pupal case was noticed during evening hours (6.30 to 7.30 pm). The adult moth was medium sized and uniformly dark brown in colour (Plate 5). The forewings were brown with a small white streak at the inner area of the base and hindwings were white in colour with broad black marginal band narrowing towards anal side. Thorax was black and abdomen was brownish elongated and tapering posteriorly.

Plate 5. Adults of *Noorda blitealis*

Oviposition: The adults start mating and mostly in evening hours (6-7pm). The moths laid eggs during late evening and night hours. The pre- oviposition, oviposition and post-oviposition period were 2.5 ± 0.51 days (2-3 days), 5.9 ± 1.02 days (5-8 days) and 3.6 ± 1.39 (3-9 days). These findings are

more or less in agreement with the findings of Munj *et al.* (1998) and Honnlingappa (2001) who reported oviposition period of 8 days. Total number of eggs laid by a female varied from 82 to 102 with average fecundity of 89.60 and fertility was 87.37 per cent.

Sex ratio and adult longevity: The percentage of male to female ratio was (1: 1.28). These findings are in agreement with the findings of Honnalingappa (2001) who reported male to female ratio of 1: 1.27. The male moth measured 7.5 ± 0.45 mm (7- 8) in length and 16 ± 0.84 mm (15- 17) in width, and female pupa measured 8.75 ± 0.80 mm (7- 9.5) in length and 17.5 ± 1.33 mm (15- 19) in width. The longevity of the male moths was 6.25 ± 1.93 days (4- 9 days) with food (10% honey solution) and that of female moths was 11.70 ± 3.35 days (7- 20 days). This is in agreement with findings of Munj *et al.* (1998) and Honnalingappa (2001), where to whom male and female longevity of 9.5 days and 16.25 days, respectively was observed. The variation may be due to high temperature and low relative humidity, prevailed during the present study.

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Evaluation of Crude Euphorbiaceae Latex Against Black Slug, *Filicaulis Alte* Ferussac

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Abstract: Feeding responses of black slug with yellow mid-dorsal streak, *Filicaulis alte* towards crude latex of different plants in wheat bran bait were observed in no-choice laboratory feeding tests. Their molluscicide effect for the control of the slug was in order of *Euphorbia splendens* > *Calotropis procera* > *Ficus bengalensis* >*Ficus elastica.* The bait with 2% crude latex of *E. splendens* was most effective bait resulting in 36.7% slug mortality. *C. procera* latex (1.5%) in wheat bran bait caused 23.3% mortality while latex of *F. bengalensis* (1.5%) caused 20% slug mortality. All concentrations of *F. elastica* latex in bait neither acted as repellent nor as molluscicide.

Key Words: *Filicaulis alte*, Molluscicide, Slug control

The slug, *Filicaulis alte*, a predominant species infestating ornamental plant nurseries and vegetable crop ultimately causing plant death. There is urgent need for its control. Since chemical control of pests often raise environmental concerns, it is desirable that alternate strategies are developed, which are eco-friendly as well as effective against such pests. Use of natural plant extracts or their derivatives hold promise in this direction since they are low-cost, locally available materials with no side effect and often compatible with other control options like biological control (Sinha 2004).

Plants belonging to family Euphorbiaceae are potent molluscicide (Singh and Agarwal 1984). Euphorbiaceae latex contain diterpenes (mainly ingenane and Lathyrane derivatives) and triterpenes, the former of which were more active having irritant, cytotoxic and tumour-inducing properties as well as molluscicidal activities (Evans and Taylor 1982, Singla and Pathak 1990). So the realistic goal should be the development of a selective and an ecological safe molluscicide, which has minimal adverse effect on the other biota sharing the same habitat with slugs. Present studies were undertaken to evaluate lethality of crude latex of *E. splendens, C. procera*, *F. bengalensis* and *F. elastic* for the control of slug, *F. alte* in separate no-choice laboratory feeding tests.

Both vegetative and reproductive stages of following plants were used:

Calotropis procera (stem, leaves and pods), *Euphorbia splendens* (stem, peduncle, flower bud), *Ficus elastic* (leaves, branches) and *Ficus bengalensis* (leaves, branches) were used for testing. The fresh latex from these plants was tested for their effectiveness by offering different concentrations viz., 0.5%, 1.0%, 1.5% and 2.0% in wheat bran.

Black slugs with yellow mid-dorsal streak were acclimatized for a week in plastic trays (each 18 x 15 x 4 cm) covered by moist muslin cloth on top. Soil was kept moist throughout the experiment by sprinkling water after removal of faeces of slugs daily.

Plain wheat bran bait was provided as control. Each concentration of latex was offered in wheat bran for four days in no-choice feeding tests to 10 slugs per replicate with 5g bait/day. Treatments were replicated three times in a completely randomized block design. Control experiment was run with 5g wheat bran/day. Bait consumption and slug mortality were recorded daily during test period and per cent mortality of slugs/tray was calculated.

The crude latex from the different parts of the *F. elastica* at different concentrations was ineffective for the control of slug, *F. alte*. Overall mean daily intake (MDI) of all the treated baits was significantly less as compared to untreated bait (Table 1). However latex from *E. splendens*, *F. bengalensis* and *C. procera* showed small to medium toxicities towards slug. *E. splendens* (T2) was consumed significantly less as compared to control and other treatments on all the four days and no slug mortality occurred during test period. In case of 2.0% latex of *E. splendens* in wheat bran bait, MDI was found to be highest i.e. 1.49 g per 10 g body weight of slugs per day on the first day, increased to 1.62 g on second day and slightly decreased on the third and fourth day. In case of *E. splendens*, feeding increased with increasing concentration and also the mortality increased. Thus, *E. splendens* latex acts not only as molluscicide but as attractant also. MDI of baits containing different

Table 1. Effect of different concentrations of Euphorbiaceae latex on feeding responses of the black slug with yellow mid-dorsal streak, *F. alte* in four days no-choice laboratory feeding test

Crude latex of plant	Treatment	Body weight of slugs (g)	Overall mean bait intake (g/10g body weight)	Mean Per cent mortality
F.elastica	Control	2.89 ± 0.10	1.30±0.04*	0
	0.5%	3.06 ± 0.14	1.06±0.02c	0
	1.0%	3.63 ± 0.12	1.10±0.02c	0
	1.5%	3.36 ± 0.12	1.23±0.03a	0
	2.0%	3.33 ± 0.13	1.18±0.05b	0
E. splendens	Control	3.15 ± 0.14	1.28±0.02*	0
	0.5%	2.94 ± 0.18	0.88±0.11c	0
	1.0%	3.35 ± 0.13	1.27±0.02b	13.3
	1.5%	2.80 ± 0.10	1.29±0.04b	16.7
	2.0%	3.27 ± 0.22	1.55±0.03a	36.7
C. procera	Control	2.62 ± 0.15	1.58±0.04*	0
	0.5%	3.39 ± 0.15	0.84±0.04b	0
	1.0%	3.08 ± 0.13	0.91±0.05b	13.3
	1.5%	2.32 ± 0.21	0.92±0.07b	23.3
	2.0%	3.64 ± 0.25	0.67±0.04c	0
F. bengalensis	Control	2.80 ± 0.12	1.42±0.03*	0
	0.5%	2.83 ± 0.11	0.83±0.03b	0
	1.0%	2.56 ± 0.09	0.88±0.03b	0
	1.5%	3.05 ± 0.13	1.02±0.02c	20
	2.0%	2.79 ± 0.11	0.84±0.02b	0

* Differences between consumption of untreated and treated baits significant at p > 0.05 Values with different superscript in a column differ significantly at P>0.05

concentrations of latex of *C. procera, F. elastica* and *F. bengalensis* by slugs showed similar trends (Table 1). MDI of latex treated baits increased from 0.5% to 1.5% but decreased in case of 2% bait. Treatment 1% (13.3% slug mortality) and 20% (23.3% slug mortality) of *C. procera* was somewhat effective than other treatments in controlling slug in laboratory feeding tests.

One fifty indigenous plants and 2000 natural products with their synthetic derivatives have been screened for molluscicidal activity (Agaceta *et al*., 1981). Feeding behavior studies of slug towards poison baits prepared in wheat bran bait in 4-days laboratory feeding tests revealed that alpha gourd, azadirachtin at 0.05 and 0.025 per cent (Econeem 0.15%) showed antifeedant effect while at lower concentration of azadirachtin, 0.005% (Nimbecidine 0.03%) and 0.0025% (Econeem plus 1%) enhanced bait take by *F. alte* (Kaur and Kaur, 2008). Evaluation of fresh water and alcohol extracts of plant parts viz., rhizome of ginger, cloves of garlic and leaves of neem in wheat bran bait in bi-choice laboratory feeding tests revealed the following order of bait acceptance as fresh water extract of ginger rhizome> fresh alcohol extract of ginger rhizome> alcohol extract of garlic bulb> fresh water extract of garlic bulb> fresh water extract of neem leaves> fresh alcohol extract of neem leaves. Out of all the extracts, fresh water extract of ginger rhizome in wheat bran bait resulted in highest (60%) slug mortality under laboratory conditions and 20-50% under field conditions in ornamental plant nursery at Ludhiana, Punjab, India. However, fortification of bait with food attractants like 3% mango flavor or 3% apple juice did not enhance the bait acceptance; rather it reduced the slug control. 0.5% fresh water extract of ginger rhizome can be used for slug control in plant nurseries (Kaur and Chhabra, 2009). The milky white latex of plant, *C. procera* was found to have potent molluscicidal activity (Singh and Kushwaha, 2011) and produces inflammation of the skin and mucous membrane on accidental exposure in rats (Sehgal and Kumar, 2005). Uscharin, isolated from *C. procera* latex was found to be most potent molluscicidal compound tested against land snails (Hussein *et al.,* 1994). Thus, plants offer a wide array of

bioactive compounds for use as molluscicides. By using simple technology, if these plant metabolites are formed sufficiently toxic, and ecologically sound, it might be possible to develop culturally acceptable and inexpensive molluscicides (Sharma *et al.,* 2009). The crude latex of *E. splendens* showed sufficient activity against slug to warrant its consideration as a potential alternative molluscicide. However, because toxic latex necessarily contains physiologically active constituents, further research should concentrate on the isolation of those compounds responsible for the molluscicidal activity.

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Characterisation of Cowpea Genotypes with Desirable QualitativeTraits

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Abstract: All the thirty five cowpea genotypes were grouped into different categories based on variation observed among different qualitative descriptors. Among the descriptors used for grouping, pigmentation on stem, flower colour, immature pod pigmentation, raceme position and pod attachment to peduncle were very reliable, distinct, uniform and stable. These characters can be utilized for identification and characterisation of cowpea varieties in protection of new plant varieties and also in various aspects of plant breeding programme and seed technology.

Key Words: Characterisation, Cowpea, Pod pigmentation, Plant level, Qualitative descriptors

Cowpea (*Vigna unguiculata* L. Walp.) a self pollinated crop of Fabaceae family is cultivated around the world primarily as a pulse, but also as a vegetable, as a cover crop, for fodder and soil fertility enhancement through biological nitrogen fixation (Dumet *et al*., 2008). It is a warm weather crop and requires less rainfall than most crops; therefore suitable for production in arid and semiarid regions (Emongor, 2007). Lack of improved varieties is one limitation to its production; hence need to increase breeding efforts. Characterisation and evaluation of available germplasm is a necessary first step to facilitate breeding efforts; it especially benefits a plant breeder in choosing proper parental materials (Cilliers and Swanevelder, 2003; Sarutayophat *et al.*, 2007). In this context, varietal description for identification of crop variation has attained a critical importance in national and international seed programmes and there is considerable need for the development of reliable methods and identifiable characters for identification purpose. Characterization can be done using morphological parameters or molecular markers, or both.

In the present study, seeds of 35 cowpea genotypes (Table 1) were obtained from the Department of Genetics and Plant Breeding, College of Agriculture, Dharwad and grown at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (latitude 15^0 26^1 N, longitude 75^0 07^1 E, altitude 678 m) during *kharif* 2009-10 to characterize and identify stable character(s) based on qualitative descriptors at plant level. The genotypes were planted in a randomised complete block design and each entry was sown in four rows of 5 m length and replicated thrice as per recommended practices. Five plants were randomly selected in each genotype per replication and labeled by following International Board for Plant Genetic Resources (*IBPGR,* 1983) for various characters and for **all colour characteristics;** Royal Horticultural Society (RHS) colour chart was used.

Based on the stem pigmentation, the genotypes were grouped into two categories i.e., pigment present and absent. All genotypes showed absence of pigmentation except IC97787 (Table 1). The stem pigmentation is under genetic control and it may also be affected by light intensity and temperature prevailing during the crop growth. Karkannavar *et al*. (1991) reported that two duplicate genes (*pp-1* and *pp-2*) responsible for stem pigmentation in cowpea. These two duplicate genes may be present in IC97787 genotype. On basis of plant growth pattern, genotypes were grouped into determinate (IC257413, IC97787, IC202868, IC214757, Mumbai local and Bailhongal local), semi determinate (IC202789, IC259159-2) and indeterminate (remaining 27 genotypes). Regarding the plant growth habit genotypes were grouped into erect, semi-spreading and spreading types. Six determinate genotypes were erect, 17 were semi-spreading and 12 spreading (Table 1) in nature. Variations in both characters were due to the genetic characters of genotypes. Determinate and indeterminate expressions of plant were stable but Jain and Khare (2002) recorded that semi-determinate expression was highly influenced by environment.

In the present investigations, leaf colour of the cowpea genotypes varied from pale green to dark green.

Table 1. Grouping of cowpea genotypes based on qualitative characteristics

Genotypes	PGP	PGH	FC	LC	IPP	RP	PAP	MP constriction	MP color	MV
IC257413	D	E	P	DG	N (G)	TC	P	L	S	GT
IC97787	D	E	PP	DG	Uniformly pigmented	AC	P	M	B	GT
IC198323	I	S	YW	I	N (G)	AC	P	M	B	GT
IC198326	I	SS	PP	I	Splashes of pigment	AC	30°-90° down from erect	L	B	GT
IC198333	I	S	PP	I	N (G)	TC	P	L	B	GT
IC198335	I	SS	P	PG	N (PG)	AC	P	L	S	GT
IC198349	I	S	PP	I	N (PG)	TC	P	M	S	GT
IC198361	I	S	PP	PG	N (G)	AC	P	H	B	GT
IC198701	I	S	P	PG	N (G)	AC	P	H	S	GT
IC201087	I	SS	YW	PG	Pigmented tip (Green)	AC	P	L	S	GT
IC202789	SD	S	P	PG	Pigmented tip (Pale Green)	AC	P	L	S	GT
IC202806	I	SS	YW	I	N (G)	AC	P	M	B	GT
IC202867	I	SS	P	I	N (G)	TC	30°-90°down from erect	L	S	GT
IC202868	D	E	P	I	N (G)	AC	P	M	B	GT
IC202881	I	SS	P	I	N (PG)	AC	P	L	S	GT
IC214757	D	E	YW	I	N (PG)	AC	P	L	S	GT
IC219574	I	S	DP	PG	Pigmented tip (Pale Green)	AC	P	L	S	GT
IC219599	I	S	PP	I	N (G)	AC	P	H	B	VT
IC212871	I	SS	YW	DG	N (G)	AC	P	M	S	GT
IC212872	I	SS	P	PG	N (PG)	AC	P	H	S	VT
IC249583	I	S	W	I	N (PG)	AC	P	M	S	VT
IC253181	I	SS	P	I	N (G)	AC	P	M	B	GT
IC253268	I	S	DP	I	N (G)	AC	P	M	S	GT
IC253270	I	S	P	I	N (G)	AC	30°-90°down from erect	M	S	GT
IC253273	I	SS	YW	I	Pigmented tip (Pale Green)	AC	30°-90°down from erect	M	S	GT
IC253275	I	SS	PP	DG	N (G)	AC	P	H	S	VT
IC257407	I	SS	DP	PG	N (PG)	AC	P	M	B	GT
IC259159-1	I	SS	PP	DG	N (PG)	AC	30°-90°down from erect	M	B	GT
IC259159-2	SD	SS	PP	DG	N (PG)	AC	30°-90°down from erect	M	S	GT
IC202784	I	SS	P	PG	N (G)	TC	P	M	S	GT
IC4506	I	SS	PP	I	Pigmented tip (Green)	AC	P	M	B	GT
IC5969	I	SS	P	I	Pigmented tip (Pale Green)	AC	P	M	S	GT
Mumbai local	D	E	W	I	Pigmented tip (Green)	AC	P	H	B	VT
Bailhongal local	D	E	P	DG	N (PG)	AC	P	L	S	GT
C-152	I	SS	P	I	N (G)	TC	P	M	B	GT

PGP- Plant growth pattern, PGH- Plant growth habit, FC- Flower color, LC- Leaf color, IPP-Immature pod pigmentation, RP- Raceme position, PAP- Pod attachment to peduncle, MP- Mature pod, MV-Market value, D- Determinate, I- Indeterminate, E- Erect, S- Spreading, SS- Semi spreading, SD-Semi determinate P- Purple, PP- Pale purple, YW-Yellowish white, DG- Dark green, PG- Pale green, N-None, G- Green, H- High, W- White, AC- Above canopy, TC- Throughout canopy, P- Pendent, L- Least, M- Medium, S- Straw, B- Brown, GT- Grain type, VG- Vegetable type

Among the 35 genotypes, nine were pale green, seven were dark green and remaining genotypes were intermediate.

Based on variation in the flower colour, the genotypes were grouped as white (IC249583 and Mumbai local), yellowish white (six genotypes), pale purple (10 genotypes), purple (14 genotypes) and dark purple (three genotypes). The genes responsible for flower colour development determine the colour of the petal by developing or blocking of anthocyanin pigmentation. A lot of variation was observed for immature pod pigmentation character in the present study and the genotypes were grouped into none (no pigmentation or green colour pods), pigmented tip, splashes of pigment and uniformly pigmented. The genotype IC97787 was uniformly pigmented, IC198326 showed splashes of pigment, whereas, seven genotypes showed pigmented tip and remaining all did not had pod pigmentation *i.e.*, green colored pods. Nkouannessi (2005) and Naima *et al*. (2009) were also reported similar results in cowpea. Jain and Khare (2002) were of the opinion that the expression of the trait was stable and uniform. The exact reason for pigmentation was not known.

The stem pubescence on stem was absent in all the genotypes under study. Though Nkouannesi (2005) observed variation in stem pubescence as glabrescent, short appressed hairs and pubescent to hirsute in cowpea genotypes, the genotypes under the present study did not vary in their stem pubescence. Marked variation was observed in raceme position and attachment to peduncle in present study. The raceme position in IC257413, IC198333, IC198349, IC202867, IC2027854 and C-152 was throughout canopy and remaining all were above canopy, whereas, with respect to pod attachment, IC198326, IC202867, IC253270, IC253273, IC259159-1 and IC259159-2 were 30°-90°down from erect and remaining all were pendent. The pod constriction at maturity also varied within the genotypes. Grouping of the genotypes was made on the basis of pod constriction as least (11 genotypes), medium (18 genotypes) and high (six genotypes) constricted pods. The expression of constrictions on pod is uniform and stable character, which it can be used to verify the genetic purity (Jain and Khare, 2002). A fair grouping of the cowpea genotypes were made based on pod colour at maturity as either straw (21 genotypes) or brown colored (14 genotypes). Similar results was reported by Sarutayophat *et al*. (2007) in cowpea. Based on the market value, the 35 genotypes were classified into grain type and vegetable type as per the descriptors given by IBPGR for cowpea (IBPGR, 1983). The genotypes IC219599, IC219872, IC249583, IC253275 and Mumbai local were grouped under vegetable type and remaining all were grain type.

Among the descriptors used for grouping, pigmentation on stem, flower colour, immature pod pigmentation, raceme position and pod attachment to peduncle were found very reliable, distinct, uniform and stable. Plant growth pattern and growth habit also found fairly good. These characters can be utilized for identification and characterisation of cowpea varieties in protection of new plant varieties.

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Cluster Analysis on Area of Major Crops across Different Agro-Climatic Zones of Karnataka

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***Abstract*:** The study was carried out to make clusters based on area of major selected crops in Karnataka. Secondary data regarding different crops considered for the study were obtained from the population various issues of 'Karnataka at a Glance' for the period of 1992-2012. The study spans over a period of 20 years from 1992 to 2012 and was divided into two phases i.e., period from 1992-2002 and period from 2002-2012. Ward's method of clustering has been used in this study to make clusters based on area of major crops. The dendrogram shows the graphical representation of the results of hierarchical cluster analysis. The study revealed that, for first period (1992-2002) crops like sorghum, paddy, groundnut, sunflower and ragi, exhibited similarity in area. For second period (2002-2012) crops like paddy, jower and ragi had similarity in area across different agro-climatic zones of Karnataka.

Key Words: Agro-climatic zones, Cluster analysis, Dendrogram, Euclidean distance, Word's method

The cluster analysis is a multivariate analysis which deals with grouping of objects or individuals into unknown objects based on the homogeneity of the objects. This method involves an agglomerative cluster algorithm. Ward's method starts out with 'n' clusters of size one and continues until all the observations are included into one cluster. The dendrogram shows the graphical representation of the results of hierarchical cluster analysis. There is tree-like plot where each step of hierarchical clustering was represented as a fusion of two branches of the tree into a single one. The branches represent clusters obtained on each step of hierarchical clustering.to facilitate the policy formulation. The Karnataka state was classified into 10 agro-climatic zones, which included three transitional zones and one coastal and hilly zone each and five dry zones.

Data used for the study on the area of different crops was obtained from various issues of 'Karnataka at a Glance' across different agro-climatic zones of Karnataka over 20 years (1992-2012) and the data were divided in to two period of study, a) from 1992-2002 and b) from 2002-2012, to know the similarity of crops with respect to area over two different period of study.

Cluster analysis is usually done in an attempt to combine cases in to groups when the group membership is not known prior to the analysis. Cluster analysis is a technique for grouping individual or objects into unknown groups.

Euclidean Distance - This is the most commonly used. For instance, intwo dimensions, we can plot the observations in a scatter plot, and simply measure the distances between the pairs of points. More generally following equation is used:

$$d(\mathbf{X}_i, \mathbf{X}_j) = \sqrt{\sum_{k=1}^{p} (X_{ik} - X_{jk})^2}$$

For each variable *k*, take the difference between the observations for sites *i* and *j* . These differences are then squared, and summed over *p* variables. This gives us the sum of the squared difference between the measurements for each variable. Finally, take the square-root of the result.

Ward's Method: Ward's method starts out with *n* clusters of size 1 and continues until all the observations are included into one cluster, this method is most appropriate for quantitative variables, and not binary variables. Based on the notion that clusters of multivariate observations should be approximately elliptical in shape, we assume that the data from each of the clusters will be realized in a multivariate distribution.

Dendrogram: The Dendrogram is a graphical representation of the results of hierarchical cluster analysis. This is a tree-like plot where each step of hierarchical clustering is represented as a fusion of two branches of the tree into a single one. The branches represent clusters obtained on each step of hierarchical clustering.

Table 1 indicates the results of the Eigen values of the Correlation Matrix for the Area of 17 different agricultural crops (rice, ragi, bajra, wheat, jowar, maize, Bengal gram, horse gram, green gram, black gram, red gram, sesamum, avare, sunflower, groundnut, sugarcane and cotton) which are predominantly grown in the zones for the period 1992-2002, first, second and third, initial clusters have the Eigen

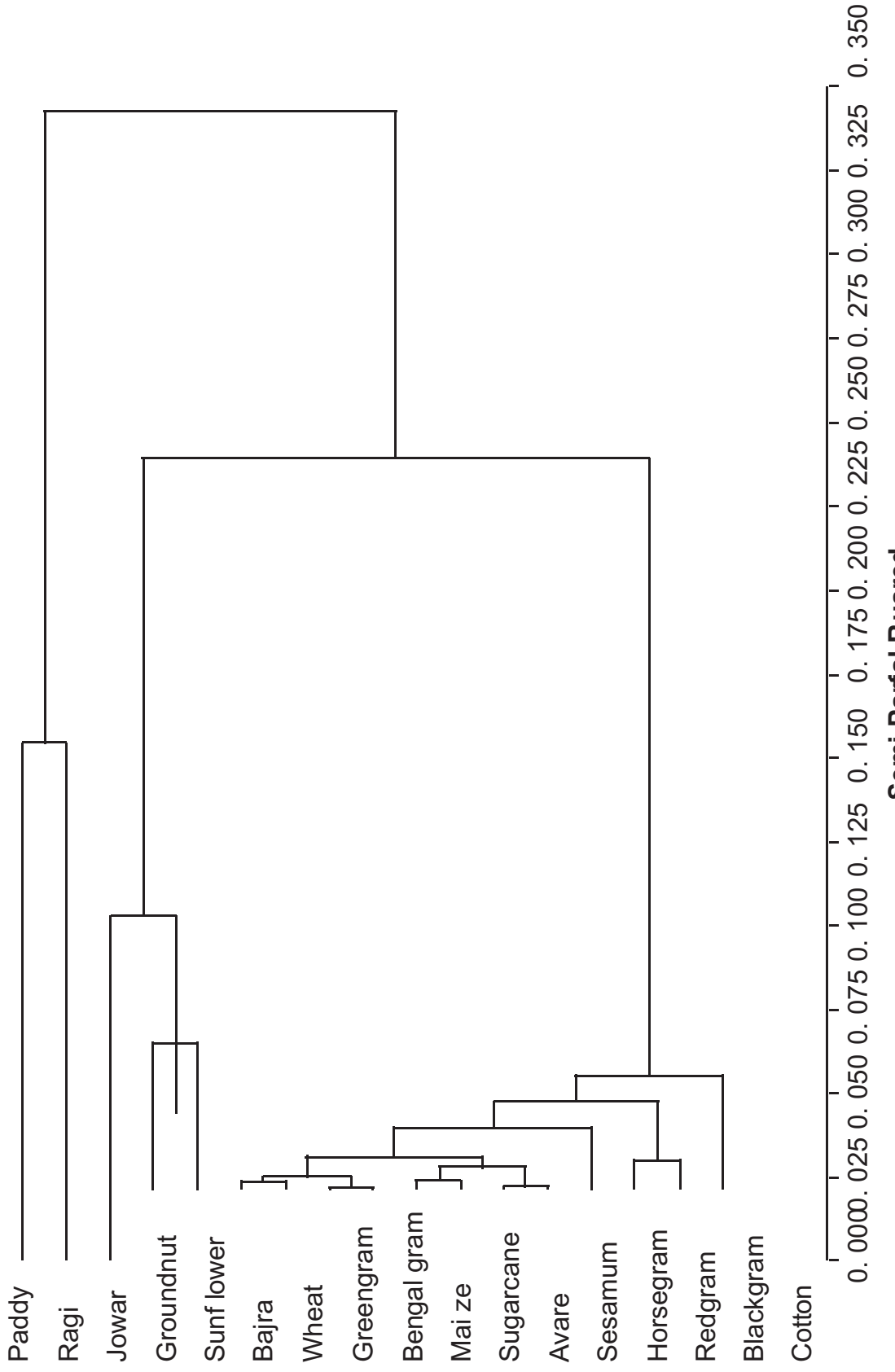

Fig. 1. Dendrogram method of crop cluster based on area during 1992-2002

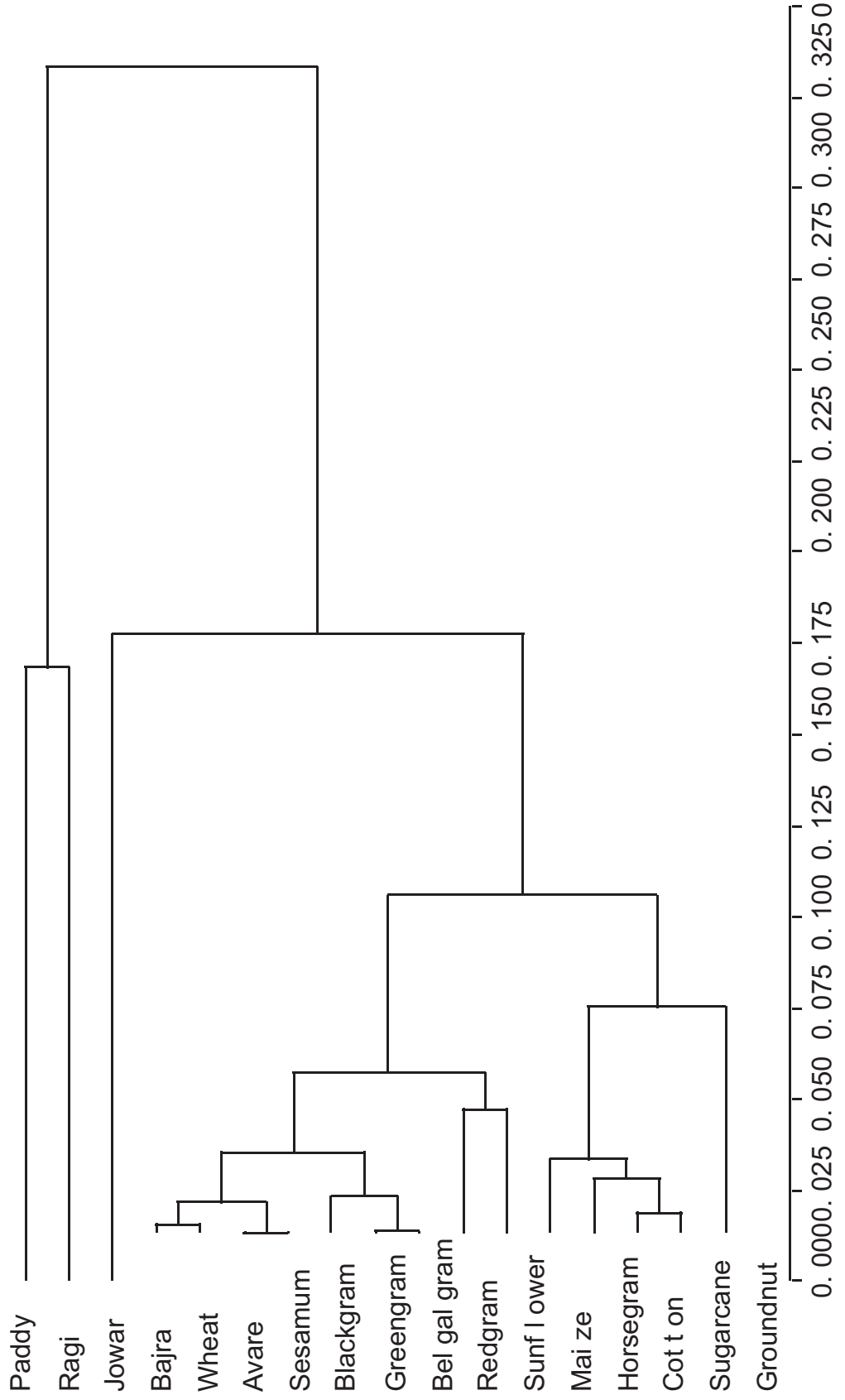

Fig. 2. Dendrogram method of Crop Cluster Based on Area during 2002-2012

Table 1. Eigen values of the correlation matrix for crop area for period 1992-2002

	Eigen value	Difference	Proportion	Cumulative
1	3.856298	0.710262	0.3856	0.3856
2	3.146035	1.387073	0.3146	0.7002
3	1.758961	1.173077	0.1759	0.8761
4	0.585884	0.242300	0.0586	0.9347
5	0.343583	0.156266	0.0344	0.9691
6	0.187317	0.133592	0.0187	0.9878
7	0.053725	0.015130	0.0054	0.9932
8	0.038595	0.010160	0.0039	0.9970
9	0.028434	0.027271	0.0028	0.9999
10	0.001163	-	0.0001	1.0000

Table 2. Eigen values of the correlation matrix for crop area for period 2002-2012

	Eigen value	Difference	Proportion	Cumulative
1	3.893319	1.200803	0.3893	0.3893
2	2.692516	1.078158	0.2693	0.6586
3	1.614357	0.685923	0.1614	0.8200
4	0.928433	0.569433	0.0928	0.9129
5	0.358999	0.046492	0.0359	0.9488
6	0.312507	0.223922	0.0313	0.9800
7	0.088584	0.013093	0.0089	0.9889
8	0.075491	0.040372	0.0075	0.9964
9	0.035118	0.034447	0.0035	0.9999
10	0.000671	-	0.0001	1.0000

value 3.856, 3.146 and 1.758, respectively, in which Eigen value greater than one resulting only three final clusters.

The Eigen value and their corresponding proportion of variation as well as their cumulative proportion for ten initial clusters (Table 2). First, second and third, initial clusters have the Eigen value 3.8933, 2.6925, and 1.6143, respectively, which have Eigen value greater than one, hence in ward's method of clustering only three final clusters are possible for this period of study.

The dendrogram (Fig. 1) shows that the cluster analysis is done based on the area of cultivation of different crops across all the zones of Karnataka for the period of 1992-2002 at 10% semi-partial R-square. Only three final clusters will be possible; the first cluster is formed by paddy and ragi. This indicates that these crops have similarity in area of cultivation across all the zones of Karnataka. The second cluster is mainly formed by groundnut, jowar and sunflower. This indicates that these crops have similarity in area of cultivation across all the zones of Karnataka. Further the third cluster is formed by remaining all other crops. The dendrogram (Fig. 2) shows the cluster analysis for the period 2002-2012 at 10% semi partial R-square. The result shows that there are only three final clusters will be possible; the first cluster is formed by paddy and ragi. The second cluster is mainly formed by jowar. Further third cluster is formed by remaining all other crops.

Based on this cluster, dendrogram indicate that the sunflower and groundnut area has been shifted, because they have undertaking similarity in area of cultivation during the period 1992-2002 when compared to the area during 2002-2012.

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Effect of Different Cropping Systems on Crop Productivity, Profitability and Soil Properties in Alluvial Tract of Uttar Pradesh, India

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***Abstract*:** Rice (*Oryza sativa* L.) equivalent yield was recorded maximum (392.94 q ha^{-1}) through maize + black gram-potato-onion crop sequence followed by 319.30 q ha^{-1} through maize-garlic-green gram crop sequence. Maximum production efficiency (169.37 kg ha^{-1} day^{-1}) was also recorded with maize +black gram-potato-onion cropping system while maximum land use efficiency (99.17 %) was measured in maize-mustard-onion crop sequence. Economic analysis revealed that the maximum net return of Rs. 2,10,997 ha^{-1} was earned through maize+ blackgram-potato-onion crop sequence while maximum B:C ratio 2.81 was recorded through hybrid rice-wheat crop sequence. All cropping sequences showed slight improvement in physico-chemical properties of soil but maximum improvement was in green manuring of green gram in summer and inclusion of legumes in cropping sequence. Maize + blackgram-potato-onion cropping sequence identified as the most productive and profitable cropping sequence while hybrid rice-wheat cropping sequence was identified as most economical crop sequence.

Key Words: Cropping systems, Economic analysis, Land use efficiency, Production efficiency, Soil properties, System productivity

The *Central Plain Zone* of Uttar Pradesh is the largest zone having highly fertile and productive alluvial soil with intensive irrigation and highly cropping intensity. The rice and maize crops are the most common crops utilized as base crop for different sequential cropping systems. Rice-wheat is the pre-dominant cropping system in the *central plain zone* of U.P. due to its high productivity and stability with less risk. Though the system has sustained over the years, yield gradually stagnated due to the exhaustive nature of cereal-cereal crop sequences. Inclusion of crops like oilseed, pulse and vegetable in the system is most essential to fulfill the demand of food, fibre and vegetable for increasing human population and improve the economic condition of the farmers owing to higher price and higher volume of their main and by-products. Kampawat (2001) reported beneficial effect of inclusion of pulses, oilseeds and vegetables in the system than cereals followed by cereals. Legumes have favourable impact on the soil fertility and help in increasing yield of the succeeding rice crop (Kharub *et al.* 2003). Keeping above points in view, the present investigation was undertaken to identify most productive, profitable and sustainable cropping system for the farmers of *Central Plain Zone* of Uttar Pradesh.

A field experiment was carried out at C.S.Azad University of Agriculture and Technology, Kanpur during 2006-07 to 2009-10 to identify biologically most efficient and profitable cropping system for *Central Plain Zone* of U.P. The experiment comprised of 9 crop sequences viz. (i) Rice-wheat (ii) Hy. Rice-wheat (iii) Hy. rice-wheat- green gram, (grain + residue), (iv) Maize-wheat (v) Maize-mustard-onion (vi) Maize-mustard-green gram (vii) Maize + green gram - potato-wheat (viii) maize+ blackgram-potato-onion (ix) maize-garlic-green gram (G+R). The Crop sequences were raised with recommended agronomic practices in Randomized Block Design with three replications. The soil of the experimental field was sandy clay loam in texture, slightly alkaline in nature having pH 8.1,EC 0.21dSm^{-1}, medium in organic carbon (0.56 %), available phosphorus (18.5 kg ha^{-1}) and available potassium (275 kg ha^{-1}). For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield on economic basis. The economics was computed at prevailing market rate of different commodities during 2009-10. The benefit-cost ratio was calculated as gross return divided by cost of cultivation. Production efficiency was worked out by total production in a crop rotation divided by total duration of crop in that rotation. Land use efficiency was obtained by taking total duration of crop in individual crop rotation divided by 365 days. The soil samples (0-15 cm) were collected from each treatment after harvesting the zaid crops. The soil samples were processed and analysed for pH, EC, organic carbon, available P and K by standard methods.

System productivity: The mean yield of 4 years experimentation revealed that maximum grain yield of rice (9612 kg ha^{-1}) was obtained in rice-wheat-greengram (grain + residue) sequence over other rice based crop sequences

while maximum grain yield of maize (3545 kg ha^{-1}) was obtained in Maize-garlic-green gram crop sequence over other maize based crop sequences, presumably due to beneficial effect of green manuring of green gram into the soil. In wheat, maximum grain yield of 5444 kg ha^{-1} was achieved through maize-wheat crop sequence in comparison to other rice as well as maize based crop sequences. It may be due to the improvement in physio-chemical condition of the soil. The total production of a sequence in terms of rice equivalent yield was significantly higher in maize + blackgram-potato-onion (392.94 q ha^{-1}) than other sequences (Table 1) but immediate second was maize-garlic-greengram (G+R). Significantly lowest rice equivalent yield (129.24 q ha^{-1}) was recorded in maize-wheat sequence, which was significantly lower in comparison to existing rice-wheat cropping sequence.

The highest Production efficiency (169.37 kg/ha/day) was obtained through maize + blackgram-potato-onion crop sequence followed by maize-garlic-green gram (G+R) and maize + green gram-Potato-wheat while the lowest production efficiency (43.10 kg/ha/day) was noted in maize-mustard-green gram crop sequence.

Maize-mustard-onion crop sequence achieved the highest (99.17 %) Land use efficiency (LUE) followed by maize-mustard-green gram crop sequence. The lowest LUE was recorded with maize-wheat crop sequence as the land in this sequence was occupied for a short period in comparison to other crop sequences.

Economic analysis: The pooled analysis of results of successive four years (Table 1) revealed that maximum cost of cultivation (`1,23,005 ha$^{-1}$) was invested through maize + black gram-potato-onion crop sequence and minimum (` 46,919 ha^{-1}) with maize-wheat crop sequence followed by rice-wheat (` 53,805 ha^{-1}) crop sequence. Increase in cost of cultivation in maize+ black gram-potato-onion crop sequence is merely because of higher cost of cultivation of potato and onion. Among the rice based sequences, hybrid rice-wheat-green gram (G+R) crops sequence was found most profitable and fetched the highest net return of ` 1,17,081 ha$^{-1}$ followed by hybrid rice-wheat crop sequence among all nine crop sequences. Maize + blackgram-potato-onion crop sequence was found most profitable crop sequence, providing maximum net return of `2,10,997 ha^{-1} followed by maize-garlic-greengram (G+R) sequence (` 1,63,784 ha^{-1}). It was owing to higher system productivity and gross return in comparison to other nine crop sequences. Hybrid rice-wheat crop sequence was found most economical crop sequence, fetching 2.81 times more benefit over the investment of Rs.1 followed by maize + blackgram-

Table 1. Mean yield (kg ha^{-1}) and economics (` ha^{-1}) of different cropping systems during 2006-10

Crop rotations	Yield (Kg ha^{-1})						Rice equivalent yield (kg ha^{-1})	Production efficiency (kg ha^{-1} day^{-1})	Land use efficiency (%)	Cost of cultivation (` ha^{-1})	Gross return (` ha^{-1})	Net return (` ha^{-1})	B:C ratio
	Kharif		*Rabi*		*Zaid*								
	Grain	Straw	Grain	Straw	Grain	Straw							
T_1 Rice-Wheat	5442	6450	4871	5696	-	-	14065	56.94	67.67	53805	119554	65749	2.22
T_2 Hy. Rice-Wheat	9389	16042	5056	5894	-	-	18799	76.11	67.67	56895	159788	102893	2.81
T_3 Hy.Ricet –Wheat-GG(G+R)	9612	10833	5172	6023	869	-	22322	69.76	87.67	72656	189737	117081	2.61
T_4 Maize - Wheat	2930	10523	5444	6252	-	-	12924	50.88	69.58	46919	109853	62934	2.34
T_5 Maize-Mustard -Onion	3372	10242	1967	7818	13713	-	21572	59.56	99.17	82315	183363	101048	2.23
T_6 Maize-Mustard –Green Gram	3395	10200	2034	7227	1047	-	13792	43.10	87.67	59476	117228	57752	1.97
T_7 Maize+ Green Gram-Potato-Wheat	3298 363	10015 1605	21194 4378	- 4894	-	-	30587	100.95	83.01	110355	259987	149652	2.36
T_8 Maize+ Blackgram-Potato-Onion	3396 441	10364 1668	21611	-	18684	-	39294	169.37	83.56	123005	334002	210997	2.72
T_9 Maize - Garlic-G.G. (G+R)	3451	10933	8516	-	1222	-	31930	123.28	70.95	107624	271408	163784	2.52

Sale price (q-1): Rice grain : `850, straw `100, wheat grain `1080, straw ` 250, Green gram grain `3025/q, straw `60/q, maize grain `850/q, straw `30/q, mustard seed `2250/q, mustard stover `10/q, Potato: `710/q, Black gram grain `2750/q, straw: `60/q, onion `725/q , garlic : `2370/q, GG-Green gram; G +R (Grain+Residue)

Table 2. Fertility status of soil after harvest of *Zaid* crops during 2009-10

Treatments	Initial	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
pH	8.1	8.0	8.0	7.8	7.9	7.9	7.7	7.8	7.8	7.8
EC dSm^{-1}	0.21	0.20	0.20	0.20	0.20	0.19	0.19	0.20	0.19	0.20
OC%	0.56	0.61	0.64	0.66	0.63	0.63	0.66	0.65	0.65	0.67
Av. P (kg ha^{-1})	18.5	20.75	21.30	21.80	21.10	21.50	22.35	22.50	22.55	22.60
Av. K (kg ha^{-1})	275	283	286	288	286	287	290	293	291	293

potato-onion crop sequence with benefit cost ratio of 1:2.81. It showed that these are input responsive crop sequences resulted higher return per hectare.

Soil properties: Changes in soil properties over four years cropping sequences showed slight decrease in soil pH and EC values in all the treatments from the initial value. Maximum decrease in soil pH value was observed in hybrid rice-wheat-greengram (G+R) and maize-garlic-greengram (G+R), which is obviously due to release of organic acid during decomposition of green manuring in the soil and decrease in Ec values in all treatments might be due to use of inorganic fertilizers**.** The organic carbon content (%) in soil increased in all the treatments in comparison to initial values. The highest increase in organic carbon content was noted in green manuring incorporated treatment and where legume was included in sequence. This increase in organic carbon is attributed to higher contribution of biomass to the soil in the form of crop stubles and residues. The subsequent decomposition of these material might have resulted enhanced organic content of the soil. These results are in conformity with the finding of Sharma and Sharma (2002).

Available status of phosphorus and potassium was also increased in all crop sequences in comparison to its initial value. Maximum increase in available status of phosphorus and potassium was found in green manuring and legume included cropping sequences and due to use of recommended fertilizer in all crop sequences, incorporation of green manure and inclusion of legume crop in cropping sequence. These findings are supported by the earlier findings of Tolanur and Badanur (2003) and Yadvinder Singh *et al.* (2004) who also observed positive response of green manuring and inclusion of legume crops in cropping sequence to improving the fertility status of the soil.

The farmers with adequate resource can diversify the existing cropping system with Maize + Black gram-Potato–Onion for getting higher productivity and profitability, while to get maximum economic yield in hybrid rice-wheat crop sequence is the best option for the small and marginal farmers of central alluvial tract of U.P.

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Effect of Different Modes of Pollination on Yield and Quality of Broccoli *(Brassica oleracea* L. var. *italica* Plenck) Seed

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Abstract: Number of siliqua plant^{-1}, Number of seeds siliqua^{-1}, test weight (g), germination (%), seed vigour-I and seed vigour-II, of uncaged condition (open pollinated crop) were found to be significant as compared to caged condition (without insect pollination) of broccoli plant.

Key Words: Broccoli, Pollination, Quality, Yield

Broccoli (*Brassica oleracea* L. var. *italica* Plenck) belongs to family Cruciferae and is cross pollinated crop and insect play major role in pollination. Among the insects, honey bees are the major pollinator of the broccoli. Being a cross-pollinated crop its seed production is expected to be effected by the visits of the pollinating insects. However, many other insects including butterflies, moths, beetles and flies also act as pollinators. The present studies were conducted to observe the effect of pollination on yield and quality of broccoli.

The studies were carried out at CCS Haryana Agricultural University, Hisar during 2013-2014 on the varieties BFT-1, GH-1, LPH-1 and DPH-1 for seed production. Ten plants of each variety (one plant per replication) were enclosed with nylon net before initiation of flowering in the crop to restrain the entry of flower visitors. For open pollination, ten plants of each variety were selected. The total number of siliqua set plant^{-1} was recorded from 10 randomly selected plants and seed set in 10 randomly selected pods from each plant. The seed germination was observed from 100 randomly selected seeds (10 seeds replication^{-1}). The seed vigours was calculated as i). Seed vigour index-I= standard germination (%) x seedling length (cm); ii). Seed vigour index-II = standard germination (%) x seedling dry weight (gm). The test weight was recorded from 1000 seed from each replication.

Average number of siliqua per plant and average number of seeds per ten siliqua in different varieties in open-pollination was significantly higher than the average number of siliqua per plant without insect-pollination (Table 1). Irrespective of different modes of pollination, the mean maximum number of siliqua per plant was maximum in GH-1 (2,449.1) followed by LPH-1, BFT-1 and minimum in DPH-1. Similarly, irrespective of different modes of pollination, the mean number of seeds per 10 siliqua was maximum in GH-1 (77.60) followed by DPH-1, BFT-1 and minimum in LPH-1. The present findings are similar to earlier research workers. Devkota *et al.* (2003), Devkota and Thapa (2005); Chandrashekhar and Sattigi (2009) reported more number of siliqua per plant and number of seeds per siliqua in uncaged condition as compared to caged condition.

Average seed test weight (gm) in different varieties in open-pollination (2.88) was significantly higher than the average seed test weight without insect-pollination (2.09). The mean maximum test weight was recorded 3.20 in BFT-1 followed by LPH-1 (2.74), GH-1 (2.42) and DPH-1 (1.58). The mean test weight (gm) was 3.52 in BFT-1, 2.88 in GH-1, 3.19 in LPH-1 and 1.94 in DPH-1 variety under open-pollination treatment against 2.88, 1.96, 2.29 and 1.22 without insect-pollinated plants, respectively (Table 1). Pudasaini *et al.* (2014) also found that test weight was higher in opened than compared to without insect pollination.

Average germination in different varieties was also recorded significantly higher through open-pollination than without insect-pollination treatments (Table 1). Germination was noticed maximum in GH-1 (60.50) followed by LPH-1, DPH-1 and minimum in BFT-1. Bhowmik *et al.* (2014) also found higher test weight and germination in *Brassica juncea* L. in uncaged condition than in caged condition.

Average seed vigour index I and II in different varieties through open-pollination was significantly higher than without insect-pollination (Table 2). The perusal of data revealed that the mean vigour index I varied from 1560.20 to 1181.60 under open-pollination against 332.00 to 515.00 in without insect-pollination but interaction effect for seed vigour index II was non-significant. Rajasri *et al.* (2012) also found higher seed vigour index in uncaged condition as compared to caged condition in sunflower crop.

Table 1. Effect of different modes of pollination on different varieties of broccoli*

Mode of pollination	Varieties				
	BFT-1	GH-1	LPH-1	DPH-1	Mean
Number of siliqua per plant					
Open pollination	3,003 (54.54)	4,081 (63.59)	3,503 (58.75)	2,860 (53.00)	3,362 (57.47)
Without insect pollination	634 (23.86)	817 (27.83)	515 (21.42)	724 (25.69)	673 (24.70)
Mean	1,819 (39.24)	2,449 (45.71)	2,009 (40.09)	1,792 (39.35)	
Number of seeds per 10 siliqua					
Open pollination	119.60 (10.92)	125.90 (11.18)	108.80 (10.97)	120.70 (10.97)	118.75 (10.86)
Without insect pollination	25.10 (4.75)	29.30 (5.13)	23.00 (4.60)	26.00 (4.98)	25.85 (4.86)
Mean	72.35 (7.82)	77.60 (8.15)	65.90 (7.49)	73.35 (7.97)	
Test weight (g)					
Open Pollination	3.52	2.88	3.19	1.94	2.88
Without insect pollination	2.88	1.96	2.29	1.22	2.09
Mean	3.20	2.42	2.74	1.58	
Germination (%)					
Open pollination	88.00	94.00	84.00	85.00	87.50
Without insect pollination	26.00	27.00	36.00	32.00	30.25
Mean	57.00	60.50	60.00	58.50	
CD (p=0.05)					
Factors	Number of siliqua per plant	Number of seeds per 10 siliqua	Test weight (g)	Germination (%)	
Mode of pollination	3.338	0.729	0.03	5.07	
Varieties	4.720	NS	0.05	NS	
Mode of pollination x Varieties	NS	NS	0.07	NS	

*Figures in parentheses are $\sqrt{(x+1)}$ transformed values

Table 2. Effect of different modes of pollination on seed vigour index I and index II of seed of broccoli

Mode of pollination	Varieties				
	BFT-1	GH-1	LPH-1	DPH-1	Mean
Vigour I					
Open pollination	1,560.20	1,669.30	1,475.50	1,181.60	1,471.65
Without insect pollination	332.00	330.80	495.80	515.00	418.40
Mean	946.10	1,000.05	985.65	848.30	
Vigour II					
Open pollination	0.52	0.68	0.67	0.76	0.66
Without insect pollination	0.12	0.12	0.12	0.07	0.11
Mean	0.32	0.40	0.40	0.41	
CD (p=0.05)					
Factors		Vigour I		Vigour II	
Mode of pollination		153.44		0.03	
Varieties		NS		NS	
Mode of pollination x Varieties		306.88		NS	

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Influence of Weather Parameters on Bacterial Blight of Pomegranate in Punjab

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***Abstract*:** Field experiment was conducted to study the favourable environmental conditions for the development of bacterial blight of pomegranate. The mean minimum temperature, relative humidity and total rainfall were positively correlated with per cent disease index, whereas, mean maximum temperature had negative impact on disease development under field conditions.

***Key Words*:** Bacterial blight, Pomegranate, Weather parameters, *Xanthomonas axonopodis* pv. *punicae*

In India, pomegranate was cultivated over an area of 112.74 thousand hectare with production of 741.08 thousand MT in 2012-13 (Anonymous, 2013). Pomegranate crop is vulnerable to various diseases, which result in reduction of fruit yield and quality. Among the diseases, bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae* is the most important disease causing enormous losses of 60-80 per cent (Mondal and Sharma, 2009). A disease of minor importance at one time has now emerged as a constraint of significance because of increased incidence over years in all the pomegranate growing regions (Anonymous, 2002). But scanty information is available on the epidemiological aspects of this disease. The present study was under taken to determine the influence of weather parameters on the development of disease under Punjab conditions.

The studies on the appearance and subsequent development of bacterial blight were conducted from June to August, 2013 in the New orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana. Five branches of pomegranate each bearing 5 to 10 fruits were randomly marked on recommended varieties, viz. Ganesh and Kandhari for data recording. The per cent disease index was recorded at weekly interval starting from the first week of June till last week of August using scale given by Chester (1950).

The meteorological data prevailing was obtained from the observatory of School of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. The per cent disease index recorded at weekly intervals were pooled month-wise and correlated with weather parameters viz. maximum minimum temperature, morning evening relative humidity and total rainfall.

Development of bacterial blight of pomegranate in relation to weather parameters: The disease initiated during the second week of June on both Ganesh and Kandhari varieties of pomegranate under field conditions (Fig. 1), but there was no trace of the disease during first week of June, indicating the essentiality of the showers for the establishment of infection under natural conditions. Light showers received in the second week of June triggered the initiation of infection in both the varieties with mean maximum and minimum atmospheric temperature prevailing as 42.1 and 29.1°C coupled with mean maximum and minimum relative humidity as 69 and 35%, respectively. An abrupt increase in disease index from 3.25 to 12.50 and 2.56 to 8.73 per cent on Ganesh and Kandhari, respectively, was observed due to maximum rainfall received during third week of June. During the last week of June, there was slight increase in maximum atmospheric temperature while minimum atmospheric temperature and relative humidity remained at slightly low level and no rainfall was received. The disease showed upward trend registering 21.33 per cent disease index on Ganesh and 17.50 per cent disease index on Kandhari due to increase in rainfall as well as mean relative humidity. The possible impact of high relative humidity and total rainfall amounting to 53.8 mm received during the first week of July seemed to had favourable effect on the disease development registering as high as 21.33 and 17.50 per cent on Ganesh and Kandhari, respectively. The disease index registered a further rapid upward trend from 21.33 to 25.00 and 17.50 to 19.32 on Ganesh and Kandhari, respectively, during the second week of July in response to moderate rainfall. During third week of July gradual increase in rainfall and constant maximum atmospheric temperature favoured gradual increase in disease index on Ganesh (25.00 to 30.83 per cent) as well as on Kandhari (19.32 to 23.58 per cent). During the 4th week of

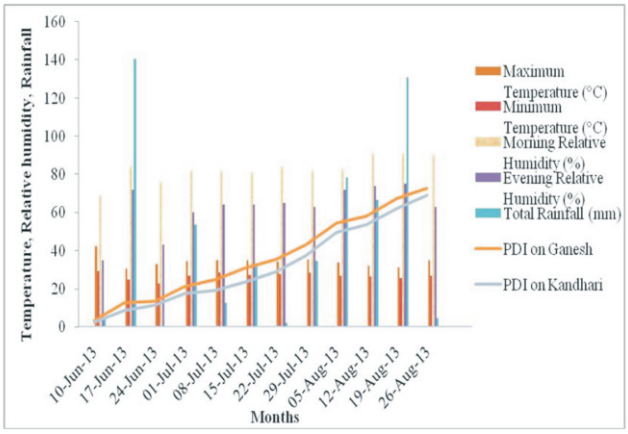

Fig. 1. Development of bacterial blight on pomegranate varieties in relation to weather parameters

Table 1. Simple correlation values for per cent index of bacterial blight with weather parameters during June-August, 2013

Weather parameter	Correlation coefficient (r)	
	Ganesh	Kandhari
Maximum temperature (°C)	-0.966	-0.979
Minimum temperature (°C)	+0.343	+0.289
Morning relative humidity (%)	+0.996	+0.990
Evening relative humidity (%)	+0.862	+0.832
Rainfall (mm)	+0.593	+0.639
r (p=0.05)	+0.549	+0.549

July as there was gradual decrease in maximum atmospheric temperature but gradual increase in minimum atmospheric temperature and relative humidity, the per cent disease index increased from 30.83 to 35.50 per cent on variety Ganesh and 23.58 to 28.76 per cent in Kandhari. During the last week of July moderate level of rainfall resulted in increase in per cent disease index from 35.50 to 43.16 and 28.76 to 37.31 per cent on Ganesh and Kandhari, respectively. During first week of August, gradual decrease in maximum and minimum atmospheric temperature and gradual increase in relative humidity and rainfall (78.4 mm) resulted in increase in disease index from 43.16 to 54.50 and 37.31 to 49.33 per cent on Ganesh and Kandhari, respectively. Similar trend prevailing in terms of maximum/minimum atmospheric temperature, relative humidity and total rainfall was observed till last week of August and a further upward trend in disease index was recorded as high as 72.83 and 68.87 per cent on variety Ganesh and Kandhari, respectively. The variety Ganesh was more susceptible than variety Kandhari in relation to per cent disease index.

Correlation of weather parameters and disease index: The simple correlation values presented in Table 1 showed that mean maximum atmospheric temperature had significant and negative impact on disease development under field conditions whereas, minimum atmospheric temperature was positively correlated with disease index. There was significant and positive correlation between per cent disease index and relative humidity total rainfall. The regression analysis was performed to find out the relationship between environmental factors and disease progress. The results revealed (Table 2) that unit change in maximum/minimum temperature and mean minimum temperature exerted influence on disease index up to an extent of 12.96 units in positive direction and 12.16 units in negative directions, respectively, while mean morning and evening relative humidity had influence on disease index (4.03 units in positive and 1.92 units in negative directions, respectively) and unit change in the total rainfall influenced disease index by 0.12 unit in negative directions in the variety Ganesh. Similar observations were noticed in the variety Kandhari.

These findings clearly indicated that bacterial blight of pomegranate was influenced by the prevailing atmospheric temperature, relative humidity and total rainfall under field conditions. Studies conducted by Yenjerappa *et al*. (2006) revealed very negligible disease intensity on foliage due to uncongenial weather such as low minimum temperature (10.8–19.4°C) and no rainfall received during growth and development stage (November–March) of the

Table 2. Multiple regression equation for bacterial blight of pomegranate

Variety	Multiple correlation coefficient (R)	Coefficient of multiple determination (R^2)	Adj. R^2	S.E.	Regression model
Ganesh	0.926	0.857	0.738	11.68	Y_i= -531.49+12.96X_1-12.16X_2+4.03X_3+1.92X_4-0.12X_5
Kandhari	0.923	0.852	0.729	11.46	Y_i= -541.70+13.26X_1-12.46X_2+4.21X_3+1.71X_4-0.10X_5

Y_i= Per cent disease index, X_1 = Maximum atmospheric temperature, X_2 = Minimum atmospheric temperature, X_3 = Morning relative humidity, X_4 = Evening relative humidity and X_5 = Total rainfall

crop. On contrary, the disease started progressing from April onwards with the receipt of unusual rains and prevalence of higher temperature during April and May (maximum temperature ranged between 36.5–42.9°C and minimum temperature between 20.8–24.2°C).

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Effect of Different Shelterbelts on Dry Matter Partitioning and Quality Parameters of Brinjal (*Solanum melongena* L.)

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Abstract: A field experiment was planned to investigate the effect of different types of the shelterbelts on microclimate of brinjal. The number of primary/secondary branches, fruit number, and quality parameters differs significantly with better performance for all the parameters in white polythene shelter belt followed by black polythene, sarkanda than control.

Key Words: Brinjal, Primary and secondary branches, Quality parameters

Brinjal/eggplant (*Solanum melongena* L.) is an important and indigenous vegetable crop of India and other parts of the world. It contributes nine per cent of the total vegetable production of the country. The yield/quality has improved due to improvement in production technology, plant protection measures and the genetic improvement. The yield of long, round, oblong and small round varieties have reached at 50, 65, 60 and 40 t ha^{-1}, respectively, whereas, F1 hybrids raised it to 62.5, 79, 75 and 50 t ha^{-1}, in these respective groups. The cultivars of low glycol-alkaloids content with different sizes, shapes and colour has increased the market acceptability of the crop (Sidhu and Dhatt, 2007). Brinjal requires a long and warm growing season, and is sensitive to frost injury and chilling weather for longer time damages the crop. A temperature in the range of 20-30°C is most favourable for its successful production.

There are number of techniques developed for the protection of crop from the frost and cold injury. Important techniques used for frost prevention are mulching, screening, use of heaters, wind machines, overhead sprinkler irrigation and wind breaks. Out of these techniques, a physical shelterbelt is considered best for it's cheap cost and amelioration of microclimate by reducing the intensity of cold winds and in turn promotes growth, yield and yield contributing characters of the crop. Shelterbelts have been found very effective in raising crop yield by increasing day time soil, air, canopy temperature and reducing wind speed on the leeward side of the barrier (Marshall 1967). Reduction of air flow in the leeward sides of shelterbelt may lead to poor vertical diffusion and air mixing causing higher day temperature (Brown and Rosenberg, 1972). Even a little variation in the microclimate at critical stages of the crop growth can lead to significant differences in plant growth, fruit set and consequently economic returns.

The field experiment was conducted at the Research Farm of the Department of Agricultural Meteorology Punjab Agricultural University Ludhiana during the *Rabi* season. The treatments consisted of four types of different shelterbelts (white polythene, black polythene, sarkanda and control) and three dates of transplanting (11th and 25th November and 9th December) replicated three times and subjected to analysis of variance in split plot design. Number of branches per plant, average plant component dry weight, numbers of fruits, fruit weight and quality parameters (anthocyanin content and total minerals) were measured.

Effect of different types of shelterbelts on dry matter partitioning: The observations on dry matter partitioning were started on 106th day after transplanting (DAT) when sufficient biomass in terms of leaf, stem and fruit was accumulated by the plant. Among the different types of shelterbelts, the crop sheltered by white polythene had higher dry matter of stem, leaf, root, fruits throughout the growing cycle of crop followed by black polythene, sarkanda and unsheltered crop. The number of primary branches differed significantly with the types of sheltered belts (Table 1) but the number of secondary branches did not show significant differences among shelters. Higher day time temperature, which increases the fixation/reduction of CO_2 and reduce respiration loss, might have favoured this rapid growth and dry matter accumulation. The improved water relation in sheltered plots might have also been responsible for the increase in dry matter production. The metabolic process in a cell is critically dependent on water content of the protoplasm therefore the water loss may also had a direct inhibitory effect on the photosynthesis. Plants subjected to shaking by wind usually have lower dry matter.

Effect of different types of shelterbelts on yield and quality parameters: The significant differences were observed in number of fruit per plant with respect to type of shelter belt and row width. The fruits per plant were higher (7.39) in crop protected by white polythene followed by black polythene sheet (7.03) and sarkanda (6.17) as compared to control (5.84). The higher number of fruits per plot in white polythene sheltered crop may be due to better vegetative

Table 1. Dry matter partitioning (gm plant^{-1}) as influenced by dates of transplanting, types of shelterbelt in brinjal

Treatment	Days after transplanting											
	Leaf			Stem		Primary branches	Secondary branches		Root		Fruit	
	106	136	166	106	136	166	166	106	136	166	166
Dates of transplanting											
11th November	1.22	4.65	8.08	1.89	3.10	44.05	8.08	5.42	1.53	6.14	17.91	21.32
25th November	1.05	4.26	6.58	1.49	2.18	32.03	6.58	4.58	0.76	1.67	16.98	13.78
9th December	1.04	1.35	6.25	1.35	1.92	20.82	6.25	3.75	0.75	1.37	9.86	9.43
CD (P=0.05)	NS	0.93	0.87	0.27	1.92	6.74	0.87	0.99	0.34	3.62	4.58	3.48
Shelterbelt												
Control	0.82	3.39	6.00	1.35	1.83	29.89	6.00	4.44	0.81	2.56	13.79	6.82
White polythene	1.83	4.17	7.56	2.31	2.96	35.49	7.56	4.78	1.26	3.47	16.42	19.90
Black polythene	0.90	4.07	7.33	1.36	2.42	33.50	7.33	4.56	1.04	3.41	14.93	19.14
Sarkanda	0.87	3.39	7.00	1.36	2.39	30.33	7.00	4.56	0.94	2.80	14.51	13.51
C.D. (P=0.05)	0.84	0.39	0.78	0.53	0.44	0.78	0.78	NS	0.28	0.67	1.02	5.58

growth and more number of primary and secondary branches. Similarly significant differences were observed in the fruit yield with different types of shelter belt (Table 2). The crop having shelter belt of white polythene sheet gave higher fruit yield of (428.36 q ha^{-1}) as compared to the other types of shelter belts but at par to black sheet (420.58 q ha^{-1}).

Table 2. Fruit yield and quality parameters as influenced by dates of transplanting, types of shelterbelt in brinjal

	Number of fruits per plant	Fruits yield (q ha^{-1})	Anthocyanin content (µg g^{-1})	Mineral content (µg g^{-1})
Dates of transplanting				
11th November	7.24	458.53	745.23	7.08
25th November	7.13	333.29	744.59	6.92
9th December	5.45	280.66	743.46	6.08
CD (P=0.05)	1.38	15.40	NS	0.58
Shelterbelt				
Control	5.84	281.43	743.45	6.33
White polythene	7.39	428.36	745.24	7.33
Black polythene	7.03	420.58	744.80	6.56
Sarkanda	6.17	299.61	744.21	6.33
C.D. (P=0.05)	1.13	17.58	NS	0.41

Anthocyanin content in brinjal showed non-significant differences among all the treatments (Table 2). Among the different types of shelterbelts, the white polythene sheet had higher mineral content (7.33µg g^{-1}) followed by black polythene (6.56µg g^{-1}) and by sarkanda (6.33µg g^{-1}) as compared to control (6.33µg g^{-1}). These differences in the pigmentation may be due to differential growth patterns and reflection of light to the extent, which altered the biochemical and physiological properties of the fruits. The quality parameters of brinjal has also been studied by Jung *et al.* (2011).

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Effect of Organic and Inorganic Fertilizers on French Bean (*Phaseolus Vulgaris* L.)

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Abstract: The organic and inorganic fertilizers combinations significantly increase the growth and green pod yield of French bean. 100% NPK + 100% poultry manure @ 5 t ha^{-1} recorded maximum plant height, number of branches, number of leaves, mean leaf area, length of pod, diameter of pod, number of pod, weight of pod, green pod yield. But highest net returns (☐ 48,013 ha^{-1}) and BCR (2.33) was calculated with application of 100% NPK + 50% PM @ 2.5 t ha^{-1} and next best treatment was 100% NPK +50% vermicompost @ 2.5 t ha^{-1} BCR (2.11).

Key Words: French bean, FYM, NPK, Poultry manure, Vermicompost

The productivity of French bean is low in Maharashtra and inadequate supply of nutrient is one of the most important reasons in Marathwada, where the black soil (Vertisols) are deficient in both nitrogen and phosphorus while these are sufficient in potassium. Therefore, nitrogen and phosphorus application is considered to be necessary for growth and yield of French bean. Use of chemical fertilizer alone increase the crop yield in the initial year but adversely affect the sustainability of yield. The cost of chemical fertilizers is also increasing day by day. Therefore, to reduce dependence on chemical fertilizers along with sustainable production are vital issues in modern agriculture which can be achieved possibly through integrated plant nutrient supply like FYM, poultry manure, vermicompost, etc., which are cheap and easily available in local condition. Application of both chemical and organic fertilizers needs to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield.

A field experiment was conducted to study the effect of organic and inorganic fertilizers on growth, green pod yield and economics of French bean in the Department of Horticulture VNMKV, Parbhani Maharashtra during the *rabi* season, 2012. Variety- HPR-35 with seed rate 75 kg ha^{-1} was sown dibbling method at 60 x 30 cm spacing in a randomized block design with three replications with plot size 3.0 m x 2.7 m with 15 treatment (Table 1). N, P and K were applied through urea, SSP and MOP, respectively. Full dose of P K and half dose of N were applied as a basal and remaining half dose of N was applied at 30 day after sowing. The poultry manure, vermicompost and FYM were incorporated in respective plots 12 day before seed sowing (Table 1). Treatment wise economics was carried out by calculating the cost of cultivation based on prevailing rate of inputs and produce. Net income was estimated by deducting the total cost of cultivation from gross income of the particular treatment. Cost benefit ratio was worked out by dividing net return from total cost of cultivation.

Yield and Yield attributing characters: Application of 100% NPK+ poultry manure @ 5 t ha^{-1}, recorded maximum plant height (37.30 cm), number of branches plant^{-1} (6.56), number of leaves plant^{-1} (19.53), leaf area (107.80 dm^2) but values were at par in T_1 , T_5 , T_4, T_2 and T_6 treatments. The lowest value of growth characters were recorded in T_{16}. This indicates the importance of adding organic manures combined with inorganic fertilizer, which increases the availability of nutrients considerably.

Application of 100% NPK + poultry manures @ 5 t ha^{-1} recorded maximum values of all yield attributing characters such as pod length (12.83 cm), pod diameter (0.93 cm), number of pods (42.18 plant^{-1}) and it was at par with T_1, T_4 and T_6 (Table 1). The efficiency of inorganic fertilizers is much pronounced when they are combined with organic manure. Higher vegetative growth might have helped in synthesis of greater amount of food material which was later translocated into developing pods resulting in increasing pod length and pod diameter. The highest green pod yield (55.81 g plant^{-1}) and pod yield (30.98 q ha^{-1}) was recorded maximum in 100% NPK + poultry manure @ 5 t ha^{-1} and it was at par with T_1, T_5, T_4, T_2 and T_6. This might be due to corresponding response to increased yield attributing characters attained previously under this treatment.

This finding has close conformity with earlier reports of Choudhari *et al.* (2001), Sathe (2007) and Kumar *et al.* (2009) who reported the increase in growth and green pod yield in French bean to combine application of organic and

Table 1. Effect of organic and inorganic fertilizers on growth and yield of French bean

Treatment	Plant height at 75 DAS (cm)	No. of branches plant^{-1} at 75 DAS	No. of leaves plant^{-1} at 60 DAS	Leaf area plant^{-1} (dm^2) at 60 DAS	Length of pod (cm)	Diameter of pod (cm)	No. of pods plant^{-1}	Weight of pods plan^{-1} (g)	Pod yield (q ha^{-1})
T_1: 100 % NPK +100% Vermicompost @ 5 t ha^{-1}	36.76	6.18	23.20	106.10	12.73	0.87	40.83	53.78	29.31
T_2: 100 % NPK + 50% Vermicompost @ 2.5 t ha^{-1}	35.30	5.53	22.10	101.83	12.40	0.78	37.13	48.60	27.16
T_3: 100 % NPK + 100% Poultry manure @ 5 t ha^{-1}	37.30	6.56	23.36	107.80	12.83	0.93	42.18	55.81	30.98
T_4: 100 % NPK + 50% Poultry manure @ 2.5 t ha^{-1}	35.73	5.76	22.40	103.10	12.50	0.84	38.12	50.62	28.01
T_5: 100 % NPK +100% FYM @ 25 t ha^{-1}	36.13	5.80	22.76	104.57	12.65	0.87	39.20	52.28	29.14
T_6: 100 % NPK + 50% FYM @ 12.5 t ha^{-1}	34.66	5.26	21.80	99.66	12.13	0.82	36.17	47.12	26.07
T_7: 50 % NPK +100% vermicompost @ 5 t ha^{-1}	34.16	4.80	21.20	96.16	11.33	0.76	34.48	45.39	24.40
T_8: 50 % NPK+ 50% vermicompost @ 2.5 t ha^{-1}	33.60	4.50	20.16	90.20	10.95	0.71	31.76	40.94	22.11
T_9: 50 % NPK + 100% Poultry manure @ 5 t ha^{-1}	34.60	4.93	21.53	97.43	11.53	0.77	34.93	46.41	25.68
T_{10}: 50 % NPK + 50% poultry manure @ 2.5 t ha^{-1}	33.63	4.56	20.50	92.93	10.97	0.74	32.10	41.24	22.74
T_{11}: 50 % NPK+100% FYM @ 25 t ha^{-1}	34.13	4.63	21.10	94.70	11.10	0.75	32.33	42.26	23.39
T_{12}: 50% NPK +50% FYM @ 12.5 t ha^{-1}	33.36	4.40	19.80	88.03	10.92	0.69	30.74	38.10	21.20
T_{13}: 100 % NPK	32.76	4.33	19.63	86.33	10.36	0.61	29.41	32.96	17.55
T_{14}: 100% poultry manure @ 5 t ha^{-1}	32.46	4.20	18.83	84.36	10.26	0.64	29.28	36.00	20.37
T_{15}: 100% vermicompost @ 5 t ha^{-1}	32.23	4.15	18.50	79.90	9.90	0.57	29.22	34.60	19.44
T_{16}:100% FYM @ 25 t ha^{-1}	31.90	4.13	17.60	77.50	9.80	0.56	27.44	31.24	16.85
CD at 5 %	3.33	1.05	2.54	10.63	2.07	0.137	7.26	6.67	4.18

Table 2. Benefit cost ratio as influenced by organic and inorganic fertilizers

Treatment*	Yield (q ha^{-1})	GMR (Rs)	Cost of cultivation	NMR (Rs.)	Benefit cost (B:C) ratio
T_1	29.31	87930	51017	36913	1.73
T_2	27.16	81480	38517	42963	2.11
T_3	30.98	92940	46017	46923	2.01
T_4	28.01	84030	36017	48013	2.33
T_5	29.14	87420	51017	36403	1.71
T_6	26.07	78210	38517	39693	2.03
T_7	24.40	73200	49843	18357	1.46
T_8	22.11	66330	37343	26487	1.77
T_9	25.68	77040	44843	32197	1.71
T_{10}^1	22.74	68220	34843	33377	1.95
T_{11}	23.39	70170	49843	20327	1.40
T_{12}^1	21.20	63600	37343	26257	1.70
T_{13}	17.55	52650	26017	26633	2.02
T_{14}	20.37	61110	43670	17440	1.39
T_{15}	19.44	58320	48670	4650	1.19
T_{16}	16.85	50550	48670	1880	1.03

*Check Table 1 for treatment details

inorganic fertilizers.

Economics of treatments: Combination of 100% NPK + poultry manure @ 2.5 t ha^{-1} (T_4) was found most profitable treatment in French bean exhibiting highest net return of ☐ 48,013 with cost benefit ratio of 1:2.3 followed by ☐ 46,923 in treatment 100% NPK + Poultry manure @ 5 t ha^{-1} (Table 2).

The applications of nutrient in combination of organic and inorganic fertilizers were found more effective than inorganic fertilizers or organic manure alone for growth and yield of French bean. The maximum benefit cost ratio in the treatment T_4 (100 % RDF + 50 % poultry manure) is optimum dose of organic and inorganic fertilizers for French bean.

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Effect of Planting Methods and Plant Population on Growth, Yield and Quality of Turmeric (*Curcuma longa* L.)

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Abstract: The flat 30 cm and bed 67.5 cm planting methods recorded significantly higher dry rhizome yield and processed turmeric yield as well as curcumin and oil yield owing to significantly higher growth parameters and yield attributes than ridge 45 cm and ridge 60 cm planting methods. Among the plant populations, dry rhizome yield and processed turmeric yield as well as curcumin and oil yield were significantly higher with plant populations of 1,66,667 and 2,00,000 plants ha^{-1} than plant population of 1,33,334 plants ha^{-1} although per plant growth parameters as well as yield attributes were significantly higher under lower plant population. Curcumin content and oil content of turmeric were not significantly influenced by different planting methods and plant populations.

Key Words: Curcumin, Essential oil, Quality, Rhizomes, Turmeric

India is the major producer (about 80 per cent of the total world production), consumer and exporter of turmeric (*Curcuma longa L.*) in the world. In India, during 2012-13, turmeric was grown on an area of 2.19 lakh hectares with total production of 11.66 lakh tonnes (Anonymous, 2013a). For the higher productivity, identification of location specific production technologies like suitable planting methods and optimum plant population are of prime importance besides genetic potential of varieties. Planting method is a soil management tool, used to effect the plant root environment. The optimum planting distance and plant population are important factors for better production and provides equal opportunity to the plants for their survival and best use of other inputs applied to them (Singh *et al.,* 1988). The full yield potential of an individual plant is achieved when sown at wider spacing, whereas, yield per unit area is maximum when individual plants are subjected to severe competition (Holliday, 1960). Keeping these points in view, the present investigation was executed to find out the suitable planting method and optimum plant population for higher productivity of turmeric.

The investigation was carried out at Punjab Agricultural University, Ludhiana during *kharif* season of 2013. The experiment was carried out in split plot design with four replications on loamy sand soil, which was normal with respect to pH and EC, low in organic carbon and nitrogen, medium in available phosphorous and potassium. The treatments consisted of four planting methods (flat 30 cm, ridge 45 cm, ridge 60 cm and bed 67.5 cm) in main plots and three plant populations (1,33,334, 1,66,667 and 2,00,000 plants ha^{-1}) in sub-plots. In flat planting method, the crop was planted at 30 cm with plant to plant spacing of 25, 20 and 16.7 cm, in 45 cm ridge planting method, the crop was planted at 45 cm with plant to plant spacing of 16.7 , 13.3 and 11.1 cm, in 60 cm ridge planting method, the crop was planted at 60 cm with plant to plant spacing of 12.5, 10, 8.3 cm and in bed 67.5 cm planting method, 2 rows were planted on each bed with plant to plant spacing of 22.2, 17.7 and 14.8 cm to maintain the required plant populations of 1,33,334, 1,66,667 and 2,00,000 plants ha^{-1}, respectively. Crop was raised by adopting recommended package of practices (Anonymous, 2013 b). Earthing up in ridge and bed planting methods was done in the month of September. The crop was harvested during the first week of January.

The data on emergence count was recorded at 30, 45 and 60 days after planting (DAP). The crop leaf area index was recorded at 210 DAP and the weight of rhizomes per plant at harvest. The essential oil (% v/w) content was determined using Clevenger's apparatus in which 25 g of turmeric powder was distilled for 4.5 hours. The curcumin content was determined following the method given by Thimmaiah (1999). For calculating the curcumin and oil yield of turmeric (q ha^{-1}), the per cent curcumin and oil contents of turmeric were multiplied with the processed turmeric yield, respectively and data for curcumin.

Effect of planting methods: After 60 days of planting, the differences for emergence among different planting methods were non-significant. Delay in crop emergence under ridge planting method might be due to drying of ridge top due to inefficiency of the soil to retain enough moisture on ridge top to promote proper germination. Leaf area index of flat 30 cm planting method was statistically at par with bed 67.5 cm planting method and both these planting methods recorded significantly higher leaf area index than ridge 45 cm and ridge

60 cm planting methods, however, ridge 45 cm and ridge 60 cm planting methods were statistically at par with each other. Higher leaf area under flat 30 cm and bed 67.5 cm planting methods might be due to early crop emergence and better crop growth under flat and bed planting methods as compared to ridge 45 cm and ridge 60 cm planting methods.

The different planting methods registered significant effect on the fresh weight of turmeric rhizomes per plant. The fresh weight of mother, primary, secondary and total rhizomes per plant with flat 30 cm planting method was statistically at par with bed 67.5 cm planting and both these planting methods recorded significantly higher weight of mother, primary, secondary and total rhizomes per plant than ridge 45 cm and ridge 60 cm planting methods except that of primary rhizomes which were statistically at par in flat 30 cm, bed 67.5 cm and ridge 45 cm planting methods. Among the ridge planting methods, ridge 45 cm planted turmeric recorded significantly higher weight of mother, secondary and total rhizomes per plant than ridge 60 cm planted turmeric, however, primary rhizomes were statistically at par (Table 1). Dry rhizome yield and processed turmeric yield with flat 30 cm planting method was statistically at par with bed 67.5 cm planting method and both these planting methods recorded significantly higher dry rhizome yield and processed turmeric yield than ridge 45 cm and ridge 60 cm planting methods. However, the dry rhizome yield as well as processed turmeric yield with ridge 45 cm planting method was statistically at par with ridge 60 cm planting method (Table 2). The higher rhizome yield in flat 30 cm and bed 67.5 cm planted crop was due to overall better crop growth in terms of early crop emergence, more leaf area index and more weight of mother, primary, secondary and total rhizomes per plant. The results are in line with the findings of Kumar and Gill (2010).

Essential oil content as well as curcumin content of turmeric were not significantly influenced by different planting methods (Table 2). Kaur (2001) also obtained non-significant effect on curcumin content due to different planting methods. However, oil as well as curcumin yield of flat 30 cm and bed 67.5 cm planting methods were significantly higher than ridge 45 cm and ridge 60 cm planting methods mainly due to higher processed rhizome yield in flat and bed planting methods than ridge 45 cm and ridge 60 cm planting methods. Both ridge 45 cm and ridge 60 cm planting methods were statistically at par with each other with respect to oil and curcumin yield of turmeric.

Effect of plant population: Plant population had significant effect on the emergence count of turmeric. Plant population of 2,00,000 plants ha^{-1} recorded significantly higher emergence count and leaf area index than plant populations of 1,66,667 and 1,33,334 plants ha^{-1} (Table 1). Kaur (2001) also reported that closer plant spacing resulted in significantly higher leaf area index than wider plant spacing of turmeric. The fresh weight of mother, primary, secondary as well as total rhizomes per plant increased significantly with each decrease in plant population. The lower plant population of 1,33,334 plants ha^{-1} recorded significantly higher weight of mother, primary, secondary as well as total rhizomes per plant than plant populations of 1,66,667 and 2,00,000 plants ha^{-1} (Table 1). The higher rhizome weight with

Table 1. Effect of planting methods and plant population on emergence count, leaf area index and weight of rhizomes of turmeric

Treatment	Emergence count (plants m^{-2})			Leaf area index 210 DAP	Weight of rhizomes (g $plant^{-1}$)			
	30 DAP*	45 DAP	60 DAP		Mother	Primary	Secondary	Total
Planting methods								
Flat 30 cm	8.75	15.09	16.27	4.54	109.3	234.2	74.08	417.5
Ridge 45 cm	7.21	12.88	16.09	4.19	97.3	214.2	71.04	382.5
Ridge 60 cm	6.70	11.81	15.93	4.08	87.5	200.3	66.83	354.6
Bed 67.5 cm	7.98	14.35	16.24	4.53	108.8	232.8	74.58	416.2
CD (p=0.05)	0.22	1.41	NS	0.33	5.8	23.5	3.04	27.0
Plant population ha^{-1}								
1,33,334	6.08	11.46	12.80	3.90	115.4	240.1	76.44	432.0
1,66,667	7.69	13.75	16.04	4.37	99.4	224.8	71.25	395.4
2,00,000	9.21	15.39	19.57	4.75	87.3	196.2	67.21	350.7
CD (p=0.05)	0.29	1.02	0.43	0.17	5.7	20.7	2.14	22.7

* Days after planting (DAP)

Table 2. Effect of planting methods and plant population on dry rhizome yield, processed turmeric yield and quality of turmeric

Treatment	Dry rhizome yield (q ha^{-1})	Processed turmeric yield (q ha^{-1})	Oil content (%)	Oil yield (liter ha^{-1})	Curcumin content (%)	Curcumin yield (kg ha^{-1})
Planting methods						
Flat 30 cm	60.55	57.94	5.47	317.4	3.64	211.0
Ridge 45 cm	54.59	52.24	5.42	283.2	3.62	188.9
Ridge 60 cm	53.01	50.71	5.39	273.4	3.60	182.5
Bed 67.5 cm	59.51	57.03	5.46	311.2	3.66	208.9
CD (p=0.05)	4.49	2.91	NS	22.6	NS	11.8
Plant population ha^{-1}						
1,33,334	53.42	51.61	5.48	283.1	3.67	189.7
1,66,667	57.79	55.62	5.44	302.9	3.62	201.5
2,00,000	60.28	56.20	5.39	302.9	3.60	202.3
CD (p=0.05)	3.80	1.93	NS	13.45	NS	8.7

lesser plant population might be due to the better nourishment and space due to more feeding area per plant. Dry rhizome yield as well as processed turmeric yield with plant populations of 2,00,000 and 1,66,667 plants ha^{-1} were statistically at par with each other and both these plant populations were significantly better than plant population of 1,33,334 plants ha^{-1} (Table 2). The higher yield at closer spacing was mainly attributed to more plant population per unit area. Manjunathgoud *et al.* (2002) also observed higher cured/processed rhizome yield in closer spacing than in wider spacing due to higher fresh rhizome yield in closely spaced crop. Oil content and curcumin content of turmeric were not significantly influenced by different plant populations. Plant populations of 1,66,667 and 2,00,000 plants ha^{-1} being statistically at par with each other recorded significantly higher curcumin as well as oil yield of turmeric than plant population of 1,33,334 plants ha^{-1} mainly due to higher processed turmeric yield with higher plant populations than lower plant population.

Bed planting methods at 1,66,667 plants ha^{-1} population was found optimum for higher yield and quality of turmeric.

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Effect of Pre-Treatments on Quality and Stability of Dehydrated Red Onion Slices during Storage

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***Abstract*:** Significantly least OD value (0.31) was recorded for non enzymatic browning in the slices pretreated with 0.50% sodium metabisulphite + 0.50% citric acid at 3 month after storage (MAS) whereas, highest OD value (0.83) for browning was recorded in the slices pretreated with 0.50% KMS at 3MAS. The best quality dehydrated red onion slices were obtained by treating with 0.50% sodium metabisulphite + 0.50% citric acid. The bacterial and fungal load was observed minimum (2.75×10^5 CFU g^{-1} and 1.25×10^3 CFU g^{-1}) in the slices treated with 0.50% KMS + 0.50% citric acid after 3 MAS, whereas, the bacterial and fungal population was recorded maximum (5.45×10^5 CFU g^{-1} and 2 3.40×10^3 CFU g^{-1}) in untreated control (3 MAS).

***Key Words*:** Arka Kalyan, Browning, Dehydration, KMS, Red onion

Onion (*Allium cepa* L.) is one of the oldest bulb crops known to mankind and consumed worldwide. It is one of the most important commercial vegetable and spice crops grown in India. Onion is popularly known as the queen of kitchen (Selvaraj, 1976). Onion plays an important role in preventing heart diseases and other ailments. According to Bose *et al*. (2003), the composition of 100 g of edible portion of onion bulbs has 86.8g moisture, 11.0 g carbohydrates, 1.2 g protein, 0.4 g minerals, 0.08 mg thiamine, 11 mg vitamine, 180 mg Ca and 0.01 mg riboflavin. Onion is used fresh as well as in the processed form *viz*. dehydrated flakes, powder, pickles, etc. As compared to other processed products, the dehydrated flakes are widely used. Further, the quality of a dehydrated product depends on various factors like drying method used, time taken for drying and packaging material. Apart from this, there is also possibility of enhancing quality of dehydrated product by the use of various pretreatments. Therefore, the present study was undertaken to assess the quality of the dehydrated onion slices.

An investigation on effect of pretreatments on quality and stability of dehydrated red onion slices during storage was carried out in Kittur Rani Channamma College of Horticulture Arabhavi, Karnataka, during the year 2012-2013. The experiment was laid out in Completely Randomized Design (CRD) with nine treatments and three replications (Table 1). The healthy red onions (Cv. Arka Kalyan) of uniform size and shape were selected and peeled. The peeled onions were washed in tap water. The sliced onions were subjected to various pretreatments for 5 minutes. All the treated and untreated (control) onion slices were placed in a single layer on stainless steel trays. The loaded trays were kept in electrical dryer at 55^0C temperature. After completion of drying, onion slices were packed in air tight polythene bags of 400 gauges and stored at ambient storage conditions up to 3 months of storage. During storage non-enzymetic browning was recorded at monthly interval up to three months of storage. The non-enzymetic browning was expressed in terms of OD value at 440 nm (Srivastava and Sanjeevkumar, 1998). The organoleptic evaluation was conducted out by a panel of 10 semi trained judges including teachers and post-graduate students of Kittur Rani Channamma College of Horticulture Arabhavi. The score card was assigned based on a five point hedonic scale (5,4,3,2 and 1) such as highly acceptable with score of 5 followed by acceptable, fairly acceptable, poorly acceptable and not acceptable, respectively (Vie *et al*., 1991). The microbial count of onion was taken for both fresh and dehydrated samples stored for three months as per the methods described by Harrigan and McCance (1996).

In case of fresh onion, 10g of sample was used for analysis. In case of dehydrated produce, a representative sample of 10 g was taken from three replications in each treatment and was mixed with 90 ml distilled water blank in a conical flask and serial dilution technique was carried out to estimate the fungal and bacterial load in the onion. Rose Bengal Agar and Nutrient Agar were used to enumerate fungal and bacterial count in fresh and dehydrated onion samples. One ml of the aliquot from respective dilutions was transferred to petriplates in duplicate and sterilized molten Rose Bengal Agar and Nutrient Agar were poured to isolate fungi and bacteria, respectively. After solidification, the plates were incubated at 37 ± 1^0C for three to five days and colony counts were recorded and tabulated and expressed as CFU

per gram of the sample.

Among the different pretreatments the least OD value (0.23, 0.27 and 0.31) recorded for non enzymatic browning was in the slices pretreated with 0.50% sodium metabisulphite + 0.50% citric acid at first, second and third MAS, respectively. Whereas, highest OD value for browning was recorded in the slices pretreated with 0.50% KMS at first, second and third MAS, respectively. This may be attributed to the release of SO_2, which helps to maintain colour and acts as an antioxidant that might have reduced the discoloration of dried onion slices during storage. Similar findings were reported by Guadalupe and Diane (2006) and Rathod (2013) in tomato and onion, respectively. The microbial analysis of the dehydrated red onion slices revealed that the bacterial, fungal population was negligible at three months (Table 1). The microbial load (bacterial and fungal) of fresh onion was 6.55×10^5 CFU g^{-1} and 3.20×10^3 CFU g^{-1}, respectively.

The microbial load on dried onions increased with advancement of storage period. During storage, among the different treatments, the bacterial and fungal load was minimum (2.1, 2.35 and 2.75×10^5 CFU g^{-1} and 0.58, 0.95 and 1.25×10^3 CFU g^{-1}) in the slices treated with 0.50% KMS + 0.50% citric acid after one, two and three MAS, respectively. However, the bacterial and fungal population was maximum in untreated samples. This may be due to KMS action as a fungistatic and bacteriostatic effect at lower pH. However, this lower population of microorganisms might be due to the presence of citric acid which reduced the pH and created unfavorable condition for microbial growth may be attributed to have several inhibitory mechanisms such as depression of internal pH of microbial cell by ionization of undissociated acid molecules and disruption of substrate transport by altering cell membrane permeability or reduction of proton motive force. Thus, it helps to prevent the spoilage during storage even up to three months of storage.

Highest scores for colour and appearance (4.50, 4.32, 4.20 and 4.05) were in the slices pretreated with 0.50% sodium metabisulphite + 0.50% citric acid in initial, first, second and third month after storage, respectively whereas, lowest scores for colour and appearance) were in the slices pretreated with 0.50% KMS (Table 2). The highest scores for texture (4.60, 4.47, 4.30 and 4.10) was in the slices pretreated with 0.25% sodium metabisulphite + 0.50% citric acid, whereas, lowest scores (3.25, 3.15, 3.00 and 2.90) were observed in the slices pretreated with 0.50% KMS at initial, first, second and third month after storage, respectively. This may be attributed to the beneficial effects of combination of sodium metabisulphite and citric acid on the above mentioned parameters than alone. Because, these combinations help to inhibit non-enzymatic browning of the product, which results in retaining the colour and appearance, texture and thereby maximum score for overall acceptability.

The highest scores for taste and flavour and overall acceptability were noticed in the slices pretreated with 0.50% sodium metabisulphite + 0.50% citric acid, whereas, least score for taste and flavour and overall acceptability was noticed in untreated control (T_9) at initial period, first, second and third MAS. This may be attributed to the beneficial effects of combination of sodium metabisulphite and citric acid on the above mentioned parameters than alone, as these combinations help to inhibit non-enzymatic reaction. Therefore, maintains the colour and appearance, texture and thereby according maximum score for overall acceptability. The pre-treatments helped in retaining better

Table 1. Browning and microbial load of dehydrated red onion slices as affected by different pre-treatments

Pre-treatment's	Browning (OD-values)			Bacteria N×10^5 CFU g^{-1}			Fungi N×10^3 CFU g^{-1}		
	1	2	3	1	2	3	1	2	3
T_1 - 0.25% KMS	0.55	0.66	0.78	3.25	3.75	4.15	1.40	1.75	2.20
T_2 - 0.50% KMS	0.67	0.74	0.83	3.10	3.50	4.00	1.20	1.60	2.00
T_3 - 0.25% SM	0.43	0.59	0.67	3.55	3.85	4.25	1.62	1.95	2.40
T_4 - 0.50% SM	0.41	0.58	0.65	3.60	4.00	4.40	1.80	2.20	2.70
T_5 - 0.25%KMS+0.50% CA	0.52	0.64	0.75	2.25	2.50	3.00	0.72	1.00	1.35
T_6 - 0.50% KMS+0.50% CA	0.60	0.70	0.80	2.10	2.35	2.75	0.58	0.95	1.25
T_7 - 0.25% SM+0.50% CA	0.31	0.40	0.51	3.00	3.40	3.90	0.90	1.25	1.60
T_8 - 0.50% SM+0.50% CA	0.23	0.27	0.31	3.20	3.65	4.00	1.00	1.40	1.95
T_9 - Control	0.64	0.73	0.81	4.10	4.75	5.45	2.00	2.65	3.40
C.D.(p=0.01)	0.07	0.30	0.04						

KMS - Potassium metabisulphite; SM - Sodium metabisulphite; CA - Citric acid.
Fresh onion contained 6.55×10^5 CFU g^{-1} bacteria and 3.2×10^3 CFU g^{-1} fungi.

Table 2. Effect of pre-treatments on colour and appearance, texture, taste and flavor and overall acceptability of dehydrated red onion

Pre-treatments*	Colour and appearance				Texture				Taste and flavour				Overall acceptability			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
T_1	3.55	3.40	3.25	3.00	3.35	3.18	3.10	3.02	3.85	3.30	3.10	3.00	3.75	3.55	3.20	3.00
T_2	3.20	3.00	2.90	2.71	3.25	3.15	3.00	2.90	4.00	3.40	3.25	3.10	3.60	3.48	3.20	2.92
T_3	4.00	3.85	3.60	3.40	3.70	3.50	3.35	3.20	4.10	3.95	3.80	3.70	4.00	3.73	3.55	3.40
T_4	4.20	4.00	3.85	3.70	4.00	3.85	3.62	3.41	4.24	4.10	4.05	3.90	4.15	4.00	3.82	3.52
T_5	4.10	4.00	3.80	3.65	4.05	3.90	3.75	3.55	4.38	4.15	4.04	3.89	4.20	4.12	3.90	3.78
T_6	4.18	4.10	4.00	3.85	4.15	3.95	3.80	3.66	4.40	4.19	4.07	3.95	4.35	3.15	4.05	3.95
T_7	4.40	4.30	4.15	4.00	4.60	4.47	4.30	4.10	4.60	4.40	4.22	4.05	4.52	4.38	4.20	4.00
T_8	4.50	4.32	4.20	4.05	4.55	4.35	4.24	4.06	4.76	4.50	4.35	4.12	4.62	4.47	4.30	4.15
T_9	3.50	3.30	3.10	3.00	3.50	3.25	3.05	3.00	3.15	3.00	2.90	2.75	3.50	3.25	3.05	2.85

*Check table 1 for details

organoleptic quality parameters during storage.

The better quality dehydrated onion slices with acceptable organoleptic qualities and minimum non enzymatic browning could be obtained by treating with 0.50% sodium metabisulphite + 0.50% citric acid.

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Studies on Intercropping of Rabi Onion in Mentha in Light Textured Soils

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Abstract: The present study to know the effect of intercropping of onion in mentha (*Mentha arvensis* L.) was conducted at Krishi Vigyan Kendra Samrala (Ludhiana) during *rabi* seasons of 2009-10 and 2010-11 to assess the feasibility of raising *rabi* onion as intercrop in mentha in light textured soils. The maximum fresh herb yield of mentha was obtained in treatment of sole mentha crop in both the years. The highest mentha equivalent oil yield was reported in treatment where one row of onion was planted in between two rows of mentha crop in both the years. Similarly, gross returns were observed the highest in treatment of mentha intercropped with one row of onion in both the years.

Key Words: Intercropping, Mentha, Onion, Yield

Japanese mint (*Mentha arvensis L.*), an essential oil crop is cultivated for mentha oil obtained by distilling green herb, which is widely used in food preparations, pharmaceuticals, perfumery and flavouring industry. It offers good scope in diversification of rice-wheat cropping system in Punjab. The crop is planted during the second fortnight of January in Punjab at a wider row spacing which can be utilized to earn additional income from intercrops like onion, sunflower, etc. In north central India, radish, okra and cowpea when intercropped with *M. arvensis* gave higher returns (Singh *et al.,* 1998). The present study was also undertaken to assess the feasibility of raising *rabi* onion as intercrop in mentha in light textured soils.

The experiment was conducted at Krishi Vigyan Kendra, Samrala.Ludhiana for two years during *rabi* seasons of 2009-10 and 2010-11 on loamy sand soil in Randomized Block Design with five treatments and three replications. Mentha (var. Kosi) and onion (var. Punjab Naroya) crops were planted simultaneously in the third week of January and fertilized and harvested as per the recommended practices (Anonymous, 2011). The onion was harvested in the last week of May and mentha in the third week of June. The essential oil content in fresh mentha herb was determined by steam distillation in Clevenger's apparatus and oil yield was calculated on the basis of fresh herb yield. The Japanese mint equivalent oil yield of various treatments was calculated using the prevailing market prices of mentha and onion.

The maximum fresh herb yield of mentha was obtained in treatment of sole mentha crop (281.3 q ha^{-1}) which was statistically higher than all other treatments. The yield of mentha was significantly more in treatment where one row of onion was planted in between two rows of mentha as compared to treatment where two rows of onion were planted in between two rows of mentha crop. Similarly, minimum mentha yield was obtained in treatment where one row of onion was planted on beds and mentha in furrows which was significantly lower than all other treatments (Table 1). This might be due to low temperature in furrows and hence low germination (emergence count was 28.5 stools/m^2 in flat while it was 21.6 stools/m^2 in furrows). Similar trend was obtained in both the years of study. Gill *et al*. (2007) observed that fresh herb yield was highest in sole Japanese mint (mentha), which was statistically at par with Japenese mint with one row of onion.

The data revealed that onion bulbs yield was maximum in sole onion crop treatment (Table 1), which was significantly higher than all other treatments. The yield of onion in treatment of two rows of onion in mentha was 96.5 q ha^{-1}, which was at par with the mentha intercropped with one row of onion (80.0 q ha^{-1}) during 2009-10. The onion crop under treatment of two rows of onion planted in two rows of mentha gave significantly higher yield 75.3 q ha^{-1} than treatment where one row of onion was planted in between rows of mentha crop (46.2 q ha^{-1}) in 2010-11. The increase in yield might be due to increased plant population (i.e. 30 plants sq m^{-1} were more in two rows of onion).

Similar trend of mentha oil yield was observed as in case of fresh herb yield during both the years (Table 1). Mentha equivalent oil yield was significantly higher where one row of onion was planted in between two rows of mentha crop during both the years. The mentha equivalent oil yield in mentha intercropped with one row of onion in the first year was at par with mentha intercropped with two rows of onion

Table 1. Herb yield of mentha and gross returns in different treatment combinations

Treatment	Fresh herb yield (q ha^{-1})			Bulb yield (q ha^{-1})			Mentha oil yield (l ha^{-1})		Mentha equivalent oil yield (l ha^{-1})		Gross returns (Rs ha^{-1})	
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Mentha sole crop	235.0	327.5	281.3	-	-	-	185.7	243.0	185.7	243.0	129990	206550
Mentha+ 1 row of onion	212.1	295.2	253.7	80	46.2	63.1	157.0	219.1	208.4	257.1	145880	218535
Mentha+ 2 rows of onion	175.0	236.8	205.9	96.5	75.3	85.9	130.0	175.5	192.0	237.4	134400	201790
Mentha+ 1 row of onion on beds	142.1	159.1	150.6	65.2	53.8	59.5	102.3	116.1	137.0	160.4	95900	136340
Onion sole crop	-	-	-	197.0	117.0	157.0	-	-	126.7	96.3	88690	81855
CD (0.05)	21.3	18.6	9.47	17.5	15.0	12.55	16.5	12.0	21.7	13.8	-	-

Sale price : 2009-10 2010-11
Mentha Rs 700/- Rs 850/-
Onion Rs 450/- Rs 700/-

treatment although in the second year the differences were significant because of more onion yield in mentha intercropped with two rows of onion treatment. Gross returns were also maximum in mentha intercropped with one row of onion in both the years. In the first year, mentha intercropped with two rows of onion gave more returns because of more onion yield than sole mentha crop but in second year, mentha sole crop gave more gross returns. Gill *et al*. (2007) also observed that Japanese mint equivalent oil yield was highest in Japanese mint intercropped with one row of onion which was at par with Japanese mint intercropped with two rows of onion. The gross returns were also the maximum in Japanese mint intercropped with one row of onion.

The study indicated that maximum fresh herb yield of mentha was observed in sole mentha crop. Mentha equivalent oil yield and gross returns were more when one row of onion was intercropped in two rows of mentha crop.

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Effect of Resin Tapping Methods on Oleoresin Quality in Blue Pine (*Pinus wallichiana* A B Jackson)

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Abstract: Two resin tapping methods i.e. rill method and borehole method were used to evaluate the oleoresin quality. The quality of oleoresin obtained by borehole tapping method was superior and contained more monoterpene composition of turpentine as compared to rill method of oleoresin tapping. The turpentine contents were found significantly higher in borehole method of tapping. The specific gravity of borehole turpentine was lower than the turpentine obtained through rill method, whereas the relative flowrate was higher in borehole turpentine as compared to rill method. Monoterpene composition i.e. alpha-pinene and limonene were higher in the turpentine of borehole method, but camphene, beta-pinene and other terpenes were higher in rill method. The rosin content, specific gravity of resin, ash content and iron contents were lower in borehole method thanrill method.

Key Words: Monoterpene, Oleoresin, Rosin, Specific gravity, Tapping methods, Turpentine

Pinus wallichiana (A.B. Jackson) commonly known as blue pine or kail of Pinaceae family, is one of the important timber trees of greater part of Himalayas. The distribution zone of blue pine extends from Kashmir to Bhutan. In India, oleoresin extraction was started in 19th century, earlier it was extracted on a small scale, but knowing the importance of oleoresin and its products, its extraction was started on a commercial scale by developing different scientific methods for its extraction. Initially resin tapping was done with "French Cup and lip" method, but this method led to deterioration of the wood because of repeated deep cuts on the same face of the tree, which results breakage of trees under strong wind pressure. To overcome this problem, a new method of oleoresin extraction called "Rill method" was developed, but this method also failed to solve the problem, because a new rill is required to be made after four days with continuous acid freshening. The excessive use of chemical in this method was the major constraint, which not only dries the trees but also deteriorates the quality of oleoresin components. To overcome all these problems a new method of oleoresin extraction called borehole method was developed (Hodges, 1995). The extraction process in this method involves drilling holes into the wood to open the resin ducts and collect the oleoresin in closed containers. Prolonged resin flow from boreholes for a period of several months is a key feature of this system. The holes are drilled near the ground level so that there is no damage to the merchantable part of the tree.

The present investigations were carried out in Jelly UPF-167 (Unprotected forest) of Mashobra range of Shimla Division of the State Forest Department, Himachal Pradesh. The chemical analysis of the oleoresin samples were done in the laboratory of Departmental of Forest Products and Utilization, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP).For comparison of oleoresin quality, five samples of different colours were collected from five trees each tapped with borehole and rill method. The colour of oleoresin sample was compared with colour chart of the Royal Horticulture Society (Kew, 1968) and the oleoresin colour were categorized into three classes i.e. light yellow (LY 2C), Yellow white (YW 10D) and white (W 155A). The samples of high and low oleoresin yield were also collected for the comparison of oleoresin quality. Standard ,methods for the chemical estimations (turpentine, Rosin content ,specific gravity, ash, camphene and iron content of rosin, etc.) were followed. The data obtained were suitably analyzed by usingstatistically software under randomized block design.

The perusal of data in Table 1 revealed significant differences in turpentine content of oleoresin obtained from borehole method and rill method of tapping. The turpentine content of 33.48 (5.786) to 36.32 per cent (6.027) and 28.48 per cent (5.336) have been recorded in borehole method and rill methods, respectively. The designated high resin yielders (36.32%) had high turpentine as compared to low resin yielders (30.25 %). The scrutiny of Table 1 depicted significant difference in specific gravity of turpentine. The specific gravity of turpentine was recorded to be 0.8476 for the turpentine obtained from oleoresin of rill method. The turpentine obtained from borehole method had the specific gravity ranging from 0.8052 to 0.8167. The high resin yielder recorded higher specific gravity (0.8167) as compared to low

resin yielder (0.8040). The data pertaining to relative flow rate of turpentine revealed significant variation in the turpentine obtained from the borehole and rill methods. The relative flow rate of turpentine was noticed to be 1.42 in rill method.

The relative flow rate ranging from 1.580 to 1.586 was recorded in the turpentine obtained from the oleoresin of borehole method. The high resin yielder recorded higher relative flow rate (1.586) as compared to low resin yielder (1.500). The perusal of data in Table 1 revealed significant variation in alpha- pinene content of turpentine obtained from borehole and rill methods. The alpha-pinene content ranging from 88.56 (70.23) to 95.50 (77.76) per cent was obtained in the turpentine of borehole method. The higher alpha-pinene content (95.50%) was noticed higher resin yielder than in low resin yielder(93.12 %). In rill method, the alpha-pinene content was recorded to be 91.49 per cent (73.04) .The critical scrutiny of data revealed that the camphene content of 0.88 per cent (0.939) was noticed in the turpentine obtained from the oleoresin of rill method. In borehole method, the camphene content ranged from 0.65 (0.805) to 0.79 (0.883) per cent. for beta-pinene content ranged from 0.79 (0.886) to 1.63 per cent (1.282). The turpentine obtained from the oleoresin of low resin yielder (2.06 %) contained more beta-pinene than the turpentine obtained from the oleoresin of rill methodThe limonene percentage ranged between 0.94 (0.968) to 4.37 per cent (2.090) in turpentine obtained from the oleoresin of borehole method. The limonene percentage was noticed to be high in low resin yielder (2.75 %) as compared to high resin yielder (0.94 %). The limonene percentage in the turpentine obtained from rill method was noticed to be 1.45 (1.205) per cent. The turpentine obtained from borehole and rill methods of oleoresin depicted significant variation in other terpenes. The other terpenes ranged from 1.28 (1.131) to 3.50 per cent (1.870) in turpentine obtained from the oleoresin of borehole method. The Higher values (1.28 %) for other terpenes were noticed in high resin yielder as compared to low resin yielder (0.86 %). The turpentine content (%) in borehole method of oleoresin was significantly more as compared to rill method oleoresin. The specific gravity of borehole turpentine was lower than rill method turpentine, which might be due to higher content of low boiling monoterpenes in turpentine. Similarly, the highest relative flow rate was observed in borehole turpentine. The increase in specific gravity and decrease in relative flow rate in rill method turpentine was likely due to the evaporation of some of its volatile constituents with lower boiling points and oxidation of other constituents. Higher alpha-pinene and limonene in borehole method might be due to negligible losses of these components, where as in rill method the decrease in alpha-pinene might be due to its fast evaporation or polymerization. Persad (1983) reported that alpha-pinene get isomerized into beta-pinene at higher temperature.

The perusal of data depicted significant difference (Table 2) in rosin percentage. The rosin percentage of higher value of 68.50 (55.86) per cent was obtained in rill method as compared to 63.62 per cent (52.90) to 65.69 per cent (54.15) in the oleoresin extracted by borehole method. The 1.062 specific gravity was recorded in rill method rosin and 1.010 was recorded in the rosin extracted by borehole method (Light yellow colour). The ash content of rosin revealed significant differences among the rosin obtained from the oleoresin extracted by using borehole and rill methods. The

Table 1. Effect of tapping methods on turpentine % age, specific gravity, relative flow rate and monoterpene contents of oleoresin

Treatments	Turpentine content (%)	Specific gravity	Relative flow rate	a-pinene (%)	Camphene (%)	(3-pinene (%)	Limonene (%)	Other terpenes (%)
Borehole method								
a) Yellow white (high resin yielder)	36.32 (6.027)	0.8167	1.586	95.50 (77.76)	0.65 (0.805)	1.63 (1.282)	0.94 (0.968)	1.28 (1.131)
b) Light yellow	34.40 (5.865)	0.8114	1.581	93.88 (75.68)	0.68 (0.823)	1.75 (1.321)	2.02 (1.422)	1.67 (1.293)
c) White	33.48 (5.786)	0.8052	1.580	88.56 (70.23)	0.79 (0.883)	0.79 (0.886)	4.37 (2.090)	3.50 (1.870)
Low resin yielder	30.25 (5.500)	0.8040	1.500	93.12 (74.80)	0.66 (0.811)	2.60 (1.613)	2.75 (1.659)	0.S6 (0.929)
Rill method	28.48 (5.336)	0.8476	1.421	91.49 (73.04)	0.88 (0.939)	2.19 (1.480)	1.45 (1.205)	3.93 (1.982)
Mean	31.15 (5.560)	0.8230	1.510	82.46 (67.68)	0.73 (0.852)	11.96 (2.41)	2.30 (1.46)	2.69 (1.57)
SEd(+)	0.026	0.00062	0.00096	0.084	0.0012	0.0024	0.00042	0.0025
CDQ 05	0.057	0.0014	0.0021	0.188	0.0029	0.0055	0.00098	0.0056

Figure in parentheses are square root and angular transformed values

Table 2. Effect of tapping methods on rosin content, specific gravity, ash content **and i**ron content

Treatments	Parameters				
	Rosin colour	Rosin content **(%)**	Specific gravity	Ash content **(%)**	Iron content (ppm)
Borehole method	Yellowish white				
a) Yellow white		63.62 (52.90)	1.012	0.18 (0.431)	2.25
b) light yellow		64.78 (53.60)	1.010	0.17(0.422)	3.15
c) White		65.69(54.15)	1.014	0.19(0.412)	2.05
Rill method	Light brown	68.50 (55.86)	1.062	0.38 (0.0618)	5.05
Mean		65.64 (54.03)	1.024	0.023 (0.470)	3.12
SEd(±)		0.124	0.00062	0.0030	0.020
		0.270	0.0014	0.0065	0.045

Figures in parentheses are square root and angular transformed values

ash content in rosin from borehole method was found 0.17 per cent (0.42) (Light yellow) and 0.38 per cent (0.062) in rill method rosin. The 5.05 ppm of iron content was recorded in rill method rosin and 2.05 ppm in borehole method (White). The increase in rosin content in rill method oleoresin has due to the evaporation of turpentine as the containers used for collection are open and not closed as in case of borehole method. The higher specific gravity and ash content in rill method might be due to the presence of impurities. The high iron content in rill method might be due to the corrosive effect of resin acids present in oleoresin on the iron cup, in which it is collected (Sharma, 1987 and Chanderlekha, 2002).

Conclusively, it was observed that the oleoresin extracted through borehole method was superior, free from the impurities as compared to the oleoresin obtained through rill method.

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Effect of Size of Rhizomes on Growth and Yield of Turmeric

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***Abstract*:** The growth and yield of turmeric with 25 g rhizome size was maximum than 10 and 5 g rhizomes. The plant height, pseudostem girth, leaf area, number of tillers per clump, harvest index, number of rhizomes per clump, diameter of rhizome clump and clump size were significantly higher in 25 g rhizome. The yield per hectare (18.65 t ha^{-1}) at 180 DAP was also significantly more in with 25 g rhizome

Key Words: Growth and yield attributes, Rhizome sizes, Turmeric

India is the world's largest producer and exporter of turmeric and it produces nearly 50 per cent of global turmeric production. It is grown in an area of 1.92 lakh hectares with an average production of 8.93 lakh MT (Anonymous 2012). The cost of planting material amounts to 50 % of crop production in turmeric and the size of rhizome effect the productivity of turmeric. Hence there is need to study the effect of different rhizome sizes of turmeric to know the best suited rhizome size for getting higher yields.

The study was carried out at College of Horticulture, Arabhavi during May of 2012-2013. There were three treatments i.e. finger rhizomes used commercially (25 g), finger rhizomes of 10 g and finger rhizomes of 5 g. The field trial was laid out in RBD at spacing of 45 cm between rows and 22.5 cm between the plants (ridge and furrow method) was followed, accommodating 98,765 plants per hectare. Observations on growth parameters were recorded on five randomly selected clumps in each treatment at monthly intervals starting from 30 days after planting (DAP) till harvest i.e upto 180 DAP.

25 g rhizome recorded maximum plant height (81.57 cm), pseudostem girth (7.19 mm), leaf area (253.1 cm^2), number of tillers per clump (5.38), harvest index (82.52 %), number of rhizomes per clump (35.78), diameter of rhizome clump (33.17 mm), clump size (49.05 **cm^2)** and yield per hectare (18.65) at 180 DAP and it differed significantly from all other treatments while the 5 g rhizome was inferior in all these parameters at 180 DAP. Growth attributes were highest in 25 g rhizomes, which can be attributed to the bigger rhizome size used for planting had enough stored food, initially required for the better germination and supply of food material for good plant growth. The results obtained are in conformity with the findings of *Manhas and Gill (2010) and* Balwinder and Gill (2010) recommending bigger size rhizomes for planting of turmeric.

Table 1. Effect of types of rhizome sizes on growth parameters and productivity in turmeric var. Suroma

Rhizome size	Plant height (cm)	Pseudo stem girth (mm)	Leaf area (cm^2)	No. of tillers $clump^{-1}$	Harvest index (%)	Number of rhizomes $clump^{-1}$	Diameter of rhizome clump (mm)	Clump size (cm^2)	Yield (tons ha^{-1})
25 g	81.57	7.19	253.10	5.38	82.52	35.78	33.17	49.05	18.65
10 g	71.36	6.93	219.06	4.41	78.15	25.53	24.85	35.24	12.52
5 g	62.89	6.57	198.29	4.26	74.54	17.84	17.53	24.13	11.13
CD (p=0.05)	3.99	0.33	12.30	0.38	4.35	1.34	1.33	1.93	1.01

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Relative Contribution of Characters to Genetic Divergence in Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract: One hundred and ninety two pigeonpea genotypes were grouped into nine clusters. The Cluster I, having 108 genotypes, emerged with highest number of entries; followed by cluster II (50) and III (12). Four characters *viz.,* seed yield per plant (55.12 %), number of pods per plant (28.59 %), plant height (7.34 %) and days to maturity (4.35 %) contributed maximum in genetic diversity. The maximum intra-cluster and inter-cluster distance was observed for cluster VII (146.77) and between I and VI clusters (385.01), respectively. The genotypes CORG-295, PUSA-92 and ICP 4392, MA-29, ICP 13270, PG-12 and ICP 3049, KARITHOGARI and ICP 14801 were identified as genetically diverse parents, which can be utilized for future crop improvement programme.

Key Words: Clustering pattern, Genetic diversity, Pigeonpea, Polygenic traits

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of the major grain legume (pulse) crop grown in about 50 countries in the tropics and subtropics. It is the second important pulse crop of India, which has diversified uses as food, feed, fodder and fuel (Rao *et al.,* 2002). It is a major source of protein for about 20% of the world population (Thu *et al.,* 2003) and is an abundant source of minerals and vitamins (Saxena *et al.,* 2002). India is the centre of origin and largest producer of pigeonpea in the world sharing approximately 70% of the production and covering 74% of the area (Bohra *et al.,* 2012). Compared to other food legumes, breeding in pigeonpea has been more challenging due to various crop specific traits and highly sensitive nature to biotic and abiotic stresses. Further, pigeonpea offers a rich source of variability in the form of wild relatives, which could be utilized for disease resistance, good agronomic traits, enhancing nutritional quality, identification and diversification of cytoplasmic base of cytoplasmic male sterility (CMS) system, etc. In any genetic improvement programme, genetic diversity is the basic requirement for effective improvement. Effective hybridization program between genetically diverse parents will lead to considerable amount of heterotic response in F1 hybrids and broad spectrum of variability in segregating generations. Mahalnobis D^2 statistics is a powerful tool in quantifying the degree of variability at the genotype level. An experiment was conducted to study genetic diversity for selecting the diverse parents for hybridization programme aimed at isolating desirable segregants for seed yield and other important characters in pigeonpea.

The experimental material comprising 192 genotypes of pigeonpea was grown during *kharif* 2012-13 in augmented experimental design at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experimental plot was divided in to 5 blocks. Each block contained 38 genotypes and 4 checks, where all the lines and checks were raised at spacing of 60 cm between rows and 30 cm between plants in a 6 meter row. Checks were replicated in each block while genotypes were un-replicated. Standard package of practices was followed for raising a good and healthy crop. The observations were recorded on five randomly tagged plants of a genotype for ten characters *viz.,* plant height (cm), number of primary branches per plant, number of pods per plant, pod length (cm), number of seeds per pod, days to 50 per cent flowering, days to maturity, 100-seed weight (g), harvest index (%) and seed yield per hectare (kg). Pooled data were subjected to statistical analysis. The D^2 analysis (Mahalanobis, 1936) was used to assess genetic diversity among one ninety two genotypes and Tochers' method was employed for grouping the genotypes into different clusters as described by Rao (1952).

The analysis of variance revealed significant differences in all the characters indicating the genetic divergence among the genotypes. This indicated that there was ample scope for selection of promising lines from the available genetic pool of pigeonpea. All the 192 pigeonpea genotypes for the present investigation were grouped into nine distinct non-overlapping clusters following Tocher's methods (Table 1). Cluster I included 108 genotypes, forming the largest cluster followed by cluster II (50), cluster III (12), cluster V (12), cluster VII (4) and cluster VI (3). Clusters IV, VIII and IX were ungrouped, comprising single genotype.

The intra-cluster D^2 value ranged from 0.00 to 146.77 while inter-cluster D^2 value ranged from 107.41 to

385.01. The selected genotypes were highly divergent (Table 2). The maximum intra-cluster distance was observed for cluster VII (146.77) followed by V (100.1), III (89.53), II (85.59), I (77.46) and VI (68.34), while cluster IV, cluster VIII and IX were solitary cluster indicating comparatively homogenous nature of the genotype within the cluster. The maximum inter-cluster D^2 value was observed between cluster I and VI (385.01) followed by cluster VI and VIII (383.46), whereas, the minimum distance was observed between I and III clusters (107.41) followed by II and IV

Table 1. Clustering pattern of 192 genotypes of pigeonpea based on D^2 analysis

Cluster group	Number of genotypes	Genotypes
I	108	ICP 14294, TM 224, ICP 16264, ICP 9691, ICP 7803, ICP 14569, ICP 1550, ICP 10095, TTB-7, ICP 14471, ICP 9414, ICP 11627, ICP 9655, BRG-9-2, BRG-9-2, ICP 2577, ICP 6815, ICP 6668, ICP 10228 , UPAS-120, ICP 1224, TM-26, ICP 8012, TS-3®, ICP 12410, ICP 11946, ICP11281, ICP 15161, ICP 7869, ICP 6929, HY-3-C, GC-11-39, UPAS-120, ICP 11059, ICP 9750, ICP 13575, ICP 5142, ICP 15068, ICP 1366, ICP 12105, ICP 1730, ICP 11910, PUSA 992, ICP 12596, BRG-7-3, ICP 8757, ICP 11833, ICP 10397, ICP 13244, ICP 10654, ICP 12654, ICP 11823, ICP 12674, ICP 10559, ICP 12680, ICP 11690, ICP 8384, ICP 13579, ICP 10447, ICP 14229, ICP 8255, ICP 7366, ICP 7260, ICP 12142, ICP 11015, BRG-6-12, ICP 5863, ICP 13270, ICP 13884, ICP 7426, ICP 12123, ICP 9045, ICP 15185, ICP 4317, ICP 6123, ICP 12460, ICP 13571, ICP 5641, ICP1550, ICP 8860, ICP 348, ICP 7057, ICP 8921, ICP 8602, ICP 12515, ICP 6739, ICP 13139, ICP 7221, ICP 7148, ICP 6992, ICP 6528, ICP 9903, ICP 14116, ICP 6049, ICP 8840, JKM-197, ICP 12298, ICP14900, ICP 15049, ICP 13359, ICP 10503, ICP 13191, ICP 11230, GULLYAL LOCAL, ICP 995, BRG-7-2, ICP 12301, TM-389.
II	50	ICP 14701, ICPL-87, ICPB 2091, CORG-295, ICP 3451, ICP 4167, ICP 655, CORG-9701, CHAPLE, ICP 6971, JAMADHAR LOCAL, ICP 6128, PJT-501, ICP 1156, ICP 7223, ICP 3576, ICP 12692, ICP 4029, ICP 1071, BENNUR LOCAL, ICP 3046, GRG-2-95, GULLYAL WHITE, ICP 12266, ICP 10804, ICP 4275, ICP 4878, DM-158, ICP 939, GULLYAL RED, CORG-2004-01, ICP 14638, ICP 12333, ICP 14976, WRP-1, RUDRAWADI LOAL, BIDAR LOCAL, JKE-144, BRG-7-6, GRG-206, WRP-1 (W), ICP 14722, ICP 8266, ICP 2746, ICP 2698, GRG-801, ICP 12282, PUSA-92, ICP 4392, ICP 12675.
III	12	DPD-2-38, ICP 8863, BRG-7-4, BRG-7-5, ICP 11477, DM-155, ICP 14444, ICP 4395, ICP 14819, ICP 13304, ICP 13662, ICP 14368.
IV	1	MA-29
V	12	ICP 6859, ICP 15382, ICP 7507, ICP 6992, ICP 8949, ICP 11320, ICP 7076, ICP 13577, ICP 4575, ICP 14832, ICP 13431, ICP 14147.
VI	3	ICP 13270, PG-12, ICP 3049.
VII	4	ICP 4019, BRG-207, ICP 13633, ICP 13167.
VIII	1	KARITHOGARI
IX	1	ICP 14801.

Table 2. Average intra-cluster and inter-cluster D^2 values of clusters in pigeonpea genotypes (*Cajanus cajan* (L.) Millsp.)

	I	II	III	IV	V	VI	VII	VIII	IX
I	77.46 (8.80)	160.95 (12.69)	107.41 (10.36)	231.59 (15.22)	120.24 (10.96)	385.01 (19.62)	138.2 (11.75)	261.99 (16.19)	231.62 (15.22)
II		85.59 (9.25)	143.57 (11.98)	109.17 (10.45)	164.94 (12.84)	252.36 (15.88)	186.36 (13.65)	185.1 (13.60)	153.32 (12.38)
III			89.53 (9.46)	198.13 (14.07)	163.71 (12.79)	352.06 (18.76)	135.12 (11.62)	277.03 (16.64)	215.84 (14.69)
IV				0	234.83 (15.32)	162.32 (12.74)	234.46 (15.31)	195.08 (13.97)	118.88 (10.90)
V					100.1 (10.00)	374.15 (19.34)	184.95 (13.60)	207.66 (14.41)	234.58 (15.31)
VI						68.34 (8.27)	383.46 (19.58)	258.55 (16.08)	225.37 (15.01)
VII							146.77 (12.11)	312.17 (17.67)	218.53 (14.78)
VIII								0	224.54 (14.98)
IX									0

Table 3. Cluster mean for 14 quantitative characters of pigeonpea genotypes

Clusters	Plant height (cm)	Number of primary branches per plant	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Days to 50 % flowering	Days to maturity	100- seed weight (g)	Harvest index (%)	Seed yield per ha (kg)
I	244.76	5.25	117.67	5.09	4.00	126.06	185.65	12.83	17.52	131.22
II	235.12	5.20	123.10	5.32	3.98	116.30	173.91	13.25	33.66	265.88
III	227.91	5.27	67.43	5.11	4.43	112.33	164.25	13.16	19.78	168.02
IV	235.00	4.80	93.40	5.80	4.00	123.00	176.00	12.80	54.67	347.85
V	259.30	5.50	195.13	5.02	4.00	132.38	189.68	13.50	22.34	155.34
VI	231.07	5.19	106.97	5.35	3.93	123.00	186.27	13.93	61.48	501.37
VII	285.65	5.47	61.40	5.18	4.45	126.00	162.59	14.55	67.45	144.15
VIII	223.00	4.20	274.95	5.80	4.20	163.00	213.00	14.20	17.66	323.68
IX	271.00	5.40	89.00	6.20	4.40	167.00	235.05	13.40	129.34	308.58

Table 4. Per cent contribution of 13 characters towards divergence in 192 pigeonpea genotypes

Sl. No.	Characters	Times ranked 1st	Contribution %
1	Plant height (cm)	1346	7.34
2	Number of primary branches per plant	00	0.00
3	Number of pods per plant	5242	28.59
4	Pod length (cm)	00	0.00
5	Number of seeds per pod	00	0.00
6	Days to 50 % flowering	392	2.14
7	Days to maturity	797	4.35
8	100-seed weight (g)	00	0.00
9	Harvest index (%)	387	2.11
10	Seed yield per ha (kg)	10106	55.12

(109.17) suggesting that the genotypes belonging to these clusters may be used as parents for hybridization programme to develop desirable type because crosses between genetically divergent lines will generate heterotic segregants. These results are in conformity with Saxesena *et al.* (2013).

The cluster VII showed high mean value for plant height (cm), number of seeds per pod and 100-seed weight (g), whereas cluster IX recorded highest mean performance for pod length (cm), days to 50 per cent flowering, days to maturity and harvest index (%). The cluster VIII exhibited highest means for number of pods per plant where as cluster V (12) and VI (3) recorded high means for number of primary branches per plant and seed yield per hectare (kg) respectively (Table 3).

The highest contribution in manifestation of genetic divergence was exhibited by seed yield per hectare (55.12 %) followed by number of pods per plant (28.59 %), plant height (7.34 %) and days to maturity (4.35 %) had the greater contribution to genetic diversity therefore required necessary attention for these characters (Table 4).

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Evaluation of Botanicals and Insecticides Against *Rhyzopertha dominica* (Fabr.) in Stored Wheat

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Abstract: At bi-monthly interval, the maximum mortality in grain borer was recorded in deltamethrin (0.005%) followed by sweet flag (5%). Sweet flag remained effective with the maximum mortality of 98.80 and 97.70% at 30 and 90 days after storage, however, deltamethrin with 96.23 and 93.59% at 150 and 210 days after storage, respectively. The toxicity with the advent of time could not sustain, as a result there was no monitoring of pest build up in stored wheat.

Key Words: Deltamethrin, Gunny bags, Lesser grain borer, Sweet flag

Rhyzopertha dominica, the lesser grain borer is a storage pest of economic significance in the United States of America, Southern Canada, Argentina, New South Wales, South East Australia and Indo-Pakistan sub-continent (Toews *et al*., 2005; Fields, 2006) and is the most difficult storage pest to control with grain protectants (Edde, 2012). The detrimental environmental issues caused by the over use of insecticides have become a matter of great concern for scientists (Koul *et al*., 2008). Unlike insecticides, which mostly kill insects, plant ingredients are known to suppress the feeding and breeding behavior of insects in many ways in addition to direct mortality (Epidi *et al*., 2008). Use of plant parts with insecticidal properties have been reported from all over the world as they are convenient, less expensive, highly effective and safer for the humans and environment. Many plants like *Annona squamosa L., Cremato gasterinermis, Cassia fistula, Azadirachta indica* and *Calotropi sprocera* proved lethal for various stored grain pests and delayed the developmental stages by interfering with their apolytic and molting processes (Morya *et al., 2010).* Leaves of *Ocimum sanctum, Vitex negundo, Aegle marmelos* and *Lippia geminate* were used for protection of stored rice forms in rural India (Prakash and Rao, 2006). Thus, there is need to build up pest control strategies by harnessing the efficacy of phytochemicals, which have insecticidal value to the fullest extent, which are not only affordable and effective but are also easily accessible to most farmers. Keeping in view, the following advantages, the study was undertaken to evaluate the effectiveness and persistence in consequent to the surface treatment of gunny bags using various botanicals and insecticides to prevent the infestation by lesser grain borer in stored wheat.

Studies on the impact of using various plant products and insecticides on the surface treatment of gunny bags against lesser grain borer, *Rhyzopertha dominica* Fabr. for their bioefficacy, cross infestation, persistence, survival and multiplication in wheat grains was carried out at Agricultural Research Station, Gulbarga among the above products during 2012-13.

Stock culture of lesser grain borer was maintained by collecting adult beetles from the infested wheat grains from the college farm stores. The adults of lesser grain borer were reared in the laboratory on whole wheat flour containing 5% denied brewer's yeast at 29°C. Fresh grains were provided periodically for the development of beetles. Culture so maintained was used throughout the storage period as per the method of Howe (1991). Evaluation of bio-efficacy was carried out by surface treatment of gunny bags at bimonthly and monthly. The toxicity of plant products and insecticides to *Rhyzopertha dominica* Fabr. was determined in completely randomized design with 12 treatments including untreated check, which were replicated thrice (Table 1).

The maximum mortality was 100, 97.65, 100 and 98.5 per cent at 30, 90, 150 and 210 days after storage in delatmethrin and was significantly higher than in other treatments. This was followed by sweet flag (5%), which was significantly more than in other treatments (Table 1). The present findings are in conformity with Nighat *et al.* (2007) who reported high toxicity of deltamethrin to *R. dominica* (LC_{50} 10.55 ppm). The recommended dose of deltamethrin for the application is 0.25 ppm for short-term and long-term protection of goods (www.bayercropscience.com).

Sweet flag at 5% caused the highest mortality at 98.8 and 97.7% with least population of live adults of *R. dominica* (zero and 11%) at 30 and 90 days after storage followed by deltamethrin (Table 2). Similarly at 150 and 210

Table 1. Per cent mortality and live adult population of *Rhyzopertha dominica* Fab. consequent to the surface treatment of gunny bags with botanicals and insecticides at bimonthly intervals in stored wheat

Treatments	Dose (%) v/v or w/v	Adult mortality (%)				Live adult population (%)			
		30 DAS	90 DAS	150 DAS	210 DAS	30 DAS	90 DAS	150 DAS	210 DAS
Neem seed kernel extract	5	85.23^{f}	82.60^{e}	83.71^{d}	84.45^{c}	0.00	14.55^{c}	17.45^{c}	21.70^{c}
Neem leaf dust	5	84.15^{f}	93.45^{c}	83.95^{d}	85.00^{c}	0.00	14.95^{c}	18.40^{c}	21.90^{c}
Sweet flag rhizome dust	5	97.60^{b}	94.65^{b}	96.65^{b}	95.23^{b}	0.00	13.65^{b}	16.50^{b}	19.55^{b}
Nochi leaf dust	5	85.59^{f}	80.45^{e}	82.62^{d}	84.75^{c}	0.00	15.75^{c}	20.25^{c}	23.75^{c}
Clerodendron leaf dust	5	75.62^{g}	75.25^{f}	77.54^{e}	75.89^{d}	0.00	16.85^{c}	20.65^{c}	22.70^{c}
Bouganvillea leaf dust	5	75.00^{g}	81.65^{e}	76.12^{e}	74.85^{d}	0.00	16.90^{c}	19.30^{c}	23.65^{c}
Tulsi leaf dust	5	70.15^{g}	72.60^{g}	68.25^{f}	68.55^{e}	0.00	17.75^{c}	26.00^{d}	36.50^{d}
Carbaryl 50 WP	0.4	93.69^{d}	92.50^{c}	90.89^{c}	85.55^{c}	0.00	15.85^{c}	21.30^{c}	20.25^{c}
Malathion 50 EC	0.05	95.25^{c}	88.75^{d}	89.95^{c}	85.00^{c}	0.00	15.75^{c}	19.60^{c}	22.65^{c}
Fenitrothion 50 EC	0.05	90.45^{e}	88.90^{d}	89.00^{c}	85.65^{c}	0.00	15.65^{c}	19.75^{c}	22.23^{c}
Deltamethrin 2.8 EC	0.005	100.00^{a}	97.65^{a}	100.00^{a}	98.50^{a}	0.00	11.25^{a}	13.45^{a}	16.56^{a}
Untreated check	-	1.95^{h}	2.10^{h}	2.95^{g}	3.01^{f}	0.00	30.15^{d}	36.65^{e}	41.23^{e}

DAS – Days after storage
In the verticals columns means followed by same letters are not different statiscally (P = 0.01) by DMRT.

Table 2. Per cent mortality and live adult population of *Rhyzopertha dominica* Fab. consequent to the surface treatment of gunny bags using various botanicals and insecticides at monthly intervals in stored wheat

Treatments	Dose (%) v/v or w/v	Per cent adult mortality of *Rhyzopertha dominica* on the surface of gunny bags				Per cent live adult population of *Rhyzopertha dominica* inside the gunny bags (100 gms of wheat seeds)			
		30 DAS	90 DAS	150 DAS	210 DAS	30 DAS	90 DAS	150 DAS	210 DAS
Neem seed kernel extract	5	88.78^{d}	89.65^{c}	85.24^{e}	82.50^{d}	0.00	15.25^{c}	20.65^{d}	21.20^{c}
Neem leaf dust	5	87.15^{d}	85.60^{e}	85.29^{e}	81.55^{d}	0.00	15.65^{c}	19.23^{c}	22.75^{c}
Sweet flag rhizome dust	5	98.80^{a}	97.70^{a}	93.55^{b}	89.95^{b}	0.00	11.00^{a}	17.75^{b}	20.60^{b}
Nochi leaf dust	5	85.35^{d}	83.05^{e}	84.64^{e}	74.15^{e}	0.00	16.25^{d}	21.80^{d}	24.85^{d}
Clerodendron leaf dust	5	86.95^{d}	81.15^{f}	85.93^{e}	69.23^{f}	0.00	16.6^{d}	21.95^{d}	22.70^{c}
Bouganvillea leaf dust	5	86.62^{d}	84.00^{e}	85.50^{e}	68.15^{f}	0.00	17.80^{d}	19.60^{c}	24.60^{d}
Tulsi leaf dust	5	78.00^{e}	71.30^{g}	75.63^{f}	56.55^{g}	0.00	18.95^{d}	25.75^{e}	35.23^{e}
Carbaryl 50 WP	0.4	93.44^{c}	85.70^{e}	90.68^{d}	82.55^{d}	0.00	16.80^{d}	24.60^{e}	22.90^{c}
Malathion 50 EC	0.05	92.00^{c}	87.75^{d}	92.80^{c}	85.65^{c}	0.00	18.90^{d}	19.85^{c}	21.66^{c}
Fenitrothion 50 EC	0.05	92.69^{c}	87.70^{d}	90.85^{d}	84.70^{c}	0.00	16.95^{d}	19.95^{c}	21.75^{c}
Deltamethrin 2.8 EC	0.005	95.75^{b}	94.42^{b}	96.23^{a}	93.59^{a}	0.00	14.45^{b}	14.23^{a}	17.95^{a}
Untreated check	-	2.15^{f}	2.65^{h}	1.95^{g}	2.50^{h}	0.00	25.95^{e}	35.65^{f}	40.15^{f}

DAS – Days after storage
In the verticals columns means followed by same letters are not different statiscally (P = 0.01) by DMRT.

days after storage deltamethrin at 0.005% recorded maximum mortality of *R. dominica* (96.23 and 93.59%) with minimum live adult population (14.23 and 17.95%) followed by sweet flag (5%) with a mortality of 93.55 and 89.95% differing significantly over all other treatments. The findings were in accordance with Shiva *et al.* (2015), who reported the insecticidal effects of *Eucalyptus dundasii* Maiden essential oil on the adults of the lesser grain borer, *R. dominica.* However, upon comparison with untreated check all other protectants have saved the wheat grain from *R. dominica i*nfestation effectively.

Bimonthly method of application was found effective against *R. dominica* Fabr. and was found promising throughout the storage period followed by sweet flag, which too offered the best protection. However, in monthly method of application of treatments, sweet flag though remained effective but only upto 90 days, unable to sustain its toxicity throughout the storage period followed by deltamelthrin.

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Evaluation of Ginger (*Zingiber officinale* Rosc.) Cultivars for Growth, Yield and Quality Attributes under Hill Zone of Karnataka

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Abstract: Significant differences among the ten cultivars were observed for growth and yield characteristics. Cultivar Maran recorded maximum plant height (71.80 cm), tillers per plant (23.43), leaves per clump (308.33), leaf area (45.06 cm^2) and leaf area index (15.41) at 180 days after planting. Cultivar Maran also recorded higher fresh rhizome yield of 29.37 t ha^{-1} which was followed by Rio-de-Janeiro and Karkal Local. The highest crude fiber content was in cultivar Karkal Local (6.73%). Essential oil content was maximum in cultivar Rio-de-Janeiro (2.31%). Maran, Rio-de-Janeiro and Karkal Local showed better performance with respect to growth, yield and quality parameters for rainfed hilly region of Karnataka.

Key Words: Ginger, Growth, Hill zone, Quality attributes, Yield

Ginger (*Zingiber officinale* Rosc.) is one of the important and widely used spices throughout the world and has spread to tropical and subtropical countries from the Indo-China region, where ginger cultivation was prevalent from the days of unrecorded history (Nybe and Miniraj, 2005). India is the largest producer in the world with annual production of 7.56 lakh tonnes from 1.49 lakh hectares, contributing approximately 30 to 40 per cent of the world production (Anonymous, 2012). Nearly 10 to 15 per cent of Indian ginger is exported to about 50 countries around the world. Though wide genetic variability exists in this crop with regard to the yield and yield attributes, however, not much work has been done on crop improvement through the selection of superior types with high yield under hill zone of Karnataka. Hence, the present study was carried out to evaluate the performance of different cultivars with regard to vegetative parameters, yield and quality of ginger.

Ten cultivars of ginger were evaluated at College of Horticulture, Mudigere, Karnataka, India at an altitude of 982 m MSL during 2012-2013 for growth and yield (Table 1). The field experiment was conducted in a randomized block design with three replications, in a plot size of 2.4x1.5 m^2 at the spacing of 30x30 cm. The soil of the experimental field was well drained with pH of 5.97, O.C. - 1.15%, available nitrogen-336 kg ha^{-1}, available P_2O_5-18.5 kg ha^{-1} and available K-295 kg ha^{-1}. The planting of ginger was done in the last week of April and fertilizers were applied as recommended. Three plants were selected at random for recording growth characters. The crop was harvested after eight months and the yield of fresh ginger was recorded. Equal quantity of fresh ginger from each treatment was sun dried uniformly after hand peeling and then quality of ginger was estimated.

Cultivar Maran recorded the maximum plant height (71.80 cm), which was atn par with Rio-de-Janeiro and Karkal local. Cultivar Maran differed significantly from rest of the cultivars for leaves per clump. The highest number of tillers per clump (23.43) was in Maran, which was at par with Humanabad local. Cultivar Maran also recorded the higher leaf length (25.70 cm) which was on par with Cv. Rio-de-Janeiro and Karkal local (Table 1). The lower leaf length was in Cv. Humanabad local. The cultivar Maran produced maximum leaf area of (45.06 cm^2), which was on par with Cv. Rio-de-Janeiro. The highest leaf area index (15.41) and girth of pseudo-stem (1.20cm) was in the Maran, which was followed by Rio-de-Janeiro, IISR-Varada and the lowest was in Humanabad local. Earlier studies also revealed significant variations in these characters among the cultivars by Pariari *et al.* (2008); Dhatt *et al*. (2008) and Ashok Kumar *et al.* (2012). Maximum number of rhizomes and number of primary fingers was recorded in Maran followed by Cv. Rio-de-Janeiro, Humanabad local and the minimum number of rhizomes were in IISR-Varada. The minimum number of primary fingers per plant was recorded in IISR-Mahima. The maximum number of secondary fingers was recorded in cultivar Maran (22.00) followed by Rio-de-Janeiro, Humanabad local and minimum number of secondary fingers per plant was recorded in IISR-Varada.

Cultivar Maran recorded the higher yield per clump (323.89 g) and rhizome yield (29.37 t ha^{-1}), which was at par with Rio-de-Janeiro and the lower was recorded in the cultivar Humanabad local. The variations in rhizome yield

Table 1. Evaluation of ginger cultivars for growth, yield and quality attributes

Cultivars	Plant height (cm)	Number of tillers per clump	Leaf area (cm^2)	Leaf area index	Pseudo-stem girth (cm)	Number of rhizomes per clump	Number of primary fingers*	Yield per clump (g)**	Crude fibre (%)	Oleoresin (%)***
IISR-Mahima	64.23	18.77	37.60	10.98	1.05	20.60	5.93 (14.67)	244.03 (22.12)	3.85	4.33 (1.62)
IISR-Varada	63.88	17.83	36.06	11.07	1.04	20.13	6.07 (14.07)	213.69 (19.36)	3.70	6.34 (1.26)
IISR-Rajatha	57.23	19.53	33.17	9.55	1.01	23.60	6.40 (17.20)	225.39 (20.48)	3.85	6.27 (1.85)
Suravi	64.10	17.57	33.10	10.04	1.03	21.27	6.47 (14.80)	245.75 (20.83)	3.75	7.24 (1.62)
Suprabha	62.53	19.80	36.87	10.77	1.04	26.80	7.20 (19.93)	250.39 (21.31)	3.98	8.27 (1.59)
Himagiri	63.63	20.27	36.78	10.95	0.93	21.53	6.87 (15.00)	215.07 (19.81)	5.23	4.20 (1.44)
Rio-de-Janeiro	67.90	20.33	40.89	12.97	1.07	28.07	7.60 (20.47)	309.33 (28.04)	6.30	9.06 (2.31)
Maran	71.80	23.43	45.06	15.41	1.20	30.20	8.20 (22.00)	323.89 (29.37)	5.98	8.47 (1.96)
Karkal local	67.63	20.20	33.90	10.57	1.04	21.93	6.00 (15.93)	285.05 (25.84)	6.73	6.38 (1.93)
Humanabad local	52.87	21.07	29.57	9.46	0.89	27.27	7.53 (19.73)	207.92 (18.77)	4.28	4.80 (1.06)
CD (p=0.05)	7.30	2.66	4.36	1.65	0.15	1.41	0.58 (1.40)	19.89 (2.15)	0.41	0.35 (0.35)

*Number of secondary fingers; ** Yield per hectare (t ha^{-1}); *** Essential oil (%) in parentheses

among the cultivars were mainly due to variation in number of tillers produced per plant, which is a genetically controlled character. The yield of fresh rhizome is the inherent capacity of the cultivar to put forth better growth in terms of leaf area, number of leaves and height of the plant and better growth and production of yield attributes like weight of the rhizome, length of the rhizome and girth of the rhizomes. It can be concluded that the yield of a cultivar is dependent on vigour of the plant and other plant characters. Earlier studies also revealed significant variations in these characters among the cultivars by Pariari *et al.* (2008) and Ashok Kumar *et al.* (2012).

The cultivar Karkal Local recorded the higher crude fiber content (6.73%) followed by the Cv. Rio-de-Janeiro (6.30%) and Maran (5.98%). The higher essential oil was recorded in the Rio-de-Janeiro (2.31%), which was at par with Maran (1.96%). The cultivar Rio-de-Janeiro recorded highest oleoresin content of 9.06 per cent closely followed by Maran and Suprabha. Earlier studies also revealed significant variations in these characters among the cultivars (Hegde *et al.,* 2006 and Sanwal *et al*., 2012).

The investigation concluded that cultivars Maran, Rio-de-Janeiro and Karkal local showed better performance with respect to growth, yield and quality parameters and found promising cultivars for rainfed situations of hilly region of Karnataka.

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Genetic Variability in Chickpea (*Cicer arietinum* L.) Under Temperate Conditions of Kashmir

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***Abstract*:** Significant variability among the genotypes was recorded with high heritability (b.s) high for number of pods plant^{-1}, number of primary branches plant^{-1}, 100-seed weight, harvest index and seed yield plant^{-1}. Phenotypic and genotypic correlation coefficients revealed significant positive association of grain yield with number of pods plant^{-1}, number of primary branches plant^{-1}, number of seeds pod^{-1}, 100-seed weight and harvest index, and significant negative correlation with protein content. Path coefficient analysis of seed yield plant^{-1} at genotypic level revealed that number of seeds pod^{-1} showed highest positive direct effect (0.577) towards seed yield plant^{-1} followed by number of pods plant^{-1} (0.429) and 100-seed weight (0.333). Therefore, selection for number of pods plant^{-1}, number of seeds pod^{-1} and 100-seed weight would lead to high seed yield.

Key Words: Chickpea, Genetic variability, Heritability, Path analysis

Pulses are important crops for food security worldwide and for the livelihood of millions of people, especially in the developing countries. The newly emerging health consciousness among the people is creating a genuine need for adopting nutritionally complete vegetarian diet involving legumes as a component. Chickpea (*Cicer arietinum* L.) or Bengal gram is an important *rabi* pulse crop in India and grown on about 8.75 million hectare production of about 8.25 million tonnes (Anonymous, 2010). Presence of genetic variability is of utmost importance for any breeding programme and for that reason plant breeders have emphasised the evaluation and characterization of germplasm for the improvement of crop yield. Interrelationship among direct and indirect effect of component characters of yield is important in predicting the correlated response to direct selection and in the identification of traits contributing towards yield. The present study was undertaken to elucidate the association between yield and its attributes in chickpea.

The experimental material for the present study comprised of 70 genotypes of chickpea. Out of seventy genotypes, 50 were received from ICARDA and 20 ICRISAT. The experimental trial was laid out in randomised block design with three replications during *rabi* 2010-11 at Pulses Research Station, Habak, Shalimar (34°15' N latitude and 74°84' E longitude) at 1524 m above mean sea level. Each experimental plot consisted of 4 rows of 3m length. The inter and intra-row spacing was maintained at 30 and 10 cm, respectively. Uniform standard plant population was maintained. Recommended package of practices were adopted to raise a good crop. Ten competitive representative plants were taken at random from each experimental plot in each replication and tagged for recording the biometrical observations on eleven morphological, maturity, quality, yield and yield component traits viz. days to 50% flowering and maturity, plant height, number of primary branches, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield plant^{-1}, 100-seed weight, biological yield plant^{-1}, harvest index and protein content. Estimates of genotypic and phenotypic variances and covariances were substituted as per the formula suggested by Johnson *et al*. (1955) to calculate correlation coefficient between pairs of traits. The methodology for path analysis proposed by Dewey and Lu (1959) was adopted.

The magnitude of total phenotypic variability for different traits present in the material has been depicted in Table 1. Variation in climatic factors like temperature and photoperiod affect maturity of genotypes and therefore overall yield. Earlier studies have also confirmed significant variability in days to 50% flowering and days to maturity (Atta *et al*., 2008; Saleem *et al*., 2008 and Khan and Khan, 2011). The phenotypic and genotypic co-efficient of variations were high for number of pods plant^{-1}. For seed yield^{-1}, high values of phenotypic coefficient of variation and genotypic coefficient of variation were recorded among all the characters. Similar results were obtained by Jeena and Arora (2000) and Somyasharma and Singh (2001). The present findings suggest negligible influence of extraneous factors on this trait. Estimates of heritability (broad sense) were very high (> 80%) for all the traits and ranged from 0.85 to 0.96 except for days to 50% flowering, days to maturity, plant height and for

protein content, it was moderate ranging from 0.68 to 0.79. Expected genetic gain measured as per cent of mean at 5% selection intensity was low (< 10%) for days to 50% flowering, days to maturity and number of seeds pod^{-1} whereas, it was moderate (10.0-20.0%) for plant height, 100-seed weight, biological yield plant^{-1}, harvest index and protein content and high (> 20%) for number of primary branches plant^{-1}and number of pods plant^{-1}. In the present study, high amount of heritability estimates coupled with moderate genetic advance were recorded for days to 50 per cent flowering, primary branches plant^{-1}, number of pods per plant. High estimates of heritability along with high genetic advance were noticed for 100-seed weight and seed yield plant^{-1}, which suggest the importance of additive gene action for these traits (Sidramappa, 2003). These traits could be improved through simple selection.

Seed yield plant^{-1} revealed positive and significant correlation with number of primary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight, biological yield plant^{-1} and harvest index but it exhibited negative and significant correlation with protein content (Table 2). Similar results were reported by Ali *et al*. (2011). Number of primary branches^{-1} showed positive and significant correlation with number of seeds pod^{-1}, 100-seed weight, seed yield, biological yield plant^{-1} and harvest index, and negative correlation with protein content. Number of seeds pod^{-1} showed positive and significant correlation with number of primary branches plant^{-1}, number of pods plant^{-1}, 100-seed weight, seed yield plant^{-1}, biological yield plant^{-1}, harvest index but negative and significant correlation both at genotypic and phenotypic level with protein content. Biological yield plant^{-1} exhibited significant positive correlation with number of primary branches plant^{-1}, number of pods plant^{-1}, 100-seed weight, seed yield plant^{-1} and

Table 1. Estimation of genetic parameters for yield, yield contributing and quality traits in chickpea

Characters	Days to 50% flowering	Days to maturity	Plant height	No. Of primary branches	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight	Seed yield plant^{-1}	Biological yield plant^{-1}	Harvest index	Protein content
Maximum	147	177	55.1	4.6	60.9	1.4	40.8	8.3	17.4	0.34	25.3
Minimum	138.6	168.3	32.9	2.2	24.1	0.9	25.7	4.1	12.7	0.21	18.6
Mean	143.6	173.9	46.1	3.2	36.4	1.1	34.6	6.1	15.7	0.27	21.78
ECV	0.7	0.7	5.1	6.1	2.5	11.4	1.8	4.1	2.6	2.7	4.3
GCV	1.3	1.0	10.1	16.3	17.0	4.8	9.5	14.8	6.2	9.0	6.9
PCV	1.5	1.2	11.4	17.4	17.7	12.4	9.6	15.4	6.8	9.4	8.2
h^2 (bs)	75	68	79	87	94	15	96	92	85	91	71
Genetic advance as % of mean 5%	2.3	1.7	18.7	31.5	35.9	3.9	19.2	29.5	11.9	17.8	12.1

Table 2. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among different plant traits

Parameter	DF	DM	PH	PB	PP	SP	HSW	SY	BY	HI	PC
DF	-	0.98**	0.12	0.06	0.13	0.00	0.24	0.05	0.14	-0.03	-0.27*
DM	0.94	-	0.17	0.05	0.08	-0.08	0.23	-0.00	0.14	-0.10	-0.21
PH	0.13	0.17	-	0.23	0.17	-0.23*	0.17	0.10	-0.03	0.11	0.01
PB	0.05	0.04	0.20	-	0.76	0.79**	0.69**	0.67**	0.35**		-0.33*
PP	0.12	0.07	0.15	0.71	-	0.78**	0.78**	0.87**	0.53**	0.73**	-0.63**
SP	-0.05	-0.06	-0.05	0.29	0.32	-	0.65**	0.77**	0.47**	0.66**	-0.61**
HSW	0.20	0.19	0.15	0.64	0.77	0.27	-	0.80**	0.76**	0.57**	-0.56**
SY	0.05	0.01	0.09	0.61	0.85	0.31	0.79	-	0.59**	0.88**	-0.69**
BY	0.12	0.13	-0.02	0.33	0.52	0.17	0.72	0.58	-	0.19	0.53**
HI	-0.02	-0.06	0.10	0.53	0.70	0.26	0.55	0.87	0.18	-	-0.53**
PC	-0.20	-0.16	-0.00	-0.28	-0.54	-0.22	-0.49	-0.60	-0.49	-0.45	-

DF (Days to 50% flowering), DM (Days to maturity), PH (Plant height), PB (Primary branches), PP (pods per plant), SP (seeds per pod), HSW (100 seed weight), SY (seed yield), BY (biological yield), HI (harvest index), PC (protein content).

Table 3. Estimates of direct and indirect effects of different plant traits

Parameters	Plant height (cm)	Number of primary branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-seed weight (g)	Genotypic correlation coefficient with seed yield plant^{-1}
Plant height (cm)	0.1989	-0.0906	0.0752	-0.1382	0.0578	0.1031
Number of primary branches plant^{-1}	0.0462	-0.3896	0.3285	0.4591	0.2323	0.6765**
Number of pods plant^{-1}	0.0349	-0.2983	0.4290	0.4530	0.2613	0.8799**
Number of seeds pod^{-1}	-0.0476	-0.3099	0.3367	0.5771	0.2178	0.7741**
100-seed weight (g)	0.0345	-0.2716	0.3364	0.3772	0.3333	0.8098**

number of seeds per pod.

Number of seeds pod^{-1} had the highest positive (0.57) direct effect followed by number of pods plant^{-1} (0.42) and 100-seed weight (0.33). The above three characters showed highly significant positive correlation with yield (Table 3). Number of primary branches plant^{-1} showed direct negative effect on seed yield (-0.38). Number of pods plant^{-1} and number of seed pod^{-1} besides having high positive significant direct effect on seed yield plant^{-1}, had also indirect contribution via 100-seed weight.

The present study revealed significant genetic variability for all the morphological, maturity, yield, yield components and quality traits. The promising exotic germplasm lines may be involved in hybridization programmes to widen the genetic base for further improvement and development of superior varieties of chickpea suitable for Kashmir region.

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Growth, Yield and Water Productivity of Bed-Planted Summer Moong in Relation to Irrigation Regimes

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Abstract: The growth and yield parameters of moong bean were significantly influenced by different dates of sowing. The maximum seed yield (12.9 q ha^{-1}) was obtained when crop was sown on 20 March. Various irrigation schedules, significantly influenced all the growth and yield attributing parameters. Significantly higher values of all the growth and yield attributing parameters were observed under 1.2 IW/CPE irrigation schedule being statistically at par with 1.0 IW/CPE.

Key Words: Dates of sowing, Irrigation schedules, Summer moong, Yield and water productivity

Moongbean is the third most important pulse crop of India in terms of cultivated area and production (Gupta 2011). It is mainly practiced in the *kharif* season but under irrigated ecosystem, it is being extensively grown during summer season. In Punjab, it is cultivated on fifty thousand hectares (Anonymous 2013). Time of sowing is the most important non-monetary factor for realizing the maximum genetic potential. Summer moongbean growing season is from mid March to end June. The water needs of the crop becomes high during this period on account of harsh weather conditions at the reproductive stage. Under such situation, it becomes necessary to find the proper irrigation schedule. Irrigation schedule also varies with the dates of sowing.

A field experiment was conducted during the summer season of 2014 at Research Farm of Department of Agronomy, Punjab Agricultural University, Ludhiana. The experiment was laid out in factorial randomized complete block design with four replications using three dates of sowing i.e. 20 March, 30 March and 10 April and four irrigation schedules based on IW/CPE ratio of 0.6, 0.8, 1.0 and 1.2. The recommended agronomic practices were adopted for raising the crop. The observations for growth and yield attributing parameters were recorded from five tagged plants. Grain yield was obtained on the basis of net plot yield. The soil of the experimental site was loamy sand in texture, neutral in reaction (pH 7.8), low in organic carbon (0.33%) and available nitrogen (175.9 Kg ha^{-1}), medium in available phosphorous (13.5 Kg ha^{-1}) and potassium (136.5 Kg ha^{-1}). The field capacity and permanent wilting point values for 0-180 cm soil profile were 37.88 cm and 13.13 cm, respectively. The average bulk density of the field was 1.59 g cm^{-3}. The total rainfall received during the growing season of crop was 99.4 mm.

Leaf area and dry matter accumulation: The leaf area was significantly higher in 20 March sown crop as compared to 30 March and 10 April. Among various irrigation schedules, 1.2 IW/CPE maintained its superiority in terms of leaf area and was statistically at par with 1.0 IW/CPE irrigation schedule. More frequent irrigations under these two regimes of irrigation favoured higher vegetative growth, thus a higher leaf area had been observed. This change might have been due to more tissue elongation for maintenance of turgidity in the leaf tissue. The dry matter accumulation also followed the same trend. The March sown crop had better physiological conditions in terms of better temperature and environment that always recorded higher dry matter accumulation. Among different irrigation schedules, the higher values of dry matter were under more frequently irrigated treatments. This might be attributed to higher photosynthesis and thereby higher dry matter accumulation while the treatments with wider interval between irrigations might have undergone moisture stress for some period of life cycle and this might have adversely affected photosynthesis and dry matter accumulation. These results are in conformity with the findings of Yadav and Singh (2014).

Number of pods per plant: Maximum number of pods per plant (22.2) were recorded in March 20 sowing, which were significantly more than other two sowing dates. Higher number of pods per plant in March sowing might be attributed to favourable temperature and humidity conditions prevailing at the time of flowering for higher pod set. Sekhon and Singh (2005) also recorded significant decrease in number of pods per plant with delay in sowing. Irrigation schedule of I_4 produced maximum number of pods per plant (21.3) and was statistically at par with I_3 and significantly better than I_2 and I_1 irrigation schedules. Yadav and Singh (2014) also reported

increase in number of pods per plant with increase in number of irrigations. The pod length did not vary significantly due to sowing dates and on account of irrigation schedules.

Seeds per pod and 1000-seed weight: The number of seeds per pod indicated no significant differences due to different dates of sowing and subsequent irrigation schedules. Higher 1000-seed weight under March 20 sowing might be due to proper filling of seeds because of more light penetration and utilization. Sarkar *et al*. (2004) also found decrease in 1000-seed along with delay in sowing. 1000-seed weight was 7.3 per cent higher when irrigation was scheduled at I_4 as compared to I_1. This might be due to the fact that frequent irrigations led to higher accumulation and higher number of filled seeds that ultimately increased thousand seed weight.

Seed yield: The crop sown on 20 March recorded significantly higher seed yield (12.9 q ha^{-1}) as compared to extended sowing dates. The higher seed yield obtained under D_1 sowing date might be due to higher number of pods per plant, seeds per pod and 1000-seed weight as compared to 30 March and 10 April sowing. Kumar *et al.* (2009) also reported decrease in seed yield along with delay in sowing. Irrigation schedules too had a significant effect on the seed yield of summer moong. The data showed a progressive increase in seed yield along with increase in number of irrigations. Maximum seed yield (12.5 q ha^{-1}) was recorded under I_4 irrigation schedule being statistically at par with I_3 irrigation schedule but significantly better as compared to I_2 and I_1 irrigation schedules.

Crop water use and water use efficiency: The maximum water use was observed in 10 April sowing, which was higher than in March 30 and March 20 sowing mainly due to higher temperature resulting in higher evapo-transpirational losses. The crop used more water to meet ET rates in I_4 irrigation schedule, which received more number of irrigations as compared to other three irrigation schedules. The maintenance of higher level of moisture in the soil through frequent irrigations resulted in increased evapo-transpiration losses and hence crop water use was the highest with I_4 irrigation schedule. These results are in confirmation with the findings of Tripathi and Bastia (2012) who also recorded increased crop water use along with increase in number of irrigations.

The maximum water use efficiency was recorded in March 20 sowing leading to higher water use significantly higher seed yield. Kingra and Kaur (2012) also observed increased water use efficiency in *Brassica* under early sown conditions where yield was maximum and crop water use was minimum. The highest value of water use efficiency

Table 1. Effect of sowing dates and irrigation schedules on the growth, yield attributes, yield and soil moisture of summer moong

Treatments	Leaf area (cm^2)	Dry matter accumulation (q ha^{-1})	Pods per plant (No.)	Pod length (cm)	Seeds per pod (No.)	1000-seed weight (g)	Seed yield (q ha^{-1})	Crop water use (cm)	WUE (q $ha^{-1}cm^{-1}$)
Date of sowing									
March 20 (D_1)	276.2	51.6	22.2	9.0	10.3	52.8	12.9	48.4	0.26
March 30 (D_2)	272.0	50.2	19.2	8.8	9.6	51.4	11.7	49.4	0.23
April 10 (D_3)	267.2	48.5	17.8	8.3	9.2	50.0	10.2	52.8	0.19
CD (p=0.05)	6.1	1.4	1.4	NS	NS	1.1	0.9	-	-
Irrigation schedule									
0.6 IW/CPE (I_1)	266.5	48.1	17.8	8.3	9.0	49.2	10.6	47.7	0.22
0.8 IW/CPE (I_2)	270.4	49.5	19.0	8.5	9.5	50.7	11.0	51.8	0.21
1.0 IW/CPE (I_3)	274.2	51.2	20.9	8.8	10.1	52.7	12.3	55.7	0.22
1.2 IW/CPE (I_4)	276.0	51.7	21.3	9.1	10.2	53.1	12.5	57.6	0.21
CD (p=0.05)	7.0	1.6	1.7	NS	NS	1.3	1.1	-	-
Interaction	NS	NS	NS	NS	NS	NS	NS	-	-

under I_1 irrigation schedule was due to efficient use of applied water and relatively more seed yield. These results are in similarity with the findings of Yadav and Singh (2014).

The results revealed that for high seed yield realization in summer moongbean, the crop should be sown around 20 March and irrigation should be applied to bed sown crop based on IW/CPE ratio of 1.0.

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Induced Flower Colour Mutations in Chickpea (*Cicer arietinum* L.)

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Abstract: Significant differences was observed in seed germination, floral and pollen fertility of M_1 generation in ethyl methyl sulphonate mutated seeds of chickpea. Xanthia and chlorina type of leaf chlorophyll mutants were also scored from both the treatments. A notable white flower mutant was also observed in 1% EMS treated plants, whereas, control plants showed normal pinkish red flower. 1% EMS concentration showed almost complete lethality (only 8 % germination).

Key Words: Chlorina, EMS, Genotype, Mutant, Xanthia

Chickpea (*Cicer arietinum* L.) is world's second-largest cultivated food legume, native of Mediterranean region. India is the world's largest producer (82.21 lakh tonnes) and consumer of chickpea, accounting an area of 91.85 lakh hectares, with an average productivity of 895 kg ha^{-1} (FAO, 2010) .Despite its high morphological variability, genetic variation is limited probably due to its monophyletic descendence from *Cicer reticulatum*. Induced mutation by physical and chemical mutagens has played an important role in origin of new cultivars in pulse crops. Although extensive studies have been undertaken on mutagenesis and its utilization for improving pulse crops. Determination of a suitable concentration of chemical mutagen for a particular cultivar is of primary importance in studies on mutation breeding. Higher dose produces very drastic effect that may lead to death of the organism, whereas, a relatively lower dose often results in altered growth characteristics (Fowler and Macqueen, 1972). Hence, the present investigation was undertaken to elicit the response of chickpea genotype BG-256 to different concentrations of EMS. Any mutants recovered will have the advantage of improvement in the desirable traits of the crop.

The chickpea genotype BG-256, developed by Indian Agricultural Research Institute (IARI) with pedigree (BG-62 × K-850-3/127) × (2250 × H 75-35) has included in the present investigation. Samples of dry seeds of chickpea genotype BG-256 were soaked for 12 h in distilled water at room temperature (24°C). 300 seeds were treated with two dosages of EMS (0.5% and 1% v/v concentration) for 4 hours. Treated seeds were washed thoroughly under running tap water for 1 hour to remove the residues of the chemical, and then used for rising M1 generation. Hundred seeds of each treatment were grown in randomized block design with three replications during 2013. The data relating to seed germination and survival, floral and pollen fertility were recorded from entire plant population during M_1 generation. The pollens fertility was examined using Alexander's stain. The fertile pollens took stain whereas sterile one remains unstained.

The germination percentage in M1 generation for two mutagenic treatments revealed that seed germination percentage was drastically decreased (8%) at higher concentrations of EMS. Similar inhibitory effect on seed germination by the mutagens was reported earlier in mungbean (Khan *et al.,* 2006). However the number of plants survived till maturity was reduced in all the treatments as well as control. Since the 1 % EMS concentration was found almost at the lethal dose-50 (LD-50) for chickpea. The M1 seeds lost its germination up to 60-90% from the effect of EMS, while, some seedling from both 0.5% and 1% EMS

Table 1. Effect of different concentrations of EMS on various characters in M1 generation of chickpea variety BG-256

Treatment	Germination (%)	No. of plant survived	Pollen fertility (%)	Day to first flowering	Day to maturity	Pod $plant^{-1}$
Control	70.0	195.0	84.0	78.0	119.0	56.0
0.5% EMS	43.0	97.0	62.0	80.0	122.0	29.0
1% EMS	8.0	20.0	18.0	83.0	132.0	5.0
CD(p=0.05)	5.6	6.3	8.5	6.2	6.4	5.9

treatments showed xantha and chlorine type leaf chlorophyll mutation and died prematurely (Fig. 1C). Samiullah *et al.* (2005) also revealed the similar results in chickpea verities of Avrodhi and BG-256.

The pollen fertility was reduced significantly and only 18% fertile pollens were observed in 1% EMS treated plants whereas 0.5 % treated plants showed 62 % fertile pollens. The appearance of first flowering was non-significant in both the EMS treatment as compare to untreated control. Number of pods per plant was varied significantly in both the treatments as compared to untreated control and only 5 pods per plant were recorded in 1 % EMS treated plants, it revealed that drastic reduction in plant yield.

In the present investigation a notable flower colour

Fig. 1. Untreated control with pinkish red color flower (A) 1% EMS treated plant with white color flower (B) 0.5% EMS treated plant showing leaf chlorophyll mutation (c)

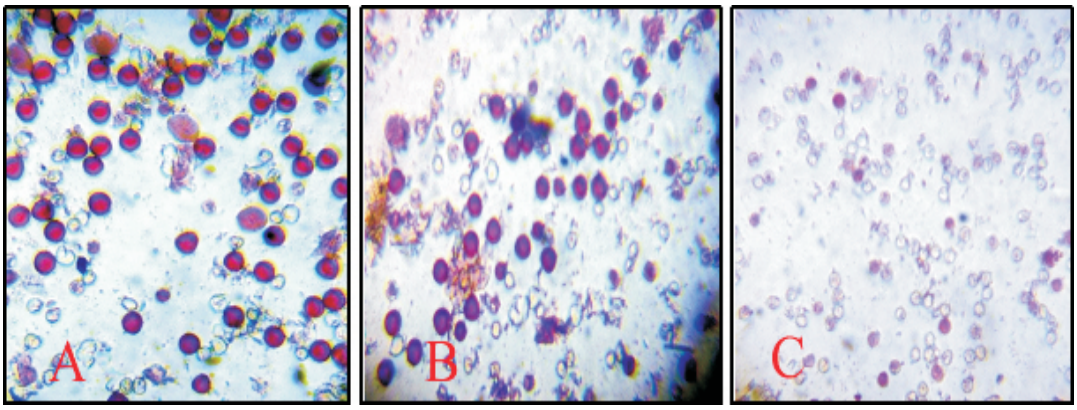

Fig. 2. Effect of different EMS concentrations on pollen fertility of chickpea cultivar BG-256 (A) control (B) 0.5% EMS treatment (C) 1% EMS treatment

Fig. 3. Flower color mutant of chickpea cultivar BG-256, showing white color flower as result of 1% EMS treatment and untreated control with pinkish red color flower

mutant was also observed in 1% EMS treated plant of chickpea variety BG-256, it needs further study in the subsequent generation. The mutant plants appeared with flower of white petals, wings and keel instead of pinkish red flower in control (Fig. 3). These changes in the M_1 generation might be due to immediate effect of mutagens and its nature has to be confirmed in the M_2 generation. The same phenomenon was also observed in the EMS treated plants of chickpea (Atta *et al.,* 2003: Khan *et al.,* 2004).

The foregoing observations depict the effective usefulness of the Ethyl methane sulphonate (EMS) for induction of mutations in chickpea. The 1% EMS concentration showed almost complete lethality whereas, the low concentrations of 0.5% EMS was found to be more or less safe treatment. It suggests that EMS concentration below 1% would be suitable for chickpea to give better result in creating genetic variability.

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Periodic Application of Fertilizers in Kinnow Mandarin for Plant Growth and Fruit Yield

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Abstract: The effect of splitting of nutrients on vegetative performance and quality of 5 years old Kinnow mandarins raised on rough lemon rootstocks at 6x6m spacing was studied at RRS, Bathinda. The nutrients were applied at six different stages in split doses of nitrogen and phosphorus. Maximum increase in plant height, scion girth fruits/plant, average fruit weight and yield was observed in T_1, whereas, maximum increase in spread was observed with recommended package of practice for cultivation. Fruit quality in terms of juice content, TSS and acidity were not affected. Leaf nitrogen and calcium content was influenced by stage wise application of nutrients but phosphorus and potassium contents were not affected by any of the treatments. Leaf magnesium content showed little response to split application of nutrients.

Key Words: Fertilizer, Growth, Leaf nutrient content, Split application, Yield

Nutrition has become an increasingly important consideration in management of Kinnow. Crop is nutrient loving and responsive, therefore, it requires adequate nutrition for proper growth and development. The bearing trees remove considerable amount of nutrients from the soil and these must be replenished to maintain soil fertility to get sustainable yields of good quality fruits. The nutrition has gained much importance to affect the vigour and fruit yield. Kinnow mandarin has a special importance for its taste, brilliant color and flavor. Plant nutrients are indispensable for their growth but these are not synthesized by the plants. Therefore, all of the essential elements must be present in optimum amounts and forms in the soil. Out of these elements, N is required in abundance both for vegetative and reproductive growth of plant. Kinnow trees require a balanced mixture of NPK during early stage of vegetative growth, blooming and at fruit set to strengthen tree structure and also maximize the number of flowers that ultimately increase fruit yield. Yaseen and Ahmad (2010) while studying the nutrition management in citrus explained that plant nutrient management can influence the amount of vegetative growth and fruit characteristics. By carefully choosing the fertilizer programme, the grower can nudge a crop toward heavier and good quality crop (Abd-Allah, 2006, Alva *et al.,* 2006). A balanced dose of NPK fertilization is required at right time, place and amount to maintain healthy growth, fruit quality and yield. Saleem *et al*. (2005) found that the split application of compound fertilizer was more effective than single application of the same or simple fertilizer.

Maintaining health of Kinnow plants by nutrition management is need of horticulture industry. There is tremendous scope to boost growth, production and quality of Kinnow fruits through proper cultural practices and maintenance of suitable nutrition level in trees. Split fertilizer applications can play an important role in a nutrient management strategy. Hence, the present investigations were undertaken with a perception to optimize the best dose and stage of NP fertilization in comparison to dose of traditional fertilizers.

The experiment was conducted on five years old Kinnow mandarins raised on rough lemon rootstocks at 6x6m spacing at RRS, Bathinda to find out the appropriate nutrient spliting for Kinnow in arid-irrigated region. The nutrients were applied at six different stages (January-February, March-April, May-June, July-August, September-October and November-December) in split doses of nitrogen and phosphorus (treatment details in Table 1). The statistical analysis of data was done using RBD with five replications. Nitrogen and phosphorus was applied in urea & DAP form. Potassium was not applied as it is not recommended and already available in sufficient range in soil. The cultural practices were followed as recommended by PAU, Ludhiana.

The tree vigor of Kinnow mandarin was measured on the basis of gain in height, spread and scion girth at the start and after termination of the experiment. The height and tree spread of each selected tree was measured with the help of calibrated bamboo stick. To get a tree spread (canopy diameter), two observations, one each on east-west and north-south sides of selected tress were recorded. The circumferential measurement was taken 5 cm above the bud union in the budded plants for trunk girth. All the values were expressed in centimeters and percentage increase over

initial value was calculated. The percentage of the juice was calculated on fresh weight basis. The chemical characters like TSS and acidity were measured as per standard procedures of AOAC (1990).

Among growth parameters, the maximum increase in plant height and scion girth was observed in T_1 with 4.27 and 14.16 per cent increase in plant height and scion girth, respectively (Table 2). The maximum increase in plant spread was recorded in T_4 treatment with 22.98 and 20.49 per cent increase in plant spread (E-W and N-S, respectively). Junior *et al*. (2012) also advocated that the application of N in 3 or 4 splits during the year increases fertilizer efficiency by reducing losses of soil nutrients with water drainage, and favours proper timing of nutrient supply at different stages of development of citrus (flowering to fruit maturation). They recommended applying 30 to 40% of N and K at flowering. However, further they elucidated that when leaf N levels are below the recommended dose, trees may suffer from gradual reduction in growth and lead to losses in fruit production.

The maximum number of fruits/plant (290.80), average fruit weight (164.52g) and yield (47.84 Kg/tree) was registered in T_1 (Table 2). Split application may have resulted in the greater increase in cross sectional area, height and spread that ultimately increased fruit yield in the tree. Fruit quality, however, in terms of juice content (47.32%), TSS (11%) and acidity (0.86%) was not affected by any of the treatment. Obreza *et al*. (2006) also documented the advantage in making split fertilizer applications in citrus throughout the season to reduce exposure to leaching due to rains or excessive irrigation and enhance overall growth of tree and achieve maximum yield/fruit quality. Srivastava and Singh (2006) also supported the results that adequate and regular fertilization results in good quality citrus production.

Leaf nitrogen content was found more (2.56 per cent) in T_3 and T_4 and minimum in T_1 (2.25%) and T_2 (2.35%) at stage III (Table 3). At stage IV, maximum leaf nitrogen content was found in T_2 (2.65%) and T_4 (2.59%) and minimum in T_3 and T_1, whereas, at stage V there was no significant difference in N content under different treatments. However, at stage VI maximum content was recorded in T_2 (2.59%) and minimum in T_3 (1.89%). Phosphorus and Potassium contents were not affected by any of the treatments, thus data not included in the table.

Calcium content was found in low range in all the treatments and stages. The minimum Ca content was observed in T_4 at all the stages and maximum in T_3 (2.53%) at stage IV. Magnesium content was not affected by any of treatments at stages III, V and VI but stage IV only. However, the maximum values were found in T_2 and T_3 treatments (Table 3). These results appear in lines with the previous findings of Tahair *et al*. (2005) and Saleem *et al*. (2005).

It is observed that the careful synchronization of nutrient supply, throughout the cropping season, allows soil nutrients to be available to the tree for various utilization processes. Fertilizer concentration must be maintained at

Table 1. Treatment details

Treatment	Percent RDF to be supplied through soil application											
	Stage I (Jan-Feb.)		Stage II (Mar-Apr)		Stage III (May-June)		Stage IV (July-Aug.)		Stage V (Sept.-Oct.)		Stage VI (Nov.-Dec.)	
	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5
T_1	0	0	40	50	40	50	20	0	0	0	0	0
T_2	0	0	30	40	30	35	20	25	10	0	10	0
T_3	0	0	30	40	30	35	40	25	0	0	0	0
T_4	Control (RDF) in split as per the package of practices of PAU											

*RDF – Recommended dose of fertilizer

Table 2. Effect of stage-wise nutrient application on per cent increase in growth, yield and quality of kinnow mandarin

Treatment	Plant height (cm)	Scion girth (cm)	Spread 'E-W' (cm)	Spread 'N-S' (cm)	Number of fruits plant^{-1}	Average fruit wt. (gm)	Yield (Kg tree^{-1})
T_1	4.27 (11.84)	14.16 (22.07)	8.33 (16.71)	12.00 (20.18)	290.80	164.52	47.84
T_2	3.52 (10.75)	04.80 (12.54)	22.83 (28.50)	18.90 (25.66)	278.80	157.28	43.85
T_3	4.19 (11.66)	06.14 (14.15)	18.85 (25.67)	16.60 (23.92)	287.80	143.74	41.37
T_4	2.02 (8.15)	12.35 (20.44)	22.98 (28.57)	20.49 (26.83)	269.00	153.58	41.31
CD (p=0.05)	2.02	1.86	3.08	4.02	17.33	15.41	6.2

Parenthesis values represent transformed values

Table 3. Effect of stage-wise nutrient application on leaf N, Ca and Mg contents of kinnow mandarin at different stages

Treatment	Nitrogen (%)				Calcium (%)				Magnesium (%)			
	III	IV	V	VI	III	IV	V	VI	III	IV	V	VI
T_1	2.25	2.50	2.28	2.41	2.20	2.43	2.27	2.20	0.34	0.38	0.35	0.36
T_2	2.35	2.65	2.22	2.59	2.45	2.40	2.17	2.12	0.36	0.40	0.36	0.38
T_3	2.56	2.34	2.38	1.89	2.40	2.53	2.27	1.83	0.36	0.42	0.36	0.38
T_4	2.56	2.59	2.38	1.90	1.83	1.77	2.05	1.83	0.35	0.36	0.36	0.35
CD (p=0.05)	0.20	0.21	NS	0.27	0.20	0.31	0.17	0.18	NS	0.03	NS	NS

optimum level to provide tree nutritional requirements without constraint. The timing of fertilizer application during peak periods of utilization is foremost important for adequate tree growth and to obtain healthy fruits.

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Maturity Standard in Plum (*Prunus domestica* L.) cv. Satluj Purple

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Abstract: An investigation was carried out in the Department of Horticulture, Khalsa College,Amritsar during the year 2013-14 to acknowledge maturity standard in Plum under Punjab conditions. In the study fruit samples from Satluj Purple plum trees growing on Kabul green gage rootstock were collected from 65 to 88 days after full bloom at variable intervals and analysed for physio-chemical changes. The results of the study showed that on the basis of fruit parameters, the maturity standard in this cultivar can be fixed between 84 and 86 days after full bloom under humid sub-tropical climate of Amritsar in Punjab.

Key Words: DFFB (Days from full bloom), Fruit physical and chemical characters, Kabul green gage rootstock, Satluj Purple

Plum (*Prunus domestica* L.) belongs to the group of deciduous fruits commonly known as stone or drupe fruit. It is a true fruit and is characterized by having a distinct three layered peri-carp, an exo-carp, meso-carp and a stony endo-carp, which encloses the seed. Off late, the cultivation of Satluj Purple plum has become exceedingly popular in Punjab due to its early ripening, better quality fruits and higher economic returns over all other sub-tropical plum cultivars. Harvesting of the fruit at its proper stage of maturity has a direct effect on the quality and shelf life thereby fetching higher premium to the grower as well as ensuring quality products to the consumers. The fruits remain starchy, poor in the quality and develop storage disorders when picked early too late. The present paper deals with devising the harvesting criteria of cv. Satluj Purple plum with a view to exploit and accomplish its excellent quality. Physio-chemical characters are the important parameters in determining the maturity of the fruits, which however, depends upon the cultivar.

The field experiment was conducted during 2013-14 in the orchard and Nursery of Department of Horticulture, Khalsa College, Amritsar. Five year old 12 trees of Satluj Purple plum having uniformity in size and vigour were selected from college orchard. The plants were raised on Kabul green gage rootstock and given uniform cultural treatments throughout the period of study.Healthy and uniform sized fruits were marked all around the selected trees, approximately at shoulder height. The samples each comprising of ten fruits, were taken 65 days after full bloom and subsequently at varying intervals till the fruits were over matured. The observations on various aspects of physico-chemical characters of the fruits were recorded as per the standard procedures given in AOAC (2000) and the data analysed by following Randomised Block Design.

The data presented in Table 1 indicate that the fruit diameter and weight of Satluj Purple plum showed a significant increase on each observation right from the first date of sampling on 65 days after full bloom on April 4 to 84 days after full bloom on May 13 and a decreasing trend till last date of observation on 88 days after full bloom (May 17). The pulp/stone ratio registered almost the same pattern and trend but the increase was not well marked after 80 days of full bloom. These observations confirm the earlier findings of Singh (2000) who also reported these parameters as good indicators of fruit maturity.

The fruit colour underwent vast changes with the advancement of the maturity being green on the first date of observation, reddish colouration after 80 days, crimson red with moderate bloom after 82 days and bright crimson with intensified bloom afterwards, which covered entire red surface giving the fruit a very attractive appearance onwards. Such type of colour change was considered to be an important indices in fixing maturity standard in plum (Tandon, 2006). The specific gravity of the fruits decreased significantly upto 86 days after full bloom and become constant thereafter. The decrease was well marked after 84 days of full bloom when it gave the value of 1.00 and the fruits were considered to have attained the maturity stage. These results are in agreement with the earlier findings of Bal *et al.* (1990)

TSS and Total sugars were low in the immature fruits (Table 2) but showed an increasing trend as the fruits approached maturity but the significant increase in TSS was

Table 1. Physical characteristics of plum cv. Satluj Purple

Date of observation	Days after full bloom	Fruit diameter (cm)		Fruit weight (g)	pulp/stone ratio	Fruit colour	Specific gravity
(2013)		Length	Breadth				
April 24	65	3034	3.16	15.26	10.22	Green	1.08
May 1	72	3.60	3.40	20.01	13.00	Yellowish green with pink red tinge	1.06
May 6	77	3.70	3.52	24.32	15.00	Yellow with red tinge	1.05
May 9	80	3.76	3.60	26.41	15.82	Reddish coloration	1.03
May 11	82	3.80	3.66	26.98	15.96	Crimson red	1.02
May 13	84	3.84	3.72	27.22	16.01	Bright crimson red	1.00
May 15	86	3.81	3.70	27.20	16.00	Bright crimson red	0.99
May 17	88	3.80	3.69	27.02	15.99	Bright crimson red	0.99
CD (0.05)		0.02	0.03	0.14	0.20	Bright crimson red	0.01

Table 2. Chemical characteristics of plum cv. Satluj Purple

Date of observation	Days after full bloom	TSS (%)	TSS/Acid ratio	Acidity (%)	Total sugar (%)	Ascorbic acid
April 24	65	8.71	5.92	1.47	5.32	4.73
May 1	72	9.25	7.00	1.32	6.02	5.23
May 6	77	10.30	9.73	1.11	7.67	5.91
May 9	80	11.95	14.40	0.83	9.57	5.22
May 11	82	12.40	15.69	0.79	10.62	4.60
May 13	84	12.50	16.66	0.75	10.98	4.20
May 15	86	12.57	17.00	0.74	11.20	3.92
May 17	88	12.60	17.26	0.73	11.24	3.80
CD (0.05)		0.15	0.27	0.02	0.28	0.27

registered upto 82 days and the total sugars upto 84 days of full bloom.The increase in their level with the advancement of maturity may be due to conversion of starch and other polysaccharides into sugars. These results are in line with the findings of Singh (2000).The acidity levels of the fruits was recorded maximum during the initial stage, which decreased rapidly and significantly afterwards.The TSS/acid ratio followed the same trend as observed in case of TSS and total sugars. There was a significant increase in TSS/acid ratio upto 86 days of full bloom. Dhuria *et al*.(1978) in Santa Rosa, Singh *et al*.(1990) in Kala Amritsari and Kataru Chak and Singh (2000) in Satluj Purple plum used physio-chemical characters such as fruit size, fruit weight, specific gravity, TSS and acidity as reliable criteria in fixing the maturity standard of the fruits.

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Performance of Wheat+Chickpea Intercropping under Limited Moisture and Organically Manured Conditions

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Abstract: Wheat+chickpea row ratio of 2:1 gave significantly higher grain yield of wheat (54.6 q ha^{-1}) than sole wheat (46.7 q ha^{-1}), whereas, wheat grain yields of wheat+chickpea row ratios of 1:1 and 3:1 were statistically at par with sole wheat. Chickpea gave significantly higher seed yield as sole crop than that of all the wheat+chickpea row ratios. Wheat+chickpea in 2:1 row ratio gave significantly higher wheat equivalent yield, gross net returns, benefit cost ratio and land equivalent ratio than sole wheat.

Key Words: Chickpea, Intercropping system, Limited moisture, Organic, Row ratio, Wheat

Wheat (*Triticum aestivum L.*) is the world's most important crop and is a staple food of about one third of the world's population (Hussain *et al.,* 2002). The wheat in Punjab is generally grown as an irrigated crop except sub-mountainous areas, where considerable wheat area is rainfed. Pulse crops have played an important role in Indian agriculture. India stands first in the world in area and production of pulses, but still there is a wide gap between demand and supply of pulses. The ability of leguminous crops to use atmospheric nitrogen through biological nitrogen fixation (BNF) is economically more sound and environmentally acceptable. Nitrogen fixation by legumes is further enhanced when associated with cereals as the excessive nitrate in the root zone fixed by legumes is utilized by cereals (Fujita *et al.,* 1992). The chickpea when intercropped in wheat, being legume will provide nutrition to wheat through N fixation and consume less water and that also from different soil layers as that of wheat. Wheat+chickpea intercropping is generally not successful under irrigated conditions due to poor performance of chickpea if wheat is irrigated as per the recommended irrigation schedules. So the successful intercropping of these crops can be done only under limited irrigations. Moreover, wheat and chickpea both are in demand as organic products. Though organic farming is gaining importance but it is not practicable to go in for organic wheat production in whole Punjab. It can be practised in some specific areas like *kandi* area of Punjab (areas adjoining to Himachal boundary) where fertilizer consumption is less due to limited supply of water. Intercropping of chickpea in organically manured wheat can be a better option in this area for enhanced production and economics.

The field experiment was conducted in the Department of Agronomy, Punjab Agricultural University, Ludhiana (30º 54' N latitude and 75º 48' E longitude at a height of 247 metres above the mean sea level) during *rabi* season 2013-14. The site has been characterized by sub-tropical and semi-arid type of climate with average annual rainfall is 500-750 mm. The soil of the experimental field was loamy sand having normal pH (7.8), low organic carbon (0.36%), low available nitrogen (125.4 kg ha^{-1}), high available phosphorus (52.3 kg ha^{-1}) and medium available potassium (147.5 kg ha^{-1}). Farmyard manure (1.2% N, 0.63% P and 0.82% K) was applied to the field to supply 80 kg N ha^{-1} to wheat. The total rainfall received during the crop season was 192.0 mm. Nine combinations of wheat+chickpea row ratios along with sole wheat and chickpea were evaluated in randomized complete block design with four replications. The treatments consisted of sole wheat, sole chickpea, wheat+chickpea in the ratio of 1:1, 1:2, 1:3, 2:1, 2:2, 2:3, 3:1, 3:2 and 3:3.

Wheat variety PBW 644 and chickpea variety GPF 2 were sown at 8 and 12 cm depth, respectively with a seed drill at row spacings of 30 cm on 25th October, 2013. A seed rate of 100 kg ha^{-1} for wheat and 45 kg ha^{-1} for chickpea was used. Seeds of chickpea were treated with *Rhizobium* culture. A plant to plant distance of 10 cm in chickpea was maintained by thinning after 10 days of emergence of the crop. The harvesting of wheat was done manually on 18th April, 2014 and the harvesting of gram was done on 6th May, 2014.

The highest grain yield (54.6 q ha^{-1}) was recorded in wheat+chickpea (2:1) and it was statistically at par with

wheat+chickpea (3:1) but significantly higher than sole wheat and other wheat+chickpea combinatioins (Table 1). Grain yields of wheat+chickpea in the row ratio of 1:2, 2:2, 2:3, 3:2 and 3:3 were statistically at par among each other. The higher grain yield in wheat+chickpea (2:1) and wheat+chickpea (3:1) row ratios might be due to relatively higher wheat population as compared to other row ratios and improvement in yield attributing characters which might have resulted due to the contribution of nitrogen by chickpea and higher availability of soil moisture especially under limited nutrition and moisture conditions. Dhakad *et al.* (2005) also reported significantly higher grain yield of wheat in wheat+chickpea (2:1) row ratio than other wheat+chickpea row ratios.

Sole chickpea gave significantly higher seed yield (11.9 q ha^{-1}) than all the wheat+chickpea row ratios (Table 1). Wheat+chickpea (1:3) gave significantly higher seed yield than all the other wheat+chickpea row ratios except wheat+chickpea (1:2). The highest seed yield in sole chickpea might be due to least competition to the chickpea plants by wheat and also due to proportionally higher area under chickpea. The lowest seed yield in wheat+chickpea (3:1) might be due to proportionally less area under chickpea in this combination. Wheat+chickpea (2:1) with higher grain yield of wheat gave significantly lesser seed yield of chickpea than all the wheat+chickpea row ratios except wheat+chickpea (3:1) and wheat+chickpea (3:2) where it was statistically at par.

Wheat equivalent yield: Maximum wheat equivalent yield (64.2 q ha^{-1}) was recorded in wheat+chickpea (2:1) row ratio, which was statistically at par with wheat+chickpea (1:1, 1: and 3:1) row ratio and was significantly higher than all the other wheat+chickpea row ratios. The wheat+chickpea row

Table 1. Effect of intercropping system on wheat grain yield, chickpea seed yield, wheat equivalent yield (WEY) and land equivalent ratio (LER)

Intercropping system	Wheat yield (q ha^{-1})	Chickpea seed yield (q ha^{-1})	WEY (q ha^{-1})	LER
Sole wheat	46.7	-	46.7	1.00
Sole chickpea	-	11.9	29.7	1.00
Wheat+chickpea (1:1)	43.5	6.57	59.9	1.50
Wheat+chickpea (1:2)	35.6	7.90	55.4	1.45
Wheat+chickpea (1:3)	24.8	8.26	35.5	1.23
Wheat+chickpea (2:1)	54.6	3.82	64.2	1.53
Wheat+chickpea (2:2)	38.2	5.94	53.1	1.30
Wheat+chickpea (2:3)	36.2	6.99	53.7	1.35
Wheat+chickpea (3:1)	50.1	3.28	58.3	1.33
Wheat+chickpea (3:2)	37.7	4.22	48.3	1.18
Wheat+chickpea (3:3)	39.6	5.36	53.0	1.28
CD (p=0.05)	5.0	1.58	10.1	0.15

Table 2. Effect of intercropping system on gross returns, net returns, variable cost and benefit cost ratio

Intercropping system	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Variable cost (Rs ha^{-1})	B: C
Sole wheat	79,892	52,694	27,198	2.94
Sole chickpea	41,545	20,075	21,470	1.93
Wheat+chickpea (1:1)	97,483	70,199	27,284	3.57
Wheat+chickpea (1:2)	89,332	65,021	24,311	3.68
Wheat+chickpea (1:3)	71,887	47,135	24,752	2.90
Wheat+chickpea (2:1)	1,04,972	80,535	24,437	4.30
Wheat+chickpea (2:2)	86,537	59,253	27,284	3.17
Wheat+chickpea (2:3)	87,318	63,586	23,733	3.68
Wheat+chickpea (3:1)	95,961	70,128	25,833	3.72
Wheat+chickpea (3:2)	80,010	55,593	24,417	3.28
Wheat+chickpea (3:3)	86,782	59,498	27,284	3.18
CD (p=0.05)	6658	6658	-	0.27

ratios of 1:1, 2:1 and 3:1, though were statistically at par with each other, but recorded significantly higher wheat equivalent yield than sole wheat. Sole chickpea recorded the lowest wheat equivalent yield (29.7 q ha^{-1}) and it was statistically at par with wheat+chickpea (1:3) row ratio (35.5 q ha^{-1}).

Land equivalent ratio: Intercropping system of wheat+chickpea (2:1) recorded maximum land equivalent ratio (LER) of 1.53, which was statistically at par with wheat+chickpea 1:1 and 1:2 row ratio (1.50 and 1.45, respectively) and was significantly higher than all the other wheat+chickpea intercropping systems.

Economic analysis: All the wheat+chickpea row ratios recorded significantly higher gross and net returns as compared to the sole cropping of chickpea and wheat except the wheat+chickpea 2:2 and 3:2 row ratios, which were statistically at par with sole wheat and wheat+chickpea (1:3). Intercropping system of wheat+chickpea (2:1) recorded significantly highest net returns and benefit cost ratio (Rs 80,535 ha^{-1} and 4.3, respectively) than all other intercropping and sole crop treatments. Lowest net returns and benefit cost ratio (Rs 20,075 ha^{-1} and 1.93, respectively) were recorded in sole chickpea. Chickpea can successfully be grown in organically manured wheat under limited moisture at 2:1 row ratio to get higher wheat grain yield and economic gains than sole wheat.

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Wheat and Barley Crop Performance under Different Sowing Methods under Poplar based Agroforestry System

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Abstract: Two cereal crops, wheat and barley performance was assessed under different age poplar trees with different sowing methods. Significant differences for growth and crop yield were observed under canopy than in open condition in both the crops. Crop performance on raised bed and normal sowing was non-significant but better than other sowing methods i.e., zero tillage and open furrow method.

Key Words: Agroforestry, Barley, Cereal crops, Cultivation methods, Poplar, Wheat

Agroforestry, one of the important alternative for diversification in traditional crop rotations is gaining importance in irrigated agro-ecosystem for economics and ecological services. The shortage of timber for domestic and industrial use has cautioned to look for alternatives, and the short rotation fast growing species like *Populus deltoides, Eucalyptus tereticornis, Gmelina arborea, Melia composita, Leucaena leucocephala, Salix alba, Casuarina equisetifolia,* etc. have raised the hope for sustainable higher productivity upto 20-25m^3 ha^{-1} yr^{-1} against less than 1m^3 ha^{-1} yr^{-1} in India's forests (Lal 2007). Poplar based agroforestry system has been recognized a viable land use system in Punjab and adjoining states to prevent land degradation and obtain higher biological production on sustainable basis. This system provides various products, which contributes to commercial and subsistence in agricultural productivity as well as to farm family livelihood (Chauhan and Mangat, 2006). Practically, it is not possible to divert as such the fertile agricultural land to forestry in view of prevailing socio-economic and agro-climate conditions favourable for agriculture in Punjab. Therefore, the available option is to integrate both the combination to meet the aspiration of multiple products and environmental stability.

Much has been explored with reference to the increasing direct financial returns and environmental services in agroforestry systems, but realization has been slightly discouraging in different regions. Natural resources exploitation (water, nutrients, etc.) by the short rotation trees has been highlighted (Zomer *et al.,* 2007; Durai *et al.,* 2009) for necessary remedial measures for long term sustainability of the system but intensive sole agricultural management is also depleting the resources and increasing the production cost. Conservation agriculture is a long term strategy to offset some production cost and conserve natural resources as well. Change in growing crops on raised bed or zero till technology than flat fields have been found more effective in water conservation, reduced aeration stress and resulted in increased yield (Singh *et al*., 2008; Ram *et al.,* 2012). Therefore, a similar study was conducted under poplar canopy for two cereal crops i.e., wheat and barley to study the yield differences in different planting methods.

The study was carried out at the experimental area of the department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana, India. The research site is situated at 247m above the mean sea level and lies at 30°-54'N latitude and 75°-61'E longitude, which represent the central irrigated agro-climatic zone of the Punjab state. The region receives maximum rainfall of about 700 mm during July-September and a few occasional showers during winters. During this period, temperature fluctuates around 29.9°C. The wheat (PBW 343) and barley (PL 426) crop was sown in four different methods (zero tillage, raised bed, open furrow and normal flat bed sowing) under poplar and flat bed sowing as control in open. Wheat crop was raised for three years under three to five year poplars plantation whereas barley crop was raised for two years (under fourth and fifth year poplar canopy). The initial soil status of experimental site was loamy in nature with pH 7.5, available N, P and K as 202.80, 24.52 and 158.10kg ha^{-1}, respectively.

The crop plant height was recorded from randomly selected plants in each quadrat (1x1m^2) from ground level to the tip of plant at the time of harvesting. Number of grains per ear of the randomly selected ear heads were also recorded at the time of harvesting. Grain yield were recorded from 1m^2 quadrat from three spots and mean values represented the each replication. The average grain yield of each quadrat

was extrapolated to give per hectare value in quintals. Tree growth height, diameter and cropwn spread were also recorded for all the three years. The data generated for three years on trees/inter-cultivated crop were analysed and the significant differences between treatment means for growth, yield, biomass, etc. were tested at $p \leq 0.05$ using least significant difference test.

Crop yield and yield contributing parameters: An appraisal of the data presented in Table 1 revealed significant differences for plant height, number of grains per ear and grain yield in both the crops (wheat and barley) with respect to different sowing methods. The response effect on crops for growth and yield under tree canopy and open condition was significant. Crops differed for growth and yield significantly with higher values in open than under a poplar canopy. The reduction in plant height under poplar canopy may be due to the increase in competition for light/moisture, presence of poplar leaf litter mulch and modification of micro-environment (Sharma *et al.* 2005). Similarly, Nandal and Hooda (2005), Chauhan *et al.* (2007), Sharma and Dadhwal (2007) also reported lower plant height in wheat intercropped with poplar than open condition. Chauhan *et al.* (2010) and Verma *et al.* (2013) also reported similar results i.e., more grains ear^{-1} and total yield in open than under poplar during their study in different parts of Punjab. The crop yield declined with increase in age of poplar trees. The increase in age of poplar is associated with root and canopy development, this cause intense competition for light/nutrient/water, and thus, reduced the yield of both the cereal crops with increase in age of poplar plantation.

The grain yield under different cultivation methods under poplar canopy was at par with each other but significantly less than control. The plant height under poplar plantation irrespective of sowing method was statistically at par among themselves but significantly lower than control in wheat. However, some changes in trend in barley were observed. Number of grains ear^{-1} under poplar in zero tillage, open furrow and normal sowing were statistically alike. The number of grains ear^{-1} in plots without trees had maximum value, whereas, minimum was recorded in zero tillage. Reduction in zero tillage than other methods under poplar was observed though the differences were non-significant. Numerically higher yield was recorded in both the crops under raised bed planting through differences were non-significant than control plots. The reduction in wheat/barley yield under zero tillage system have been reported to partial crop residue retention and stubble removal by Huang *et al.* (2008) and Kienzler *et al.* (2012). The sowing methods enhance water use efficiency than normal sowing. Ram *et al.* (2012) reported 22.7% higher water use efficiency in raised beds than flat bed. Lal *et al* . (2012) also reported water saving and improvement in biological quality through conservation technologies. Kumar *et al.* (2010) and Jin *et al.* (2013) reported 40 per cent saving in irrigation water through furrow irrigated bed planting than flat planting and substantial saving in oxidation of carbon through conservation tillage. An increase of 1 ton of soil carbon pool of degraded cropland soils may increase crop yield by 20 to 40 kg ha^{-1} for wheat, 10 to 20 kg ha^{-1} for maize, and 0.5 to 1 kg ha^{-1} for cowpeas.

Tree parameters: Poplar plants were maintained in two different conditions i.e., with inter-cultivated crops and without inter-cultivation at 4x4m^2 spacing. Data recorded during the month of January for three years reflected

Table 1. Effect of poplar on yield and yield contributing parameters of wheat and barley* under poplar based agroforestry system

Parameters/ Treatments	Plant height (cm)			Grains ear^{-1}			Grain yield (q ha^{-1})		
	3rd year poplar	4th year poplar	5th year poplar	3rd year poplar	4th year poplar	5th year poplar	3rd year poplar	4th year poplar	5th year poplar
Zero tillage	74.8	73.75 (77.26)	71.0 (77.36)	43.58	35.31 (22.25)	36.3 (21.40)	30.4	24.67 (25.83)	26.0 (21.56)
Raised bed	80.6	75.64 (78.20)	76.0 (81.0)	44.15	39.43 (25.03)	39.3 (20.00)	34.9	31.15 (25.00)	27.13 (20.33)
Normal sowing	79.0	69.99 (80.25)	70.0 (80.0)	48.75	36.28 (20.00)	37.6 (17.68)	35.8	28.46 (26.45)	30.6 (19.00)
Open furrow	78.5	69.00 (85.00)	74.0 (88.0)	45.95	36.40 (23.00)	36.6 (19.5)	33.8	24.41 (18.54)	24.81 (18.00)
Control (normal sowing - no poplar shade)	91.3	80.60 (88.00)	82.0 (88.0)	49.9	44.48 (35.00)	44.2 (29.5)	45.3	42.93 (28.29)	42.0 (30.86)
CD (p=0.05)	4.66	3.90 (2.14)	2.33 (1.42)	1.42	2.78 (3.38)	5.36 (1.59)	2.64	6.66 (3.65)	4.28 (2.44)

*Barley crop parameters in parentheses

significant differences for tree growth between two growing environments. The pooled mean values revealed significantly better growth in agroforestry plantation than in pure sole plantation (15 and 12.5% increase in tree height and diameter at breast height, respectively) was probably due to the advantage of cultural practices being followed for the crop cultivation.

Wheat and barley yield parameters under poplar canopy though were less than open condition yet the poplar based agroforestry with traditional wheat crop offer an excellent opportunity for farm diversification and more income than sole cropping system. Even the cultivation of crops enhances the tree growth. Conservation agriculture improve soil quality and saves precious irrigation water as well.

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Effect of Sowing on Growth and Yield of Direct Seeded Basmati Rice Cultivars

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Abstract: The maximum productivity was obtained when direct-seeded crop was raised on 20th June. Short-duration, early-maturing 'Pusa Basmati 1121' variety excelled other medium- and long-duration varieties in all growth and yield determinants.

Key Words: Cultivars, Growth determinants, Rice, Sowing dates, Yield

Rice is grown in 114 countries across the world and on an area about 150 million hectares with annual production of over 525 million tons, constituting nearly 11 per cent of the world's cultivated land. In India, it is cultivated on an area of 36.95 million ha, which is maximum among all rice growing countries, with annual production of about 80.41 million tones and productivity of 21.77 q ha^{-1} (Anonymous, 2011). In Punjab, rice is grown as main *Kharif* crop and occupies 2.73 million ha with the production 12.9 million tones and an average yield of 57.42 q ha^{-1}.

The common method of rice cultivation in Punjab is transplanting the nursery. This technique is however, cumbersome, labor intensive and requires continuous ponding of water for initial 15 days, leading to loss of nutrients through leaching. Moreover, this practice is also a cause of concern for declining water table of majority of the areas of Punjab. Under such conditions direct seeding of rice is an affordable and suitable alternative to traditional transplanting of rice. It provides one of the options through which, saving in labor expenses, water use and optimum plant population can be achieved. Further, direct seeded rice, takes about a fortnight less to mature as compared to transplanted rice.

In transplanted basmati rice, a number of cultivars have been recommended by agricultural universities. These cultivars vary in their seedling vigour, weed competitiveness, vegetative growth habitats, lodging resistance, yield, etc. But under direct seeded conditions these cultivars may vary vegetative growth, nutrient requirement, weed management strategies, irrigation requirement, etc. Time of sowing is a vital aspect for higher productivity, advanced sowing leads to excessive vegetative growth and causes imbalance in source-sink relationship. There is need to find out optimum time for direct seeded basmati rice for different cultivars.

Three Basmati Rice cultivars viz. Punjab Basmati 2, Pusa Basmati 1121 and Basmati 386 were sown on 20th June,1st, 10th and 20th of July in a split plot design with four replications. Three cultivars were subjected to main plots and four dates of sowing as sub-plots. The seeds were sown by broadcasting method and were covered lightly with top soil and recommended practices were followed. Data on yield and growth parameters were recorded by using standard procedures.

Growth parameters: Plant height, tiller number, dry matter accumulation of test varieties varied significantly due to the variation of sowing dates. The Basmati 386 gave significantly taller plant height (116.3 cm) followed by Punjab Basmati 2 (113.3cm) and Pusa Basmati 1121 (109.4cm). Significantly highest number of effective tillers (156.6 m^{-2}) and dry matter accumulation (68.5 q ha^{-1}) were in Pusa Basmati 1121. The more dry matter accumulation observed in short stature plant of Pusa Basmati 1121 might be due to varietal characters.

Among sowing dates, significant variations in plant height was observed at all the periodic intervals. In taller plants, more effective tillers (173.7 m^{-2}) and more dry matter accumulation (71.9 q ha^{-1}) were observed in early sown crop (20th June) and these characters decreased with delay in sowing of crop. The length of vegetative phase of rice progressively reduced due to delayed sowing resulting in short plant height. More number of effective tillers with earlier sown crop may be attributed to favorable environmental conditions conducive for profuse tillering. These results are in conformity with the findings of Salam *et al* (2004) and Shin *et al* (2002).

Number of spikelets: Pusa Basmati 1121 produced maximum number of spikelets 61.5 per panicle and decreased progressively as the sowing was delayed up to 20th July. Higher number of spikelets 68.6 per panicle were produced when crop was sown on 20th June and it may be due to optimum number of tillers and effective tillers per

Table 1. Effect of sowing dates on yield attributing characters of direct seeded Basmati Rice cultivars

Treatment combinations	Plant height (cm) at harvest	Effective tillers (m^{-2})	Number of spikelets per panicle	Sterility (%)	Paddy yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Dry matter accumulation (q ha^{-1}) at harvest
Punjab Basmati 2	113.3	155.8	60.0	8.02	2.86	5.72	41.1	65.3
Pusa Basmati 1121	109.4	156.6	61.5	6.75	3.36	4.98	48.0	68.5
Basmati 386	116.3	151.0	56.6	9.43	2.45	6.72	34.6	62.7
CD (p=0.05)	2.2	NS	NS	0.87	0.39	1.1	6.2	2.1
Date of sowing								
20th June	118.5	173.7	68.6	9.46	3.35	6.70	47.3	71.9
1st July	116.5	164.7	64.6	8.59	3.19	6.38	45.2	70.4
10th July	110.5	157.7	60.3	8.31	3.03	6.06	43.5	62.3
20th July	105.7	121.8	44.1	6.90	2.04	4.08	36.4	57.3
CD (p=0.05)	NS	9.8	4.8	0.95	0.21	0.50	2.4	NS

square meter resulting in normal development of panicles. Similar findings have been reported by Lee and Jun (2000), who reported that spkielets per panicle were reduced as sowing was delayed.

Sterility percentage: Sterility was significantly more in Basmati 386 (9.43%) than Punjab Basmati 2 (8.02%) and Pusa Basmati 1121 (6.75%). Higher value for sterility percentage was observed in 20th June sown crop. The probable reason for the higher number of unfertilized and unfilled spikelets in 20th June sown crop might be due to more number effective tillers per square meter, which caused severe competition among spikelets and encouraged the occurrence of sterility.

Grain and straw yield: Pusa Basmati 1121 gave significantly higher paddy yield (3.36 t ha^{-1}) than Punjab Basmati 2 (2.86 t ha^{-1}) and Basmati 386 (2.45t ha^{-1}). The higher grain yield by Pusa Basmati 1121 may be attributed to more 1000 grain weight which varies because of genetic character of the crop variety. Moreover, because of photoperiod insensitive nature of the variety there may be better regulation of moisture and nutrition supplies. These data are in agreement with those reported by Pirdashfy *et al*. (2000), and Abou Khalifa (2007). Early sowing of crop on 20th June recorded higher paddy yield as compared to 20th July sowing. Paddy yield decreased by 5%,10% and 64%, respectively when crop was sown on 1st July, 10th July and 20th July. Higher paddy yield may be due to increase in cumulative mean value of temperature and sunshine hours and more number of tillers, number of effective tillers m^{-2}, number of spikelets per panicle and 1000 grain weight. Similar trend was observed in straw yield as well

Harvest index (%): Highest value of harvest index was noted in Pusa Basmati 1121(48%) and was significantly superior than Punjab Basmati 2 and Basmati 386. More harvest index of Pusa Basmati 1121 might be due to more assimilation and partitioning of photosynthates towards grains during grain filling stage, which is supported by better growth characteristics of the variety. Among sowing dates, higher value of harvest index was recorded in 20th June sown crop than 10th July and 20th July sown crops.

Pusa Basmati 1121 perform better under direct seeding method. The, optimum sowing time for growing under direct seeding method was 1st July to get maximum yield economically and ecologically than 10th July and 20th July sown crops.

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Effect of Intercropping System and Fertility Levels on Productivity, Quality and Economics of Pigeonpea [*Cajanus cajan* (L.) Millp.]

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Abstract: The pigeonpea + urdbean intercropping system recorded highest seed yield (1792.29 kg ha^{-1}) of pigeonpea as compare to pigeonpea + sorghum intercropping system. Among the fertility level, application of 100% recommended dose of fertilizer (RDF) + 2.5t vermicompost (VC) recorded maximum production (1831.82 kg ha^{-1}) of pigeonpea. The protein yield of pigeonpea was also improved under pigeonpea + urdbean (394.35 kg ha^{-1}) and 100% RDF + 2.5t VC level (432.06 kg ha^{-1}), which is necessary for human and animal health.

Key Words: Fertility levels, Intercropping, Pigeonpea, Quality, Yield

Pigeonpea is the fifth prominent pulse crop in the world and second in India after chickpea. It is one of the most important *kharif* pulse suitable for rainfed situation. It is grown worldwide mostly in tropical and subtropical countries for grain, green manuring, fodder and forage as sole crop, intercrop, mixed crop and in sequential cropping system. India ranks first with about 90% area and 85% production of world i.e., 2.89 million tonnes with productivity of 914 kg ha^{-1} (Ali and Gupta, 2012). The pigeonpea productivity is very low and had shown a declining trend in the recent years. Intercropping has been a popular practice in India as well as for several centuries. The initial growth of pigeonpea is very slow and the accompanying intercrops enjoy unrestricted growth, and experience almost no competition from pigeonpea during the first two months. By the time, the intercrop is ready for harvest in October-November, the pigeonpea crop gets well established with the roots penetrating deep down into the soil profile. It provide full opportunity for the long duration pigeonpea crop to grow during the next four to five months making more comprehensive use of land than by any alternate cropping system under rainfed condition (Rathod *et al.,* 2004). The low yield of pigeonpea is not only due to its cultivation on sub-marginal lands, but also because of inadequate and imbalance fertilization as well as continuous use of inorganic fertilizers, which decreased the productivity, sustainability, soil health and finally affecting environment (Singh, 2007). Eastern Uttar Pradesh has a major area under pigeonpea under rainfed condition. It is grown as a sole as well as intercropped with short duration crops. Eventually, an adequate fertilizer management appreciable for higher yield is needed to be worked out.

The experiment was conducted at Banaras Hindu University, Varanasi, Uttar Pradesh (2518 N latitude, 8303 E longitude and at altitude of 128.93 meters above mean sea level). The meteorological data collected from Meteorological department of Banaras Hindu University is depicted in figure 1. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (pH 7.6), low in available nitrogen (189.80 kg N ha^{-1}) and medium in available phosphorus (19.5kg P ha^{-1}) and potassium (200.3kg K ha^{-1}). The experiment comprised of two pigeonpea based intercropping systems (pigeonpea + sorghum and pigeonpea + urdbean) and six fertility levels [100% recommended dose of fertilizer (RDF), 100% RDF + 2.5t vermicompost (VC), 100% RDF + PSB + rhizobium (Rh), 50% RDF, 50% RDF + 2.5t VC and 50%RDF +PSB + Rh]. The cultivars, Bahar of pigeonpea, Pant U 19 of urd bean and GK-4031 of sorghum were used in the experiment. Growth parameters were collected by randomly selected fiveplants in each plot. The yield of each net plot was obtained and converted into kg ha^{-1}.The quality of grain was chemically analyzed for nitrogen and protein content. The grain and stalk sample were analyzed separately for N content by MicroKjeldhal method as described by Jackson (1973) and crude protein yield in grain (kg ha^{-1}) was obtained by multiplying the nitrogen content in grain with a standard factor, 6.25.

The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984). The differences in the treatment mean were tested by using critical difference (CD) at 5% level of probability.

The plant height of pigeonpea was significantly

higher in pigeonpea + urdbean intercropping system as compared to pigeonpea + sorghum intercropping system at 60, 120 and 180 DAS (Table 1). The fertility levels significantly affected growth parameters of pigeonpea. The maximum plant height of pigeonpea (89.73, 183.63 and 198.38 cm at 60, 120 and 180 DAS, respectively) was recorded under 100% RDF +2.5t VC ha^{-1} fertility level as compared to fertilizer levels. The lowest plant height was observed in 50% RDF fertility level at all growing stages. Among the different fertility levels, 100% RDF +2.5t VC recorded maximum dry matter in pigeonpea (18.67, 53.43 and 166.33 g at 60, 120 and 180 DAS, respectively), whereas, the minimum dry matter was recorded under 50%RDF fertility level. Similar results were also reported by Kumawat *et al.* (2012).

Yield: The maximum grain and stalk yield of pigeonpea were recorded 1792.3 and 7615.0 kg ha^{-1} under pigeonpea + urdbean intercropping system, which were significantly higher over rest intercropping system. These results were supported by Kantwa *et al.* (2006). Whereas, the fertility levels significantly affected yield of pigeonpea. The maximum grain (1831.82 kg ha^{-1}) and stalk yield (8221.61 kg ha^{-1}) were recorded with 100%RDF + 2.5t VC fertility level over rest. The grain yield under100% RDF +2.5t VC fertility level was recorded 2.61, 6.27, 6.34 and 9.89% higher as compared to 50% RDF + 2.5t VC, 100% RDF + PSB + Rh, 50% RDF +PSB + Rh and 100% RDF, respectively. The fertility levels of 100% RDF + PSB + Rh, 50% RDF + 2.5t VC, 50% RDF + PSB + Rh and 100% RDF were recorded 8.04, 8.27, 12.48 and 12.68 %, respectively, lower stalk yield as compare to 100%RDF + 2.5t VC fertility level.The minimum grain and stalk yield were recorded in the 50% RDF.

Quality traits: The nitrogen content and nitrogen uptake in grain (3.51% and 63.10 kg ha^{-1}, respectively) and stalk (0.99 % and 75.31 kg ha^{-1}, respectively) of pigeonpea were found significantly higher in Pigeonpea + Urdbean than Pigeonpea + Sorghum intercropping system. These results are in conformity with the findings of Jat and Ahlawat (2002). In fertility level, the maximum nitrogen content of grain (3.77 %) and stalk (1.02%) of pigeonpea were obtained under 100% RDF + PSB + Rh followed by 50% RDF + PSB + Rh, 100% RDF + 2.5t VC, 50% RDF + 2.5t VC and 100% RDF fertility level. Whereas, lowest nitrogen content of grain (3.18%) and stalk (0.93%) of pigeonpea were found in 50% RDFfertility level. The maximum nitrogen uptake of grain (69.13 kg ha^{-1}) and stalk (83.52 kg ha^{-1}) of pigeonpea were observed under 100% RDF + 2.5t VC fertility level, it was 9.12, 13.87, 17.97, 23.14 and 33.97% higher in grain and 12.33, 13.00, 20.92, 24.42 and 36.25% higher in stalk as compared to 50% RDF + 2.5t VC, 100% RDF + PSB + Rh, 50% RDF + PSB + Rh, 100% RDF and 50%RDF fertility level, respectively.

The maximum protein content (21.94%) and protein yield (394.35 kg ha^{-1}) in grain of pigeonpea were obtained under pigeonpea + urdbean intercropping system followed by pigeonpea + sorghum intercropping system. These results corroborated with Kothari *et al.* (2004). The fertility levels significantly affected either protein content or protein yield in grain of pigeonpea crop. The highest protein content (23.54 %) was observed under 100% RDF + 2.5t VC fertility level and it was 6.08, 7.10, 10.78, 11.88 and 18.29% higher than 50% RDF + 2.5t VC, 100% RDF + PSB + Rh, 50% RDF + PSB + Rh, 100% RDF and 50% RDFfertility levels, respectively. The protein yield in grain of pigeonpea revealed similar trend in fertility levels.

On the basis of experimental findings, it was concluded that maximum growth, yield attributes, yields and

Table 1. Growth attributes and yield of pigeonpea as influenced by intercropping system and fertility levels

Treatment	Plant height			Drymatter			Yield (kg ha^{-1})	
	60	120	180	60	120	180	Grain	Stalk
Intercropping system								
Pigeonpea + sorghum	73.7	167.8	185.2	16.5	49.1	160.2	1658.1	7159.6
Pigeonpea + urdbean	89.8	179.4	199.1	17.9	51.3	163.0	1792.3	7615.0
CD (p=0.05)	1.1	1.7	1.8	0.2	0.2	0.3	27.5	117.8
Fertility level								
100% RDF	75.6	167.1	189.8	16.6	48.3	162.8	1667.0	7179.3
100% RDF + 2.5t VC	89.7	183.6	198.4	18.7	53.4	166.3	1831.8	8221.6
100% RDF + PSB + Rh	84.6	176.5	193.4	17.7	51.1	157.3	1723.7	7560.8
50% RDF	73.7	165.2	187.3	15.8	47.0	160.2	1620.7	6624.9
50% RDF + 2.5t VC	87.6	178.1	192.3	17.5	51.6	163.4	1785.3	7541.8
50% RDF + PSB + Rh	80.6	171.0	189.6	16.8	49.8	161.2	1722.7	7195.3
CD(p=0.05)	0.5	0.8	0.8	0.1	0.1	0.1	12.3	52.7

Table 2. Influence intercropping system and fertility levels on quality of pigeonpea

Treatment	Nitrogen content(%)		Nitrogen uptake(kg ha^{-1})		Grain protein	
	Grain	Stalk	Grain	Stalk	Content (%)	Yield (kg ha^{-1})
Intercropping system						
Pigeonpea + sorghum	3.42	0.95	56.8	67.8	21.4	354.7
Pigeonpea + urdbean	3.51	0.99	63.1	75.3	21.9	394.4
...	0.02	0.00	0.5	0.4	0.1	3.2
CD (p=0.05)	0.05	0.01	1.5	1.2	0.3	9.3
Fertility level						
100% RDF	3.37	0.94	56.1	67.1	21.0	350.9
100% RDF + 2.5t VC	3.52	0.98	69.1	83.5	23.5	432.1
100% RDF + PSB + Rh	3.77	1.02	60.7	73.9	22.0	379.5
50% RDF	3.18	0.93	51.6	61.3	19.9	322.5
50% RDF + 2.5t VC	3.40	0.96	63.4	74.4	22.2	395.9
50% RDF + PSB + Rh	3.55	0.99	58.6	69.1	21.3	366.3
CD (p=0.05)	0.02	0.00	0.7	0.6	0.1	4.2

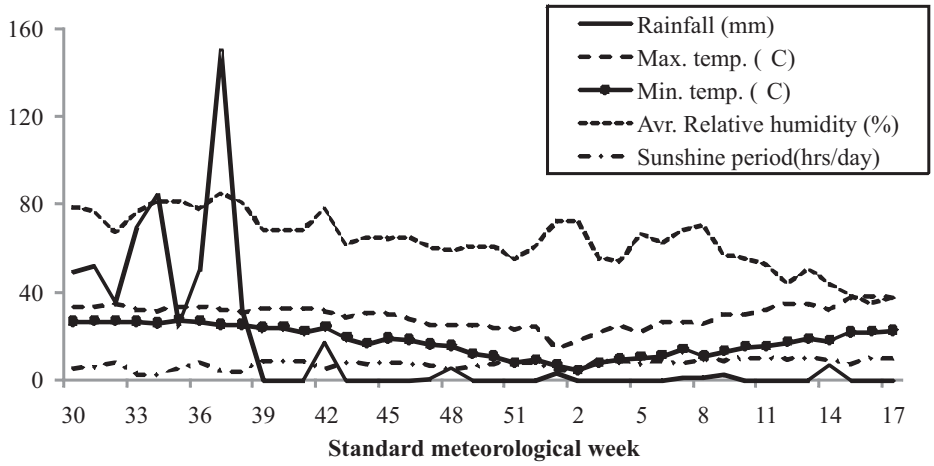

Fig. 1. Meteorological data during the cropping period of Pigeonpea intercropping

quality were found under pigeonpea + urdbean intercropping system. The highest growth, yield attributes, yield and quality were found with 100% RDF +2.5t VC fertility level.

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Genetic Variability Studies in Chilli (*Capsicum annuum* L.) for Yield and Quality Attributes

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Abstract: Genetic variability, heritability, and genetic advance as a per cent over mean for eleven characters were assessed by field evaluation of fifty chilli genotypes. High degree of variation was observed for all characters. The difference between phenotypic coefficient of variation and genotypic coefficient of variation were found to be narrow for most of the traits. The high estimates of heritability was found for number of fruits per plant at first picking (98.20%), total number of fruits per plant (94.67%), early yield (94.67%), late yield (95.62%) and total yield (91.37%), fruit length (96.22%), fruit width (96.22%), stalk length (81.04%) and ten fruit weight (96.44%), ascorbic acid (98.30%), chlorophyll-a (95.45%), chlorophyll-b (97.52%) and their total chlorophyll (97.87%).

Key Words: Ascorbic acid, Chlorophyll, Genetic variance, Genetic advance, Green chilli, Heritability, Phenotypicvariance

In India, chilli (*Capsicum annuum* L.) is grown over an area of 7.92 lakh hectares with a production of 12.23 lakh tonnes and the productivity of 1.5 tonnes per hectare (Anon, 2011). The productivity of the crop is low and there is need for development of new varieties and hybrids with high productivity. The critical assessment of nature and magnitude of variability in the germplasm stock is one of the important pre-requisites for formulating effective breeding methods as the genetic improvement of any crop depends on magnitude of genetic variability and the extent of heritability of economically important characters, though the part played by environment in the expression of such character also needs to be taken into account. Hence, the present study is undertaken to estimate the content of ascorbic acid and yield in fifty genotypes of chilli maintained at College of Horticulture, Bagalkot (Karnataka).

Fifty genetically diverse chilli accessions comprising of established varieties and advanced breeding lines were presented in Table 1 and accessions were grown in a randomized block design with three replications during *kharif* (2010-2011). Each experimental plot comprised of single row of ten plants. From each plot three plants were randomly selected for recording observations on number of fruits per plant at first picking, total number of fruits per plant, fruit length, fruit width, stalk length and ten fruit weight, ascorbic acid, chlorophyll-a, chlorophyll-b and their total. Genotypic coefficient of variation and phenotypic coefficient of variation were computed by the method of Burton and Devane (1953). Heritability (broad sense), genetic advance (GA) and genetic advance as a per cent over mean (GAM) were worked by the methods suggested by Falconer (1981) and Robinson *et al. (1949)*.

Table 1. Details of chilli accessions used in the experiment and their source of collection

Name	Source
SSD,Halga-Local,ChainaChilli (JintaVariety), BGM-Yellow, Intermediate Capsicum, CW X 1-CSPC, BGN2 X S-33, IC-SPC, NO-52, NO-58A, GCS-94-53, GPC-82, CW X NS-33, GCS-94-10, GC -0710, EC-28DPS-06-01, GC-0708, GC-07-03, CH-1, PMR-21 X PANT-C-1, HC-0708, EC-33DCS-06-01, GC-0705, HC-0705, HC-0707, GC-0702, HC-0715, EC-28-DPS-06-01, HC-0702, HC-0711, HC-0716, COS-1, EC-13DCS-06-01, EC-33DCS-06-02, HC-0718, ES-32-DPS-06-01, DC-10D-06-01, HC-0714	Regional Horticultural Research and extension centre, Kumbapur, Dharwad
Pusa-Jwala	Indian Institute of Agricultural Research Institute, New Dehli
Cholachagudda local (BCM-1)	Badami, Karnataka
ArkaLohith	Indian Institute of Horticultural Research, Bengalore
DCA-58, DCA-60, DCA-77, DCA-187, DCA-192, DCA-195, DCA-199, DCA-202, DCA-203	RHREC, Devihosur

The Best performing top ten genotypes of chilli for yield and quality attributes are presented in (Table 3). High heritability with high GAM was recorded for most of yield characters *viz.,* number of fruits per plant, early yield, late yield and total yield indicating the predominance of additive gene components in governing these traits. Thus, there is ample scope for improving these characters based on direct selection from the genetic stock studied.

The difference between the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were found to be narrow for most of the characters. The results suggest that these traits are least affected by environment and selection for these traits on phenotypic would be rewarding. For rest of the characters, the estimates of PCV were greater than GCV. This indicates that the variation for these traits is not only by genotypes but also due to environment. Selection based on phenotypes may mislead as their expression depends more on environmental factors. Similar observations were reported in chilli by Manjuand Sreelathakumary (2002) and Chattopadhyay*et al.,* (2011).

The high estimates of heritability for number of fruits per plant at first picking (98.20%),total number of fruits per plant (95.64%), early yield (94.67%), late yield (95.62%),total yield (91.37%), fruit length (91.22%), fruit width (96.22%), Stalk length (81.04%), ten fruit weight (96.44%), ascorbic acid (98.30%), chlorophyll a (95.45%), b (97.52%) and their total (97.87%)suggest that selection will be effective for these characters. In the present study, high heritability was accompanied with high values of genetic advance for early yield, late yield, total yield, ten fruit weight, and ascorbicacid indicating predominance of additive gene component. Thus, there is ample scope for improving these characters based on direct selection. High heritability with moderate genetic advance noticed for number of fruits per plant at first picking andten fruit weight implied equal importance of additive and non-additive gene action. These results are agreement with the earlier findings of Smitha (2006), Shirshat (2007) and Sharma *et al.,*(2010)**.** From the present study based on their *per se* performance (Table 3) the top performing genotypes, HC-0705, DCA-199, EC-28DPS-06-01, EC-33DCS-06-02, HC-0714, EC-33DCS-06-01 and SSD can be further assessed for stability so as to exploit them for commercial

Table 2. Estimates of mean, range, components of variance, heritability and genetic advance for growth, earliness yield and quality parameters inchilli (*Capsicum annuum*. L)

Character	Range	Mean	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
Number of fruits/plant at first picking	1.30-54.80	11.93	85.89	87.46	77.68	78.39	98.20	18.92	158.59
Total number of fruits/ plant	13.17-192.89	77.04	1579.28	1651.21	51.58	52.74	95.64	80.05	103.42
Early yield (g/plant)	35.80-387.60	155.98	4823.95	5081.71	44.52	45.70	94.67	139.02	89.12
Late yield (g/plant)	8.05-232.00	91.21	2341.63	2448.89	53.05	54.25	95.62	97.47	106.86
Total yield (g/plant)	69.15-549.40	247.26	8395.12	9187.87	37.05	38.76	91.37	180.42	72.96
Fruit length (cm)	2.30-12.35	6.16	4.68	5.14	35.14	36.80	91.22	4.26	10.79
Fruit width (cm)	0.35-3.60	1.44	0.63	0.66	55.39	56.47	96.22	1.61	111.80
Stalk length (cm)	1.15-3.90	2.58	0.30	0.38	21.53	23.92	81.04	1.03	39.92
Ten Fruit weight (g)	10.50-133.50	39.45	555.59	576.08	59.74	60.84	96.44	47.68	120.86
Ascorbic acid (mg/100 g)	30.00-247.50	86.01	1881.9469	1914.3488	50.43	50.86	98.30	88.60	103.01
chlorophyll-“a” (mg/100 g)	0.03-0.17	0.06	0.0007	0.0007	40.24	41.19	95.45	0.052	86.66
chlorophyll-“b” (mg/100 g)	0.03-0.17	0.06	0.0007	0.0007	41.56	42.08	97.52	0.053	88.33
Total chlorophyll (mg/100 g)	0.06-0.34	0.13	0.0027	0.0028	40.84	41.28	97.87	0.106	81.53

Table 3. The Best performing top ten genotypes of chilli for yield and quality attributes

S.No.	Characters	I	II	II	IV	V	VI	VII	VIII	IX	X
1	Number of fruits/plant at first picking	EC-28DPS-06-01 (26.50)	HC-0702 (26.15)	EC-33DCS-06-02 (25.15)	GC-0702 (23.15)	EC-33DCS-06-01 (21.50)	HC-0714 (20.65)	Pusa-Jwala (20.30)	SSD (19.65)	NO-58A (18.80)	HC-0716 (18.65)
2	Total number of fruits /plant	HC-0705 (192.89)	GC-07-03 (173.60)	GC-0702 (155.98)	NO-58A (146.92)	HC-0716 (129.50)	SSD (124.80)	DCA-195 (122.96)	GPC-82 (118.65)	HC-0715 (117.04)	GC -0710 (107.50)
3	Early yield (g/plant)	HC-0705 (387.60)	HC-0702 (320.45)	SSD (306.32)	EC-33DCS-06-02 (260.15)	EC-28DPS-06-01 (253.35)	HC-0714 (251.00)	HC-0716 (241.65)	BGN2 X S-33 (226.50)	Pusa-Jwala (214.50)	Intermediate Capsicum (207.00)
4	Late yield (g/plant)	GC-07-03 (232.00)	GPC-82 (200.00)	GC -0710 (173.15)	HC-0705 (161.80)	GC-0702 (158.15)	HC-0714 (157.15)	GC-0708 (140.5)	GC-0705 (134.30)	DCA-58 (123.80)	EC-28-DPS-06-01 (122.65)
5	Total yield (g/plant)	HC-0705 (549.40)	HC-0702 (411.45)	HC-0714 (408.15)	GC-07-03 (381.95)	SSD (375.45)	EC-28DPS-06-01 (369.85)	GC-0702 (358.75)	GPC-82 (356.45)	EC-33DCS-06-02 (351.65)	HC-0708 (350.60)
6	Fruit length (cm)	HC-0705 (12.35)	GCS-94-10 (9.90)	HC-0711 (9.60)	DCA-192 (9.60)	HC-0702 (9.45)	GC -0710 (9.40)	GPC-82 (8.65)	GC-0708 (8.55)	HC-0708 (8.50)	EC-28DPS-06-01 (8.35)
7	Fruit width (cm)	Cholachagudda local (BCM-1) (3.60)	CW X NS-33 (3.45)	CW X 1-CSPC (3.30)	Intermediate Capsicum (3.15)	BGM-Yellow (3.05)	ES-32-DPS-06-01 (3.00)	Halga-Local (2.2)	HC-0718 (2.00)	SSD (1.95)	CH-1 (1.95)
8	Stalk length (cm)	IC-SPC (3.90)	SSD (3.80)	GC-07-03 (3.60)	GCS-94-53 (3.20)	HC-0702 (3.15)	DCA-77 (3.15)	GCS-94-10 (3.1)	DCA-58 (3.10)	GPC-82 (3.05)	HC-0716 (3.05)
9	Ten Fruit weight (g)	HC-0705 (133.50)	HC-0708 (87.50)	Intermediate Capsicum (79.00)	CW X NS-33 (77.00)	EC-28DPS-06-01 (77.00)	BGM-Yellow (74.00)	Pusa-Jwala (72.5)	BGN2 X S-33 (70.00)	HC-0702 (60.50)	Halga-Local (57.50)
10	Ascorbic acid (mg/100g)	BGM-Yellow (247.50)	SSD (220.50)	Halga-Local (185.00)	Pusa-Jwala (155.00)	ChainaChilli (JintaVariety) (152.50)	GC-0702 (145.00)	GC-0710 (115)	DCA-77 (115.00)	NO-52 (110.00)	GC-0708 (95.00)
11	chlorophyll “a”(mg/100g)	Cholachagudda local (BCM-1) (0.17)	DCA-58 (0.15)	DCA-192 (0.12)	GC-0708 (0.09)	ArkaLohith (0.09)	DCA-195 (0.09)	DCA-199 (0.09)	DCA-202 (0.09)	Pusa-Jwala (0.08)	NO-58A (0.08)
12	chlorophyll-“b” (mg/100g)	Cholachagudda local (BCM-1) (0.17)	DCA-58 (0.15)	DCA-192 (0.12)	GC-0708 (0.09)	ArkaLohith (0.09)	DCA-195 (0.09)	DCA-199 (0.09)	DCA-202 (0.09)	Pusa-Jwala (0.08)	NO-58A (0.08)
13	Total chlorophyll	Cholachagudda local (BCM-1) (0.34)	DCA-58 (0.31)	DCA-192 (0.24)	GC-0708 (0.18)	ArkaLohith (0.18)	DCA-195 (0.18)	DCA-199 (0.18)	DCA-202 (0.18)	Pusa-Jwala (0.16)	NO-58A (0.16)

Mean of two replications are given in parenthesis of respective genotypes

cultivation as high fruit quality (ascorbic acid) genotypes.

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Evaluation of Plant Products as Impregnation of Packaging Material against *Tribolium Castaneum* (Herbst)

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Abstract: The plant materials, *viz*., neem seed kernel extract, karanj seed extract, neem oil and castor oil (5.0, 7.5 and 10%) were tested against *Tribolium castaneum* (Herbst) as impregnation of packaging materials (cloth and plastic fibre bags). Impregnation of bags with neem seed kernel extract, neem oil, castor oil at 10% was effective in reducing the adult emergence. The per cent weight loss in cloth and plastic bags impregnated with neem seed kernel extract at 10% was 1.8 and 1.13, which was found most efficacious in protecting the wheat flour from *T. castaneum.*

Key Words: Castor, Karanj, Neem, Seed oil*, Tribolium castaneum,* Wheat

A number of workers have suggested the use of fumigants and other chemicals to combat with the population of rust red flour beetle, *Tribolium castaneum* (Herbst) in the stored grains and stored products (Gillani *et al.*, 1994; Arthur, 1995) but toxic chemicals evidently pose several problems, *viz.,* chronic and acute toxicity, development of insect resistance, environmental pollution, etc. Therefore, to explore the safer methods with low cost for the management of the pest under question is prime objective of the study. The impregnation of packaging material is of practical significance in the management of stored grain pests as no toxic residue is left on the grain or grain product and such technique is also helpful in economical management of the target pest. The efficacy of some of the plant products, extracts and oils has been evaluated by Bareth and Gupta (1989), Yadav and Singh (1994) and Naga *et al.* (2007) but definite information on mortality dosages, efficacy of plant extract and plant oil treatments by impregnation of packaging materials and their residual life is meager and needs detailed investigation.

The plant materials, *viz*., neem seed kernel extract, karanj seed extract, neem oil and castor oil (5.0, 7.5 and 10.0%) were tested along with malathion 50 EC at 0.05 and 0.1% as check agaist the rust red flour beetle. The control (acetone and water spray) were used for comparison. The solutions of plant extracts and malathion were made in water while the solutions of oils were prepared in acetone. The cloth and plastic fibre bags of 12 x 15 cm^2 were used for the study and impregnated with plant extracts and oils, and finally kept for drying under shade. The flour (100 g) was filled in the bags treated with each treatment, replicated thrice. The closed bags were kept with *T. castaneum* infested stock to have the natural infestation. The observations were recorded on adult emergence and weight loss at fortnightly interval upto 150 days of treatment. The adult emergence was recorded at fortnightly interval by sieving the flour. After counting the emerged adults, these were discarded from the sample so as to avoid further counting of the same. The weight loss in flour due to incessant feeding by the grub and adult stage was recorded by sieving the flour to exclude the excreta and insect stages.

At 75 days after treatment (DAT), the adult emergence was zero in both the bags treated with neem and karanj seed extract at 7.5%, neem oil and, castor oil 5.0% and malathion 0.1% (Table 1). Similar trend was observed 105 days after treatment. In cloth bags, maximum adults (6.33) were emerged from control which differed significantly more or less over the treated bags, whereas, minimum in malathion 0.05% (0.33). The other treatments except karanj seed extract (1.00) revealed nil adult emergence.

The maximum number of adults (6.33) emerged in control (water). The karanj seed extract at 5.0% (4.67) differed non-significantly with control acetone (5.00). The minimum number of adults emerged from bags treated with neem seed kernel extract 7.5% (1.00), neem oil 10.0% (1.00) and malathion 0.1% (1.33). The rest of the plant products were in the middle order. Similar trend was observed 105 days after treatment.

Upto 60 days of impregnation of cloth and plastic fibre bags, no weight loss in wheat flour was observed. However, weight loss was observed at 75 DAT in cloth bag but weight loss was nil in plastic bag. Similar trend was observed in treated bags 75 DAT except karanj seed extract at 5.0, 7.5, 10%, neem oil 5.0, 7.5, 10%, castor oil 5, 7.5, 10% and malathion 0.1% was nil (Table 1). The minimum weight loss was in cloth bag in malathion 0.05% followed by karanj seed extract 5.0% but in control (water and acetone) in plastic bag.

Table 1. Effect of plant products impregnated packaging materials on the *T. castaneum* adult emergence and weight loss in wheat flour

S. No.	Treatment	Dose (%)	Cloth bags						Plastic fibre bags					
			Adult emergence after days of storage*			Weight loss after days of storage (%)**			Adult emergence after days of storage*			Weight loss after days of storage (%)**		
			75	105	150	75	105	150	75	105	150	75	105	150
1.	NSKE	5.0	0.00 (0.00)	1.67 (0.43)	3.67 (0.67)	0.00 (0.00)	1.27 (6.47)	3.40 (10.63)	0.00 (0.00)	1.33 (0.37)	2.33 (0.52)	0.00 (0.00)	1.27 (6.47)	3.40 (10.63)
		7.5	0.00 (0.00)	1.00 (0.30)	2.00 (0.48)	0.00 (0.00)	0.47 (3.93)	2.20 (8.53)	0.00 (0.00)	0.67 (0.22)	1.00 (0.30)	0.00 (0.00)	0.47 (3.93)	2.20 (8.53)
		10.0	0.00 (0.00)	0.00 (0.00)	1.33 (0.37)	0.00 (0.00)	0.00 (0.00)	1.87 (7.86)	0.00 (0.00)	0.00 (0.00)	0.67 (0.22)	0.00 (0.00)	0.00 (0.00)	1.87 (7.86)
2.	KSE	5.0	1.00 (0.30)	4.67 (0.75)	5.67 (0.82)	0.40 (3.63)	1.93 (7.99)	4.93 (12.83)	0.33 (0.12)	3.67 (0.67)	5.00 (0.78)	0.40 (3.63)	1.93 (7.99)	4.93 (12.83)
		7.5	0.00 (0.00)	2.67 (0.56)	5.67 (0.82)	0.00 (0.00)	1.40 (6.80)	3.53 (10.83)	0.00 (0.00)	2.00 (0.48)	4.00 (0.70)	0.00 (0.00)	1.40 (6.80)	3.53 (10.83)
		10.0	0.00 (0.00)	2.00 (0.48)	3.67 (0.67)	0.00 (0.00)	0.93 (5.33)	3.00 (9.97)	0.00 (0.00)	1.00 (0.30)	2.00 (0.48)	0.00 (0.00)	0.93 (5.33)	3.00 (9.97)
3.	Neem oil	5.0	0.00 (0.00)	2.00 (0.48)	3.67 (0.67)	0.00 (0.00)	1.47 (6.96)	3.80 (11.24)	0.00 (0.00)	0.67 (0.22)	3.33 (0.64)	0.00 (0.00)	1.47 (6.96)	3.80 (11.24)
		7.5	0.00 (0.00)	2.00 (0.48)	3.33 (0.64)	0.00 (0.00)	0.67 (4.70)	2.67 (9.40)	0.00 (0.00)	0.67 (0.22)	1.33 (0.37)	0.00 (0.00)	0.67 (4.70)	2.67 (9.40)
		10.0	0.00 (0.00)	1.00 (0.30)	1.33 (0.37)	0.00 (0.00)	0.53 (4.17)	2.40 (8.91)	0.00 (0.00)	0.33 (0.12)	1.00 (0.30)	0.00 (0.00)	0.53 (4.17)	2.40 (8.91)
4.	Castor oil	5.0	0.00 (0.00)	3.67 (0.67)	5.00 (0.78)	0.00 (0.00)	1.20 (6.29)	4.33 (12.01)	0.00 (0.00)	2.33 (0.52)	3.33 (0.64)	0.00 (0.00)	1.20 (6.29)	4.33 (12.01)
		7.5	0.00 (0.00)	2.67 (0.56)	4.67 (0.75)	0.00 (0.00)	1.33 (6.62)	3.13 (10.19)	0.00 (0.00)	2.33 (0.52)	2.67 (0.56)	0.00 (0.00)	1.33 (6.62)	3.13 (10.19)
		10.0	0.00 (0.00)	2.00 (0.48)	1.67 (0.43)	0.00 (0.00)	1.27 (6.47)	3.20 (10.30)	0.00 (0.00)	1.00 (0.30)	1.00 (0.30)	0.00 (0.00)	1.27 (6.47)	3.20 (10.30)
5.	Malathion	0.05	0.33 (0.12)	3.67 (0.67)	2.00 (0.48)	0.27 (2.98)	1.20 (6.29)	2.53 (9.15)	0.00 (0.00)	1.33 (0.37)	1.33 (0.37)	0.27 (2.98)	1.20 (6.29)	2.53 (9.15)
		0.1	0.00 (0.00)	1.33 (0.37)	1.67 (0.43)	0.00 (0.00)	1.13 (6.10)	2.40 (8.91)	0.00 (0.00)	0.67 (0.22)	1.00 (0.30)	0.00 (0.00)	1.13 (6.10)	2.40 (8.91)
6.	Control (acetone)	-	2.67 (0.56)	5.00 (0.78)	7.33 (0.92)	1.93 (7.99)	2.93 (9.86)	5.67 (13.78)	1.67 (0.43)	4.33 (0.73)	6.00 (0.85)	1.93 (7.99)	2.93 (9.86)	5.67 (13.78)
7.	Control (water)	-	6.33 (0.87)	6.33 (0.87)	8.00 (0.95)	2.20 (8.53)	3.27 (10.42)	6.33 (14.57)	5.67 (0.82)	6.33 (0.87)	7.33 (0.92)	2.20 (8.53)	3.27 (10.42)	6.33 (14.57)
	CD at 5%		(0.02)	(0.05)	(0.06)	(0.26)	(0.58)	(0.94)	(0.01)	(0.04)	(0.06)	(0.26)	(0.58)	(0.94)

*Figures in the parenthesis are log X +1 values. **Figures in the parenthesis are angular transformed values

After 150 days of impregnation of cloth bags, the weight loss in wheat flour was in the range of 1.87 to 6.33 per cent. The minimum weight loss was with neem seed kernel extract 10.0% and 7.5% (1.87 and 2.20%, respectively). However, after 105 days of impregnation of plastic fibre bags, no weight loss was observed in the neem seed kernel extract 10.0%, neem oil 10.0% (0.20%), neem seed kernel extract 7.5% (0.33%) and neem oil 7.5% (0.40%). After 150 days of impregnation of plastic fibre bags, same trend was observed. A slight variation in order of effectiveness of plant impregnation materials on plastic fibre bags was observed from that of cloth bags. The order of effecacy was: neem seed kernel extract 10.0> neem seed kernel extract 7.5> neem oil 10.0> karanj seed extract 10.0> malathion 0.1> castor oil 10.0> neem seed kernel extract 5.0> neem oil 7.5 and 5.0> malathion 0.05> castor oil 7.5> karanj seed extract 7.5%> castor oil 5.0> karanj seed extract 5.0> control (acetone)> control (water). These findings are in close approximation with that of Naga *et al.* (2007).

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Propagation of Hard to Root Biofuel Species of Himalayan Region- *Wendlandia exserta* Roxb. DC.

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Abstract: Application of 1.0% Indole butyric acid + 2% captan + 2% sucrose-talc gave maximum sprouting (72.22%) and rooting (5.56%). Highest rooting and root number were recorded in apical cuttings of tree donor. The effect of donor x position was significant on root length. The highest rooting (10.00%) was observed in the apical position of pole and tree donor when treated with 1.0% Indole butyric acid + 2% captan + 2% sucrose-talc and 0.75% Indole butyric acid + 2% captan + 2% sucrose – talc.

***Key Words*:** Auxins, Donor, Position, Vegetative propagation, *Wedlandia exserata*

Wendlandia exserta Roxb. DC. Commonly known as chila, ratela, tikli, etc. has been well distributed throughout the sub-Himalayan tract upto 1400m elevation in outer Himalaya, Chotanagpur and parts of Indian peninsula. Its prominence in Shivalik hills can be seen where the land is prone to landslides. It comes gregariously in areas where soil is exposed due to disturbances or on abandoned agriculture land. It prefers to grow in loose soils, which are exposed to direct sunlight since the species is light demander. The tree flower in March-April and the seeds of the species are very minute and mature in May-June. The wood of this species is used for construction purposes and fuel. This tree species is useful in re-clothing the bare hill slopes and newly exposed as well as geologically vulnerable areas but its regeneration is very poor. Seed of the species is very minute and fail to germinate on vulnerable sites. In this regard, an attempt was made to study the influence of growth regulators on vegetative propagation of the species.

The experiment was centered at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan. For rooting studies, the cuttings were taken from three Donor stages viz., Sapling (D_1), Pole (D_2) and Tree (D_3) at two different positions viz., apical (excised tip) (A_1) and sub-apical (A_2). The stem cuttings selected were 0.5-1.5 cm in diameter and up to 20 cm in length so as to include three-four nodes to ensure maximum sprouting. These cuttings were treated with six different treatments [control - (talc only) (T_1), 2% captan + 2% sucrose - talc (T_2), 0.25 IBA + 2% captan + 2% sucrose - talc (T_3), 0.5% IBA + 2% captan + 2% sucrose - talc (T_4), 0.75% IBA + 2% captan + 2% sucrose - talc (T_5) and 1% IBA + 2% captan + 2% sucrose – talc (T_6)]. The cuttings were planted in Randomized Block Design in February 2011 with 10 cuttings in each replication. The observations on sprouting were recorded one week after planting to two months while the callusing was recorded after four months. The data was recorded for rooting, root length and root number after a period of six months of planting.

The donor stage, position and auxin formulation and their interaction exerted a significant influence on rooting behaviour of *Wendlendia exserta* (Table 1). The sprouting was 66.94% in cuttings collected from tree donor in comparison to 61.39% from pole donor. For position, maximum sprouting was in non-apical cuttings with 60.93 per cent success. For sprouting, the effect of auxin concentrations was highest i.e., 72.22% in cuttings treated with 1.0% IBA + *2%* captan + 2% sucrose- talc concentration. Higher and equal callusing per cent (40.28%) was observed in tree donor and pole . The non-apical position resulted in higher success rate of 42.04 per cent and significantly maximum callusing of 55.56 per cent was recorded in 1.0% IBA + 2% captan + 2% sucrose- talc formulation. Significantly the highest rooting of 3.06% was observed in the cuttings collected from tree donor. The maximum rooting was observed in apical cuttings followed by 1.0% IBA + 2% captan + 2% sucrose- talc concentration. The root number varied from 2.08 to 0.86 roots when cuttings were taken from tree and pole donor, respectively. The apical cuttings exhibited significantly higher root number i.e., 1.43. Maximum root length (2.56cm) was noticed in tree donor cuttings. 0.75% IBA + 2% captan + 2% sucrose- talc concentration gave the maximum mean root length of 6.01 cm. It had been widely reported that the ability of cutting to root decreases with age of cutting donors (Hartmann *et al.,* 2009), but the results obtained were in contradiction in the present findings where the best results were obtained in tree

Table 1. Mean interaction effect of donor stage, position and auxin concentration on sprouting, callusing and rooting of *Wendlandia exserta* cuttings

Treatment	Sprouting (%)	Callusing (%)	Rooting (%)	Root Number	Root Length (cm)
			Donor (D)		
D_1	44.44(41.85)	31.67(33.29)	1.67(1.39)	0.97(1.26)	1.77(1.39)
D_2	61.39(52.11)	40.28(39.24)	1.39(1.38)	0.86(1.23)	1.24(1.29)
D_3	66.94(55.81)	40.28(39.19)	3.06(1.71)	2.08(1.54)	2.56(1.63)
CD (P=0.05)	6.29	4.94	0.26	0.20	0.26
			Position (A)		
A_1	54.26	32.78(34.33)	2.22 (1.52)	1.43(1.37)	1.55(1.38)
A_2	60.93	42.04(40.15)	1.85(1.43)	1.19(1.31)	2.16(1.49)
CD (P=0.05)	NS	4.03	0.21	0.16	0.22
			Auxin concentration (T)		
T_1	45.00(42.07)	28.33(31.62)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2	50.00(44.88)	33.33(34.79)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_3	55.56(49.10)	32.22(34.10)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_4	58.89(50.69)	39.44(38.38)	1.67(1.38)	0.89(1.25)	1.63(1.37)
T_5	63.89(53.55)	40.50(39.17)	5.00(2.16)	3.06(1.82)	6.01(2.38)
T_6	72.22(59.24)	55.56(45.37)	5.56(2.29)	3.89(2.00)	3.49(1.87)
CD (P=0.05)	8.89	6.98	0.37	0.28	0.38
			Auxin concentration x position (T x A)		
T_1A_1	41.11	25.56	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_1A_2	48.89	31.11	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2A_1	44.44	27.78	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2A_2	55.56	38.89	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_3A_1	50.00	28.89	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_3A_2	61.11	35.56	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_4A_1	56.67	34.44	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_4A_2	61.11	44.44	3.33(1.77)	1.78(1.49)	3.26(1.75)
T_5A_1	62.22	35.56	6.67(2.54)	4.00(2.08)	5.66(2.36)
T_5A_2	65.56	45.56	3.33(1.77)	2.11(1.56)	6.36(2.40)
T_6A_1	71.11	44.44	6.67(2.54)	4.56(2.18)	3.62(1.92)
T_6A_2	73.33	56.67	4.44(2.03)	3.22(1.83)	3.37(1.83)
CD (P=0.05)	NS	NS	0.64	0.28	0.38
			Donor x position (DXA)		
D_1A_1	31.67(33.29)	24.44	0.56(1.13)	0.33(1.09)	0.51(1.12)
D_2A_1	61.11(51.93)	35.00	2.78(1.64)	1.72(1.46)	2.49(1.59)
D_3A_1	70.00(58.11)	38.89	3.33(1.77)	2.22(1.57)	1.65(1.43)
D_1A_2	57.22(50.42)	38.89	2.78(1.64)	1.61(1.44)	3.03(1.67)
D_2A_2	61.67(52.29)	45.56	0.00(1.00)	0.00(1.00)	0.00(1.00)
D_3A_2	63.89(53.50)	41.67	2.78(1.64)	1.94(1.50)	3.46(1.82)
$CD_{(0.05)}$	8.89	NS	0.37	0.19	0.26
			Donor x auxin concentration (DXT)		
T_1D_1	18.33	6.67	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_1D_2	21.67	10.00	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_1D_3	13.33	11.67	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2D_1	30.00	11.67	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2D_2	31.67	18.33	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2D_3	26.67	18.33	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_3D_1	36.67	16.67	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_3D_2	38.33	23.33	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_3D_3	31.67	26.67	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_4D_1	36.67	21.67	3.33(1.77)	1.33(1.41)	2.94(1.69)
T_4D_2	45.00	31.67	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_4D_3	40.00	28.33	1.67(1.39)	1.33(1.33)	1.95(1.43)
T_5D_1	45.00	31.67	3.33(1.77)	2.33(1.61)	3.80(1.84)
T_5D_2	46.67	36.67	5.00(2.15)	3.33(1.88)	4.58(2.09)
T_5D_3	35.00	33.33	6.67(2.544)	3.50(1.98)	9.66(3.23)
T_6D_1	53.33	40.00	3.33(1.77)	2.17(1.58)	3.88(1.85)
T_6D_2	53.33	41.67	3.33(1.77)	1.83(1.52)	2.88(1.68)
T_6D_3	51.67	48.33	10.00(3.32)	7.67(2.91)	3.71(2.10)
CD (P=0.05)	NS	NS	0.64	0.34	0.46

Figures in parentheses indicate the arc sin and square root transformed values

donors than those of sapling and pole donors. However, these results are in agreement with the findings of Shamet and Naveen (2005) who reported that tree donor cuttings performed remarkably better than pole and sapling donors in spring season in *Celtis australis*.

The effect of position and auxin concentration (T x A) was non-significant on sprouting and callusing, while it was significant on rooting of cuttings (Table 1). Significantly maximum rooting of 6.67 per cent recorded in T_5 and T_6. All combinations were significantly superior to control. Significantly highest number of roots (4.56) was obtained in apical cuttings treated with 1.0% IBA + 2% captan + 2% sucrose- talc. Root length was significantly maximum (6.36cm) when non-apical cuttings were treated with 0.75% IBA + 2% captan + 2% sucrose- talc concentration. The effect of donor stage and position (D x A) was non-significant on callusing while the same was significant for sprouting and rooting. Maximum sprouting of 70.00 per cent was obtained in non-apical cuttings from tree donor (D_3A_1). The highest rooting (3.33%) and root number (2.22) were obtained when apical cuttings of tree donor (D_3A_1) were used. The highest value for root length (3.46 cm) was observed in D_3A_2. Maximum rooting of 10% was recorded when tree cuttings were treated with 1.0% IBA + 2% captan + 2% sucrose- talc (T_6D_3). Highest number of roots (7.67) was obtained in tree cuttings treated with 1.0% IBA + 2% captan + 2% sucrose-talc. Root length was significantly maximum (9.66 cm) when tree cuttings were treated with 0.75% IBA + 2% captan + 2% sucrose- talc concentration. The results of present investigation are in line with the findings of Hamooh (2004) who reported that basal cuttings of *Ficus carica* resulted in highest rooting and root number when treated with 1500 ppm IBA. Similarly, Akoumianaki *et. al.* (2004) reported highest rooting when *Bauhinia variegata* cuttings from basal region of shoots, treated with 2000 ppm IBA. The better performance of apical type cuttings of *Wendlandia exserta* may be attributed to the better status of growth regulators (auxins) in comparison to those of lower /non-apical ones.

The effect of auxin concentration, position and donor stage (T x A x D) was non-significant on sprouting and callusing but the effect was significant on rooting. Maximum 10% rooting was recorded $T_3A_1D_1$, $T_5A_1D_2$ and $T_5A_1D_3$ combinations of donor, position and auxin concentration. The total phenol (mg g^{-1}), sugar, reducing sugar, total carbohydrate and nitrogen varied numerically but differences were non-significant among different treatments. The apical and non apical portions also showed the same trend.

It can be concluded from the present study that wendlandia exserta is a difficult – to - root species. However, it can be made to root under nursery (protected) conditions by applying the best auxin-formulation (1.0% IBA + 2% captan + 2% sucrose- talc) to the apical cuttings in spring season.

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Response of Fertility Levels and Spacing on Productivity of Pearl millet Hybrids (*Pennisetum glaucum* L.) under Dryland Condition

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Abstract: The grain yield was maximum in Ankur 068. Sowing pearl millet at 40×15 cm spacing produced highest grain and stover yield. The maximum grain (26.70 qha^{-1}) and stover (52.85 qha^{-1}) yield was obtained with the application of $N_{120}P_{60}K_{60}$ kg ha^{-1}. Ankur 068 had significantly higher total uptake over Super sony. Wider spacing of 40×20cm had higher NPK content but 40×15 cm resulted into higher total uptake of NPK. NPK content and uptake was higher when pearl millet was fertilized with $N_{120}P_{60}K_{60}$ kg ha^{-1}.

Key Words: Hybrids, Nutrient uptake, Plant population, Pearl millet

In India, pearl millet occupies an area of 12.4 million hectare with the production and productivity of 11.8 million tones and 0.75 tones ha^{-1}, respectively (Anonymous, 2010-11). The productivity of pearl millet is very low in India mainly due to poor plant stand and less use of fertilizers. At the present productivity level, pearl millet removes 72 kg N, P_2O_5 and K_2O ha^{-1} annum^{-1}, whereas, only 10-12 kg of these nutrients are being supplied through fertilizers. Therefore, there is need to improve fertility management along with optimum plant density of current hybrids for sustainable productivity of this important crop of India. Keeping the above points in view, the field experiment was conducted to study the crop productivity, concentration and uptake behavior of nitrogen, phosphorus and potassium in pearl millet crop as influenced by hybrids, plant density and fertility levels.

The field experiment was conducted during *kharif* seasons of 2011 and 2012 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil of the experimental field was Gangetic alluvial (Ustochrept) with a pH of 7.1, moderately fertile being medium in organic carbon (0.45 %), low in available nitrogen (202.5%) and medium in available P_2O_5 (23.2 kg ha^{-1}) and K_2O (232 kg ha^{-1}). The factors under study comprised two pearl millet hybrids (Ankur 068 and Super sony) as main treatments, three fertility levels ($N_{40}P_{20}K_{20}$, $N_{80}P_{40}K_{40}$ and $N_{120}P_{60}K_{60}$ kg ha^{-1}), and three plant spacing (40 × 10, 40 × 15 and 40 × 20 cm) as sub and sub-sub treatment in split-split plot design with 18 treatment combinations. Each treatment was replicated three times with plot size of 11.4 m^2. The total rainfall received during the crop season was 754.2 and 349.7 mm during *kharif* 2011 and 2012, respectively. Total P_2O_5, K_2O and half N as per treatments were drilled at the time of sowing and rest of the N was top dressed after thinning and gap filling (21 DAS). The seed of pearl millet hybrids as per treatment were sown on July 25, 2011 and July 27, 2012 by drilling as per plant density treatment using 5 kg seed ha^{-1}. Recommended package of practices were followed in the crop for other agronomic operations. Nitrogen content in plants was determined by modified Kjeldahl method (Jackson, 1973). Phosphorus and potassium content were determined by Vanadomolybdo phosphoric acid yellow colour method and flame photometric method, respectively. The uptake was computed from the data on nitrogen, phosphorus and potassium concentration multiplied by grain/stover yield. The total uptake of N, P and K was computed by summing up the nutrient uptake by grain and stover.

In hybrid, Ankur 068 recorded significantly higher plant height, tillet plant^{-1} and dry matter over super sony in pooled years. The fertility levels affected plant height significantly. The maximum values for all the growth parameters were obtained with $N_{120}P_{60}K_{60}$, which was significantly more than $N_{80}P_{40}K_{40}$ and $N_{40}P_{20}K_{20}$. The maximum plant height, tiller plant^{-1} and dry matter was recorded at 40 × 20 cm spacing, which was statistically at par with 40 × 15 cm and superior than 40 × 10 cm. Spacing 40 × 20 cm recorded significantly higher value of dry matter accumulation per plant than rest of the spacing (40 × 15 and 40 × 10 cm). 40 × 20 cm spacing resulted in an increase of 16.98 per cent in dry matter accumulation plant^{-1} over 40 × 10 cm. Wider row spacing helped in proper utilization of natural resources *i.e.* moisture and nutrients but such benefits could not be realized in closer spacing due to mutual plant competition.

Productivity of pearl millet: Hybrids Ankur 068 produced significantly higher grain and stover yield over Super sony. Maximum pooled grain (26.70 q ha^{-1}) as well as stover yield

Table 1. Effect of various treatments on growth, yield and nutrient content of pearl millet (pooled)

Treatment	Plant height (cm)	Tillers (No. plant^{-1})	Dry matter accumulation (g plant^{-1})	Yield (q ha^{-1})		Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
				Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Pearl millet hybrids											
Ankur 068	200.51	3.08	127.34	24.58	48.99	1.85	0.585	0.415	0.135	0.69	2.765
Super sony	178.75	2.68	103.31	22.35	44.35	1.79	0.565	0.39	0.125	0.63	2.555
CD (P=0.05)	7.23	0.21	3.61	1.12	2.57	0.02	NS	NS	NS	0.02	0.10
Fertility levels (kg ha^{-1})											
$N_{40}P_{20}K_{20}$	180.21	2.165	95.08	20.43	42.15	1.775	0.545	0.37	0.115	0.63	2.55
$N_{80}P_{40}K_{40}$	187.27	2.88	117.54	23.26	45.02	1.815	0.58	0.39	0.13	0.66	2.64
$N_{120}P_{60}K_{60}$	199.40	3.595	133.35	26.70	52.85	1.87	0.61	0.43	0.14	0.7	2.76
CD (P=0.05)	9.19	0.28	4.2	1.37	3.14	0.04	0.01	0.02	NS	0.02	NS
Spacing (cm)											
40 × 10	186.32	2.70	107.07	22.14	45.96	1.805	0.565	0.39	0.125	0.63	2.56
40 × 15	188.33	2.86	113.65	25.54	48.59	1.81	0.575	0.39	0.125	0.65	2.65
40 × 20	194.28	3.09	125.25	22.71	45.47	1.845	0.59	0.43	0.14	0.71	2.71
CD (P=0.05)	6.12	0.20	3.28	1.08	2.43	0.02	0.01	0.02	NS	0.01	NS

(52.85 q ha^{-1}) was harvested with $N_{120}P_{60}K_{60}$, which was superior to other fertilizer combinations (Table 1). Spacing of 40 × 15 cm was found significantly better as compare to other two spacing i.e. 40 × 10 and 40 × 20 cm in respect of grain and stover yields.

Nutrient content and uptake: Pearl millet hybrid Ankur 068 gained more value inrespect of N, P and K content (%) in grain and stover than Super sony (Table 2). Ankur 068 had significantly higher total uptakeof N, P and K, which might be ascribed to its relatively higher grain and stover yield than Super sony. Corroborative findings have been reported by Sewhag (2003). The NPK content both in grain and stover increased with increasing levels of fertility. Such results are obvious as application of nitrogen, phosphorus and potash are known to increase the cation exchange capacity of roots and enhance NPK absorption (Elgabaly, 1962) by plants. Corroborative findings have also been reported by Singh (1997). The total NPK uptake was observed to be highest when pearl millet was fertilized with $N_{120}P_{60}K_{60}$ during both the years. Since uptake is a function of yield so the treatment producing higher yield also recorded high uptake. Corroborative findings have been reported by Parihar *et al*. (2005). Wider spacing of 40 × 20 cm obtained significantly higher N, P and K content in grain and stover than narrow spacing (40 × 10 cm). However, 40 × 15 cm spacing had significantly higher total uptake of N, P and K, which might be ascribed to it's relatively higher grain and stover yield than wider (40 × 20 cm) and narrow (40 × 10 cm) spacing.

Table 2. Effect of various treatments on nutrient uptake of pearl millet (pooled)

Treatment	Total nitrogen uptake(kgha^{-1})	Total phosphorus uptake (kgha^{-1})	Total potassium uptake(kgha^{-1})
Pearl millet hybrids			
Ankur 068	74.56	17.07	152.62
Super sony	65.53	14.57	127.06
CD (P=0.05)	2.42	1.34	10.21
Fertility levels (ha^{-1})			
$N_{40}P_{20}K_{20}$	59.39	13.17	122.30
$N_{80}P_{40}K_{40}$	68.49	15.33	133.01
$N_{120}P_{60}K_{60}$	82.26	18.96	164.21
CD (P=0.05)	3.19	1.68	11.73
Spacing (cm)			
40 × 10	66.93	14.72	136.04
40 × 15	76.16	18.03	147.93
40 × 20	67.04	14.71	135.56
CD (P=0.05)	2.51	1.01	NS

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Response of Oats to Cu Applied through Seed Priming, Foliar and Soil Application

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Abstract: The plant height, number of tillers plant^{-1}, number of leaves plant^{-1} and shoot dry matter yield increased significantly by seed priming with 0.05 per cent copper sulphate, one spray of copper sulphate and with soil application of 5 mg Cu kg^{-1} soil over control. The root dry matter yield increased significantly with seed priming of 0.05 per cent copper sulphate and with soil application of 5 mg Cu kg^{-1} soil, however, the foliar application was found to be ineffective. A significant increase in Cu concentration and uptake by shoot was observed with seed priming up to a level of 0.05 per copper sulphate, with two sprays of 0.1 per cent copper sulphate and soil application of 5 mg Cu kg^{-1} soil over control.

Key Words: Copper, Cu concentration, Cu uptake, Growth parameters, Oats, Yield

Micronutrient deficiency has become a major constraint for crop production in many Indian soils. The deficiency of micronutrients may be either primary, due to their low content or secondary, caused by soil factors that reduce their availability to plants (Sharma and Chaudhary 2007). Copper is one of the essential micronutrients for normal growth and metabolism of plants and animals. In plants, it is required for chlorophyll synthesis, respiration, and carbohydrate/protein metabolism (Marschner, 1995). Studies in Punjab have indicated that about 3-4 per cent of soils have become deficient in available Cu (Anonymous 2008). Oats is the second most important fodder crop after berseem in Punjab during *rabi* season. It is being cultivated on an area of about 0.9 lac ha annually (Anonymous 2012). It is highly susceptible to Cu deficiency and hence, the present study was undertaken to study the effect of Cu fertilization through seed priming, soil and foliar application on the growth, yield, and Cu nutrition of oats.

A pot experiment was conducted with oats in the greenhouse, Department of Soil Science, Punjab Agricultural University, Ludhiana during the *Rabi* season of 2013-14. Physicochemical characteristics of the soil were recorded (texture- loamy sand, pH-8.2, EC-0.38 dS m^{-1}, organic carbon-0.57%, $CaCO_3$-0.14%, diethylene triamine penta acetic acid (DTPA) extractable Cu, Fe, Mn and Zn were 0.17, 3.23, 2.70 and 1.15 mg kg^{-1} soil, respectively). A basal dose of 30 mg N kg^{-1} soil through urea, 8 mg P kg^{-1} soil through potassium dihydrogen orthophosphate, 50 mg Mn kg^{-1} soil as manganese sulphate and 10 mg Zn kg^{-1} soil as zinc sulphate was applied to each pot before sowing. There were three modes of Cu fertilization i.e., seed priming, soil and foliar application. The experiment consisted of three levels of each of seed priming (0, 0.025 and 0.05 per cent $CuSO_4 5H_2O$ for 6 hours) and foliar application (0, 1 and 2 sprays) with concentration of 0.1 per cent copper sulphate solution and four levels of soil application (0, 2.5, 5.0 and 10 mg Cu kg^{-1} soil) as copper sulphate with three replications.

The fertilized soil was filled in plastic pots (8 kg soil pot^{-1}). Ten seeds of oats were sown in each pot and were thinned five per pot after germination. The pots were irrigated with equal measured quantity of tap water as per the need of the crop. Data pertaining to growth parameters including plant height, number of tillers plant^{-1}, number of leaves plant^{-1}, chlorophyll content (SPAD value), shoot and root dry matter yield were recorded. Plants were harvested after 75 days of sowing. The plant samples were washed thoroughly in succession with tap water, 0.01 N HCl, deionized water and air-dried followed by oven drying at 60°C. The root samples were carefully separated from the soil by washing and floating over sieves. The root samples were processed in a similar manner as done for shoot samples. The shoot and root samples were grinded and stored for chemical analysis. Half gram of ground sample was digested in a diacid mixture of distilled HNO_3 and $HClO_4$ (4:1). The Cu content in plant digests was determined using Atomic Absorption Spectrophotometer (Varian-Spectra AA-20 plus). The data was analysed statistically using completely randomized design (CRD).

Effect of Cu seed priming on growth,yield and Cu nutrition of oats: A significant increase in plant height from 58.89 cm in control to 61.98 cm, number of tillers plant^{-1}from 2.53 in control to 3.07,number of leaves plant^{-1}from 11.29 in control to 12.15 and SPAD value from 43.37 in control to 45.60 was observed with Cu seed priming using 0.05 per cent

copper sulphate solution (Table 1). Both shoot and root dry matter yield increased significantly with Cu seed priming up to a level of 0.05 per cent copper sulphate solution over control (Table 1). The Cu concentration and its uptake by shoot significantly increased with Cu application through seed priming up to the level of 0.05 per cent copper sulphate (Table 1). These results are in line with findings of Nazir *et al.* (2000), who reported that treating wheat seeds with copper sulphate solution increased the plant height, shoot and root dry matter yield of wheat significantly. Jaryal (2012) also found that the application of Cu through seed coating improved shoot and root dry matter production and Cu uptake by wheat.

Effect of foliar application of Cu on growth, yield and Cu nutrition of oats: The foliar application of copper sulphate had a significant positive effect on plant height, number of tillers plant^{-1}, number of leaves plant^{-1} and SPAD value. Values increased with one spray of 0.1 per cent copper sulphate but two sprays were found ineffective (Table 2). The plant height increased from 59.69 cm in control to 61.41 cm, number of tillers plant^{-1} from 2.48 in control to 3.07, number of leaves plant^{-1} from 10.85 in control to 12.36 and SPAD value from 43.47 in control to 45.58 with one spray of 0.1 per cent copper sulphate solution (Table 2). Shoot dry matter yield also increased significantly with foliar application of copper sulphate. Though, the one spray of copper sulphate significantly increased the dry matter yield over control but two sprays produced dry matter at par with that of 1 spray while the foliar application of copper sulphate was ineffective in improving root dry matter yield (Table 2). The mean Cu concentration and uptake by shoot also increased significantly with one foliar application of Cu as 0.1 per cent spray of copper sulphate (Table 2).

Effect of soil application of Cu on growth, yield and Cu nutrition of oats: The plant height increased significantly from 60.15 cm in control to 62.07 cm with the soil application of 5.0 mg Cu kg^{-1} soil (Table 3). A significant positive effect of soil application of Cu was also observed on number of tillers plant^{-1} and number of leaves plant^{-1}. Number of tillers plant^{-1} increased significantly from 2.43 in control to 3.04 and number of leaves plant^{-1} from 11.01 in control to 12.32 with application of 5 mg Cu kg^{-1} soil (Table 3). The soil application of copper sulphate also progressively and significantly improved both shoot and root dry matter production up to the level of 5 mg Cu kg^{-1} soil over control and further application of 10 mg Cu kg^{-1} soil failed to improve it (Table 3). The increase in shoot dry matter was attributed to improved shoot Cu content and uptake. A significant and positive coefficient of correlation of Cu content of shoot (r = 0.84*) and Cu uptake by shoot of oats (r = 0.90*) was recorded with shoot dry matter yield. Soil application of Cu also increased plant height, number of tillers plant^{-1}and number of leaves plant^{-1}

Table 1. Effect of Cu seed priming on growth, yield and Cu nutrition of oats

$CuSO_4$ conc. (%) in priming solution	Plant height (cm)	No. of tillers plant^{-1}	No. of leaves plant^{-1}	SPAD value	Shoot dry matter yield (g pot^{-1})	Root dry matter yield (g pot^{-1})	Cu concentration (µg g^{-1})	Cu uptake (µg pot^{-1})
0.000	58.89	2.53	11.29	43.37	6.85	2.22	8.6	60.4
0.025	60.98	2.83	11.68	44.73	7.48	2.40	10.1	77.3
0.050	61.98	3.07	12.15	45.60	7.75	2.46	11.1	87.1
CD (0.05)	1.27	0.13	0.42	0.94	0.21	0.12	0.9	6.7

Table 2. Effect of foliar application of Cu on growth, yield and Cu nutrition of oats

No. of sprays (0.1 % $CuSO_4$)	Plant height (cm)	No. of tillers plant^{-1}	No. of leaves plant^{-1}	SPAD value	Shoot dry matter yield (g pot^{-1})	Root dry matter yield (g pot^{-1})	Cu concentration (µg g^{-1})	Cu uptake (µg pot^{-1})
0	59.69	2.48	10.85	43.47	6.90	2.33	7.8	55.4
1	61.41	3.07	12.36	45.58	7.51	2.36	10.1	76.8
2	60.76	2.89	11.92	44.66	7.67	2.38	11.9	92.5
CD (0.05)	1.27	0.13	0.42	0.94	0.21	NS	0.9	6.7

Table 3. Effect of soil application of Cu on growth, yield and Cu nutrition of oats

Soil application (mg Cu kg^{-1} soil)	Plant height (cm)	No. of tillers $plant^{-1}$	No. of leaves $plant^{-1}$	SPAD value	Shoot dry matter yield (g pot^{-1})	Root dry matter yield (g pot^{-1})	Cu concentration (µg g^{-1})	Cu uptake (µg pot^{-1})
0	60.15	2.43	11.01	43.11	6.33	2.05	8.0	51.6
2.5	61.92	2.89	11.64	44.54	7.27	2.34	9.8	71.9
5.0	62.07	3.04	12.32	45.82	7.99	2.54	10.6	85.3
10.0	58.33	2.88	11.84	44.79	7.85	2.50	11.5	90.9
CD (0.05)	1.47	0.16	0.49	1.08	0.24	0.14	1.0	7.8

(Table 3), which ultimately increased the fresh and dry matter production. A positive and significant correlation of plant height (r = 0.81*), number of tillers $plant^{-1}$ (r = 0.83*) and number of leaves $plant^{-1}$ (r = 0.78*) with dry matter production of oats was obtained. The increase in root biomass production is mainly attributed to the increased Cu content and uptake by roots, as it increased by Cu seed priming and soil application of Cu. A significant and positive correlation between Cu concentration of root (r = 0.70 *) and Cu uptake by root (r = 0.75*) with root dry matter yield of oats was recorded. The Cu concentration and uptake by shoot increased significantly with soil application of Cu up to 5 mg kg^{-1} soil (Table 3). Both shoot dry matter accumulation and shoot Cu concentration increased with Cu application that resulted in improved Cu uptake by oats. The Cu application through different methods improved the root growth. The vigorous root system is mainly responsible for higher Cu concentration and plant growth, ultimately resulted in better Cu uptake. A positive and significant correlation between shoot Cu concentration (r = 0.98*), shoot dry matter yield (r = 0.90*), root Cu concentration (r = 0.62*) and root dry matter yield (r = 0.79*) was obtained with Cu uptake by shoots.

The results of this investigation revealed that seed priming up to 0.05 per cent copper sulphate, one spray of 0.1per cent copper sulphate and soil application of Cu up to 5 mg kg^{-1} soil showed significant increase in growth parameters, dry matter yield, Cu content and its uptake by oats. Hence, appropriate method and adequate rate of Cu fertilization can contribute to a great deal in enhancing the yield of oats crop, especially in Cu deficient loamy sand soils of Punjab.

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Screening of Soybean Varieties against *Callosobruchus Chinensis* Linnaeus under Storage Condition

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Abstract: The variety NRC-37 recorded significantly lowest number of adult emergence (2.49), weight loss (1.53%) and germination loss (13.62%) due to *Callosobruchus chinensis* followed by JS-335 and JS-9752 varieties. The variety Gujarat Soybean-1 recorded significantly the highest number of adult emergence weight.

Key Words: *Callosobruchus chinensis L.,* Soybean, Varietal susceptibility

Soybean, *Glycine max* (L.) Merrillis one of the most important pulse crops of the world, both in respect of area and production. In 2012-13, the major edible oils consumed in the country are palm oil, soybean oil and mustard oil, with their respective shares of 46%, 16% and 12% (Kumar, 2014). Soybean suffers a great damage during storage due to insect pests. Three species *viz., Callosobruchus chinensis* (Linnaeus), *Callosobruchus maculatus* (Fabricius) and *Callosobruchus analis* (Fabricius) of pulse beetle are infesting soybean in India under storage condition. Infestation by *C. chinensis* and *C. maculatus* is responsible to seed losses to 20 to 60 per cent (Tarver *et al*., 2007). The average seasonal loss due to *C. chinensis* ranged from 10.58 to 42.64 and 4.40 to 18.20 per cent in terms of number and weight, respectively in different species of legume seeds (Ghosal, 2011). The damage incurred in terms of per cent weight loss of pulses due to *C. chinensis* was about 18.6 per cent (Rawat and Srivastava, 2011). Large cultivation of soybean alone is not enough but making more efforts for reducing losses due to the infestation of insect pests during storage.

For initiation of culture, about 300 adults of *C. chinensis* were introduced in plastic jar (20 cm height and 14 cm diameter) containing 1 kg soybean (variety NRC-37) grains previously sterilized at 55 °C temperature for 4 hours in oven. The jar was covered tightly with muslin and adults of *C. chinensis* thuso btained from the laboratory culture were used for further studies. Eight varieties *viz*., JS-335, JS-95-60, NRC-37, JS-9305, JS-9752, PK-472, Gujarat Soybean-2 and Gujarat Soybean-1were screened for their susceptibility to *C. chinensis*.

Population growth: Three samples of soybean seed each of 50 g were filled in plastic tube (6 cm x 5 cm). Twenty adults (two days old) of *C. chinensis* were released in each tube for egg laying and each tube was covered with two-fold muslin cloth kept in position using rubber band. The adults were discarded from each tube after 7 days. The observations on number of adults (live + dead) were made after six months of storage.

Weight and germination loss: Hundred grains were collected randomly from each sample and segregated into damaged by pulse beetle and germ eaten grain. The damaged grains, germ eaten and 100 undamaged grains were weighed to know the per cent loss in weight.

Three samples of 100 seeds each were drawn from each treatment. The germination test was carried out on moist circular Whatman no. 1 filter paper kept in petri-plates (diameter 10 cm). The seeds were spread on filter paper at uniform distance in the petri-plate. The petri-plate was covered with the lid carrying the moist filter paper and kept in a seed germinator maintained at 21 ± 1°C temperature and 95 ± 2 per cent relative humidity. Small quantity of distilled water was sprinkled on filter paper once a day to keep it moist. The number of grains germinated was counted after 7 days of incubation.

Categorization of varieties: The soybean varieties were grouped into four categories of susceptibility to *C. chinensis* viz., highly resistant, resistant, susceptible and highly susceptible based on three parameters viz., population growth, per cent loss in weight and germination loss. For the purpose, mean value of individual variety ($\overline{X_i}$) was compared with mean value of all varieties ($\overline{X_i}$) and standard deviation (SD) following the scale as adopted by Patel *et al.* (2002). The scale for categorization of different varieties/ genotypes was as under:

Category of resistance	Scale for resistance
Highly Resistant	$\overline{X}_i < \overline{X}$
Resistant	$\overline{X}_i > \overline{X} < \overline{X} + 1$ SD
Susceptible	$\overline{X}_i > (\overline{X} + Sd) < (\overline{X} + 2 Sd)$
Highly Susceptible	$\overline{X}_i > (\overline{X} + 2 Sd)$

RESULTS AND DISCUSSION

The variety NRC-37 recorded significantly the lowest number of *C. chinensis* adult emergence (2.49) after six months of soybean storage (Table 1). Variety JS-335 and variety JS-9752 also recorded lower population growth of the pest and were at par with each other while, variety JS 93-05 and Gujarat soybean-2 were highly preferred by the pest. Among the varieties under investigation, significantly the highest (45.09) number of *C. chinensis* adults emerged out from variety Gujarat Soybean-1 and proved to be most preferred soybean variety followed by JS 95-60 and PK-472.

The varieties NRC-37, JS-335, JS-9752, JS 93-05 and Gujarat soybean-2 recorded less than 15.85 adult emergence and were categorized as highly resistant (HR) to *C. chinensis*. Variety PK-472 recorded more than 15.85 but less than 28.85 adult emergence and hence it was considered as resistant (R) variety. Variety JS 95-60 recorded adult emergence more than 28.85 but less than 41.65 considered as susceptible (S). While variety Gujarat soybean-1 recorded more than 41.65 emergence of adults and as such, this variety was grouped in the highly susceptible (HS) category.

Weight loss: The weight loss was the lowest in NRC-37 (1.53%) after six months of storage and it was at par with JS-335, JS-9752 and JS 93-05. The per cent weight loss due to *C. chinensis in* Gujarat Soybean-2 (2.27%) and PK-472 (2.35%) was almost equal whereas, variety JS 95-60 recorded significantly higher weight loss (3.12%). Among the soybean varieties under screening, Gujarat Soybean-1 recorded significantly the highest (7.15) per cent weight loss due to the infestation of *C. chinensis*.

NRC-37, JS-335, JS 93-05, JS-9752, Gujarat Soybean-2 and PK-472 recorded less than 2.74 per cent weight loss and were categorized in to the highly resistant (HR) category. Variety JS 95-60 recorded weight loss between 2.74 and 4.37 per cent and was considered as resistant. None of the varieties fall under susceptible (S) category. Variety Gujarat Soybean-1 came under highly susceptible (HS) category as it recorded more than 6 per cent weight loss due the infestation of *C. chinensis* in soybean.

Germination loss: The germination count of different soybean varieties before adult release ranged from 80.12 to 92.16 per cent with statistical non-significant differences. The per cent seed germination due to the infestation of *C. chinensis* after six months revealed significantly higher percentage of germination (76.26) in NRC-37. Varieties JS 93-05, Gujarat Soybean-2 and PK-472 (49.97%) were almost equal with each other in terms of germination. The significantly lower percentage of germination was recorded in variety Gujarat Soybean-1 (32.96), which was at par with JS 95-60 .The loss in germination was significantly less in NRC-37 (13.62%) and JS-335 (14.18%). This was followed by JS-9752, JS 93-05 and Gujarat Soybean-2. However, the highest per cent germination loss was recorded in Gujarat Soybean-1 (58.80) and was at par with JS 95-60 (52.55).

NRC-37, JS-335, JS-9752 and JS 93-05 recorded less than 33.64 per cent loss in germination and were categorized in to highly resistant (HR) group to *C. chinensis*.

Table 1. Susceptibility of soybean varieties to *C. chinensis* based on population growth and weight loss after six months of storage

Varieties	Number of adult emerged*	Weight loss (%)**	Germination (%)		Germination loss (%)
			Before adult release	6 months after infestation	
JS-335	2.22b (4.33)	7.37ab (1.65)	63.52	59.00def (73.47)	22.12a (14.18)
JS 95-60	5.44e (29.09)	10.17d (3.12)	66.60	39.19ab (39.60)	46.46de (52.55)
NRC-37	1.73a (2.49)	7.11a (1.53)	70.35	60.84f (76.26)	21.66a (13.62)
JS 93-05	3.38c (10.92)	8.34abc (2.10)	73.74	53.31de (64.30)	32.75bc (29.27)
JS-9752	2.37b (5.12)	7.55abc (1.73)	73.74	57.21def (70.67)	28.35b (22.55)
Gujarat Soybean-1	6.75f (45.09)	15.51e (7.15)	66.72	35.04a (32.96)	50.07e (58.80)
Gujarat Soybean-2	3.60c (12.47)	8.67bc (2.27)	72.19	50.96cd (60.33)	35.52c (33.75)
PK-472	4.31d (18.08)	8.82cd (2.35)	71.53	44.98bc (49.97)	41.78d (44.39)

Treatment mean with letter in common are not significant at 5 % level of significance within a column.

Table 2. Categorization of different varieties of soybean for their susceptibility to *C. chinensis* based on different parameters

Category of resistance	Scale	Varieties
	Based on population (number of adults emerged)	
	$\overline{X}$ = 15.85 SD = 12.90	
Highly resistant (HR)	$\overline{X}_i$ < 15.85	NRC-37, JS-335, JS-9752, JS 93-05, Gujarat Soybean-2
Resistant (R)	$\overline{X}_i$ > 15.85 < 28.85	PK-472
Susceptible (S)	$\overline{X}_i$ > 28.85 < 41.65	JS 95-60
Highly susceptible (HS)	$\overline{X}_i$ > 41.65	Gujarat Soybean-1
	Based on per cent loss in weight	
	$\overline{X}$ = 2.74 SD = 1.63	
Highly resistant (HR)	$\overline{X}_i$ < 2.74	NRC-37, JS-335, JS 93-05, JS-9752, GujaratSoybean-2, PK-472
Resistant (R)	$\overline{X}_i$ > 2.74 < 4.37	JS 95-60
Susceptible (S)	$\overline{X}_i$ > 4.37 < 6.00	-
Highly susceptible (HS)	$\overline{X}_i$ > 6.00	Gujarat Soybean-1
	Based on per cent loss in germination	
	$\overline{X}$ = 33.64 SD = 15.01	
Highly resistant (HR)	$\overline{X}_i$ < 33.64	NRC-37, JS-335, JS 93-05, JS-9752
Resistant (R)	$\overline{X}_i$ > 33.64 < 48.65	Gujarat Soybean-2, PK-472
Susceptible (S)	$\overline{X}_i$ > 48.65 < 63.66	JS 95-60, Gujarat Soybean-1
Highly susceptible (HS)	$\overline{X}_i$ > 63.66	-

Gujarat Soybean-2 and PK-472 found resistant varieties as they recorded more than 33.64 but less than 48.65 per cent germination loss. JS 95-60 and Gujarat Soybean-1 emerged out as susceptible varieties to *C. chinensis* because of per cent loss in germination were more than 48.65 but less than 63.66 per cent. None of the variety was found in highly susceptible category in respect to germination loss.

It was concluded that JS-335, JS-9752, NRC-37 and JS 93-05 emerged out as highly resistant (HR) varieties based on all the three parameters to *C. chinensis*.

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Seasonal Incidence of Seed Midge, *Systole albipennis* Walker Infesting Fennel

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***Abstract*:** The infestation of the seed midge commenced in the last week of March and first week of April and reached to maximum in the first week of May (15.50 and 17.50%*)*. The maximum and minimum temperatures and the average relative humidity had non-significant correlation with regards to seed midge damage during 2011-12. A positively significant correlation was observed between seed midge damage and maximum and minimum temperatures but such correlation was negative with average relative humidity during 2012-13.

***Key Words*:** Fennel, Incidence, Infestation, Seed midge, *Systole albipennis, Tetrastichus sp.*

Fennel, *Foeniculum vulgare* Miller plant is stout, aromatic annual herb of family Apiaceae and commonly known as *saunf.* The plant is pleasantly aromatic and different parts of the plant, *viz.,* leaves, stalks, bulbs and seeds are edible. The fish string like leaves are valued as source of flavour garnish and also possess diuretic properties. The roots are regarded as a purgative while seeds are used in curing diseases like cholera, constipation, dysentery, diarrhea beside bile disturbances and nervous disorders. In India, seeds are also used for mastication and chewing either alone or with betel leaves. The volatile oil is primarily beneficial for digestive system and also exhibits vermicidal, antispasmodic and anti-flatulence properties (Murty and Sridhar, 2001). Insect-pests are one of the major limiting factors for higher production of fennel. Among these *Systole albipennis* Walker has been reported to occur as a regular pest in Rajasthan and other parts of the country (Agrawal *et al.,* 2004; Kalra, 2007). Its damage cause both qualitative and quantitative losses in seed yield of fennel both in fields as well as in storage. For developing effective management programme of pest, there is a need to have studies on ecological aspects for better understanding of insect-pests in relation to a crop and environment. With this view studies were carried out on the quantitative estimation of seed midge infestation in relation to key abiotic factors, like maximum and minimum temperatures, relative humidity and rainfall under the prevailing agroclimatic conditions.

RF-125 was sown in the third week of October during 2011-12 and 2012-13 in four plots of 2 x 2.25 m^2 size keeping row to row and plant to plant distance of 45 cm and 20 cm, respectively at S.K.N. College of Agriculture, Jobner. Crop was left for natural infestation of *S. albipennis.* 40 days old five plants were randomly selected and tagged for observations. Nine umbels (three umbels each from upper, middle and lower) from each of the tagged plants were labeled to record the seed midge damage. Total number of seeds/umbel and damaged seeds present on selected umbel were thoroughly checked and counted with the help of magnifying glass (10x). The seeds with appearance of black spot or insect exit hole were recorded at weekly intervals from the first appearance till harvesting of the crop. The simple correlation was computed between damaged seeds and abiotic factors, *viz.,* maximum and minimum temperatures, relative humidity and rainfall.

The infestation of the seed midge during *rabi*, 2011-12 commenced in the last week of March and continued upto crop harvest, *i.e.* first week of May (Table 1). Initially, the infestation was recorded to be 0.50 per cent, which increased gradually and reached to maximum 15.50 per cent at 38.7 ^0C *maximum*, 19.8 ^0C *minimum temperatures and* 31.5 per cent *relative humidity* in the first week of May. The *maximum and* minimum temperatures, average relative humidity and total rainfall had non-significant correlation with seed midge damage *(r= 0.239, 0.524, -0.346 and -0.124, respectively).*

The infestation of seed midge during *rabi*, 2012-13 (Table 1) started in the first week of April (one week late than 2011-12). The *infestation* gradually *increased* and reached to maximum (17.50 %*)* at 39.1 ^0C *maximum*, 20.0 ^0C *minimum temperature and* 30.0 per cent *relative humidity* in the first week of May. The data also indicated comparatively higher seed midge damage during, 2012-13 in comparison to 2011-12 and the seed midge damage also started one week later than first year. The *maximum and* minimum temperatures had significant positive correlation with seed midge infestation (r= 0.889 and 0.914, respectively), while average

Table 1. Seasonal incidence of *S. albipennis* infesting fennel crop in relation to weather parameters during *rabi,* 2011-12 (2012-13 in paremtheses)

Standard Meteorological weeks	Date of observations	Per cent seed damage	Temperature (^{0}C) Maximum	Minimum	Average relative humidity (%)	Total rainfall (mm)
12	20.03.2012 (22.03.2013)	0.00 (0.00)	32.9 (34.2)	11.2 (15.2)	37.0 (50.0)	0.0 (0.0)
13	27.03.2012 (29.03.2013)	0.50 (0.00)	36.4 (31.7)	17.0 (15.0)	39.5 (48.5)	0.0 (0.0)
14	03.04.2012 (05.04.2013)	1.50 (2.00)	39.0 (33.8)	19.4 (15.2)	32.5 (49.5)	0.0 (2.2)
15	10.04.2012 (12.04.2013)	3.00 (3.50)	36.6 (35.8)	18.9 (18.2)	45.0 (43.5)	4.8 (0.0)
16	17.04.2012 (19.04.2013)	6.50 (8.25)	34.0 (37.1)	18.7 (18.2)	41.5 (40.5)	3.0 (0.4)
17	24.04.2012 (26.04.2013)	11.25 (13.75)	34.8 (36.7)	18.4 (20.8)	38.0 (43.5)	0.0 (0.0)
18	01.05.2012 (03.05.2013)	15.50 (17.50)	38.7 (39.1)	19.8 (20.0)	31.5 (30.0)	0.0 (0.0)
Correlation coefficient (r) with per cent seed damage		-	0.239 (0.889**)	0.524 (0.914**)	-0.346 (-0.873**)	-0.124 (-0.263)

relative humidity had significant negative correlation (r= -0.873). Total rainfall had non-significant correlation with seed midge damage *(r= -0.263).*

The results are in close conformity with the findings of Patel and Patel (2003) in Gujarat who found that the seed midge infestation commenced with the initiation of seed setting in the umbel and continued up to harvest. The damage (0.50 – 17.50%) caused by *S. albipennis* are more or less close with the findings of Patel *et al.* (2009) who also reported that the damage of *S. albipennis* in fennel ranged from 5.4 to 20.7 per cent. However, they reported minimum and maximum incidence in January and March, respectively which differ with the present findings where it was recorded in April and May, respectively. The probable reason for the variation in damage intensity might be due to the difference in crop husbandry at respective locations.

A parasitic wasp, *Tetrastichus* sp. was reported to parasitized seed midge, *S. albipennis* under field conditions. The incidence of *Tetrastichus* sp. commenced in the third week of April and continued upto crop harvest during both the years. The parasitic wasp laid eggs (generally one or two) in the seeds already infested by *S. albipennis* and developed into adult which emerged out of the seed by boring a hole in the seed coat. It was worthy to mention that the hole on seed coat infested with *S. albipennis* was comparatively larger in size as compared to hole made by *Tetrastichus* sp. The present findings corroborates with the earlier findings of Batra *et. al.* (1959) and Sehgal (1966) who had also reported the parasitization of *S. albipennis* by *Tetrastichus* sp.

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Role of Chemical Floral Preservatives on Vase Life of Cut Flowers of Gerbera cv. Shangria

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Abstract: Gerbera cv. Shangria was subjected to twelve different treatment combinations to study the vase life. The application of 50ppm silver nitrate + 4% sucrose + 200 ppm 8-HQS + 100ppm silver thiosulphate was found beneficial in extending the vase life of the cultivar to 9 days. This provides an option for extending the vase life of cut gerbera flowers.

Key Words: Gerbera, Shangria, Silver nitrate, Vase life

Gerbera is an elegant garden flower of immense value. They are real attraction in the garden with their star like flowers of varying color shades. Borne terminally on slender long stems, they form effective, colorful flower borders or beds (Thangaraj *et al*., 1990). The objective of this study was to determine the effects of different chemicals in extending vase life of gerbera flowers in different combinations and different concentrations so as to standardize the vase solution and to improve the vase life of the flowers.

The present investigation was carried out in the University of Agricultural Sciences, Bengaluru during 2009-10. Flowers selected for the experiment were harvested when outer ray florets were completely elongated or when outer two rows of disc florets are perpendicular to the flower stalk and were kept in clean water. Flowers were sorted out for uniform head size so as to maintain uniformity within the replication and 2.5 cm of basal portion of stem was cut to evaluate for presence of bacteria. Each flower stalk were placed in 500ml bottle containing 250 ml of aqueous solutions of different chemical preservatives used individually or in combination and a set of treatment containing 250 ml of distilled water as control. Distilled water was used to increase experimental variability.

Cumulative water uptake was recorded for the entire period of vase life of the flower stalk. Difference between consecutive weights of bottle + solution + flower represents transpirational loss of water (in grams) for that period. Cumulative water loss was recorded for the entire period of vase life of the flower stalk. Water balance was calculated (water balance = water uptake - transpirational loss of water). Fresh weight of the flower (in grams) was recorded daily by calculating the difference between weight of bottle + solution + flower and weight of bottle + solution. Vase life commenced at the onset of placing the flowers in holding solutions up to the date of discard. Vase life was decided depending upon wilting of one or two petals of outer row of ray florets. Plate count technique was adopted to estimate the presence of bacteria. Stem pieces of 2.5 cm were taken in 100ml sterile water and placed in a shaker for 10 minutes. Afterwards serial dilution was made up to 10^{-7}. The dilutions of 10^{-5}, 10^{-6} and 10^{-7} were plated on nutrient agar for presence or absence of bacteria. Bengal agar was used to find out the presence of different bacteria.

The cut flowers of Gerbera cv. Shangria treated with chemicals at different concentration significantly increased the cumulative water uptake compared to control. Maximum cumulative water uptake of 62.33 g flower^{-1} was recorded in 50ppm silver nitrate + 4% sucrose + 200 ppm 8-HQS + 100ppm silver thiosulphate followed by 50 ppm silver nitrate + 4% sucrose + 200 ppm 8-HQS compared to other concentrations and control The cut flowers treated with chemicals at different concentration also showed the same trend. All the treatments including control showed minimum water uptake to water loss ratio. However, among the different treatments T_1, T_6, T_7 and T_9 recorded maximum water uptake to water loss (0.94) and the cut flowers recorded a negative water balance in all the treatments including control (Table 1). Cut flowers treated with chemicals at different concentration significantly increased the fresh weight compared to control. Maximum fresh weight of 23.67 g flower^{-1} was recorded in 50 ppm silver nitrate + 100 ppm silver thiosulphate + 4% sucrose + 200 ppm 8-HQS followed by 200 ppm aluminum sulphate + 100 ppm silver thiosulphate + 4% sucrose + 200 ppm 8-HQS. Maximum vase life of 9.03 days was recorded in 50 ppm silver nitrate + 100 ppm silver

Table 1 . Effect of chemical floral preservatives on vase life of cut flowers of Gerbera cv. Shangria

Treatment	Water uptake	Water loss	Water uptake : loss ratio	Water balance	Fresh weight	Vase life
T_1: 200ppm Aluminum sulphate +4% Sucrose + 200 ppm 8-HQS	47.33	50.33	0.94	-3.0	20.33	8.67
T_2: 400ppm Aluminum sulphate +6% Sucrose + 400 ppm 8-HQS	48.67	53.67	0.91	-5.0	19.00	8.68
T_3:T_1 + 100ppm Silver thiosulphate	37.33	50.33	0.74	-13.0	21.67	8.83
T_4:T_2 + 150ppm Silver thiosulphate	28.67	33.67	0.85	-5.0	15.00	8.19
T_5:200ppm Sodium benzoate +4% Sucrose + 200 ppm 8-HQS	54.00	59.00	0.92	-5.0	17.33	8.32
T_6:300ppm Sodium benzoate + 6% Sucrose + 400 ppm 8-HQS	60.67	64.67	0.94	-4.0	19.33	8.54
T_7:T_5 + 100ppm Silver thiosulphate	46.67	49.67	0.94	-3.0	15.67	8.62
T_8:T_6 + 150ppm Silver thiosulphate	36.33	41.33	0.88	-5.0	15.33	8.72
T_9:50ppm Silver nitrate + 4% Sucrose + 200 ppm 8-HQS	61.67	65.67	0.94	-4.0	18.33	8.46
T_{10}:100ppm Silver nitrate + 6% Sucrose + 400 ppm 8-HQS	58.67	63.67	0.92	-5.0	20.33	8.31
T_{11}: T_9 + 100ppm Silver thiosulphate	62.33	69.33	0.90	-7.0	23.67	9.03
T_{12}:T_{10} +150ppm Silver thiosulphate	39.67	44.67	0.89	-5.0	16.67	8.50
T_{13}: Control (Distilled water)	50.33	54.00	0.93	-3.7	15.00	8.47
CD (p=0.05)	1.14	1.37	0.06	1.2	1.76	0.07

thiosulphate + 4% sucrose + 200 ppm 8-HQS followed by treatment with 200 ppm aluminum sulphate + 100 ppm silver thiosulphate + 4% sucrose + 200 ppm 8-HQS (8.83 days). Nair *et al.* (2003) and Yoo and Kim (2003) also recorded similar findings of extended vase life in gerbera. The basal stem portion recorded the presence of *Pseudomonas* and *Bacillus*. They were found more in control as compared to the treatment 50ppm silver nitrate + 4% sucrose + 200 ppm 8-HQS + 100ppm silver thiosulphate.

The use of 50ppm silver nitrate + 4% sucrose + 200 ppm 8-HQS +100ppm silver thiosulphate preservative solution for flower longevity and maintaining post-harvest characteristics of Gerbera cv. Shangria cut flowers is appropriate.

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Standardization of Drying Level and Time in Microwave Oven of Carnation (*Dianthus caryophyllus L.*) var. Soto

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Abstract: Maximum dry weight (2.36 g/flower) and minimum moisture loss (67.37 %) was recorded by the flowers dried at medium low level for 2.0 minutes and then at low level for 4.0 minutes. Minimum dry weight (1.69 g/flower) and maximum moisture loss of 76.63 per cent was recorded by the flowers dried at medium low level for 2.5 minutes and then at low level for 4.5 minutes. Superior quality display of good colour (3.92), texture (3.67), shape (3.75) and over all acceptance of flower (3.80) was found in the treatment medium low level for 2.0 minutes and then at low level for 4.5 minutes compared to the other treatments.

Key Words: Carnation, Drying levels, Micro wave oven, Silica gel

Carnation (*Dianthus caryophyllus* L.) is used extensively in flower arrangement and as a cut flower. The cut flowers are short lived, as they are perishable in nature. However, the concept of flower drying offers viable solution to preserve the beauty of carnation flowers and their marketability. The dry flower industry in India is about years old and its products have got high export value. As a matter of fact, this industry was introduced initially by the British and located at Kolkata for its nearness to the north-east and eastern regions where exotic and diverse blooms were available in nature. Export of dried flowers and plants from India is worth of about

The present investigation was carried out to standardize drying level and time in microwave oven of carnation var. Soto during 2011-12 at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shimoga, Karnataka, India. Fully opened flowers 8-10 cm diameter of carnation var. Sotowere harvested in morning hours and kept in bucketcontaining water. The flowers were embedded in silica gel keeping position face up and dried in microwave oven at different drying level and time duration i.e., Medium low level for 2.5 minutes and then at low level for 3.5 minutes,T_2: Medium low level for 2.0 minutes and then at low level for 3.5 minutes, T_3: Medium low level for 2.5 minutes and then at low level for 4.0 minutes, T_4: Medium low level for 2.0 minutes and then at low level for 4.0 minutes, T_5: Medium low level for 2.5 minutes and then at low level for 4.5 minutes,$T_{6:}$ Medium low level for 2.0 minutes and then at low level for 4.5 minutes, T_7: Drying at medium high level for 3.0 min. The low, medium low and medium high level referred to 30, 40 and 50 per cent microwave power density. The experiment was laid out in a completely randomized block design with three replications. The different parameters as mentioned in Table 1 were recorded to meet the objective of the study.

There was no significant difference in the fresh flower weight used for drying in micro wave oven. Maximum fresh weight was recorded in medium low level for 2.5 minutes and then at low level for 3.5 minutes (7.42 g/flower). However, minimum fresh weight (6.97 g/flower) was noticed in T_2 (Medium low level for 2.0 minutes and then at low level for 3.5 minutes) Significant difference was noticed with respect to dry weight of Carnation var. Soto. Maximum dry weight (2.36 g/flower) was observed in T_4 (Medium low level for 2.0 minutes and then at low level for 4.0 minutes) and minimum dry weight in T_5 (Medium low level for 2.5 minutes and then at low level for 4.5 minutes). The microwave oven drying exhibited a significant variation in moisture loss in Carnation flowers. However, the highest value of 76.63 per cent moisture loss was in T_5 and least moisture loss in $T_{4.}$ There was no significant difference in the fresh flower diameter used for micro-wave oven drying and no significant difference was noticed in dried flower diameter. It was observed that increase in duration of treatment decreases the weight and increases the per cent moisture loss in Carnation var. Soto. Thus higher moisture loss with increased duration of microwave drying and temperature rise caused augmented reduction of flower size during drying treatment. The rapid method of drying coupled with increased moisture loss and increased duration also affected the shape of the dried flower. Similarly rapid drying at higher temperature was practiced earlier in Carnation and Roses (Chen *et al*., 2000). The results of the present study were in

Table 1. Effect of microwave oven drying on quantitative and quality parameters of Soto variety of Carnation flowers

Treatment	Fresh weight (g/flower)	Dry weight (g/flower)	Per cent Moisture loss	Fresh flower diameter (cm)	Dried flower diameter (cm)	Colour	Texture	Shape	Over all acceptability
T_1	7.42	2.10	71.70	6.26	6.15	2.67	2.67	2.67	2.80
T_2	6.97	1.94	72.14	6.66	6.53	3.00	2.92	3.25	3.00
T_3	7.08	2.27	67.87	6.66	6.58	3.00	2.75	3.08	3.10
T_4	7.23	2.36	67.37	6.55	6.49	3.00	3.17	2.67	3.33
T_5	7.23	1.69	76.63	6.51	6.37	3.33	3.25	3.33	3.40
T_6	7.36	1.99	72.94	6.53	6.41	3.92	3.67	3.75	3.80
T_7	7.14	2.12	70.33	6.64	6.54	3.58	3.32	3.42	3.40
CD at 1%	NS	0.24	2.99	NS	NS	0.04	0.06	0.11	0.13

harmony with the foresaid reports where increase in duration of treatment decreased the weight and increased the per cent moisture loss in Carnation flowers. Same results were recorded by Bhattacharjee and Dutta (2001) and Dahiya *et al*. (2003). There is an increase in weight loss and increased per cent moisture loss with increased time duration when cut Carnation flowers were subjected for drying in microwave oven and also may be due to additive effect of the desiccating property of silica gel (Biswas and Dhua, 2010).

The micro-wave oven drying exhibited a significant variation in colour retention of dried flowers (Table 1). The maximum sensory score (3.92) was recorded in T_6 (Medium low level for 2.0 minutes and then at low level for 4.5 minutes), whereas, low in T_1. Significant differences were noticed with respect to dried flower texture. Maximum score (3.67) was recorded in T_6. The minimum score was in T_1. There was a significant difference with respect to dried flower shape due to different power output levels and duration in the microwave oven. The maximum score (3.75) was recorded in T_6 followed by T_7 (drying at medium high level for 3.0 min). Over all acceptance of flowers varied significantly due to different drying levels. Among the different durations and levels of drying, drying at medium low level for 2.0 minutes and then at low level for 4.5 minutes was best (3.80) followed by T_5 and T_7. The least score was recorded in T_1. The change in colour might be due to the stability of colouring pigments with advanced stage of harvest, attractive architecture of loosened petals and optimum moisture retention of flowers. Similar results were found in Arvinda and Jayanthi (2004), Aprajita *et al.* (2010) and Hulgur (2011). The texture and shape were significantly affected due to increase in time at low level and high moisture loss. Therefore, the carnation flowers treated with 1:5 glycerol to water for 12 hours and drying in microwave oven for 2.0 minutes at medium low level and 4.5 minutes at low level (T_6) could produce better quality dry flowers.

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Radiation and Heat Use Efficiency in *Brassica* under Debranching and Defoliation Treatments

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Abstract: Variety GSC-6 intercepted higher PAR interception at pod formation and pod filling stage, whereas, PAR interception was higher at flowering stage in variety GSL-2. Higher PAR interception was recorded in defoliation from flowering to pod filling stage, whereas, in debranching PAR interception was more at pod filling stage than defoliation. On an average 4 to 7 per cent increase in PAR interception was recorded in defoliation and debranching over control. Radiation use efficiency was higher under debranching as compared to defoliation.

Key Words: Debranching, Defoliation, Heat use efficiency, PAR interception, Radiation use efficiency

Oilseed crops play an important role in agricultural economy of India. India ranks second in area after China and third in production after Canada and China contributing about 17.9 per cent of total area and 11.2 per cent of total production of rapeseed-mustard in the world (DRMR 2013). To improve the economic yield of oilseed crops there are many ways of which, improved breeding and biotechnological applications are on fore fronts nowadays. Chakravarty *et al* (2008) reported that yield can be improved by modification of micro-environment in the crop through debranching of lower branches at flowering and pod filling stages in *Brassica* crop. Debranched plants experience better PAR interception and improved translocation of photosynthesis to remaining branches, which become more productive (Kumar *et al.*, 2010 and Adak *et al.*, 2011). Growth and yield were significantly increased by the defoliation treatment. The present study was also conducted to generate quantitative information on debranching relating the mustard crop's performance under differential thermal environments under semi-arid conditions of northern India.

The experiment was conducted at Punjab Agricultural University, Ludhiana in split plot design with three sowing dates (October 10, October 25 and November 10) and two varieties (GSC-6 and GSL-2) in main plots; and debranching and defoliation treatments along with the control in sub plots with three replications. The micro-environment modification was created by removing 5-6 lower secondary branches at 50% pod filling stage from every plant sown on different dates in both the varieties under debranching, and 3-4 leaves were removed from the lower part of the plants at flowering and pod filling stage in defoliation. A control was also maintained by keeping all the branches and leaves intact. The photosynthetically active radiation (PAR) interception was measured on clear sunny day at different phenological stages with the help of a Line Quantum Sensor (Model LI-190 SB) and output of Quantum Sensor was recorded with a digital multivoltmeter. The incoming and outgoing PAR on the top of the canopy and radiation penetration at the ground surface below the crop canopy was measured. The observations were taken at random from two places in each plot. The per cent interception was calculated as under:

$$\text{PAR interception (\%)} = \frac{\text{PAR (I)} - [\text{PAR (T)} + \text{PAR (R)}]}{\text{PAR (I)}} \times 100$$

Where

PAR (I) -PAR incoming above the canopy; PAR (T)-PAR transmitted to the ground; PAR (R)-PAR reflected from the canopy

The radiation use efficiency was calculated by the ratio of dry matter yield to the intercepted PAR using the following formula:

$$\text{RUE} = \frac{\text{Dry matter yield (g/m}^2\text{)}}{\text{AIPAR (MJ/m}^2\text{/s)}}$$

Where,

RUE = Radiation use efficiency (g/MJ)

Y = Yield (g/m^2)

AIPAR = Accumulated Intercepted photosynthetically active radiation (MJ/m^2/day)

The PAR values were converted from mol m^{-2} s^{-1} to the MJ/m^2/day using the following formula given by Kumar *et al* (2010):

1 MJ/m^2/day = 0.0007826 PAR (mol m^{-2} s^{-1}) BSS-Bright sunshine hours

The heat use efficiency is the amount of above ground dry matter produced per degree-day. It was calculated by using the formula.

$$\text{Heat Use Efficiency (g/m}^2\text{/°C day)} = \frac{\text{Dry matter yield (g/m}^2\text{)/Grain yield}}{\text{Accumulated growing degree days (°C day)}}$$

PAR interception (%): The PAR interception was higher in 10th October sowing as compared to 25th October sowing and 10th November sowing. This may be due to higher leaf area index (LAI) under 10th October sowing. But PAR interception under 10th October and 25th October was same (Tables 1 to 2). PAR interception increased at the flowering stage and showed a decreasing trend up to pod filling stage.

Among the varieties, PAR interception was higher in variety GSL-6 compared to GSL-2 at pod formation and pod filling stage under all the dates of sowing, but, the trend reversed for flowering stage. The defoliated crop showed more PAR interception from flowering to pod filling stage than control but at pod filling stage, the PAR interception increased than that of control due to debranching and defoliated crop. Adak *et al* (2012) also reported that magnitude of radiation penetration within the crop canopy was higher in debranched crop than control, indicating a strong correlation between radiation penetration and branch removal.

Radiation use efficiency: The radiation use efficiency decreased with the delay in sowing. The radiation use efficiency increased due to more light interception and decreased with each delay in sowing. The more light interception in 10th October sowing was due to more leaf area index that decreased with delay in sowing. The decreased leaf area resulted in low interception of photosynthetically active radiation, which in turn caused decrease in radiation use efficiency with delayed sowing. Amongst the varieties, GSL-2 recorded higher radiation use efficiency than GSC-6 at the flowering, pod formation and pod filling stage under all the dates of sowing. Among the modification treatments, the control recorded the high radiation use efficiency than debranched and defoliated crop at all the stages, whereas in more RUE was recorded debranched crop than the defoliated crop.

Heat use efficiency (HUE): The HUE started increasing

Table 1. PAR interception at different phonological stages under different micro-environments

Phenological stages	Treatments	PAR interception (%)					
		GSL-2			GSC-6		
		10th Oct	25th Oct	10th Nov	10th Oct	25th Oct	10th Nov
Flowering	Defoliation	67.2	66.2	60.3	63.2	62.7	59
	Control	62.5	61.6	56	59.2	59.3	54.2
Pod formation	Defoliation	66.1	63.7	59.4	70.1	66.5	61.5
	Control	59	58	54.1	65.8	63.2	56.4
	Debranching	62.1	59.5	56.7	64.2	61.7	58.6
Podfilling	Defoliation	60.1	57.7	54.4	61.2	60.1	57.5
	Control	57.7	54.4	52.2	58.4	56.4	54.2

Table 2. Periodic heat use efficiency (g/m^{2o}Cday) of *Brassica napus* varieties under three dates of sowing and three modification treatments during *rabi* 2013-14

Treatments	Days after sowing				Straw yield	Seed yield
	30	60	90	120		
Date of sowing						
10-Oct	0.013	0.138	0.566	0.549	0.479	0.123
25-Oct	0.013	0.164	0.616	0.605	0.505	0.126
10-Nov	0.011	0.169	0.534	0.522	0.437	0.107
CD (p=0.05)	0.001	0.009	0.019	0.029	0.030	0.009
Varieties						
GSL 2	0.013	0.151	0.564	0.560	0.451	0.106
GSC 6	0.013	0.163	0.573	0.567	0.518	0.131
CD (p=0.05)	NS	0.008	NS	NS	0.025	0.008
Modification treatments						
Debranching	0.013	0.158	0.579	0.585	0.455	0.126
Defoliation	0.012	0.156	0.548	0.561	0.475	0.118
Control	0.013	0.157	0.579	0.605	0.523	0.114
CD (p=0.05)	NS	NS	0.016	0.040	0.021	0.004

from 60 DAS to 90 DAS and than decreased towards maturity. Among the dates of sowing heat use efficiency was higher in 25th October sowing followed by the crop sown on 10th October and 10th November at all the growth stages (Table 2). The higher value of HUE was attained at 90 days after sowing (DAS) under all the dates of sowing. Amongst the varieties, the differences were non-significant at 30, 90 and 120 DAS but at 60 DAS, variety GSC-6 had significantly more heat use efficiency than GSL-2. Reduction in HUE under late sown conditions indicates that the early sown crop used heat more efficiently as compared to late sown crop. The defoliated crop recorded significantly low heat use efficiency than control followed by debranched crop due to the removal of leaves and branches. The heat use efficiency of straw and seed yield was significantly higher in 25th October sowing than 10th November sowing but was at par with 10th October sowing. The variety GSC-6 had significantly higher heat use efficiency than GSL-2. The GSC-6 recorded significantly higher heat use efficiency than GSL, whereas debranched crop had significantly higher heat use efficiency than defoliated crop. Similar results were reported for the response effect of date of sowing and varieties on heat use efficiency for mustard crops by Hundal *et al.* (2003) and Tripathi *et al.* (2007).

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Studies on Food Consumption and Utilization Behaviour in Susceptible and Resistant Diamondback Moth, *Plutella Xylostella* (Linnaeus)

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Abstract: Various consumption and utilization indices i.e. relative consumption rate (RCR), relative growth rate (RGR), efficiency of conversion of ingested food to body substance (ECI), efficiency of conversion of digested food to body substance (ECD) and approximate digestibility (AD) were determined. The resistant *P. xylostella* larvae differed from the susceptible ones as regards fresh larval weight, fresh weight of food eaten and weight of faeces. The mean larval fresh weight of resistant larvae was significantly higher (1.21 mg) than that of susceptible larvae (1.07 mg); fresh weight of food eaten was significantly higher (17.84 mg) for resistant larvae than the susceptible larvae (14.42 mg) and also mean weight of faeces of resistant larvae was significantly higher (2.57 mg) than the susceptible ones (2.20 mg). The mean fresh weight gain of resistant larvae (2.79 mg) as well as susceptible larvae (2.76 mg) were at par. Similarly relative consumption rate (RCR) was 3.69 for resistant and 3.38 for susceptible larvae, approximate digestibility (AD) was 85.59 for resistant and 84.7 for susceptible larvae, relative growth rate (RGR) was 0.58 for resistant and 0.65 for susceptible larvae and efficacy of conversion of ingested food to body substance (ECI) i.e. 15.64 for resistant and 19.14 for susceptible larvae; were at par. However, efficiency of conversion of digested food to body substance (ECD) for susceptible larvae (22.59) was significantly higher than the resistant ones (18.20).

Key Words: Food consumption, *Plutella xylostella,* Susceptible, Utilization indices

Diamondback moth (DBM), *Plutella xylostella* (Linnaeus) (Lepidoptera: Plutellidae) is cosmopolitan and most noxious pest of cole crops in Punjab, India and rest of the world where it has posed very serious threat to the crops causing over US $ 1 billion worth damage globally per annum and has become very challenging to control (Sarfraz and Keddie 2005, Roux *et al* 2007, Khaliq *et al* 2007) and ranks among the top 20 most resistant insect species reported so far (Mota-Sanchez *et al* 2002). Presently, it is known to have developed resistance to more than 46 insecticides from all groups including new generation insecticides such as neonicotinoids, avermectins, macrocyclic lactones, IGRs and Bt formulations etc. (Dhumale *et al* 2009, Kim *et al* 2011, Oliveira *et al* 2011).

To manage insecticide resistance in any insect, comprehensive knowledge of its behavioural physiology is of paramount importance. There exists a knowledge gap as regards comparative study of feeding behaviour in susceptible and insecticide-resistant populations of most of the insects, including DBM. This knowledge may help to find management solution to the diamondback moth. All this has necessitated the need of a comprehensive study of feeding behaviour of *P. xylostella* to determine variations in feeding between its susceptible and insecticide-resistant populations of *P. xylostella.*

For experiment, nearly a month old seedlings of cauliflower (*Brassica oleracea* var. *botrytis L.*) were transplanted in the field at regular intervals so as to ensure continuous supply of food for the test-insect. Two populations of *P. xylostella* i.e. susceptible and insecticide-resistant populations were maintained for conducting various experiments during the study period. The susceptible population was raised in the screen house in an insecticide-free environment for 22 generations i.e. without exposure to any xenobiotics, after collecting the larvae of diamondback moth (DBM) from the fields of cabbage/cauliflower. The second population i.e. the resistant one was maintained after collecting the DBM larvae from the cauliflower/cabbage fields subjected to intense insecticidal pressure and then reared upto one generation. Culture of *P. xylostella* was maintained on the cauliflower leaves kept in glass jars (10 ×15 cm) placed in a Plant Growth Chamber at 27° C and 65 % RH. Food was changed daily till the onset of pupation.

For this experiment, a leaf-disc from the cauliflower leaf was cut along the mid vein so that both the halves were equal; each half was weighed separately (as per method given by Sandhu 1996). The two halves were placed in two separate Petri dishes (5 cm). Ten second instar larvae of *P. xylostella* from the susceptible population were released on one half of a disc and allowed to feed for four days. Initial weight of these larvae was taken before releasing them on the disc. After four days of feeding, weight of these larvae was again recorded for larval weight gain. Simultaneously, the weight of each half leaf-disc was also measured to account

for loss in weight due to evaporation. Based upon these, the corrected weight of the leaf eaten was worked out. Excreted pellets were collected after four days and weight of the same was recorded. The experiment was replicated thrice. Similarly larvae from the resistant population of *P. xylostella* were released on leaf-disc for working out the food consumption and utilization behaviour and the experiment was again repeated with three replications.

Various consumption and utilization indices i.e. relative consumption rate (RCR), relative growth rate (RGR), efficiency of conversion of ingested food to body substance (ECI), efficiency of conversion of digested food to body substance (ECD) and approximate digestibility (AD) were determined as per equations given by Waldbauer (1968).

The resistant *P. xylostella* larvae differed from the susceptible ones as regards fresh larval weight, fresh weight of food eaten, weight of faeces; the mean larval fresh weight of resistant larvae was significantly higher (1.21 mg) than that of susceptible larvae; fresh weight of food eaten was significantly higher (17.84 mg) for resistant larvae than the susceptible larvae and also mean weight of faeces of resistant larvae was significantly higher (2.57 mg) than the susceptible ones. The mean fresh weights gain of resistant larvae and susceptible larvae were at par. Similarly relative consumption rate (RCR) was 3.69 for resistant and 3.38 for susceptible larvae, approximate digestibility (AD) was 85.59 for resistant and 84.7 for susceptible larvae, relative growth Rate (RGR) was 0.58 for resistant and 0.65 for susceptible larvae and efficacy of conversion of ingested food to body substance (ECI) for resistant and for susceptible larvae; were at par. However, efficiency of conversion of digested food to body substance (ECD) for susceptible larvae was significantly higher than the resistant ones. Obviously, the susceptible and resistant populations differ in several feeding parameters as discussed above; apart from inherent difference of the populations, those differences may also be due to the fact that susceptible population was reared in the screen house for 22 generations in contrast to the insecticide-resistant one brought from the field for experimentation after rearing in the screen house for a generation or so. The difference in various nutritional indices has already been reported.

Feeding studies on the *P. xylostella* under no choice conditions revealed minimum leaf damage (15 %) in diethyl ether closely followed by chloroform fraction of *Melia azadirach L.* as compared to 66.7 % in untreated check (Sandhu, 1996) . Fed area increased significantly with decreasing concentrations. Nutritional indices like relative growth rate (RGR), efficiency of conversion of ingested food (ECI) and efficiency of conversion of digested food (ECD) showed a linear decreasing trend over solvent check on increasing concentrations. Murugesan (2001) also studied the consumption and utilization of different cole crops by *P. xylostella* and observed that higher quantity of food consumed (11.30 mg), lower consumption index (0.74 %), higher approximate digestibility (69.21 %), and relative growth rate (0.31), efficiency of conversion of ingested food (69.95 %) on cauliflower made it most suitable for the larval development. Sandhu and Sandhu (2011) studied food consumption and utilization by *P. xylostella* on five different culitvars of cabbage and found maximum food consumption on cultivar, Pusa Mukta whereas minimum on cultivar, Pride of India. Higher consumption Index (CI), lowest approximate digestibility (AD), efficiency of conversion of ingested food (ECI), relatively low relative growth rate (RGR) was found on Pride of India; whereas, Low CI, high AD and ECI, RGR and higher leaf area damage was found on Pusa Mukta and Golden Acre. Thus, Pusa Mukta and Golden Acre were considered as most preferred hosts for development of *P. xylostella*.

Table 1. Food consumption and its utilization in susceptible (S) and resistant (R) populations of *P. xylostella*

Biological parameter	S	R	t-test
*Mean fresh larval weight (mg)	01.07 ± 0.01	01.21 ± 0.02	18.91
*Mean fresh weight of food eaten (mg)	14.42 ± 0.05	17.84 ± 0.07	18.83
*Mean weight of faeces (mg)	02.20 ± 0.36	02.57 ± 0.02	02.91
* Mean fresh weight gain of larvae (mg)	02.76 ± 0.15	02.79 ± 0.03	00.55
Relative Consumption Rate (RCR)	03.38 ± 1.53	03.69 ± 0.81	00.49
Approximate Digestibility (AD)	84.70 ± 1.83	85.59 ± 0.07	01.31
Relative Growth Rate (RGR)	00.65 ± 0.01	00.58 ± 0.48	00.40
Efficiency of conversion of ingested food to body substance (ECI)	19.14 ± 2.57	15.64 ± 6.15	01.48
Efficiency of conversion of digested food to body substance (ECD)	22.59 ± 0.29	18.20 ± 0.02	40.72

S & R denote susceptible and resistant populations, respectively of *P. xylostella*
*Mean of three replications, each comprising ten larvae

Relative consumption rate (RCR), approximate digestibility (AD), relative growth rate (RGR) and efficiency of conversion of ingested food to body substance (ECI) for the larvae of susceptible and resistant population respectively, were at par, but the values of ECD (efficiency of conversion of digested food to body substance) at 22.59 and 18.20 for susceptible and resistant *P. xylostella* larvae, respectively differed significantly.

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