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Effect of Spacing and Banana Pseudo stem-Based Nutrients on Cowpea Yield under Agroforestry

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***Abstract*:** The present investigation was carried out to check the effect of various spacings and foliar sprays of Novel (banana pseudo stem based organic liquid nutrients) on growth and yield of cowpea (*Vigna ungiculata* L.) under mango-based agroforestry system during 2021 and 2022 at Navsari Agricultural University, Navsari, India. The trial was framed with eight treatment combinations of two factors *viz*., two levels of spacing and four levels of foliar spray of banana pseudo stem based organic liquid nutrients under mango orchard and open condition. The closer spacing (S_1: 30 cm x 30 cm) recorded significantly maximum plant height of cowpea at harvest. However, the highest f collar diameter, number of branches per plant, number of clusters per plant, yield per plant, plot and hectare were observed with spacing 45 cm x 45 cm as compared to 30 cm x 30 cm under mango-based agroforestry system as well as in open condition. Among various foliar application of novel fertilizers, Novel plus containing banana pseudo stem based organic liquid nutrients + botanical pesticides @ 1 % recorded significantly maximum cowpea growth parameters (plant height, collar diameter and number of branches per plant) as well as yield parameters (number of clusters per plant, and yield per hectare).

***Keywords*:** Spacing, Foliar Spray, Novel, Cowpea, Agroforestry

In developing country like India, demand for food and nutrition is continuously increasing with raising population which creates pressure and challenges for agriculture. It is difficult to meet food and nutritional goals as the already limited agricultural is rapidly being diverted to other developmental activities. Therefore, diversification of land use systems with agroforestry is a necessary strategy to meet these challenges by compatible intercrops with perennial fruit crops for higher yield returns. Fruit-based agroforestry systems have been emerging in almost all the region of India on the basis of either planting of trees, pastures, arable crops *etc*. in existing fruit orchards or *vice versa* (Bhusara et al., 2016, Kumar and Chaturvedi 2017, Thakur et al., 2017). Integration of annual crops with fruit trees yields multiple outputs that ensure production and income generation in a sustainable manner (Verma and Thakur 2010, 2011, Awasthi 2018,). Among the fruit trees in the tropics *Mangifera indica* L., enjoys a dominant position both in terms of diversity and extent and farmers take intercrops in the early stage of mango orchards. Vegetables are one of the essential nutrient suppliers and can be easily integrated with fruit trees or forestry plantation or any other agroforestry systems in early stages. The cowpea is an annual herbaceous legume and can be grown under partially shade.

Due to increased inclination towards organic or natural farming is being advocated to produce chemical free vegetable, pulses grains fruits *etc*. Further health-related issues and promotion of organic and natural farming in India, use of organic fertilizers in vegetable production is increasing by researchers and farmers for quality production. Organic fertilizers are naturally available mineral sources that contain moderate amount of essential plant nutrients (Shaji et al., 2021). Novel, Novel Prime and Novel Plus [a product developed under National Agricultural Innovation Project (NAIP), Navsari Agricultural University, Navsari, are an enriched sap of banana pseudo stem contains essential plant nutrients and naturally occurring plant growth enhancers like cytokinin, NAA, GA_3, macro and micro elements with botanical fungicide and pesticide property. The study was conducted with a view to generate the information regarding tree-crop interaction with use of organic fertilizers on cowpea under commercial fruit tree canopies.

MATERIAL AND METHODS

Experimental site: This study was conducted in February-June during 2021 and 2022 at Navsari Agricultural University, Navsari, geographically situated at latitude of 20° 57' N and longitude of 72° 54' E and at an altitude of about 9 m above the mean sea level. Climate of the area is sub-humid with average annual rainfall of 1500-1700 mm. The soil of experimental site was moderately drained clayey soils classified as “Deep Black Soil” predominated with montmorillonite clay mineral by its origin and medium in fertility (Kumar et al., 2020).

Experimental design and treatments: The experiment was laid out in randomized block design with factorial concept with three replications and eight treatment combinations of two different factors. i) spacing with two levels *viz*., 30 cm x 30 cm and 45 cm x 45 cm and ii) foliar spray of novel organic liquid fertilizers with four levels *viz*., F_1: control (No spray), F_2: Novel @ 1 % (banana pseudo stem based organic liquid nutrients), F_3: Novel prime @ 1 % (banana pseudo stem based organic liquid nutrients + botanical fungicide) and F_4: Novel plus @ 1 % (banana pseudo stem based organic liquid nutrients + botanical pesticides). The experiment was carried out under 10 years old mango orchard in which mango trees were planted at 9 m x 9 m spacing in open field condition. AVCP-1 (Anand Vegetable Cowpea) variety of Cowpea (*V. ungiculata* L.) was selected for present study. The crop was raised as per the recommended package of practices.

Novel, novel plus and novel prime organic liquid fertilizers were procured in 100 per cent concentration. The required concentrations of solutions were prepared in water at the time of application. First foliar spray of novel fertilizers was carried out after the initiation of flowering and second foliar spray was applied after 15 days of first spray according to treatments in each plot under mango and in open condition. The green pods for vegetable purpose were harvested manually by plucking when they were tender and at marketable size and continued over a considerably long period of cowpea. The data pertaining to various growth parameters of cowpea were recorded at the end of experiment. The yield parameters of cowpea were recorded at each picking and then total of all picking was averaged out.

RESULTS AND DISCUSSION

Cowpea growth: The data on growth parameters (plant height, collar diameter and number of branches per plant) of cowpea variety AVCP – 1 as influenced by spacing and foliar spray of novel organic liquid fertilizers under mango-based agroforestry system and open condition was recorded (Table 1). Effect of spacing on plant height, collar diameter and number of branches per plant at harvest of cowpea was significant under mango based agroforestry system and in open condition. The maximum plant height (47.40 cm,), minimum collar diameter (11.94 mm) and number of branches per plant (7.48) were registered in closer spacing (S_1: 30 cm x 30 cm) under mango-based agroforestry system. The minimum plant height (41.04 cm), maximum collar diameter (14.05 mm) and number of branches per plant (8.13) were registered in wider spacing (S_2: 45 cm x 45 cm). Moreover, in open condition, maximum plant height (51.40 cm), minimum collar diameter (14.42 mm) and numberof branches per plant (9.09) were noted in closer spacing (S_1: 30 cm x 30 cm) whereas minimum plant height (45.29 cm), maximum collar diameter (16.51 mm) and number of branches per plant (9.94) were observed in S_2: 45 cm x 45 cm (Table 1).

Significantly higher plant height was recorded in closer spacing as compared wider spacing. This might be due to more competition for available resources especially for sunlight (Singh et al., 2013). Furthermore, stems are shaded from light resulting in accumulation of auxin (a growth hormone) that stimulates cell division and elongation of internodes, thereby increasing the height. In widely spaced

Table 1. Growth parameters of cowpea as influenced by spacing and foliar spray of novel organic liquid fertilizers under mango-based agroforestry system and open condition

Treatments	Plant height (cm)		Collar diameter (mm)		No. of branches per plant	
	AF	Open	AF	Open	AF	Open
S: Spacing (S1: 30 cm x 30 cm; S2: 45 cm x 45 cm)						
S_1	47.40	51.40	11.94	14.42	7.48	9.09
S_2	41.04	45.29	14.05	16.51	8.13	9.94
CD (p=0.05)	1.66	1.78	0.62	0.59	0.39	0.40
F: Foliar spray of Novel organic liquid fertilizers (F1: Control; F2: Novel (1 %); F3: Novel prime (1%); F4: Novel plus (1%)						
F_1	41.20	45.14	11.72	14.14	6.78	8.77
F_2	44.17	48.28	12.96	15.22	7.90	9.42
F_3	45.45	49.57	13.53	15.70	8.13	9.70
F_4	46.06	50.41	13.77	16.81	8.43	10.16
CD (p=0.05)	2.34	2.52	0.88	0.84	0.55	0.56
CD (p=0.05) S×F	NS	NS	NS	NS	NS	NS
C.V. %	6.33	6.23	8.12	6.50	8.45	7.04

AF= Agroforestry system (mango-cowpea); NS=Non-significant

plants, auxin destruction by light occurs resulting in plants being shorter in height (Alemayehu et al., 2015). The results are in line with findings of Malami and Sama'ila (2012), Rima Taipodia and Nabam (2013) and Adigun et al. (2014) in cowpea; Alemayehu et al. (2015) in haricot bean (*P. vulgaris*), Katara et al. (2022) in kabuli chickpea (*Cicer arietinum*) and Chaudhari et al. (2023) in green gram (*V. radiata*).

However, collar diameter and number of branches per plant were maximum in wider spacing. This might be because of less light competition encourage lateral growth and suppress apical growth resulting in excessive branching. The results are analogues with earlier findings of Ndor et al., (2012) in cowpea; Mureithi et al., (2012) in french bean (*P. vulgaris*), Murade et al. (2014) in urd bean (*V. mungo*), Alemayehu et al. (2015) in haricot bean (*P. vulgaris*), Kalsariya et al. (2017) and Chaudhari et al., (2023) in green gram (*V. radiata*). The plant height, collar diameter and numberof branches per plant at harvest of cowpea was significantly influenced by foliar application various novel organic liquid fertilizers. Maximum plant height (46.06 cm), collar diameter (13.77 mm) and number of branches per plant (8.43) were in F_4: Novel plus (1 %) under mango-based agroforestry system. However, in case of open condition, maximum plant height (50.41 cm), collar diameter (16.81 mm) and no. of branches per plant (10.16) were obtained with F_4: Novel plus (1 %).

Significantly higher plant height, collar diameter and number of branches were recorded in plants receiving foliar spray of various novel organic liquid nutrients. The increment in plant height and higher number of branches might be due to the fostered meristematic activities which was catalyzed by growth regulator contains in novel organic liquid nutrients *viz*., gibberellic acid, naphthalene acetic acid and cytokinin which leads to enhance cell division and cell elongation (Desai et al., 2016). This might also be due ample amount of nitrogen content in liquid nutrient which enhances cell division, cell elongation as well as formation of more tissues resulting in luxuriant vegetative growth which leads to increase in plant height (Krishna Chotaliya et al., 2018). Moreover, nitrogen also increases the cation exchange capacity of plant roots which makes them efficient in absorbing other nutrients ions like phosphorus, potassium *etc*. which helps to terminate vegetative growth (Champaneri et al., 2021). Similar results are also reported by Kavitha et al. (2019), Savaliya (2020) and Rabade et al. (2022) in cowpea; Mandre et al. (2020) in black gram (*V. mungo*), Champaneri et al. (2021) in Indian bean (*Lablab purpureus*), Selvarani et al. (2021) and Akshika Bhawariya et al. (2022) in cluster bean (*C. tetragonoloba*).

The plant height and other growth parameter were higher in open condition as compared to under mango-based agroforestry system it might be due to sufficient amount of light available to cowpea plants in open condition while, under mango less availability of light suppressed the growth of plants. The interaction effect of different spacing (S) and foliar spray of Novel organic liquid fertilizers (F); S x F was not significant for all growth parameters of cowpea at harvest under mango-based agroforestry system and in open condition.

Cowpea yield: Yield parameters *viz*., number of clusters per plant, yield per plant (g) and yield (t ha^{-1}) of cowpea variety AVCP – 1 as affected by spacing and foliar spray of Novel organic liquid fertilizers under mango-based agroforestry system and open condition was recorded during the (Table 2). Effect of spacing on number of clusters per plant, yield per plant and yield per hectare was found significant under mango-based agroforestry system and in open condition. The maximum number of clusters per plant (23.88), yield per plant (147.77 g), and yield per hectare (3.65 t) was in spacing S_2: 45 cm x 45 cm under mango-based agroforestry system.

In open condition, number of clusters per plant (27.22), yield per plant (182.44 g), and total yield (9.01 t ha^{-1}) were observed in spacing S_2: 45 cm x 45 cm as compared to S_1: 30 x 30 cm (Table 2). Significantly the number of clusters per plant, and total yield of cowpea were observed in wider spacing in comparison to closer spacing. This might be due to less competition for light, moisture and nutrients associated with wider spacing and thereby having an edge in producing more reproductive parts when compared to higher plant population density (Karukonda et al., 2020). Higher number of clusters per plant observed might be due to higher number of branches per plant at wider plant spacing as higher number of branches benefits to more sites for flower development, which attributed to a prolific pod production (Alemayehu et al., 2015). These results are in conformity with the earlier findings of Malami and Sama'ila (2012), Prabhamani et al. (2019) and Karukonda et al. (2020) in cowpea; Singh et al. (2013) in faba bean (*V. faba*), Alemayehu et al. (2015) in haricot bean (*P. vulgaris*) and Katara et al. (2022) in kabuli chickpea (*C. arietinum*). The foliar spray of Novel organic liquid fertilizers significantly affects the yield parameters of cowpea under mango-based agroforestry system and in open condition.

Under mango-based agroforestry system, number of clusters per plant (21.15), yield per plant (117.11g), and total yield (3.90 t ha^{-1}) was recorded with F_4: Novel plus (1 %) (Table 2). In open condition, number of clusters per plant (25.22) and total yield (9.82 t ha^{-1}) was in F_4: Novel plus (1 %). The significantly the higher number of clusters per plant, yield per plant and total yield of cowpea were in plants receiving foliar spray of various novel organic liquid

Table 2. Yield parameters of cowpea as influenced by spacing and foliar spray of novel organic liquid fertilizers under mango-based agroforestry system and open condition

Treatments	No. of clusters per plant		Yield per plant (g)		Yield (t ha^{-1})	
	AF	Open	AF	Open	AF	Open
S: Spacing (S1: 30 cm x 30 cm; S2: 45 cm x 45 cm)						
S_1	14.21	17.26	55.69	75.98	3.09	8.44
S_2	23.88	27.22	147.77	182.44	3.65	9.01
CD (p=0.05)	1.82	2.26	6.61	5.20	0.19	0.37
F: Foliar spray of Novel organic liquid fertilizers (F1: Control; F2: Novel (1 %); F3: Novel prime (1 %); F4: Novel plus (1 %)						
F_1	15.43	18.41	84.71	112.71	2.86	7.56
F_2	19.44	21.70	96.75	123.09	3.18	8.30
F_3	20.17	23.64	108.33	136.51	3.54	9.22
F_4	21.15	25.22	117.11	144.52	3.90	9.82
CD (p=0.05)	3.13	3.20	9.34	7.35	0.28	0.53
CD (p=0.05) S×F	NS	NS	13.21	10.40	NS	NS
C.V. %	13.61	17.21	10.98	6.81	9.76	7.24

AF= Agroforestry system (mango-cowpea); NS=Non-significant

fertilizers. The increase in numbers of pods and yield might be due to a reason of supply of more nutrients at critical stage (*i.e*., flowering and fruit setting) as various novel organic liquid fertilizers contain macro and micro nutrients. It also improves photosynthetic activity which ultimately enhanced utilization of photosynthates and increased allocation of photosynthates towards the economic part.

Moreover, higher pod yield might be due to vigorous vegetative growth with accelerated photosynthetic activities thereby increasing the supply of carbohydrates to the plants (Selvarani et al., 2021). The spraying of water-soluble nutrients increase uptake of nutrients and water along with easy availability of nutrients, resulting in more photosynthesis and enhanced food accumulation in edible parts. These findings are supported by work of Kavitha et al. (2019), Fernando and Brintha Karunarathna (2020), Savaliya (2020), Mandaliya (2021) and Sakpal et al. (2021) in cowpea; Meena et al. (2017) in urd bean (*V. mungo*), Mandre et al. (2020) in black gram (*V. mungo*), Champaneri et al. (2021) in Indian bean (*Lablab purpureus*), Selvarani et al. (2021) in cluster bean (*C. tetragonoloba*) and Hiremath et al. (2023) in chickpea (*C. arietinum*).

Further, significantly the higher yield of cowpea was produced in open condition as compared to mango-based agroforestry system. The lower yield under more shaded conditions was probably due to poor photosynthetic capacity of plants as they are not receiving proper sunlight under tree canopies. These findings are supported by work of Kaushik et al. (2014), Sharma et al. (2017), Miah et al. (2018), Rahman et al. (2018), Kona et al. (2020), Bony et al. (2021) and Islam et al. (2021).

The interaction effect of different spacing (S) and foliar spray of Novel organic liquid fertilizers (F) was remained non-significant for all yield parameters of cowpea except yield per plant in pooled analysis under mango-based agroforestry system and in open condition. Significantly maximum yield per plant (168.75 and 202.06 g plant^{-1}) was produced by S_2F_4 which was on same bar with S_2F_3 (160.45 and 192.68g plant^{-1}). However, the minimum yield per plant was in S_1F_1 (49.65 and 64.47 g plant^{-1}) respectively under mango-based agroforestry system and in open condition.

CONCLUSION

Slight reduction in growth and yield parameters of cowpea was observed under mango-based agroforestry system as compared to open growing condition. Growing of cowpea in open condition resulted in significant increase in various growth as well as yield parameters as compared to mango-cowpea agroforestry system. Between two spacing, wider spacing of 45 cm x 45 cm registered overall maximum values of growth and yield parameters of cowpea. Among foliar application of various novel fertilizers, overall highest values of growth and yield parameters of cowpea was registered in foliar application of Novel plus @ 1 % (banana pseudo stem based organic liquid nutrients + botanical pesticides) in both growing conditions.

AUTHOR'S CONTRIBUTION

Mehfuza Patel- Research implementation, data collection; M. B. Tandel- Planning, management, and writing of manuscript; S. M. Patel – trial management; M. K. Desai – Data analysis; M. P. Ahir – Data collection and grouping; Y. A.

Garde – Statistical analysis and interpretation.

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