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Engineering Interventions for Increasing Farm Income and Natural Resources Conservations in Upper Krishna Command Area in North Eastern Dry Zone of Karnataka

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Abstract: Engineering interventions helps to maximizing agricultural productivity and profitability with a minimum drudgery to farm workers, especially women. In the present study, nine interventions were demonstrated at Yadgir district by ICAR-Krishi Vigyan Kendra from 2019 to 2024. The direct seeded rice (DSR), drum seeder (DS) and laser levelling (LL) has achieved the water productivity (kg/ha/mm) of 5.90, 4.50 and 4.66 compared to 4.28, 3.39 and 4.66 by saving irrigation water (%) of 22, 15 and 23.17 as compared to transplanting paddy. Use of nipping machine in pigeonpea and chickpea increased yield up to 10.25 (%) and 8.29 (%) compared to farmers practices. Cotton shredder saved 80 (%) and 55.45 (%) of labour and management cost in cotton crop. Compartment bunder in greengram helps to achieve water productivity (kg/ha/mm) and yield (q/ha) of 10.06 and 19.80 compared to 7.5 and 14.75 in farmers practices. Raised bed with plastic mulch in watermelon increased water productivity (kg/ha/mm) and yield (q/ha) of 144.45 and 650 compared to 64.44 and 388 in farmers practices by saving 33.33 (%) of irrigation water. Adaptation of engineering interventions helps to increase water productivity and crop yield by saving irrigation water, time and labour cost.

Keywords: Crop yield, Drudgery, Irrigation, Water productivity

Engineering interventions are multidisciplinary approach which integrates principles of engineering of various other disciplines with agricultural sciences for the development of innovative solutions which aims for enhancing agricultural practices for natural resources management (Sreedevi et al., 2024, Madhusudan et al., 2025). Demonstrations of such pivotal technologies provides solutions to the challenges faced by the agriculture sector, like increasing global food demand, limited land resources, and environmental sustainability. The need for engineering arises to address the growing population and the need to produce more food efficiently with limited land and other resources (Jerzak and Śmiglak-Krajewska 2020). Traditional farming methods had limitations like less productivity, un judicious use of resource utilization and environmental impact (Patel et al., 2020, Thakur and Sidana 2024,). Engineering interventions provides solutions to these challenges by applying engineering principles and technologies for development of sustainable and efficient farming systems. The aim of engineering technologies is to increase the availability of machinery, irrigation systems, and post-harvest processing techniques to optimize agricultural production. They focus on the areas like improving crop yields, minimizing waste, conserving resources, and reducing the environmental footprint of farming operations.

Mechanization in agriculture is the use of various machinery and equipment to ease farming operations, which reduces the dependence on manual labour and drudgery (Mentsiev et al., 2020). Agricultural machinery involves a variety range of equipment, including tractors, harvesters, planters, sprayers, and tillage tools. These machines are designed to perform specific tasks efficiently, which saves time and labour and improves productivity (Apoorv et al., 2025). The development of agricultural machinery has greatly affected farming practices in positive ways, which enable farmers to accomplish operations quickly and effectively. These modern machineries are equipped with modern advanced technologies such as GPS, computer control systems, and sensors, which allow precise and efficient operation. With population growth in progress, the global agriculture industry has also to progress, which is currently at 10 percent of the global GDP, to grow at least 60 percent by 2030 in order to keep the demand in check (Mentsiev et al., 2020).

Water is the fundamental resource for agriculture, and most important input for crop growth, development, and yield (Prikxit et al., 2025). Irrigation is the artificial application of water to the plants for meeting the evapotranspiration need of the plant. If there is lack of adequate water supply during various growing season of the plant optimal plant health and productivity are severely affected which also increase susceptibility to pests and diseases, and overall farm productivity decreases by many folds (Tamboli et al., 2025). Irrigation plays an important role in the productivity of the framing system and growth of agriculture, where the consumption of fresh water no less than 75 percent globally (Ramachandran et al., 2022). Water unavailability can be a major factor for the production and productivity of the agriculture sector. There are various water conservation techniques available which are essential for sustainable agriculture, particularly in regions facing water scarcity or drought conditions (Umesh et al., 2020). The study presents results of demonstration of different engineering interventions at farmers field for reducing cost of production, labour management, resource conservation and increase the crop yield under different cropping system.

MATERIAL AND METHODS

Study area: The present study was conducted at Yadgir district of Kalyan Karnataka region. The normal rainfall of the district is 710 mm and major crops in the district are paddy (148167 ha), cotton (167471 ha) and groundnut (21244 ha) of total cultivable area of 723601 ha with 222828 ha of net irrigated area. The major soil group is medium deep red clay soils covering an area of 153000 ha in the district.

Villages and farmers selection: The study was conducted at six villages of Yadgir district in Karnataka state located at 16°46'12" N and the longitude of 77°8'15" E (Fig. 1) through participatory rural appraisal (PRA) procedure. Parameters considered for selecting villages and farmers were major crop growing and area, percent of small and marginal farmers, farmers interest, soil type, farmers education and other socio-economic levels. Two farmers were selected from each village based on their interest to adopt the new technologies. Data related to crop inputs used, cost of production, labour used and market rates were recorded for both farmers practices and front-line demonstrations.

Technology selection: The technologies selected for demonstration based on cropping system, identified field problems, rainfed and irrigation situation, labour management and farmer's demand. Suitable technologies were selected and demonstrated to overcome these problems and increased farm income (Table 1).

Data collection and calculation: The field data were collected time to time under demonstration and farmers

Table 1. Technologies demonstrated at farmers field under UKP command area

Name of the technology	Crop	Year/season
Direct seeded rice method (DSR)	Paddy	2019-2020
Drum seeded rice in paddy (DS)	Paddy	2019-2020
Laser levelling technology (LLT)	Paddy	2021-2022
Nipping machine	Pigeonpea	2019-2020
Solar operated nipping (foliage collector) machine	Chickpea	2022-2023
Compartment bunding as soil moisture conservation practices	Greengram	2022-2023
Groundnut harvester & BBF for resource conservation	Groundnut	2022-2023
Tractor operated cotton shredder for cotton straw management	Cotton	2022-2023
Raised bed & plastic mulch for water conservation	Watermelon	2022-2023

Number of demonstration – 10, Area-2.5 ha

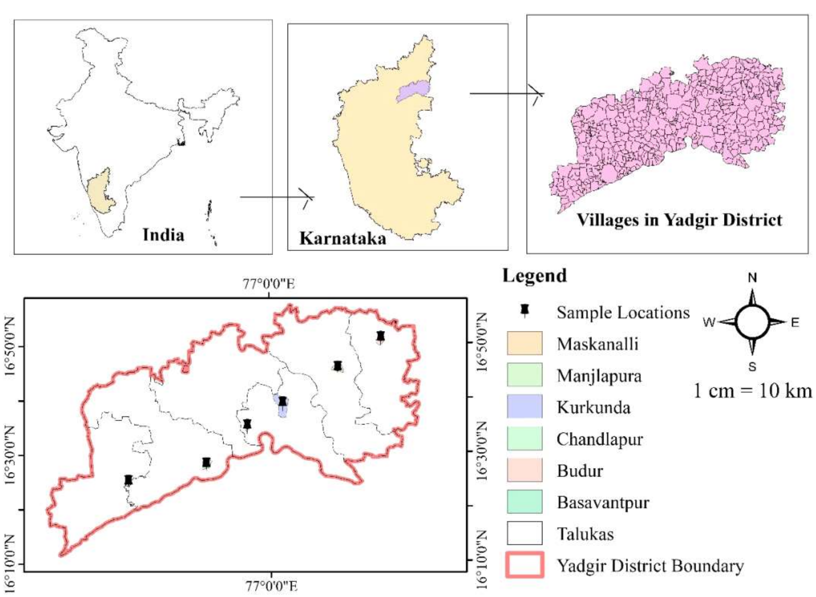

Fig. 1. Location map of study area

practices field at different crop stages to study the effect of technologies. The water productivity, water saving, technology gap, extension gap and BC ratio were calculated (Umesh et al., 2020).

RESULTS AND DISCUSSION

Paddy yield and water saving (%) under different technologies and traditional transplanting method: The average paddy yield increased by 11.29, 12.58 and 15.50 percent by saving irrigation water by 12.77, 22.05 and 23.52 percent in DS, DSR and LLT as compared to traditional transplanting method. The BC ratio increased from 1.62 to 2.58, 2.77 and 2.26 in DS, DSR and LLT as compared to traditional transplanting method (TTM) during 2019 to 2022. The yield is significantly increased by saving irrigation water 12.77 to 23.52 percent. It is observed that, the technology gap ranges from 1168 to 1469 (kg/ha) which showed huge yield gap between technologies and farmers practices. This gap can be minimised through extension programmes like demonstration, training programmes and skill enhancing programmes. The BC ratio increased from 1.62 to 2.26, 2.58 and 2.77 under LLT, DS and DSR respectively. The findings were in close agreement with earlier findings (Bista 2018, Kuchanur et al., 2018, Umesh et al., 2020, Singh and Ranguwal 2024, Tanu Oinam et al., 2025)

Yield of chickpea and pigeonpea under farmers practice and nipping operation: The nipping operation was performed through nipping machine during 45 to 55 days and 35 to 45 days after sowing in pigeonpea and chickpea respectively. The average chickpea yield increased up to 8.29 (%) from 11.10 to 12.02 q ha^{-1} in farmers practices to technology demo field (Table 3). The average pigeonpea

Table 2. Yield, water saving and water productivity of DS, DSR and LLT in paddy cultivation during 2019-2022

Parameters	Technology assessed			
	TTM	DS	DSR	LLT
Crop yield (kg/ha)	5350	6031 (+11.29)	6120 (+12.58)	6332 (+15.50)
Water used during crop growth period (mm)	1245	1104	1020	1008
Water productivity (kg/ha/mm)	4.28	5.46 (+27.57)	6.00 (+40.18)	6.28 (+46.73)
Water saving (%)	-	12.77	22.05	23.52
Technology gap (kg/ha)	-	1469	1380	1168
Extension gap (kg/ha)	-	681	770	982
Technology index (%)	-	19.58	18.40	15.57
Total expenditure (Rs/ha)	59210.00	42158.00	39784.00	50233.00
Grass income (Rs/ha)	96300.00	108558.00	110160.00	113976
Net income (Rs/ha)	37090.00	66400.00	70376.00	63743.00
B:C	1.62	2.58	2.77	2.26

Table 3. Yield parameters and BC of nipping operation and farmers practices in chickpea and pigeonpea production

Parameters	Chickpea		Pigeonpea	
	Farmers practices	Nipping operation	Farmers practices	Nipping operation
No. of pods/plant	67.84	73.60	131.56	168.13
No. of branches/plant	17.00	19.00	13.08	15.96
Average yield (q/ha)	11.10	12.02	10.50	13.60
Per cent increase	-	8.29	-	29.52
Technology gap (q/ha)	-	1.98	-	2.4
Extension gap (q/ha)	-	0.92	-	3.1
Technology index (%)	-	14.14	-	15
Gross return (Rs/ha)	49950.00	54090.00	69300	89760
Gross cost (Rs/ha)	26000.00	23400.00	21000	22000
Net profit (Rs/ha)	23950.00	30690.00	48300	67760
B:C Ratio	01.92	02.31	3.30	4.08

yield increased up to 29.52 (%) from 10.50 to 13.60 q /ha in technology demo field as compared to farmers practices. The technology gap between farmers and demon field was 1.98 and 2.4 q/ha which has to be reduced through extension activities like awareness programme and training programmes. The BC ratio was increased from 1.92 to 2.31 and 3.30 to 4.08 in chickpea and pigeonpea in nipping operation field as compared to farmers practices. The increase in yield is due to nipping operation in both chickpea and pigeonpea which reduced the growth of plant and enhanced the number branches which subsequently increase the number pods and crop yield. The use of nipping machines for operation also reduced the labour requirement and reduced the cost of production. The similar results were obtained in earlier studies on irrigation levels, sowing methods and nipping operation helps to increase the yield in pigeonpea and chickpea crop (Manjunatha et al*.,* 2019, Devaranavadagi et al., 2021 Ammaiyappan et al., 2023, Aditi Agrawal et al., 2024).

Crop yield and moisture content under compartment bunding and farmers practices in greengram crop: The compartment bunding technology was demonstrated in greengram crop for enhancing soil moisture during crop growth period (Table 4, 5). The soil moisture was reduced from 28.10 to 07.06 percent after 10 days of rainfall, however under compartment bunding field from 32.85 to 18.58 percent. This indicated that, good amount of soil moisture was retained in demo field as compared to farmers field which subsequently increase the greengram yield from 7.5 to 10.06 (q/ha). The rainwater productivity increased from 14.75 to 19.80 (kg/ha/mm) in demo field as compared to farmers practices through saving 34.23 percent of rainwater during crop growth period. The similar results were also reported in arlier studiex (Patil et al., 2016, Kalbande Devaranavadagi et al., 2021, Vishal Dashrathrao et al., 2023, Rathod Digvijay Singh et al., 2025), The studies indicated that, use of compartment bund under rainfed situation enhance the soil moisture for longer duration and helps to achieve higher crop yield.

Watermelon yield and water productivity under raised bed and plastic mulch and farmers practices: The watermelon yield increased up to 40.30 % from 388 to 650 q/ha in raised bed & plastic mulch as compared to farmers practices by saving 33.33 (%) (Table 5). The BC ratio increased from 2.15 to 2.5 in demo field as compared to farmers practices. The use of raised bed and plastic mulch minimizes the number of irrigations, enhance soil moisture and increases the water productivity from 0.64 to 1.45 q/ha/mm as compared to farmers practices. Similar results were observed in earlier studies (Kanak Lata et al., (2025), Nodar A et al., (2016), Dadheech S et al., (2018), Pawar et al., (2019) and Rao et al., (2017). The studies indicated that using plastic mulch as a soil cover increased the vegetative growth and yield of watermelon by retaining soil moisture for longer duration.

Table 4. Compartment bunding as soil moisture conservation practices soil moisture content and rainwater use efficiency

Technology details	Days after rainfall	Soil moisture (%)
Farmers practices	2	28.10
	5	19.25
	7	12.18
	10	07.06
Compartment bunder	2	32.85
	5	27.51
	7	21.12
	10	18.58

Table 6. Watermelon yield and water productivity under raised bed & plastic mulch and farmers practices

Parameters	Farmers practice	Raised bed & plastic mulching
Crop yield (q/ha)	388.00	650.00
Water used during crop growth period (mm)	600.00	450.00
Water productivity (q/ha/mm)	0.64	1.45
Water saving (%)	-	33.33
Technology gap (q/ha)		150.00
Extension gap (q/ha)		262.00
Technology index (%)		187.50
Total expenditure (Rs/ha)	1,80,000.00	2,62,000.00
Grass income (Rs/ha)	3,88,000.00	6,50,000.00
Net income (Rs/ha)	2,08,000.00	3,88,000.00
B:C	2.15	2.50

Table 5. Greengram yield, water saving and rainwater productivity under compartment bunding and farmers practice during 2022-23

Technology details	Grain yield (q/ha)	Rainwater used to during crop growth period (mm)	Rainwater productivity (kg/ha/mm)	Water saving (%)
Farmers practices	7.5	508.30	14.75	-
Compartment bunder	10.06	508.30	19.80	34.23

Table 7. Cost involved and labour requirement under cotton shredder and farmers practices

Particulars	Working hours (h/ha)		Total labour required per ha		Cost involved (Rs/ha)	
	Demo	Check	Demo	Check	Demo	Check
Cutting and uprooting of cotton straw	01	08	01	08	2340.00 (10 litre*94 Rs/lit) + Machine Hiring charges Rs.1400)	2000.00
Collection and Buring of cotton straw	-	05	-	05		1250.00
To cover one hectare of area	01	13	01	08		2000.00
Total					2340.00	5250.00

Tractor operated cotton shredder for reducing labour cost: Cotton shredder were used to shred the cotton stalks after the complete cotton picking. In farmers practice, eight-man hours is required for cutting and uprooting of cotton plants and five-man hours for collection and burning of cotton plants total of 13-man hours per hector. The same work can be completed by one cotton shredder by reducing 80 (%) of labour and time. The cost for the same work can be reduced from Rs. 5250 to Rs. 2340 per hector (Table 7). The main advantage of the cotton shredder was to incorporation of shredded materials of 2-2.5 t/ha cotton stalks per ha in to soil which could increase the soil fertility through decomposing process. The, incorporation of shredded cotton plants in to soil could enhance 1.43:0.78:0.82 % of NPK as compared to 0.5:02-04:0.5 % of NPK in adding 12.4-20 kg of N/ha, 1.6 kg of P_2O_5/ha, 12.2-13.6 kg of K_2O/ha.

CONCLUSION

The new engineering intervention reduced the cost of cultivation and increased the farm income through natural resource conservation. The study results highlighted the necessity of educating farmers through a wide range of methods to encourage the adoption of better agricultural production methods and stop the current trend of a large extension gap. The demonstrations lead the farmers to adopt new technologies through self-confidence and horizontal spread of technologies among farming community.

AUTHORS CONTRIBUTION

Barikara Umesh: Study implementation, data collection, funding acquisition, writing, review & editing, resources, conceptualization. J B Kambale: Data curation and statistical analysis, writing, review & editing. Shreevani G N: Methodology, investigation, and data curation. Jaiprakah Narayan R P: Writing – review & editing, visualization, supervision, study administration, investigation, funding acquisition, formal analysis, data curation, conceptualization. A R Kububar: Writing – review & editing, validation, supervision, resources. D K Hadimani: Writing – review & editing.

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