Environment and Ecology 42 (1A) : 335—340, January—March 2024
Article DOI: https://doi.org/10.60151/envec/OMVA9631
ISSN 0970-0420

Influence of Mechanization on Yield and Economics of Soybean

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Received 9 August 2023, Accepted 27 December 2023, Published on 6 March 2024

ABSTRACT

The present study was conducted at farmers fields of Adilabad district, Telangana state, India during *kharif* seasons of 2019 to 2021 (for 3 seasons) to appraise the effect of mechanization on soybean yield as well as economics. In this study, sowing by tractor operated seed cum fertilizer drill and harvesting by combined harvester was compared with the farmer's practice (Bullock drawn seed drill sowing and manual harvesting and threshing). In comparison to the conventional method, the sowing of soybean with tractor operated seed cum fertilizer drill and harvesting with combined harvester found to be superior in seed yield and average soybean productivity with mechanization was 1870 kg ha^{-1}, with a yield increase of 2.20% over conventional method of sowing (1830 kg ha^{-1}). Similarly, the economics of soybean were found to be highest with mechanization in terms of gross returns (Rs 79064 ha^{-1}) and net returns (Rs 52464 ha^{-1}) with a B:C ratio of 2.97:1 compared to conventional method which generated the gross returns of Rs. 77150 ha^{-1} and net returns of Rs 46966 ha^{-1} with a B:C ratio of 2.56:1.

Keywords Soybean, Tractor operated seed cum fertilizer drill, Combined harvester, Yield, Economics.

INTRODUCTION

Soybean, called as Golden Bean is a most happening crop of twenty first century, occupying pivotal position among oilseed crops of the country since 2006. The substantial economic value of soybean was realized in the first two decades of the twentieth century, therefore the crop is well known as the miracle bean of the twentieth century Swar *et al*. (2020). It is also the most important oil bearing leguminous crop of the world with high productivity potential than that of other legumes. It is a richest source of quality protein which can be used for alleviating protein calorie malnutrition (IISR 2021). Globally India stands in fourth position with the cultivable area of 12.81 million hectare with 12.90 million tonne production. The Telangana state in India is producing 0.24 million tonnes of soybean from an area of 0.16 million hectares (Directorate of Economics and Sta-

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tistics 2021) and Adilabad district contributes 39.6% area with the production of 38.2% of total states area and production, respectively (Raghuveer *et al.* 2022). Soybean is a leguminous crop capable of fixing atmospheric nitrogen into the soil through a symbiotic relationship with nitrogen-fixing bacteria. This helps to improve the soil fertility and reduces the requirement for synthetic fertilizers in succeeding crops. Soybean cultivation practices vary widely depending on geographical location, climate and agricultural practices. It can be grown in diverse climates, from tropical to temperate regions. Modern agricultural practices often involve the use of mechanization, improved seed varieties, and agronomic techniques to optimize yields and economic returns. Farm mechanization covers all levels of farming, from simple and basic hand tools to more sophisticate and powered equipment. Farm mechanization promotes timely and proper implementation of farm operations, overcomes labor shortage, improves resource use efficiency, helps in mitigate climate related hazards and enhances crop productivity. The farm power availability in the country after 1960-61 increased from 0.28 kW/ha to 2.716 kW/ha (Singh and Singh 2023).

There is a numerous scope for development in farm mechanization for crop production to improve productivity and it greatly depends on farm power availability. There are two ways to increase productivity: One is to produce a high yield varieties of crops and the other is to improve agricultural mechanization through better machines and implements. Farm mechanization eliminates labor and animal drudgery by allowing activities to be completed in the shortest period of time. Precision in metering and placing inputs, as well as timelines for the efficient use of various crop inputs such as land preparation, seeding, spraying, fertilizer, irrigation water. The ultimate focus of farm mechanization is to increase productivity and production by lowering production costs (Rahaman *et al.* 2023). Therefore, the study was conducted at farmers fields for evaluation of mechanization in soybean in Adilabad district.

MATERIALS AND METHODS

The present investigation of Frontline Demonstration (FLD) was conducted during *kharif* seasons of 2019, 2020 and 2021 by KVK, Adilabad in Adilabad district of Telangana state. In the year 2019, four village (Balapur, Raiguda, Yapalguda and Pipperwada), were six villages in 2020 (Mandagda, Kokasmannur, Jainath, Kajjarla, Ponnari and Pipperwada) were selected. Whereas, two villages (Pipperwada and Chanda T) were selected in the year 2021 for the demonstration. Farmers were accomplished to follow the package of practices recommended by the Professor Jayashankar Telangana State Agricultural University, Hydeabad (Table 1). Initially group discussion was conducted on soybean production technologies with all practicing farmers to adopt the uniform package of practices starting from field preparation, seed treatment, fertilizer management, weed management, IPM practices. At KVK, demonstration on seed treatment with Rhizobium culture @ 200 g 8 kg^{-1} seeds followed by sowing with tractor operated seed cum fertilizer drill for effective implementation of technology was organized. The farmers sown soybean using tractor operated seed cum fertilizer drill following a spacing of 45 x 5 cm^2 and seed rate of 60 kg ha^{-1} (Table 1). For control plot, farmers followed conventional method of sowing viz. bullock drawn seed drill sowing with a seed rate of 75 kg ha^{-1}. Likewise, farmers harvested soybean with combined harvester in demonstration and in control plot, manual harvesting and threshing was practiced. The yield and economics data was collected for both demonstration and farmers practice for consecutive three years and averaged (Tables 2 - 3). In the present study, technology index was operationally defined as the technical feasibility obtained due to implementation of FLD in sowing and harvesting of soybean using tractor operated seed cum fertilizer drill and combined harvester. To estimate the technology gap, extension gap and technology index following formula used by Rajkumar *et al.* (2019) and Raghuveer *et al.* (2022) have been used.

The data on adoption and horizontal spread of technology was collected from the farmers using semi structured interview. The following formulae were used to assess the impact on different parameters of soybean.

$$\text{Per cent increase in yield} = \left\{ \frac{\text{Demonstration yield} - \text{Farmers practice yield}}{\text{Farmers practice yield}} \right\} \times 100$$

Table 1. Differences between mechanization and farmers practice for soybean.

Sl. No.	Practices	Demonstrated practice	Farmers practice
1	Organic manure	5 t FYM ha^{-1}	5 t FYM ha^{-1}
2	Method of sowing	Tractor operated seed cum fertilizer drill	Bullock drawn seed drill
3	Variety	JS-335	JS-335
4	Seed treatment	Rhizobium culture @ 200 g 8 kg $seeds^{-1}$	Rhizobium culture @ 200 g 8 kg $seeds^{-1}$
5	Seed rate and spacing	60 kg ha^{-1} and 45 x 5 cm^2	75 kg ha^{-1} and line sowing at 45 cm
6	Time taken for sowing	1.5 hrs ha^{-1}	5.0 hrs ha^{-1}
7	Harvesting	Combined harvester	Manual cutting and threshing
8	Time taken for harvesting	2.0 hrs ha^{-1}	8.0 hrs ha^{-1}
9	Cost on harvesting (Rs ha^{-1})	5500/-	8700/-
10	Fertilizer management	60, 60, 40 kg NPK ha^{-1}	60, 60, 40 kg NPK ha^{-1}

Technology gap = Pi (Potential yield) - Di (Demonstration yield)

Extension gap = di (Demonstration yield) - (Farmers yield)

$$\text{Technology index} = \left\{ \frac{\text{Potential yield - Demonstration yield}}{\text{Potential yield}} \right\} \times 100$$

Net return (Rs ha^{-1}) = Gross return (Rs ha^{-1}) - Total cost of cultivation (Rs ha^{-1})

$$\text{Benefit: Cost ratio} = \frac{\text{Gross return (Rs. } ha^{-1})}{\text{Cost of cultivation (Rs } ha^{-1})}$$

Additional cost (Rs ha^{-1}) = Farmers practice cost (Rs ha^{-1}) – Demonstration cost (Rs ha^{-1})

Additional returns (Rs ha^{-1}) = Demonstration returns (Rs ha^{-1}) – Farmers practice returns (Rs ha^{-1})

Effective gain (Rs ha^{-1}) = Additional returns (Rs ha^{-1}) – Additional cost (Rs ha^{-1})

RESULTS AND DISCUSSION

Yield performance

The seed yield of demonstration plots was higher as compared to farmers practice. This might be due to optimum seed rate and maintained spacing of the plants with tractor operated seed drill. Proper seed placement at an optimal depth is also crucial as it enhances nutrient and moisture uptake efficiency. A comparison of yield performance between demonstration and farmers practice is shown in Table 2. It was observed that the average seed yield with the demonstration was 18.70 q ha^{-1} compared to 18.30 q ha^{-1} with farmers practice with an average increase in the yield by 2.20% . Precision planting techniques, such as using seed drills, can indeed contribute to better germination rates, uniform plant stands, and improved nutrient and water utilization. Also might be due to the timely harvesting and threshing of the crop helped in escape the post harvest losses due to unseasonal rains coincide with the harvesting time. Hanamant and Angadi (2018) reported that the planting method will increases the crop yield by its influence on seedling establishment, interception of solar energy, rooting pattern, moisture extraction pattern and also shading effect on weeds. The outcome clearly indicated that the yield of soybean could be increased over the yield obtained under farmer's practices by the adoption of mechanization and similar results were also reported by Nainwal *et al.* (2019). Yield of the FLDs and potential yield of the crop was compared to estimate the yield gaps which were further categorized into technology gap and extension gap (Hiremath and Nagaraju 2009).

Technology gap

As per the observations recorded (Table 2), the average technology gap was 11.30 q ha^{-1}, depicting the yield gap between demonstrated technology and potential yield which needs to be minimized by conducting FLDs. The variation if any in technology gap during the demonstration years may vary due to soil fertility, climatic condition of the area and

Table 2. Productivity, technology gap, extension gap and technology index in soybean under mechanization.

Year	Area (ha)	No. of farmers	Yield (q ha^{-1})			% Increase in yield	Technology gap (q ha^{-1})	Extension gap (q ha^{-1})	Technology index (%)
			Potential	Demonstration	Farmers practice				
2019	4.0	10	30.00	19.80	19.10	3.66	10.20	0.70	34.00
2020	4.0	10	30.00	15.80	15.70	0.64	14.20	0.10	47.33
2021	4.0	10	30.00	20.50	20.00	2.5	9.50	0.50	31.66
Average		-	30.00	18.70	18.26	2.26	11.30	0.43	37.66

management practices implemented by the farmers. Hence, more location specific recommendations and precise use of technology in the fields are necessary to bridge the technology gap as supported by Nainwal *et al*. (2019). The results clearly indicated the positive effects of FLDs over the existing practices toward enhancing the productivity of soybean. Similar yield enhancement in soybean in frontline demonstrations was documented by Gathiye *et al.* (2020), Raghuveer *et al.* (2020) and Raghuveer *et al.* (2022).

Extension gap

The average extension gap (0.43 q ha^{-1}) between mechanization and farmer practice (Table 2) should be indicated to adoption of improved transfer technology in demonstration practices resulted in higher seed yield than conventional farmers practice was mostly due to that plant growth and yield contributing characters viz., plant population, plant height, root length, root nodules, pods plant^{-1}, seed yield, straw yield and harvest index (%). The results of the experiment showed that sowing with tractor drawn seed cum fertilizer drill promotes crop growth by reducing competition amongst the plants by maintaining proper spacing and increased the availability of the nutrients throughout the crop growth period Basediya *et al.* (2020). It is recommended to educate and motivate the farmers for subsequent adoption of demonstrated technology in order to minimize the extension gap by proper planning and implementation of technologies through various means of extension. The results are in conformity with Raghuveer *et al.* (2020), who observed that, location based problem identification and thereby specific interventions may have great implications in the enhancement of crop productivity.

Technology index

The technology index shows the feasibility of the technology at farmer's field. The lower the value of technology index more is feasibility. The result of the present study presented in Table 2 revealed that the technology index value is 37.66% . This value shows that there is a gap between technology developed and technology adopted at farmer's field. This might be due to the farmer perception towards the technology involving high initial costs and aberrant climatic conditions resulted in the increasing trend of technology index values during the demonstration years. Similar findings were also reported by Ramesh *et al.* (2020) and Raghuveer *et al. (*2022).

Economics

The economics of the present study was worked out

Table 3. Average (2019, 2020 and 2021) economics of soybean under mechanization.

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio	Additional cost (Rs ha^{-1})	Additional returns (Rs ha^{-1})	Effective gain (Rs ha^{-1})
Farmers practice	30184	77150	46966	2.56:1	3584	5498	1914
Demonstration	26600	79064	52464	2.97:1			

for the experimental years i.e., *kharif* 2019, 2020 and 2021. It is observed from the average data (Table 3) of three consecutive years that the adoption of mechanization resulted higher gross returns (Rs 79064 ha^{-1}) with an increase of 2.48% than manual sowing and manual harvesting (Rs 77150 ha^{-1}). Similarly, 11.70% higher net returns were obtained with mechanization (Rs 52464 ha^{-1}) compared to manual sowing and manual harvesting (Rs 46966 ha^{-1}). Whereas, by adopting mechanization observed reduction in the cost of cultivation (Rs 26600 ha^{-1}) with 13.47% lesser than manual sowing and manual harvesting (Rs 30184 ha^{-1}). Similar results were also reported by Verma *et al*. (2017) and Basediya *et al.* (2020). The B: C ratio was higher in the mechanization (2.97) than farmers practice (2.56), as shown in Table 3. The results of the experiment proved that sowing with tractor operated seed cum fertilizer drill and harvesting with combined harvester resulted in saving the cost on seed requirement, labor requirement, better crop establishment and yield by reducing the effect of nutrient and moisture stress in the soil as a result of proper placement of seed at optimum depth and by maintaining the spacing. The results are in conformity with Shranakumar *et al.* (2011), who found that combine harvester is economical and technically feasible compared to manual harvesting and threshing.

Further examination of the data (Table 3) showed that the demonstrated technology resulted in higher additional returns of Rs. 5498 ha^{-1} and effective gain of Rs 1914 ha^{-1} as compared to farmers practice during the course of study. The higher additional returns and effective gain obtained under demonstration might be due to improved technology, non-monetary factors and timely operations of crop cultivation as well as scientific monitoring which finally resulted in higher yields and less input cost.

CONCLUSION

Soybean cultivation using tractor operated seed cum fertilizer drill method of sowing and harvesting with combined harvester is vital option in getting the better crop growth, yield, reduction in the cost of cultivation, saving the time and increasing the net returns over farmers practice. Mechanization also helps in avoid the loss due to unseasonal rains at the time of harvesting. The results of the experiment showed that the mechanization can achieve higher productivity with a higher benefit cost (B: C) ratio of soybean cultivation in rainfed condition. Horizontal spread of improved technologies may be achieved by the successful implementation of frontline demonstrations and various extensions activities like training program, field day, exposure visit organized in FLDs programs in the farmer's fields

ACKNOWLEDGMENT

The authors are grateful to Professor Jayashankar Telangana State Agricultural University, Hyderabad and ATARI zone X for financial assistance to conduct the study.

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