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Gyanendra Pratap Tiwari
Subject Matter Specialist-Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Sarvesh Tripathy
Sr. Scientist & Head, Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Jitendra Bhandari
YP-II, Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Barkha Sharma
Subject Matter Specialist-Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Ramdhan Ghaswa
Subject Matter Specialist-Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Rohatash Singh Bhadauria
Subject Matter Specialist-Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Shish Ram Jakhar
Programme Assistant, Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Shivam Mishra
YP-II, ICAR-ATARI, Zone IX, Adhartal, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Gyanendra Pratap Tiwari
Subject Matter Specialist-Krishi Vigyan Kendra, Jaora, Ratlam, Madhya Pradesh, India

Economic, production and yield effects on linseed (*Linum usitatissium* L.) crops

Gyanendra Pratap Tiwari, Sarvesh Tripathy, Jitendra Bhandari, Barkha Sharma, Ramdhan Ghaswa, Rohatash Singh Bhadauria, Shish Ram Jakhar and Shivam Mishra

Abstract
Front line to improve agricultural produce production, productivity, profitability, and quality throughout the rabi seasons in the piploda block of Ratlam district of Madhya Pradesh, demonstrations have been held at various farmer farms. The study was carried out in 2021–2022 and 2022–2023, respectively. Farmers were involved in all 100 linseed crop demonstrations, which were carried out in a 40.46 ha area with the goal of demonstrating improved linseed technology for cultivation. Use of the improved variety Pratap-2, seed treatment with Azotobacter and PSB culture, balanced nitrogen application, and integrated pest management are among the improved technologies. When comparing yields determined by CFLD to farmer procedures, it was higher. The maximum mean yield of 20.07 q/ha, which was 34.71 percent higher than that obtained with farmers' practice of 13.11 q/ha, was recorded by the improved technologies, in addition to a maximum mean number of capsules per plant of 61. The years 2022 and 2023 saw the highest grain yield (20.56 q/ha), a yield that was 32.97% more than the typical output for farmers (13.78 q/ha). The average extension gap, technology gap, and technology index were 1.93 q/ha, 6.96 q/ha, and 8.77%, respectively. In comparison to farmers' follows (Rs. 65462/ha, benefit cost ratio 3.6), improved technologies delivered an enhanced mean net return of Rs. 106933/ha with a benefit cost ratio of 5.08. Improved technology, timely crop cultivation operations, and scientific monitoring might be partially to blame for the higher additional returns (Rs. 41471/ha) obtained under demonstrations.

Keywords: Linseed, seed yield, nutrition quality, field production and growth conditions

Introduction
Due to its resistance to poor soils and its high profitability value relative to the high quality of the seed oil, which is being decreasingly appreciated by consumers, the food assiduity, the cosmetics and the eco-accoutrements diligence, linseed (*Linum usitatissimum* L.) is a traditional oilseed crop that represents a precious resource for cropping systems (Balai *et al*. 2016) [1]. The domestication of Linum bienne is thought to have begun in central Europe so as to get oil paintings and filaments; civilization in central Europe peaked during the eighteenth century due to the production of linen fabrics (Choudhary BN. 1999) [2]. Several findings made in Europe suggest that the species has played an important role in nutrition and craft since the Neolithic period. The cultivated area of linseed is minor (nearly ha around the world in 2017 and nearly ha in 2018), with an average yield of about 1 tons, even though it is a factory species with a high capacity for adapting to unsuitable environmental conditions, resulting in the expansion of the cultivated land area. In Europe, the area varied between 800,000 ha and 900,000 ha over the last five years, with a yield of 0.8 t/ha to 1.1 t/ha (Das *et al*. 2007) [3].
The main parameters applied in evaluating the dietary benefits of linseed are its oil content and the composition of its fatty acids. Knowing the factors that impact this is essential in order to achieve high linseed oil output and quality. High oil and low protein content in seeds are usual effects of cool climates (Katare *et al*. 2011) [6]. Genotype, growth season, location, and agronomic adherents are each accepted to have an impact on seed quality and quantity (Mukharjee N. 2003) [7]. Temperature and rainfall variations in the weather may have an important effect on seed quality and quantity (Patel *et al*. 2013) [8]. The key factors in reducing

agricultural output are crop growth and development, which are affected by the outside environment (Patel *et al*. 2014) [9]. Omega-3 fatty acids occur in high concentrations in temperate regions owing to the temperate environment there. Contrasting to crops from the Mediterranean and subtropical areas, crops produced in continental warmer regions tend to have more polyunsaturated fatty acids (ALA) and fewer monounsaturated oils (oleic acid) (Choudhary BN. 1999) [2]. Lower temperatures enable linseed to produce more oil. Over its growth stage (140 days), it needs 400 to 450 mm of water.

Seeds have considerable promise as a source of phenolic composites (Katare *et al*. 2011) [6] due to their availability in lignans, omega-3 adipose acids (FA), and high-quality protein. The oil painting content of linseed seed ranges between 35 and 45 (w/w), although indeed advanced values have been reported. The usual makeup of linseed seed oil painting is 9–11 impregnated acids (5–6 palmitic acids and 4–5 stearic acids) and 75–90 unsaturated adipose acids (50–55 linolenic acids, 15–20 oleic acids) (Sharma *et al*. 2011) [11]. Linseed oil painting is the greatest source of omega-3 and beta-linolenic acid (ALA) when compared to other oilseed crops (Shrivastava RL. 2009) [12]. In addition, linseed seed oil painting has a beneficial rate (n-6n-3) of adipoeic acid.

Materials and Method

Cluster front line demonstrations (CFLDs) constitute one of the most efficient approaches to extension because, in general, farmers are encouraged by the idea that "seeing is believing." Cluster frontline demos' significant goal is to display recently released crop production and protection on the internet, as well as their management methods, on a farmer's field in a microfarming scenario. The present investigation on CFLDs had been carried out by KVK Ratlam in the rain kharif periods of 2021–22 and 2022–23. With the goal of providing selected farmers with an improved set of executions, an extensive investigation was conducted to gather data progressively from them. The performance of privileged positions was used to classify the constraints encountered by farmers while nurturing linseed products. Before the show, farmers from the distinct regions conducted training. All other steps, including site selection, farmer selection, demonstration layout, farmer participation, etc., were carried out according to (Choudhary BN. 1999) [2] suggestions. To disseminate the method extensively, demonstration plot visits by farmers and extension personnel were proposed. The cluster frontline demonstrations originated as a reaction to the injustice farmers suffered. Each demonstration's data on production was carefully recorded, and at the same time, the yield of farmers' practices was also recorded. At harvest, data regarding crop growth, yield features, and yield was gathered and statistically analysed. The following formula was used to analyse the yield data from the demonstration and control plots using the appropriate statistical methods for the various parameters:

$$\text{Per cent increase in yield (\%)} = \frac{\text{Yield gain in IT plot (q/ha) - Yield gain in FP plot (q/ha)}}{\text{Yield gain in FP plot (q/ha)}} \text{X100}$$

The extension gap (q/ha), technology gap (q/ha) and technology index (%) were calculated using the following formula as suggested by Samui *et al.* (2000) [12]; Kadian *et al.* (2004) [7]; Sagar and Chandra, (2004) [11].

Extension gap (q/ha) = DY (q/ha) – LY (q/ha)

Technology gap (q/ha) = PY (q/ha) – DY (q/ha)

$$\text{Technology index (\%)} = \frac{\text{Technology gap (q/ha)}}{\text{PY (q/ha)}} \text{X 100}$$

Where is,

DY = Demonstration yield, LY = Local check yield, PY = Potential yield of variety

The B:C ratio was calculated based on the net return and cost of cultivation in each treatment.

The Ratlam region in Madhya Pradesh provided confirmation of the expertise. The climate of the district is tropical, with dry winters and summers. The district's average annual temperature is 28.68°C (83.62°F), so it's 2.71% more than the national average for India. Ratlam usually has 97.18 wet days (26.62% of the time) in a mean rainfall of roughly 121.39 millimetres (4.78 inches). For such lessons, a total of 100 farmers (25 in 2021–2022 and 75 in 2022-23) were picked in an area of 40.36 hectares divided into 8 clusters. In this study plot, a control plot with farmers' adhering to such non-descriptive forms as spread planting, no nutrient use, hand weeding, and indiscriminate plant protection methods was maintained as well.

Results and Discussion

Analysis of the differences among recommended and curr ent practices

Table 1 indicates the disparity in recommended and present te chnologies for the linseed crop in the district of Ratlam. The use of HYVs, seed treatment and fertilizer application, sowing method, weed control, irrigation, and plant protection measures all demonstrated full spaces, while the seed rate and field preparation showed partial spaces. The discrepancies may be the reason for farmers' failure to produce the intended profits. All recommended electronic devices were known to farmers. In opposition to the recommended high yielding resistant varieties, farmers typically used declined seeds of local or old-age varieties. The primary reasons for the variation in farmers' practices were a lack of prompt and local seed delivery as well as a lack of awareness. Because of a lack of knowledge and interest, farmers used more seed than was suggested, did not use seed techniques to manage diseases that are passed on via seeds, and did not know how to apply micronutrients like sulphur and zinc to increase linseed yield and quality (Patel *et al*. 2013 [10] and Patel *et al*. 2014) [9]. Farmers also reported that there is a technological gap between improved use and current techniques.

Yield Attributing Characteristics

Table 2 depicts the linseed yields under suggested practices and farmer activity over the years, in addition to yield-contributing variables like the number of capsules per plant and the harvest index (%). Compared to the range of 42 to 45, with a mean of 43.5, found under farmers' reality, the number of capsules or plants of linseed under suggested practice in farmer's fields ranged from 58 to 64, with a mean of 61. The greater values of capsules and plants in recommended usage compared to farmers' practices may be explained by the use of high-yielding cultivars, integrated nutrition management, integrated pest control, and other parameters (Patel *et al*. 2013 [10].

Seed Yield

The yield performance of the suggested addresses and farmer practices is presented in Table 2. The demonstration plot's performance during both of the following years of demonstrations in contrast to the farmers' practices of 12.44 and 13.78 q/ha, the demonstration's yield of linseed in 2021 and 2022 and 2022 and 2023, respectively, was 19.58 and 20.56 q/ha. Compared to the farmer's methods, the yield improved by 36.46 percent and 32.97 percent, respectively, as an outcome of the technology intervention. In both years, the cumulative effect of technological intervention results in an average production of 20.07 q/ha, which is 34.71 percent more than the average yield of farmers (13.11 q/ha). Changes in social, economic, and biological factors can be used to explain variations in yield from year to year [13, 15].

Technology Gap, Extension gap and Technology Index

Technology Gap

The demonstration yield and expected output differed during the study period, as shown by the average technological gap of 1.93 q/ha (Table 2). The technological gap showed an average of 2.42 qt/ha in 2021-2022 and 1.44 qt/ha in 2022–2023, respectively, and this shows how the farmers worked collectively to carry out these tests and showed excellent outcomes in the following years. Differences in soil fertility levels and local conditions, variations in appropriateness, and technological adoption could all contribute to the observed technology gap. The extension gap corresponds to what can be accomplished by the transfer of existing technologies, whereas the technological gap refers to problems that may be investigated in order to realize the potential yield. According to how the farming condition is identified and used, various remedies may have a larger impact on improving the system's manufacturing, says Mukharjee [8]. Singh and collaborators [18] and Katare *et al.* [6] presented findings that were similar.

Extension Gap

The extension gap is a parameter that helps explain yield differences between the technology that was displayed and the farmer's reality, and the data that was actually collected is presented in Table 2. In an effort to reverse this trend of an extensive extension gap, the extension gap ranged from 7.14 to 6.78 q/ha during the study period, with an average of 6.96 q/ha. This indicated the necessity to educate the farmers through a variety of media for the adoption of more varieties with higher yields and improved agrotechnology. The disturbing trend of growing extension gaps is going to be overcome when farmers use recent HYVs more and more. Farmers will eventually become dissatisfied with the new technologies and stop using the old ones in favour of the new ones. The findings confirm those of Patel *et al.* [10], who stated that location-based problem identification and, thus, particular treatments could significantly impact crop output.

Technology Index

The technology index showed that cutting-edge technologies could be used on farms. The higher technology score suggested a paucity of technology transfer extension services. The technology index's lower value indicates the efficacy of well-functioning technological solutions. The average technology index for cluster front-line demonstration was found to be 8.77 percent (Table 2). In the periods 2021-2022 and 2022-2023, the technology index averaged 11 and 6.54%, respectively. The technology index's decrease in value indicates that farmers are becoming increasingly interested in using technology. This range shows that results vary depending on the crop's susceptibility to insect and pest attack, the weather, soil fertility, and numerous other variables. The findings of [14, 17, 19, 20] correspond with the results of the current investigation.

Economic Parameter

Table 3 depicts the economic performance of linseed in a fron tline demonstration. The cost of cultivation, net returns, and benefit cost ratio were\ estimated using the input and output prices of commodities that were in use during the three years of the demonstrations. In contrast with farmers' behaviours, the investment in production by adopting recommended practices ranged from Rs. 21683 to Rs. 20466 Rs/ha, with a mean value of Rs. 21074.5 Rs/ha during the demonstrations. Linseed cultivation adhering to indicated uses provided a larger net return of Rs. 100692 to 113174 Rs/ha than cultivation under farmers' behaviours in the periods 2021_22 and 2022_ 2023, respectively. The average benefit cost ratio of recommended practices varied from 4.64 to 5.52 and was 5.08 overall, while the ratio for farmers' practices was 3.60 generally and varied from 3.19 to 4.01. This could be since recommended practices generate higher yields than farmers' practices. Earlier observations regarding comparable results were made by Tomar RKS (2010) [21].

Conclusion

Farmers were effectively affected by the cluster frontline demonstration to adopt integrated crop management in the production of linseed. After the front-line demonstration on the farms, a majority of farmers became aware of the recommended linseed production procedures. Linseed yield, net return, and B: C ratio were all found to be greater in the display plot than in the farmer's practice. The rise in productivity under CFLD over traditional methods of linseed cultivation raised awareness and motivated other farmers in the district to adopt suitable linseed production technology. As compared to farmers' behaviours, the demonstrated improved practices were superior. Through their assessments of the technology, the farmers showed a favourable attitude towards the demos. To decrease extension gaps, technology gaps, technology index gaps, adoption gaps, and thus yield gaps, the technology has to be made accessible to more people if farmers are to make greater profits. The demonstrations' economic specifics give us the go ahead to further popularize them among farmers in preparation for broad adoption.

Table 1: Comparison between technological interventions and existing farmers practice under cluster front line demonstration programme

S. No.	Particular	Recommendation	Existing	Gap (%)
1.	Variety	Improved variety Pratap-2	Old variety	Full gap
2.	Seed rate	18-20 kg/ha	30-35 kg/ha	Partial gap
3.	Field Preparation	The importance of obtaining the land with adequate tilth. 2 to 3 ploughings were needed.	Only one or two ploughs are used, which keeps the soil from splitting down into tiny fragments.	Partial gap
4.	Seed treatment and Fertilizer	Azotobacter + PSB @ 5 g/kg seed, Trichoderma viridae @ 5 g/kg seed and application of micronutrients such as Zinc sulphate 60:40:20:25 NPKS kg/ ha.	That is no soil testing done. Fertiliser is rarely used by farmers because it is grown as a residual crop. Usually, farmers apply 10 kg of DAP per acre.	Full gap
5.	Sowing Time	25 October to 10 November	October to November	No gape

6.	Sowing method	Line sowing	Broadcasting	Full gap
7.	Weed control	Hand weeding was done once 30 days after sowing.	No weeding	Full gap
8.	Irrigation	Fields were irrigated before to sowing and at pre-flowering (35 DAS) & seed setting stage (70 DAS)	This is not practiced by farmers	Full gap
9.	Plant Protection	One spray of Profenophos @ 750 ml/ha + ready mix combination of Carbendazim+ Mancozeb @ 2.5g/lit water was applied at 30 DAS.	No preventive measure is followed	Full gap

Table 2: According to the recommendations and farmer practices, yield measurements, the technology gap, the extension gap, and the technology index of linseed are all affected

Year	Area (ha)	No. of farmers	No. of capsules /plant		Grain yield (q/ha)		% increase over FP	Straw yield (q/ha)		Technology Gap (q/ha)	Extension Gap (q/ha)	Technology Index (%)
			RP	FP	RP	FP		RP	FP			
2021-22	10.11	25	58	42	19.58	12.44	36.46	28.45	20.11	2.42	7.14	11.00
2022-23	30.35	75	64	45	20.56	13.78	32.97	29.98	21.29	1.44	6.78	6.54
Total/Average	40.46	100	61	43.5	20.07	13.11	34.71	29.21	20.70	1.93	6.96	8.77

Table 3: Cluster Front Line Economics A demonstration of the way recommended follows and farmer procedures impact linseed

Year	Gross expenditure (Rs./ha)		Additional expenditure (Rs./ha)	Gross return (Rs./ha)		Net returns (Rs/ha)		Additional returns (Rs/ha)	B:C Ratio	
	RP	FP		RP	FP	RP	FP		RP	FP
2021-22	21683	18542	3141	122375	77750	100692	59208	41484	4.64	3.19
2022-23	20466	17854	2612	133640	89570	113174	71716	41458	5.52	4.01
Total/Average	21074.5	18198	2876.5	128007.5	83660	106933	65462	41471	5.08	3.6

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