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Prajakta Falke
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

ST Dangore
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

PC Pagar
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

Dhanshri Ghorad
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

CH Chambhare
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

PS Parkhi
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

Shivkanya Waghmare
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

Akanksha Nakaskar
Department of Entomology, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

Rohini Borutkar
Department of Entomology, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

Corresponding Author:
Prajakta Falke
Department of Agronomy, College of Agriculture (Dr. PDKV), Nagpur, Maharashtra, India

Influence of tillage and nutrient management practises on yield and economics of linseed

Prajakta Falke, ST Dangore, PC Pagar, Dhanshri Ghorad, CH Chambhare, PS Parkhi, Shivkanya Waghmare, Akanksha Nakaskar and Rohini Borutkar

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Abstract
Experiment was conducted at AICRP on Linseed farm, College of Agriculture, Nagpur during the rabi season of 2024 to study the influence of tillage and nutrient management practices on growth and yield of linseed. The experiment was conducted in a split-plot design comprising three tillage practices and four nutrient management treatments with twelve treatment combinations, replicated thrice. Main plot treatments comprised of three tillage practices Conventional tillage (T_1), Reduced tillage (T_2), Zero tillage (T_3) and sub-plot treatments consisted of four nutrient management practices viz., 100% RDF (N_1), 100% RDF with seed treatment using a microbial consortium- Biomix (N_2), 100% RDF with foliar application of micronutrients PDKV Grade-II at flower initiation (45-50 DAS) @ 5 ml lit^{-1} of water and at capsule development (70-80 DAS) @ 10 ml lit^{-1} of water (N_3) and 100% RDF with both seed treatment using Biomix and foliar application of micronutrients PDKV Grade-II at flower initiation (45-50 DAS) and capsule development (70-80 DAS) (N_4). Results revealed that, among the tillage treatments, conventional tillage (T_1) recorded significantly higher values of seed (1010 kg ha^{-1}) and straw yield (2141 kg ha^{-1}) compared to other tillage treatments. The gross monetary returns, net monetary returns and benefit: cost ratio of linseed was significantly higher under conventional tillage practices (T_1) than rest of other tillage practices. Among nutrient treatment practises, 100% RDF with both seed treatment using Biomix and foliar application of micronutrients (PDKV Grade-II) at flower initiation (45-50 DAS) and capsule development (70-80 DAS) (N_4) recorded highest seed (1033 kg ha^{-1}) and straw yield (2061 kg ha^{-1}). Also, significantly higher GMR, NMR and B: C ratio was recorded with the treatment N_4 amongst all other nutrient management practices. However, the interaction effect between tillage and nutrient management practices was found non-significant.

Keywords: Linseed, tillage, nutrients, yield, economics

Introduction
Linseed is the most important oilseed crop in India, stands next to rapeseed and mustard among all winter season (rabi) oilseed crops in terms of area and production. It serves as a significant source of both industrial and edible oil as well as fiber. The crop is rich in essential fatty acids with 75% polyunsaturated fatty acids, including 57% alpha-linolenic acid (an omega-3 fatty acid) and 16% linoleic acid (an omega-6 fatty acid) (Morris, 2005) [2]. It is one of the oldest rabi oilseed crops under cultivation. India accounts for about 10.81% of the global area and 5.30% of global production of linseed. Within the country, linseed covers 1,72,710 ha, producing 99,070 tonnes with an average yield of 574 kg ha^{-1} (Anonymous, 2018-19) [3]. In Maharashtra, the crop occupies 8,700 ha with a production of 2,600 tonnes and an average productivity of 299 kg ha^{-1}. In the Vidarbha region, it is cultivated on 6,570 ha, producing 2,120 tonnes with a productivity of 323 kg ha^{-1} (Anonymous, 2019-20) [4]. Tillage is a fundamental requirement in crop production, as it influences the efficient use of inputs such as water, fertilizers, and other resources. In linseed cultivation, tillage directly affects soil conditions crops establishment and yield. Being a shallow rooted crops linseed requires a well-prepared seedbed to achieve uniform germination and vigorous early growth. Conventional tillage helps in weed control loosen the soil and enables efficient incorporation of nutrients making it suitable for compact soils. Reduced tillage conserves soil moisture and structure while lowering labour and input cost, which can be advantageous for resource limited farmers.

Zero tillage as part of conservation agriculture, minimize soil disturbance, improves water use efficiency and supports sustainable farming, particularly in the dry land conditions of Vidarbha. Selecting tillage practices suited to local conditions ca improve productivity, prevent soil degradation and maintain long term soil fertility and health. Nitrogen, phosphorus and potassium are essential for improving linseed yield and quality. Nitrogen supports metabolic processes, phosphorus promotes cell division, flowering and seed development, while potassium contributes to overall plant growth (Jaga and Upadhyay, 2013) [2]. Enhancing productivity requires high-yielding cultivars and improved practices such as nitrogen fertilization, foliar urea application, and micronutrient mixtures containing Fe, Zn and Mn (Hussein, 2007) [7]. Balanced nutrient application, particularly N, P, and K, is critical for yield improvement (Singh *et al.* 2013) [14]. Therefore, the present studies were carried out to find out the influence of tillage and nutrient management practices on yield and economics of linseed.

Material and methods

Experiment was carried out during the rabi season of 2024 at All India Coordinated Research Centre on Linseed, College of Agriculture, Nagpur, Maharashtra to investigate the effects of tillage and nutrient management practices on yield and economics of linseed. Three replications and twelve treatment combinations were employed in split plot design replicated thrice. Three tillage practices viz., T_1 - Conventional tillage, T_2 - Reduced tillage, and T_3 - Zero tillage and four nutrient management practices viz., N_1 - 100% RDF, N_2 - 100% RDF with seed treatment using a microbial consortium- Biomix, N_3 - 100% RDF with foliar application of micronutrients PDKV Grade II at flower initiation (45-50 DAS) @ 5 ml lit^{-1} of water and at capsule development (70-80 DAS) @ 10 ml lit^{-1} of water, and N_4 - 100% RDF with both seed treatment using Biomix and foliar application of micronutrients PDKV Grade-II at flower initiation (45-50 DAS) and capsule development (70-80 DAS) were evaluated for the study. Biomix is a mixture of bioagents comprising Trichoderma, Azotobacter, PSB manufactured by Department of Plant Pathology, College of Agriculture, Nagpur while PDKV Grade II is a mixture of micronutrients consists of Fe, Zn, Bo, Mg, Cu and Mo developed by Dr. PDKV, Akola. Data on yield was collected from five randomly selected plants from each net plot at harvest and converted in to ha^{-1} yield by applying hectare factor. The current market price of linseed was used to study the economics. The data was analysed statistically as described by Gomez and Gomez (1984) [6].

Results and discussion

Influence of tillage and nutrient management practises on seed and straw yield of linseed

The seed yield ha^{-1} was influenced significantly by different tillage practices in linseed crop. Significantly higher seed yield of 1010 kg ha^{-1} and straw yield of 2141 kg ha^{-1} were recorded with conventional tillage (T_1) over all the other tillage practices. Zero tillage (T_3) recorded significantly lowest seed yield of 845 kg ha^{-1} and straw yield 1691 kg ha^{-1}. The higher seed yield in conventional tillage might also be to the pulverization of soil which enhanced penetration of roots to deeper layer of soils that facilitate greater uptake of water and nutrients from the soil thereby enhancing seed yield of linseed. Leaf area, greater dry matter accumulation and increased plant height may be indirectly contributed to the overall yield improvement as higher straw yield often reflects better vegetative growth and resource utilization, ultimately supporting increased productivity and crop performance. Similar findings were also reported by Kashyap *et al.* (2018) and Chandrasekaran *et al.* (2024) [9, 5].

As regards nutrient management practices, seed yield ha^{-1} was significantly influenced and found highest seed yield of 1033 kg ha^{-1} and straw yield of 2061 kg ha^{-1} with the treatment N_4 comprised of 100% RDF along with seed treatment using microbial consortium Biomix and foliar application of micronutrients PDKV Grade-II at the flower initiation stage (45-50 DAS) @ 5 ml lit^{-1} and at the capsule development stage (70-80 DAS) @ 10 ml lit^{-1} of water amongst all other nutrient management practices. Whereas, lowest seed and straw yield (795 kg ha^{-1} and 1696 kg ha^{-1}, respectively) was recorded with the treatment of 100% RDF (N_1). The improvement in seed yield of linseed may be due to the timely foliar application of micronutrients in appropriate proportions which supports key physiological functions such as chlorophyll synthesis, enzyme activation, and stomatal regulation. These processes enhanced nutrient uptake and metabolic efficiency ultimately leading to improved yield components and overall productivity. These similar findings were reported by Meena *et al.* (2024) and Mishra and Dhakar (2016) [10, 11]. Higher straw yield might due to cumulative effect of higher number of branches, leaf area and dry matter accumulation which are achieved due to greater availability of nutrients and its assimilation into carbohydrates and proteins. The results are in conformity with the Abd Eldaiem *et al*. (2016) and Mishra and Dhakar (2016) [1, 11]. Interaction between tillage and nutrient management practices was found non-significant.

Influence of tillage and nutrient management practises on economics of linseed

Gross and net monetary returns

Gross and monetary returns Rs. ha^{-1} was significantly influenced by different tillage practices. Significantly higher gross (Rs. 55558 ha^{-1}) and net monetary returns (Rs. 23106 ha^{-1}) was recorded with the treatment of conventional tillage (T_1) over all the other tillage practices. Lowest gross (Rs. 46486 ha^{-1}) and net monetary returns (Rs. 21834 ha^{-1}) was recorded with the treatment of zero tillage (T_3). This might be due to more seed and straw yield as evidenced from the data. These findings are support by Kashyap and Khajanji (2018) Upasani *et al.* (2014) [9, 15].

As regards nutrient management practices, Gross and net monetary returns significantly differed. The highest gross (Rs. 56826 ha^{-1}) and net monetary return (Rs. 27755 ha^{-1}) recorded with the treatment of 100% RDF along with seed treatment using a microbial consortium Biomix and foliar application of micronutrients PDKV Grade-II at flower initiation stage (45-50 DAS) @ 5 ml lit^{-1} and at the capsule development stage (70-80 DAS) @ 10 ml lit^{-1} of water (N_4) and was significantly superior overall nutrient management practices. Lowest gross (Rs. 43732 ha^{-1}) and net monetary return (Rs. 16633 ha^{-1}) recorded with the treatment of 100% RDF (N_1). This might be due to higher grain yield and straw yield obtained by foliar application of micronutrients and supplemented with Azotobacter and PSB. The results were found similar with those of Singh *et al.* (2020) [13] and Alam *et al.* (2021) [2]. Interaction between tillage and nutrient management practices was found non-significant.

Table 1: Influence of tillage and nutrient management practices on yield and economics of linseed

Treatments		Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B:C Ratio
Main plot treatments: Tillage practices (T)						
T_1	Conventional tillage (cultivator twice with rotavator once)	1010	2141	55558	23106	1.71
T_2	Reduce tillage (cultivator once)	894	1828	49158	22006	1.80
T_3	Zero tillage	845	1691	46486	21834	1.88
	SE (m) ±	22	80	1237	1237	-
	CD (0.05)	88	315	4857	4857	-
Sub plot treatments: Nutrient Management (N)						
N_1	100% RDF	795	1696	43732	16633	1.62
N_2	100% RDF + Seed treatment with microbial consortium	865	1841	47598	20128	1.74
N_3	100% RDF + Foliar application of micronutrient (PDKV Grade-II) at flower initiation (45-50 DAS) @ 5 ml lit^{-1} and capsule development stage (70-80 DAS) @ 10 ml lit^{-1} water	972	1949	53446	24745	1.87
N_4	100% RDF + Seed treatment with Microbial Consortium Foliar application of micronutrient (PDKV Grade-II) at flower initiation (45-50 DAS) @ 5 ml lit^{-1} and capsule development stage (70-80 DAS) @ 10 ml lit^{-1} water	1033	2061	56826	27755	1.96
	SE (m) ±	16	62	878	878	-
	CD (0.05)	49	191	2705	2705	-
	Interaction Effect (T x N)					
	SE (m) ±	28	107	1521	1521	-
	CD (0.05)	NS	NS	NS	NS	-
	GM	916	1887	50401	22315	1.80

Benefit: Cost ratio

The highest B:C ratio (1.88) was recorded under zero tillage (T_3) which may be attributed to reduced cost of cultivation. The low cost associated with land preparation and labor in zero tillage systems results in lower overall expenditure thereby improving net returns and leading to a higher B:C ratio compared to conventional tillage. As regards nutrient management practices, B:C ratio differed prominently due to different nutrient management practices. The highest B:C ratio was recorded with the treatment of 100% RDF along with seed treatment using a microbial consortium Biomix and foliar application of micronutrients PDKV Grade-II at the flower initiation stage (45-50 DAS) @ 5 ml lit^{-1} and at the capsule development stage (70-80 DAS) @ 10 ml lit^{-1} of water (N_4) as compared to all other nutrient management treatments.

Conclusions

From the present studies, it can be concluded that, for higher seed, straw yield and economics of linseed, conventional tillage may be preferred in linseed cultivation followed by 100% RDF along with seed treatment using a microbial consortium Biomix and foliar application of micronutrients PDKV Grade-II at the flower initiation stage (45-50 DAS) @ 5 ml lit^{-1} and at the capsule development stage (70-80 DAS) @ 10 ml lit^{-1} of water.

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