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Effect of fertilizers on growth and yield of linseed (*Linum usitatissimum* L.) varieties

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Abstract
A field experiment was conducted during the *rabi* season 2016-2017 0n vertisol at Oilseed Research Station, Latur. To asses the response of linseed varieties to different spacing and fertilizer levels. The experiment was laid out in a factorial randomized block design with eighteen treatment combinations, consisting of two varieties of NL-260 (V1) and LSL-93 (V2), three spacing's viz., 30 cm x 5 cm (S1), 45 cm x 5 cm (S2), 30 cm x 10 cm (S3) and three fertilizer levels viz. 50% RDF (F1), 100% RDF (F2) and 150% RDF (F3) replicated twice. The recommended dose of fertilizer (RDF) was 60:30:00 NPK kg ha-1. The result indicated that growth and yield contributing character of linseed viz., number of branches plant-1, spread plant-1, total dry matter plant-1, number of capsule plant-1, weight of capsule plant-1, number of seed capsule-1, seed yield plant-1, test weight (g) were appreciably improve with the variety LSL-93 (V2) except plant height, straw yield and biological yield (kg ha-1). The variety LSL-93 (V2) was found significantly effective in producing higher seed yield, oil yield (kg ha-1), GMR, NMR and B: C ratio over the variety NL-260(V1). Among the different spacing a wider spacing of 30 cm × 10 cm (S3) produced significantly higher growth and yield attributing characters over the spacing of 30 cm × 5 cm (S1) and found at par with 45 cm × 5 cm (S2). The closer spacing of 30 c m × 5 cm (S1) was effective in producing highest seed yield, oil yield and straw yield, GMR, NMR and B: C ratio.

Keywords: Linseed, varieties, spacing, fertilizer levels

Introduction
Linseed or flax is one of the most important *rabi* oilseed crop. It contains 35 to 45% oil. It is grown either for the oil extracted from the seed or fibre from the stem. Every part of the linseed plant is utilized commercially either directly or after processing. Edible linseed oil is used for human consumption and contains α-linolenic acid (ALA) a poly unsaturated fatty acid that has nutritional and health benefits, apart from ALA, linseed is widely used as nutritional and functional food in the western world due to its high contents of therapeutic health promoting sustains such as omega-3 fatty acid, soluble and insoluble fiber and lignin and its suitability to use with bread, breakfast cereals and other food products. Omega -3 fatty acid help to reduce the risk of cardiovascular disease and cancer. The linseed oil is an important ingredient in the manufacture of paint varnish, printing ink and linoleum.

Linseed is one of the most important crop of the world cultivated in over an area of 22.70 lakh ha with a production of 22.39 lakh tonne and productivity of 986 kg/ha. In India, it occupies an area of 3.38 lakh ha with a production of 1.47 lakh tonne and a productivity of 435 kg/ha (Anonymous-2014) [4]. The area under linseed in Maharashtra is 39 thousand ha, with an annual production of 10 thousand tones and average productivity is 246 kg/ha. The area under linseed in Marathwada is 16 thousand ha, with an annual production of 15 thousand tonnes and average productivity is 312 kg/ha (Anonymous, 2013) [3].

Recently Oilseed Research Station, Latur has released new linseed variety LSL-93. The yield is influenced by plant density suggested by various workers. At closer spacing, number of capsule per plant, number of seed per capsule, weight of capsule and seed weight per plant were decreased and at wider spacing number of capsule per plant, number of seed per capsule, weight of capsule and seed weight per plant were increased. Therefore it is necessary to find out the optimum plant population for getting higher yield.

Materials and Methods
A field experiment was conducted during 2016-17 in *rabi* season at Experimental Farm, Oilseeds Research Station, Latur. Geographically Latur is situated between 18^0 05' to 18^0 75' North latitude and between 76^0 25' to 77^0 25' East longitude.

It's height from Mean Sea Level is about 540.63 m and has sub-tropical climate. The experimental soil was medium black with initial soil fertility of alkaline in nature (P^H 8.0) containing low in available nitrogen (188.8 kg ha^{-1}), available phosphorus (14.82 kg ha^{-1}) and high in available potassium (588.72 kg ha^{-1}).The experiment was laid out in Factorial Randomised Block Design (FRBD) with eighteen treatment combinations consisting of two varieties of NL-260 (V_1) and LSL-93 (V_2), three spacing's *viz*., 30 cm x 5 cm (S_1), 45 cm x 5 cm (S_2), 30 cm x 10 cm (S_3) and three fertilizer levels *viz*. 50% RDF (F_1), 100% RDF (F_2) and 150% RDF (F_3) replicated twice. The recommended dose of fertilizer (RDF) was 60:30:00 NPK kg ha^{-1}. A half dose of nitrogen along with full dose of phosphorus was applied at the time of sowing and remaining half dose of nitrogen was applied 30 DAS. The crop was sown at different spacing and net plot size was (4.8 m X 4.2m for 30 cm row spacing and 4.5 m X 3.9 m for 45 row spacing). The source of nutrient were Diammonium phosphate (DAP) and Urea.

Results and Discussion

Effect of Fertilizer Levels

Growth and yield attributes

Perusal of data in table 1 and Fig. 1 revealed that among different fertilizer levels application of 150% RDF recorded significantly higher plant height, plant spread and dry matter accumulation $plant^{-1}$ over the application of 50% RDF and found at par with application of 100% RDF. It might be due to enhanced mostly all the growth characters with higher level of fertilizer application. Similar result were also noticed by Ranglal *et al*. (2011), Lilian *et al*. (2014), Delesa *et al*. (2016). Application of 150% RDF recorded highest number of branches $plant^{-1}$ which was significantly superior over application of 100% RDF and 50% RDF. It might be due to higher level of fertilizer application which enhanced the number of branches $plant^{-1}$. This results are inconformity with the findings of Dubey *et al.* (1997), Khajani *et al*. (2012). The yield attributing character are presenting in table revealed that among different fertilizer levels application of 150% RDF produced significantly higher number of capsule $plant^{-1}$, weight of capsule $plant^{-1}$ and seed yield $plant^{-1}$ over application of 50% RDF and found at par with 100% RDF. Application of 150% RDF was found beneficial in increasing above yield contributing characters over lower levels of fertilizers. However significantly response of applied fertilizer was up to 100% RDF. The positive response of higher level of fertilizers on above yield attribute to be ascribed to overall improvement in crop growth, enabled the plant to observed more nutrient and moisture which empowered the plant to manufacture more quantity of photosynthetic accumulate there in sink. Similar results were also reported by Malik *et al*. (2008) [15] and Khajani *et al*. (2012). Seed yield $plant^{-1}$ and test weight was not influenced significantly due to fertilizer level. Similar results were also recorded by Gabiana *et al*. (2005) [6].

Seed yield of linseed

Perusal of data presented in Fig. 2 indicated that seed yield (kg ha^{-1}), straw yield (kg ha^{-1}) and biological yield (kg ha^{-1}) were influenced significantly due to different fertilizer levels. Application of 150% RDF produced significantly higher seed yield, straw yield and biological yield over 50% RDF and found at par with application of 100% RDF. This was due to favorable effect of increasing fertilizer levels on yield attributing characters which finally resulted in higher grain yield, straw yield and biological yield. Similar result with Tanwar *et al*. (2011) [24], Patel *et al*. (2012) [18], Suryavanshi *et al*. (2012) [23]. Harvest index was no influenced significantly due to different fertilizer levels. The oil content (%) in linseed was not influenced significantly due to different fertilizer levels. The mean oil yield (kg ha^{-1}) was influenced significantly due to different fertilizer levels. Application of 150% RDF recorded highest oil yield (411 kg ha^{-1}) which was at par with 100% RDF (387 kg ha^{-1}) and significantly superior over 50% RDF (308 kg ha^{-1}). Similar result was observed by Girase *et al*. (1979), Dubey *et al*. (1997), Singh *et al.* (2013) [22], Gokhale *et al*. (2008) [8].

Economic studies

The gross monetary return and net monetary returns were influenced significantly due to different levels. Application of 150% RDF recorded significantly higher GMR (Rs.53172) and NMR (Rs.31255) over the application of 50% RDF GMR (Rs. 39710) and NMR (Rs.19451) and found at par with application of 100% RDF (Rs.50453) and NMR (Rs.29365). It might be due to higher level of yield with increased with fertilizer application. Similar result was recorded by Sharma *et al*. (1995), Choubey *et al*. (2002), Patel *et al*. (2012) [18].
Application of 150% RDF recorded higher value of B:C ratio (2.42). Amongst fertilizer levels, which was closely followed by application of 100% RDF. Similar result obtained by Tanwar *et al*. (2011) [24], Kumar and Deka (2016) [14].

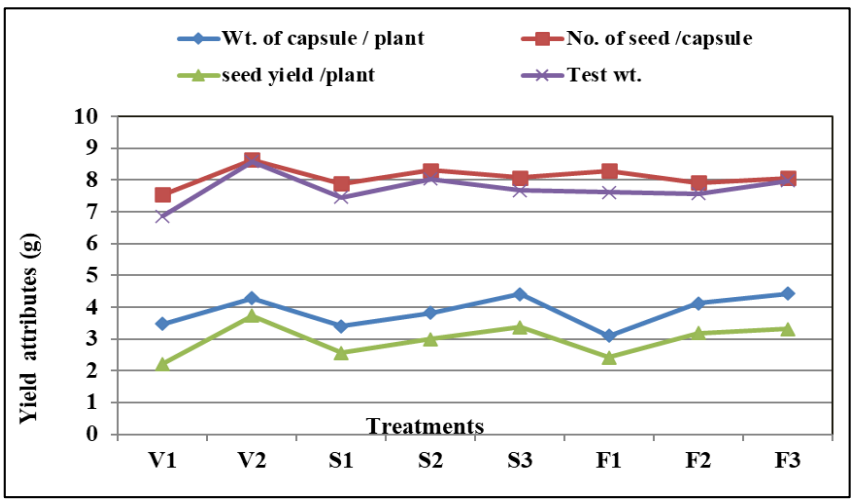

Fig 1: Treatments

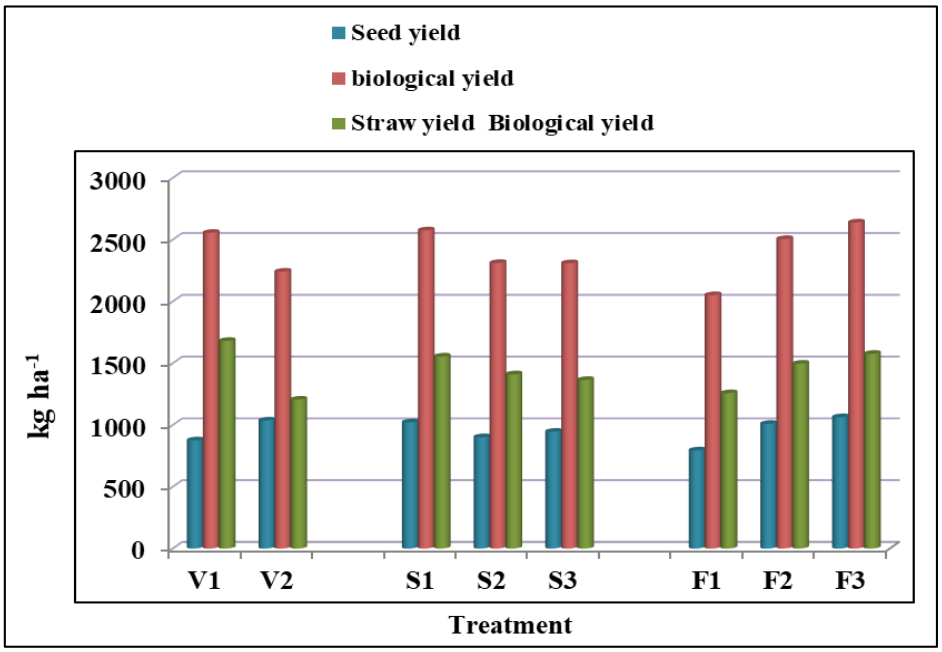

Fig 2: Treatments

Table 1: Growth studies of linseed as influenced by different treatments

	Treatment	Plant height	No. of branches	Spread plant^{-1}	Total dry matter	No. of capsule plant^{-1}
(A)	**Varieties (V)**					
	V_1 – NL-260	55.19	5.08	11.96	11.43	44.74
	V_2 – LSL-93	38.82	5.40	12.48	12.02	56.81
	S.E.±	0.73	0.10	0.17	0.20	1.25
	C.D. at 5%	2.17	0.29	0.51	0.59	3.71
(B)	**Spacings (S)**					
	S_1 – 30 cm x 5 cm	45.83	4.54	11.62	10.91	43.50
	S_2– 45 cm x 5 cm	47.32	5.31	12.36	11.64	53.07
	S_3– 30 cm x 10 cm	47.85	5.88	12.74	12.63	55.76
	S.E.±	0.89	0.12	0.21	0.24	1.53
	C.D. at 5%	NS	0.36	0.63	0.73	4.55
(C)	**Fertilizer levels (F)**					
	F_1 – 50% RDF	43.97	4.44	11.50	10.78	40.52
	F_2 – 100% RDF	47.79	5.38	12.32	11.98	54.74
	F_3 – 150% RDF	49.25	5.92	12.82	12.42	57.06
	S.E.±	0.89	0.12	0.21	0.24	1.53
	C.D. at 5%	2.65	0.36	0.63	0.73	4.55
(D)	**Interactions (4)**					
	V x S					
	S.E.±	1.25	0.16	0.29	0.34	2.15
	C.D. at 5%	NS	NS	NS	NS	NS
	V x F					
	S.E.±	1.25	0.16	0.29	0.34	2.15
	C.D. at 5%	NS	NS	NS	NS	NS
	S x F					
	S.E.±	1.54	0.20	0.36	0.42	2.64
	C.D. at 5%	NS	NS	NS	NS	NS
	V x S x F					
	S.E.±	2.18	0.29	0.51	0.59	3.73
	C.D. at 5%	NS	NS	NS	NS	NS
	General Mean	47	5.24	12.22	11.73	50.78

Table 2: Economics of linseed as influenced by different treatments

	Treatment	Harvest index	Gross monetary returns (Rs.ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Net monetary return (Rs.ha^{-1})	Benefit: cost ratio
(A)	**Varieties (V)**					
	V_1 – NL-260	34	43751	21310	22441	2.05
	V_2 – LSL-93	46	51805	20866	30939	2.48
	S.E.±	1	831	-	831	
	C.D. at 5%	2	2479	-	2479	
(B)	**Spacings (S)**					
	S_1 – 30 cm x 5 cm	40	51026	21981	29045	2.32
	S_2– 45 cm x 5 cm	39	45041	20741	24300	2.17
	S_3– 30 cm x 10 cm	42	47267	20541	26726	2.30
	S.E.±	1	1017	-	1017	
	C.D. at 5%	NS	3036	-	3036	
(C)	**Fertilizer levels (F)**					
	F_1 – 50% RDF	39	39710	20259	19451	1.96
	F_2 – 100% RDF	41	50453	21088	29365	2.39
	F_3 – 150% RDF	41	53172	21917	31255	2.42
	S.E.±	1	1017	-	1017	
	C.D. at 5%	NS	3036	-	3036	
(D)	**Interactions (4)**					
	V x S					
	S.E.±	1.32	1439	-	1439	
	C.D. at 5%	NS	NS	-	NS	
	V x F					
	S.E.±	1.32	1439	-	1439	
	C.D. at 5%	NS	NS	-	NS	
	S x F					
	S.E.±	1.62	1762	-	1762	
	C.D. at 5%	NS	NS	-	NS	
	V x S x F					
	S.E.±	2.30	2492	-	2492	
	C.D. at 5%	NS	NS	-	NS	
	General Mean	40.26	47778	21088	26690	2.26

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