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Response of different linseed (*Linum usitatissimum* L.) varieties to fertilizer levels

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Abstract
A field experiment was carried out on black soil during *rabi* season 2020-21 at Experimental Farm (Block-B), Department of Agronomy, College of Agriculture, VNMKV, Parbhani. The experiment has been laid out in split plot design with 3 replications and 12 treatment combinations. Main plot consisted of three varieties *viz.*, LSL-93 (V_1), RLC-148 (V_2) and NL-260 (V_3) and subplot consisted of four fertilizer levels *viz.,* Absolute control (F_0), 20:20:20 NPK kg ha^{-1} (F_1), 25:25:25 NPK Kg ha^{-1} (F_2) and 30:30:30 NPK Kg ha^{-1} (F_3). The varieties had a significant effect on growth and yield of linseed. The variety RLC-148 (V_2) recorded significantly higher growth parameters *viz*., plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, total dry matter accumulation plant^{-1} and yield attributes *viz*., number of capsule plant^{-1}, weight of capsules plant^{-1}, number of seeds capsule^{-1}, number of seeds plant^{-1}, seed yield plant^{-1}, test weight, seed yield, straw yield, biological yield, harvest index, oil yield, GMR, NMR and B:C ratio over the variety LSL-93 (V_1) and found to be at par with the variety NL-260 (V_2) except in oil content of seed. With respect to fertilizer levels, application of 30:30:30 NPK Kg ha^{-1} (F_3) recorded significantly higher growth parameters, yield attributes and yield as compared to absolute control (F_0) and 20:20:20 NPK kg ha^{-1} (F_1) but found at par with 25:25:25 NPK Kg ha^{-1} (F_2).

Keywords: Linseed, seed yield, growth parameters, fertilizer, variety

Introduction
Linseed (*Linum usitatissimum* L.) is one of the most versatile and useful crop also referred as flaxseed (Genser and Morris, 2003) [7]. It is purely a cool season *rabi* crop stands next to rapeseed, mustard with respect to area and production. Linseed seed contains oil, ranging from 35 to 45% (Gaikwad, 2020) [6] having high percentage of essential fatty acids, 75% polyunsaturated fatty acids, 57% alpha -linolenic acid, which is an omega -3 fatty acids, and 16% linoleic acid, which is an omega-6 fatty acid.

Now a day a new form of linseed called Linola has been specially bred to produce oil, suitable for human consumption (Rani, 2007) [15]. Linseed seeds are suitable to use with bread, breakfast cereals and other food products. Omega -3 fatty acid present in linseed seeds helps to reduce the risk of heart disease, inflammatory bowel disease, arthritis and other health issues. It contains a group of chemical substances called lignans which play an important role in cancer prevention.

The linseed oil is an important ingredient in the manufacture of currency papers, enamels, plastics, stickers, tarpaulins, soaps, paint, varnish, printing ink, linoleum and also be used in the animal care products, earthen floors, industrial lubricant, leather treatment, oil cloth particle detectors, textiles, wood preservation, seasoning of cookware etc.

The oil cake contains about 10% of oil, 32% proteins, 9% fibre, 11% moisture and 6% minerals so it is used as a feed for animals, milch cattle and poultries, therefore priced 50% more when compared to rapeseed and mustard cake. Linseed cake is also used as organic manure, as it contains about 5% nitrogen, 1.5% phosphorous, 1.8% potash. It can be used in conjugation with inorganic manures for upliftment of soil fertility.

Fibre obtained from the stem are known for its length and strength & are 2-3 times strong as those of cotton. The fibre is lustrous & blends well with wool, cotton, silk etc. Fibre is used in the preparation of powerful twines, canvas, shirting, suiting and various indispensable items for defence purpose. The woody matter and short fibre are used as a raw pulp for making good quality paper.

Major linseed growing countries are Canada, USA, India, China, and Russia. Canada is the largest producer of flax seed in the world, representing about 40% of world's production. In India Madhya Pradesh leads in yield and acreage, followed by Uttar Pradesh, Maharashtra, Bihar, Rajasthan, and Karnataka.

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 tonnes and productivity of 985 kg/ha. In India, it occupies an area of 0.017 m ha with a production of 0.09 mt and a productivity of 574 kg/ha. The area under linseed in Maharashtra is 7 Th. ha, with an annual production of 2.7 Th. tonnes and average productivity is 380 kg ha^{-1} (Anonymous 2019-20) [2].

Materials and Methods

A field experiment was carried out on black soil during *rabi* season 2020-21 at Experimental Farm (Block-B), Department of Agronomy, College of Agriculture, VNMKV, Parbhani. The experiment has been laid out in split plot design with 3 replications and 12 treatment combinations. Main plot consisted of three varieties *viz.*, LSL-93 (V_1), RLC-148 (V_2) and NL-260 (V_3) and subplot consisted of four fertilizer levels *viz.*, Absolute control (F_0), 20:20:20 NPK kg ha^{-1} (F_1), 25:25:25 NPK Kg ha^{-1} (F_2) and 30:30:30 NPK Kg ha^{-1} (F_3). The experimental site was situated at 19^0 16' North latitude and 76^0 47' East longitude. Its height from mean sea level is about 409 m and has sub-tropical climate. The soil of experimental plot was clayey in texture with medium in organic carbon (0.55%), low in available nitrogen (193.40 kg ha^{-1}), and medium in available phosphorus (15.78 kg ha^{-1}) and rich in available potassium (480.13 kg ha^{-1}) content and slightly alkaline in reaction having pH 7.8. The crop was sown with 30×15 cm spacing by adopting dibbling method. The gross and net plot size were 5.4 × 4.8 m^2 and 4.2 × 4.2 m^2, respectively. Full dose of nitrogen and full dose of phosphorus and potash (as per treatment) was applied as basal through Urea, SSP and MOP at the time of sowing and then seed was sown.

Result and Discussion

Performance of varieties on growth and yield attributes

Plant height (cm)

Data revealed that, varieties showed a significant different in plant height at all crop growth stages. The variety RLC-148 produced highest plant height over the variety LSL-93 and found at par with NL-260. The marked variation in growth could be ascribed on account of their genetic capabilities to exploit available resources for their growth and development. The experimental results are in line with those of Kumar *et al.* (2016) [8], Chopra and Badiyala (2016) [4], Kurrey and Singh (2019) [9] and Shivanand *et al.* (2020) [19].

Number of branches $plant^{-1}$

Variety RLC-148 produced significantly maximum number of branches over variety LSL-93 and which is found at par with NL-260 at all growth stages. These results indicate that the variety RLC-148 was more responsive to environmental conditions and invested towards stimulating the growth of lateral buds and then an increasing the number of branches. The result is in direct conformity with the findings of Singh *et al.* (2013) [20], Bakry *et al.* (2015) [3] and Mohammed *et al.* (2020) [13].

Number of functional leaves $plant^{-1}$

The variety RLC-148 recorded significantly maximum number of functional leaves $plant^{-1}$ over variety LSL-93 and found to be at par with variety NL-260 at all growth stages. The overall trend of the data revealed that number of functional leaves $plant^{-1}$ increased progressively up to 75 DAS thereafter declined due to senescence. The results are in agreement with the findings of Singh *et al.* (2010) [21].

Table 1: Growth parameters of linseed as influenced by different treatment

Treatment	Plant height (cm)	Number of branches $plant^{-1}$	Number of functional leaves $plant^{-1}$	Leaf area $plant^{-1}$ (dm^2)	Total dry matter accumulation $plant^{-1}$ (g)
(A) Varieties (V)					
V_1 – LSL-93	36.03	4.70	70.93	0.30	7.83
V_2- RLC-148	63.28	6.19	223.83	0.48	11.61
V_3 – NL-260	51.15	5.45	177.68	0.43	9.87
S.E.+	1.30	0.12	5.45	0.013	0.32
C.D. at 5%	3.59	0.33	16.82	0.036	0.88
(B) Fertilizer levels (F)					
F_0- Absolute control	42.71	4.08	140.82	0.35	5.48
F_1-20:20:20 NPK Kg ha^{-1}	51.43	5.27	172.37	0.40	9.17
F_2-25:25:25 NPK Kg ha^{-1}	52.47	6.02	174.90	0.42	11.39
F_3-30:30:30 NPK Kg ha^{-1}	54.09	6.42	177.90	0.44	13.14
S.E.+	1.49	0.14	6.07	0.012	0.35
C.D. at 5%	4.12	0.46	19.40	0.033	0.96
(C) Interactions (V×F)					
S.E.+	2.59	0.25	10.51	0.021	0.60
C.D. at 5%	NS	NS	NS	NS	NS
General Mean	50.15	5.45	171.76	0.40	9.77

Leaf area $plant^{-1}$ (dm^2)

Variety RLC-148 recorded significantly highest leaf area $plant^{-1}$ over the variety LSL-93 and which is statistically at par with variety NL-260. This might be due to overall favourable growth and more number of functional leaves produced by the variety which in turn resulted in more leaf area $plant^{-1}$. The result is in conformity with the findings reported by Papatheohari *et al.* (2008) [14].

Total dry matter accumulation $plant^{-1}$: The significant influence was found on total dry matter accumulation $plant^{-1}$ due to different varieties at all crop growth stages. The variety RLC-148 exceeded the variety LSL-93 in accumulation of more dry matter $plant^{-1}$ and found at par with NL-260 at all growth stages. It might be due to higher plant and branches of the variety RLC-148. This result was correlated with the findings of Singh *et al.* (2010) [21], Rokade *et al.* (2015) [16], Mohammed *et al.* (2020) [13] and Shivanand *et al.* (2020) [19].

Table 2: Yield and yield attributing characters of linseed as influenced by different treatment

Treatment	Number of capsules Plant^{-1}	Weight of capsules plant^{-1} (g)	No. of seeds capsules^{-1}	No. of seeds plant^{-1}	Seed yield plant^{-1}(g)	Test weight (g)
(A) Varieties (V)						
V_1 – LSL-93	47.94	3.97	7.71	396.7	2.87	6.84
V_2- RLC-148	54.76	4.98	8.60	453.9	3.97	8.26
V_3 – NL-260	51.23	4.38	8.14	429.2	3.31	7.45
S.E.+	1.26	0.12	0.16	10.13	0.08	0.19
C.D. at 5%	3.48	0.33	0.42	28.04	0.22	0.53
(B) Fertilizer levels (F)						
F_0- Absolute control	20.67	3.49	7.69	346.10	2.50	6.99
F_1-20:20:20 NPK Kg ha^{-1}	29.87	4.29	8.17	426.80	3.29	7.56
F_2-25:25:25 NPK Kg ha^{-1}	32.14	4.71	8.33	453.40	3.69	7.70
F_3-30:30:30 NPK Kg ha^{-1}	34.12	5.27	8.41	480.10	4.04	7.82
S.E.+	0.87	0.13	0.26	14.38	0.09	0.27
C.D. at 5%	2.41	0.35	NS	39.80	0.24	NS
(C) Interactions (V×F)						
S.E.+	1.50	0.23	0.45	24.90	0.16	0.48
C.D. at 5%	NS	NS	NS	NS	NS	NS
General Mean	29.20	4.44	8.15	426.34	3.38	7.52

Yield and yield contributing characters

Among the varieties RLC-148 recorded significantly higher number of capsules plant^{-1} (54.76), weight of capsules plant^{-1} (4.98 g), number of seeds capsule^{-1} (8.60), number of seeds plant^{-1} (453.9), seed yield plant^{-1} (3.97 g) and Test weight (8.26g) over the variety LSL-93 and observed to be at par with variety NL-260. The differences among varieties could be due to their genetical components and their response to the environmental conditions. Similar findings were also reported by Saeed *et al*. (2020) [17], Chopra and Badiyala (2016) [4] and Meenakshi *et al*. (2017) [12].

Seed yield (kg ha^{-1})

Among different varieties, variety RLC-148 yielded significantly higher seed yield (1112 kg ha^{-1}), straw yield (2448 kg ha^{-1}) and biological yield (3560 kg ha^{-1}) which was found significantly superior over the variety LSL-93 and observed to be at par with NL-260. The superiority of the variety RLC-148 could be due to increment in yield components and seed yield, the different genetic nature of linseed varieties had different response to environmental conditions which reflect on the growth and development of plants and their ability to exploit growth factors and direct them towards increasing physiological activities, including photosynthesis and its metabolic products and increasing the accumulation of dry matter in the plant. These results are showed similar response with the reports of Sharma and Prakash (2013) [18], Singh *et al*. (2010) [21], Ahmad *et al*. (2017) [1] and Emam (2019) [5].

Harvest index (%)

Variety RLC-148 (31.23%) recorded higher harvest index compared to variety LSL-93 (30.31%) and variety NL-260 (30.94%). This might be due to better efficiency of dry matter conservation from sources to sink, so the superiority of the variety RLC-148 could be due to its superiority in seed yield and biological yield. Similar results were also reported by Mohammed *et al*. (2020) [13].

Quality attribute

The variety LSL-93 recorded highest oil content (39.45%) over variety RLC-148 (35.90%) and found at par with variety NL-260 (37.56%). This may be due to the genetic potentiality of the genotype. And variety RLC-148 recorded highest oil yield (409 kg ha^{-1}) over the variety LSL-93 (338 kg ha^{-1}) and found at par with variety NL-260 (373 kg ha^{-1}). It might be due to higher yield of the variety. Similar results were also reported by Leilah *et al*. (2018) [10].

Table 3: Seed yield (kg ha^{-1}) and oil yield (kg ha^{-1}) as influenced by different treatments

Treatment	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	Biological yield kg ha^{-1}	Harvest index	Oil content (%)	Oil yield kg ha^{-1}
(A) Varieties (V)						
V_1 – LSL-93	858	1972	2830	30.31	39.35	338
V_2-RLC-148	1112	2448	3560	31.23	35.90	399
V_3- NL-260	993	2217	3210	30.94	37.56	373
S.E.+	28.90	76.47	81.60	-	1.15	11.45
C.D. at 5%	79.99	211.66	225.86	-	NS	31.69
(B) Fertilizer levels (F)						
F_0- Absolute control	783	828	2611	29.98	36.06	281
F_1-20:20:20 NPK Kg ha^{-1}	992	2214	3206	30.96	37.13	380
F_2-25:25:25 NPK Kg ha^{-1}	1062	2349	3411	31.13	38.32	400
F_3-30:30:30 NPK Kg ha^{-1}	1113	2462	3575	31.13	38.89	419
S.E.+	30.55	73.75	115.20	-	1.34	9.85
C.D. at 5%	84.56	204.14	318.87	-	NS	27.26
(D) Interactions (V×F)						
S.E.+	52.93	127.44	19954	-	2.32	17.29
C.D. at 5%	NS	NS	NS	-	NS	NS
General Mean	988	2212	3200	30.82	37.60	370

Economic studies

The gross monetary returns and net monetary returns (₹ ha^{-1}) were significantly influenced due to different varieties. From the economic analysis it was observed that among the varieties, the variety RLC-148 recorded the maximum GMR, NMR and B:C ratio over the variety LSL-93 and was found at par with NL-260. It might be due to the higher yield obtained with RLC-148. A similar trend was observed with the findings of Kumar *et al*. (2016) [8], Maurya *et al*. (2017) [11].

Table 4: Economics (₹ ha^{-1}) of linseed as influenced by different treatments

Treatment	Gross monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary Returns (₹ ha^{-1})	Benefit: Cost ratio
Varieties (V)				
V_1-LSL-93	36720	22853	13867	1.6
V_2 -RLC-148	57240	22853	34387	2.5
V_3-NL-260	48487	22853	25634	2.12
S.E.+	1610.3	-	1610.3	-
C.D. at 5%	4962.51	-	4962.51	-
Fertilizer levels (F)				
F_0-Absolute control	36687	21300	13834	1.72
F_1-20:20:20 NPK kg ha^{-1}	46393	22951	23540	2.02
F_2-25:25:25 NPK kg ha^{-1}	51043	23366	28190	2.18
F_3-30:30:30 NPK kg ha^{-1}	55805	23796	32952	2.34
S.E.+	1370	-	1370	-
C.D. at 5%	4071.3	-	4071.3	-
Interaction (V×F)				
S.E.+	2373	-	2373	-
C.D. at 5%	NS	-	NS	-
General Mean	47482	22853	24629	2.06

Conclusion

Variety RLC-148 fertilized with 30:30:30 NPK Kg ha^{-1} was used to achieve higher growth, yield attributes and yield of linseed.

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