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Study of spacing and nitrogen management practices on productivity of flax and dual purpose linseed varieties

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Abstract
A field experiment was conducted to study the effect of spacing and nitrogen management practices on productivity of flax and dual purpose linseed varieties at the Instructional-cum Research Farm, IGKV, Raipur (C. G.) during *rabi* 2021-22 & 2022-23 and the results obtained are discussed here on the basis of two years mean data. The recommended dose of fertilizer was taken 60:30:30 N, P_2O_5 and K_2O kg ha^{-1} respectively. The experiment was laid out in split-split plot design with two replications consisted treatments of four varieties of linseed *viz.* V_1: RLC-148, V_2: JLS-95, V_3: JRF-2 and V_4: RLC-92, three spacing *viz.*, S_1: 15 cm, S_2: 22.5 cm, S_3: 30 cm and three levels of nitrogen *viz.*, N_1: 100% N, N_2: 150% N, N_3: 200% N. Data revealed that the highest value of yield attributes *viz.* number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, test weight (g $plant^{-1}$) and seed yield (q ha^{-1}) were recorded with variety JLS-95 (V_2), spacing 30 cm (S_3) and 200% N (N_3). However, stover yield (q ha^{-1}), fibre length (cm) and fibre yield (kg ha^{-1}) were highest with V_3 (JRF-3) along with treatment N_3 (200% N). Oil content (%) and oil yield (kg ha^{-1}) was highest in V_4 (RLC-92) with treatment S_3 (30 cm row spacing). The closer row spacing increased plant height along with fibre length, whereas increasing nitrogen application from an optimum level had negative impact on oil content of linseed.

Keywords: Linseed, JRF-2, fibre yield, nitrogen management, retting

Introduction
Linseed (*Linum usitatissimum* L.) is an important oilseed crop in India. Every part of the plant is utilized commercially either directly or after processing. The oil primarily goes to industries for the manufacture of paints, varnish, oil-cloth, linoleum, pad-ink and printing-ink. The oil-cake is a good feed for milch cattle. Chhattisgarh is an important linseed growing state of India, where it is cultivated in about 0.026 million hectare area with a production of 0.011 million tonnes but its productivity is low in Chhattisgarh (423 kg ha^{-1}) and national (498 kg ha^{-1}) compared to global (877 kg ha^{-1}) productivity. Chhattisgarh having third highest yield gap between improved technology and farmer's practice in irrigated condition is found after Uttar Pradesh and Himachal Pradesh. The major reason for low productivity of linseed may be due to adoption of primitive sowing method like *utera* and farmers having poor knowledge with regards to INM and perpetual scarcity of basic agro-inputs like improved seed, fertilizers etc. Among the agro-techniques, judicious application of seed rates, proper spacing, nutrients, particularly the nitrogen, phosphorus and potash play the important role for increasing linseed productivity. The linseed crop in India is cultivated primarily for its oil. However, in many other countries this crop is grown primarily for its fibre. The varieties meant for fibre extraction are bred solely for high quantity and better quality of fibre. In India, efforts made in the past to develop dual-purpose varieties in linseed (for seed and fibre) did not succeed. There is no special industry for extracting any fibre from the commercially grown varieties.

Methodology
This experiment was conducted under split-split plot experimental design at the instructional-cum research farm, IGKV, Raipur (C. G.) during *rabi* 2021-22 & 2022-23. Different purpose linseed varieties *viz.*, V_1: RLC-148 (Seed purpose), V_2: JLS-95 (Oil purpose), V_3: JRF-2 (Flax purpose) and V_4: RLC-92 (Dual purpose) were taken in main plot, each factors of main plot were subjected to the treatments of sub-plot factors *i.e.*, spacings. Thus, each variety was sown at spacing of 15 cm (S_1), 22.5 cm (S_2) and 30 cm (S_3) with different nitrogen levels (sub-sub plot factor). The treatments consisting of nitrogen levels were treatment N_1: 100% N, N_2: 150% N and N_3: 200% N.

For fibre extraction, the flax fibre is first threshed then retted. In the process of water retting with the use of tanks, the deseeded stalk are placed in tanks then filled with water. The soil-inhabiting bacteria that exist on the stalk destroyed or dissolve the gums that bind the fibre to the wood. Retting is completed in 2 to 3 weeks at 32-35 °C. After retting the retted stalks are dried and scutched with fluted roller, the loosened and broken woody portion and small fibre are removed with help of comb. The strong and flexible fibre resists breaking during the process of scutching and combing or hackling. The average length of good fibre is about 50 cm. For the extraction of oil, Soxhlet extractor (SOCSPLUS unit) are used in which 2 gm of grind seed sample and 80 ml of petroleum ether. Standard procedures was adopted for recording the data on various growth and yield parameters. Data collected were statistically analyses by the procedure suggested by Gomez and Gomez (1984) [6].

Results and Discussion

In this study results are discussed on the basis of two years mean on following heads,

- Effect of varieties
- Effect of spacing
- Effect of nitrogen management
- Effect of interaction among varieties, spacing and nitrogen management practices
- Effect of varieties on yield attributes and yield

As regard to varieties, variety V_2: JLS-95 recorded significantly highest values for number of capsules plant^{-1} (60.30), test weight (8.02 g), seed yield (19.40 q ha^{-1}), harvest index (45.03%) and found at par with variety V_1: RLC-148, whereas the lowest values was recorded with variety V_3: JRF-2 for mentioned parameters. Significantly highest stover yield was registered with variety V_3: JRF-2 (27.13 q ha^{-1}).

Effect of spacing on yield attributes and yield

Among spacing, treatment S_3: 30 cm recorded significantly highest values for number of capsules plant^{-1} (57.76), test weight (7.63 g), seed yield (19.25 q ha^{-1}), stover yield (27.36 q ha^{-1}), however seed and stover yield was found at par with spacing S_2: 22.5 cm, whereas the lowest values were recorded with treatment S_1: 15 cm for discussed parameters. Spacing showed non-significant effect on number of seeds capsule^{-1} and harvest index. It is due to the exposure of individual plant to more soil moisture, nutrient and solar radiation at 30 cm (S_3) row spacing and hence their growth and development was better leading to the production of higher number of seeds capsule^{-1} (Kushwaha *et al.*, 2006) [8].

Effect of nitrogen management on yield attributes and yield

In case of nitrogen management, treatment N_3: 200% N recorded significantly highest number of capsules plant^{-1} (57.93), test weight (7.57 g), seed yield (18.83 q ha^{-1}), stover yield (26.95 q ha^{-1}), however seed and stover yield was found at par with N_2: 150% N, whereas the lowest values were recorded with treatment N_1: 100% N for discussed parameters. Spacing showed non-significant effect on number of seeds capsule^{-1} and harvest index. The application of adequate quantity of nitrogen fertilizer leads to cell division, cell elongation and tissue differentiation. The increase in yield attributing characters of linseed with the application of major nutrient (N) and secondary nutrient (S) has been reported by Khare *et al.* (1996) [7].

Effect of varieties on quality parameter

As regard to varieties, variety V_3: JRF-2 recorded significantly highest fibre length (77.16 cm) and fibre yield (397 kg ha^{-1}), whereas significantly highest oil content (39.83%) and oil yield (723 kg ha^{-1}) was recorded with variety V_4: RLC-92 and it was found at par with variety V_1: RLC-148 and V_2: JLS-95. The lowest value for fibre length, fibre yield was recorded with variety V_2: JLS-95, whereas significantly lowest value for oil content and oil yield was recorded with variety V_3: JRF-2.

Effect of spacing on quality parameter

Data showed that the significantly highest fibre yield (362 kg ha^{-1}), oil content (37.15%) and oil yield (715 kg ha^{-1}) were recorded with treatment S_3: 30 cm and oil yield was found at par with S_2: 22.5 cm. Whereas, significantly longest fibre was observed with treatment S_1: 15 cm. The lowest value for fibre yield, oil content and oil yield were recorded with treatment S_1: 15 cm. In case of fibre length, shortest fibre was obtained in plants sown in 30 cm row spacing (S_3).

Effect of nitrogen management practices on quality parameter

Results revealed that the significantly highest fibre length (61.95 cm), fibre yield (356 kg ha^{-1}) was recorded with treatment received 200% N (N_3). Whereas, highest value for oil content (37.44%) and oil yield (687 kg ha^{-1}) was recorded with treatment N_1: 100% N and N_2: 150% N, respectively. The lowest value for fibre length and fibre yield was recorded with treatment received 100% N, whereas lowest oil content was noticed with treatment N_3: 200% N, similarly lowest oil yield was recorded with treatment N_1: 100% N.

Effect of interaction among varieties, spacing and nitrogen management practices

Interaction among variety V_1: RLC-148, spacing S_3: 30 cm and nitrogen management N_3: 200% N recorded significantly highest seed yield, oil yield of linseed on mean basis and interaction among variety V_3: JRF-2, spacing S_3: 30 cm and nitrogen management N_3: 200% N registered significantly highest stover yield and fibre yield on mean basis.

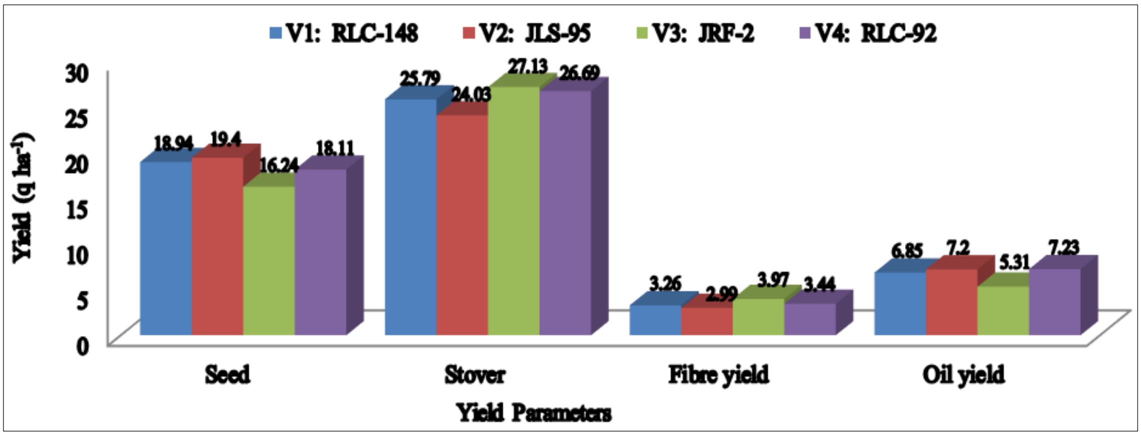

Fig 1: Seed, Stover, fibre and oil yield of linseed as influenced by varieties, (on the basis of two year mean data)

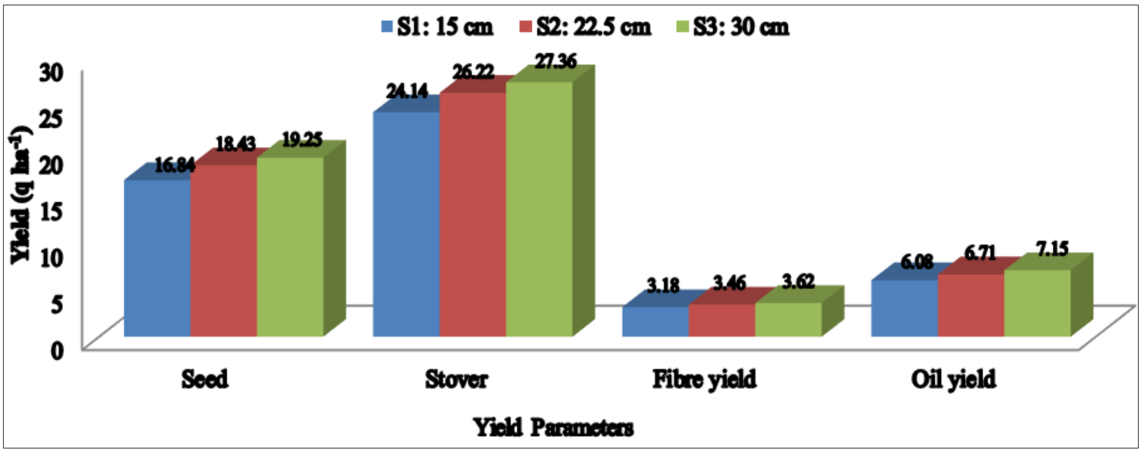

Fig 2: Seed, Stover, fibre and oil yield as influenced by spacing (on the basis of two year mean data)

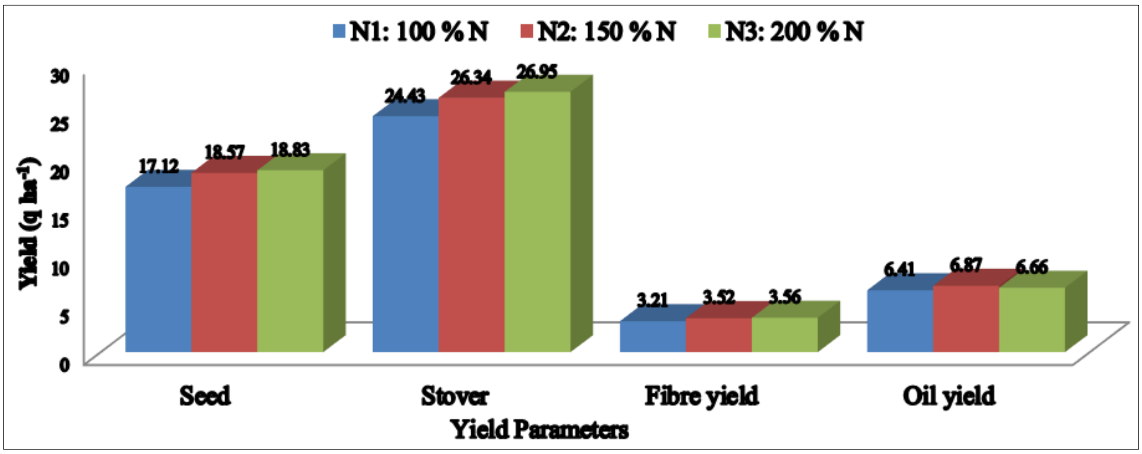

Fig 3: Seed, Stover, fibre and oil yield as influenced by nitrogen management practices (on the basis of two year mean data)

Table 1: Yield attributes, yield and quality parameter of linseed as influenced by varieties, spacing and nitrogen management practices (two years mean data)

Treatment	Yield attributes			Yield		Harvest index (%)	Fibre length (cm)	Fibre yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
	No. of capsules $plant^{-1}$	No. of seeds $capsule^{-1}$	Test weight (g)	Seed (q ha^{-1})	Stover (q ha^{-1})					
A. Main Plot: Varieties										
V_1: RLC-148	57.62	8.22	7.78	18.94	25.79	42.37	54.34	326	36.12	685
V_2: JLS-95	60.30	8.4	8.02	19.4	24.03	45.03	52.40	299	37.08	720
V_3: JRF-2	46.97	8.14	6.46	16.24	27.13	37.36	77.16	397	32.97	531
V_4: RLC-92	51.54	8.31	7.4	18.11	26.69	40.52	57.97	344	39.83	723
S.Em±	1.03	0.11	0.21	0.28	0.44	0.63	0.89	3.46	0.99	26.60
CD (P=0.05)	2.73	NS	0.67	1.31	1.97	2.84	4.00	15.58	4.44	119.70

B. Sub Plot: Spacings										
S_1: 15 cm	48.71	8.14	7.23	16.84	24.14	41.24	61.77	318	35.96	608
S_2: 22.5 cm	55.85	8.31	7.39	18.43	26.22	41.37	61.13	346	36.38	671
S_3: 30 cm	57.76	8.36	7.63	19.25	27.36	41.35	58.51	362	37.15	715
S.Em±	0.43	0.06	0.09	0.28	0.5	0.27	0.27	2.44	0.64	14.30
CD (P=0.05)	1.41	NS	0.29	0.89	1.55	NS	0.86	7.96	NS	46.63
C. Sub-Sub plot: Nitrogen management										
N_1: 100% N	50.07	8.23	7.24	17.12	24.43	41.34	58.36	321	37.44	641
N_2: 150% N	54.32	8.27	7.43	18.57	26.34	41.4	61.09	352	36.83	687
N_3: 200% N	57.93	8.31	7.57	18.83	26.95	41.22	61.95	356	35.22	666
S.Em±	0.45	0.07	0.05	0.12	0.24	0.22	0.31	1.85	0.50	11.83
CD (P=0.05)	1.31	NS	0.15	0.36	0.79	NS	0.92	5.4	1.47	34.53

Conclusion
Linseed is very important for its oil and biodegradable fibre as the current world demand focusing on bio-degradable material. All measured agronomic parameters in the study showed significant difference with varieties, spacing and nitrogen fertilizer rates. Increase of nitrogen fertilizer rate increased the flax fibre length and fibre yield. The response of varieties towards the input management particularly with spacing and nitrogen management was found significant. However oil content in seeds was reduced with increasing rate of nitrogen in linseed thus high nitrogen posed negative impact on oil content in linseed.

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