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Performance of linseed (*Linum usitatissimum* L.) varieties to different sowing dates in Northern Hills Zone of Chhattisgarh

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Abstract
A field experiment titled "Performance of Linseed (*Linum usitatissimum* L.) Varieties to Different Sowing Dates in Northern Hills Zone of Chhattisgarh*"* was conducted during the *Rabi* season of 2024-25 at the Instructional Farm, Raj Mohini Devi College of Agriculture and Research Station, Ambikapur, Chhattisgarh. The objectives were to identify the optimal sowing date and variety for maximizing growth and yield. The study utilized a split-plot design with three replications, comprising three sowing dates- last week of October (D_1) i.e. 25 Oct, second week of November (D_2) i.e. 10 Nov and last week of November (D_3) i.e. 25 Nov as main plots and three varieties RLC-143 (V_1), R-552 (V_2), and RLC-92 (V_3) as subplots. Observations included growth parameters (plant population, height, primary branches, dry matter accumulation), phenological stages (days to 50% flowering, 50% maturity, and maturity), yield attributes (capsules per plant, seeds per capsule, test weight).

Results revealed that sowing in the second week of November (D_2) resulted in the highest plant population (200.22 plants m^{-2} at 30 DAS; 179.67 at harvest, though non-significant), and significantly greater plant height (55.58 cm), number of primary branches (3.48 $plant^{-1}$), dry matter accumulation (6.77 g $plant^{-1}$), capsules $plant^{-1}$ (56.67), seeds $capsule^{-1}$ (7.84), and test weight (7.27 g). These values were at par with D_1 and significantly superior to D_3, where delayed sowing led to reduced performance and low yield. Sowing in the second week of November (D_2) recorded the highest yields with 2.85 g seed $plant^{-1}$, 1159.38 kg ha^{-1} seed yield, and 2567.33 kg ha^{-1} stover yield, which were statistically at par with the last week of October sowing (D_1: 2.63 g $plant^{-1}$, 1124.67 kg ha^{-1}, and 2502.67 kg ha^{-1}, respectively). Delayed sowing to the last week of November (D_3) resulted in significantly lower yields (2.41 g $plant^{-1}$, 1023.56 kg ha^{-1}, and 2413.67 kg ha^{-1}). Among varieties, RLC-92 (V_3) exhibited significantly superior performance in terms of plant height (61.91 cm), primary branches (3.58 $plant^{-1}$), dry matter accumulation (7.00 g $plant^{-1}$), capsules $plant^{-1}$ (57.67), seeds $capsule^{-1}$ (7.93), test weight (7.31 g), seed yield (1260.82 kg ha^{-1}), and stover yield (2635.33 kg ha^{-1}), followed by R-552 (V_2) and RLC-143 (V_1). RLC-92 (V_3) also matured earlier (115.67 days) and flowered fastest (60.44 days).

It is concluded that sowing linseed in the second week of November using variety RLC-92 is most effective for maximizing growth and productivity in the Northern Hills Zone of Chhattisgarh.

Keywords: Linseed, sowing dates, varieties, growth parameters, yield

Introduction

Linseed (*Linum usitatissimum L.*), also known as flaxseed, *alsi*, and *tisi*, is an annual crop of the linaceae family, with a height range of 30-130 cm, straight stems, and narrow leaves. It has long been cultivated mainly for its oil, of which nearly 80% is utilized in paints, varnishes, coating oils, linoleum, printing inks, and leather finishing. Globally, linseed is also grown for its fibre, flax, which is among the oldest fibres after silk and is used to manufacture linen due to its strength and durability, blending well with wool, cotton, and silk (Narayan, 1987) [11]. The oil cake remaining after oil extraction is highly valued as cattle and poultry feed, containing 36% protein (85% digestible), and is priced about 50% higher than rapeseed-mustard cake. It also serves as organic manure, providing about 5% N, 1.4% P_2O_5, and 1.8% K_2O (Muraro and Basso, 2018) [10].

Linseed is a winter season crop that thrives under moderate to cool temperatures. Ideal growth occurs between 21-26°C, while temperatures above 32°C with drought during flowering reduce yield, oil content, and quality. Frost at flowering is also harmful. It is best suited to low rainfall regions with 45-75 cm annual rainfall (Singh *et al.*, 2018) [16]. Nutritionally, linseed oil is rich in Omega-3, Omega-6, and Omega-9 fatty acids, with seeds containing 35-45% oil, 20-25% fibre, and 20-25% protein. The high proportion of alpha-linolenic acid (ALA) helps lower triglycerides, reduces heart disease risk, and may aid in rheumatoid arthritis treatment. Linseed oil has three times more Omega-3 than Omega-6, making it beneficial for intestinal health, weight management, and antioxidant activity. Industrially, it is also used in paints, varnishes, plastics, food products, and personal care items.

Variety and sowing date are critical factors influencing linseed productivity. Varieties, being genetic factors, greatly affect growth, yield, and adaptability to specific climates. ICAR and state agricultural universities have released several high-yielding varieties, requiring proper agronomic evaluation to exploit their potential. Selection of suitable varieties and adjustment of sowing dates are thus essential for maximizing yield. Sowing time is directly linked with weather conditions, as early or late sowing increases the risk of frost or drought (Casa *et al.*, 1999) [3]. Since temperature strongly impacts crop productivity, income, and food security, optimizing sowing date improves both yield and seed quality (Srivastava *et al.*, 1976) [19]. Understanding the physiological and phenological basis of yield decline in relation to sowing time is therefore crucial for devising better seed production strategies.

Linseed is cultivated in over 30 countries across 41.42 lakh hectares, producing 33.39 lakh tonnes with an average productivity of 942 kg ha^{-1} (Faostat, 2023) [4]. Russia ranks first in production, followed by Kazakhstan and Canada, while India stands 5th in area (3.2 lakh ha) and 6th in production (1.74 lakh tonnes) with 637.54 kg ha^{-1} productivity (Ministry of Agriculture and Farmers Welfare, 2023). Major producing states Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Jharkhand, Bihar, West Bengal, Odisha, Assam, and Nagaland cover 97% of the national area, with Madhya Pradesh leading (Faostat, 2023) [4]. Chhattisgarh ranks 4th with 12.82 thousand ha, producing 4.92 thousand tonnes at 384 kg ha^{-1}; its key districts include Rajnandgaon, Durg, Bilaspur, Kabirdham, Raipur, Dhamtari, Surguja, Kanker, and Raigarh. Productivity is highest in Rajasthan (1066 kg ha^{-1}), Bihar (848 kg ha^{-1}), and Nagaland (813 kg ha^{-1}) (Anonymous, 2020) [1].

Materials and Methods: The experiment was conducted during the *rabi* season of 2024-25 at Instructional farm of Raj Mohini Devi College of Agriculture and Research Station, Ambikapur. The experimental site was located in the northern part of Chhattisgarh at 23°12′ N latitude and 83°19′ E longitude, with an elevation of about 623 metres above mean sea level (MSL). The site falls within the Eastern Plateau and Hill region of India, characterized by undulating topography and red to lateritic soils. The experimental site was well drained with assured source of water supply. The soil of the experimental field was "Inceptisol". The soil was slightly acidic in nature and medium in fertility status, having low N, medium P_2O_5, and K_2O.

The experimental site at Ambikapur, Chhattisgarh, has a sub-humid climate with annual rainfall of 1200-1400 mm, mostly during the southwest monsoon. During the 2024-25 crop season, rainfall was 112.8 mm, mean weekly temperatures ranged from 4.6°C to 34.4°C, and relative humidity varied between 34-100%. Sunshine averaged 7.25 hours/day, while total evaporation during the crop period was 294.7 mm.

The experiment was laid out in a split plot design with three sowing dates: last week of October (D_1), second week of November (D_2), and last week of November (D_3) assigned to main plots, and three linseed varieties: RLC-143 (V_1), R-552 (V_2), and RLC-92 (V_3) assigned to subplots as illustrated in Table 1. The treatments were replicated thrice. Recommended agronomic practices were followed to raise the experimental crop.

Table 1: Treatments details

Notation	Treatments
A. Date of sowing (Main plot-03)	
D_1	Last week of October (25 Oct)
D_2	Second week of November (10 Nov)
D_3	Last week of November (25 Nov)
B. Variety (Sub plot-03)	
V_1	Utera Alsi (RLC-143)
V_2	Jawahar-552 (R-552)
V_3	RLC-92

Results and Discussion

Pre-harvest Observations

Plant population (m^{-2})

Plant population did not differ significantly due to sowing dates or varieties. At 30 DAS, it ranged from 193.89 plants m^{-2} in the last week of November sowing to 200.22 plants m^{-2} in the second week of November sowing, while at harvest values varied between 174.44 (last week of November) and 179.67 (second week of November). Among varieties, RLC-92 maintained the highest stand (199.56 and 179.22 plants m^{-2} at 30 DAS and harvest, respectively), followed by R-552 and RLC-143. The results are in accordance with the findings of Singh (2018), Maurya *et al.* (2017), Sahu *et al.* (2020) and Patel *et al.* (2019) [9, 12, 13, 16].

Plant height (cm): Plant height was significantly influenced by sowing dates at all stages. Sowing during the second week of November produced the tallest plants (15.30, 50.89, 54.20, and 55.58 cm at 30, 60, 90 DAS, and harvest), followed by the last week of October, whereas the last week of November consistently recorded the shortest plants (14.17-50.94 cm). Among varieties, RLC-92 remained superior throughout growth, attaining 61.91 cm at harvest, compared with R-552 (52.30 cm) and RLC-143 (44.38 cm). The results are in accordance with the findings of Patel *et al.* (2019), Singh (2018), Sahu *et al.* (2020) and Gupta *et al.* (2021) [5, 12, 13, 16].

Number of primary branches $plant^{-1}$

Branching ability was significantly affected by both sowing dates and varieties. The second week of November sowing exhibited the maximum branches (2.39, 3.78, 3.51, and 3.48 at 30, 60, 90 DAS, and harvest, respectively), followed by the last week of October, while the last week of November produced the least (1.99-2.83). Among varieties, RLC-92 consistently outperformed with 3.58 branches at harvest, compared with R-552 (3.08) and RLC-143 (2.77). This result is aligned with the findings of Katoch *et al.* (2023), Singh *et al.* (2016), Gupta *et al.* (2021) and Sahu *et al.* (2020) [5, 7, 13, 17].

Dry matter accumulation (g) $plant^{-1}$

Dry matter increased progressively with crop age, showing significant variation due to treatments. The second week of

November sowing accumulated the highest biomass (0.21, 2.90, 6.72, and 6.77 g at 30, 60, 90 DAS, and harvest), at par with the last week of October, whereas the last week of November was lowest (0.15-6.21 g). Among varieties, RLC-92 recorded the maximum accumulation (0.23-7.00 g), followed by R-552 (6.60 g) and RLC-143 (5.86 g). The results are similar with the findings of Singh *et al.* (2016), Tzudir *et al.* (2023), Sahu *et al.* (2020) and Gupta *et al.* (2021) [5, 13, 17, 21].

Days to 50% flowering

Sowing dates and varieties significantly influenced the flowering behavior of linseed. The earliest 50% flowering (60.56 days) was observed under late sowing in the last week of November, followed by the second week of November (62.22 days), while the last week of October sowing recorded the maximum duration (65.22 days). Among varieties, RLC-92 flowered earliest (60.44 days), followed by R-552, whereas RLC-143 took the longest time to reach 50% flowering (65.67 days). This indicates that delayed sowing accelerates flowering due to shorter crop duration, whereas varietal differences reflect inherent genetic factors. Similar findings were also reported by Shaikh *et al.* (2009), Tzudir *et al.* (2023), Gupta *et al.* (2021) and Sahu *et al.* (2020) [5, 13, 14, 21].

Days to 50% maturity

Significant variation in physiological maturity was observed due to sowing dates and varieties. The earliest 50% maturity (103.33 days) was recorded when linseed was sown in the last week of November, followed by the second week of November (105.00 days), while the crop sown in the last week of October took the maximum duration (108.33 days). Among varieties, RLC-92 reached 50% maturity earliest (102.44 days), followed by R-552 (106.22 days), whereas RLC-143 was the latest (108.00 days). Similar results were reported by Shaikh *et al.* (2009), Tzudir *et al.* (2023), Gupta *et al.* (2021), and Sahu *et al.* (2020) [5, 13, 14, 21].

Days to maturity

Final crop maturity also showed significant differences across treatments. The shortest maturity period (116.00 days) was observed under the last week of November sowing, followed by the second week of November (118.78 days), whereas the last week of October sowing took the longest time (123.22 days). Among varieties, RLC-92 matured earliest (115.67 days), followed by R-552 (118.78 days), while RLC-143 recorded the longest duration (123.56 days). The results corroborate the observations of Shaikh *et al.* (2009), Tzudir *et al.* (2023), Gupta *et al.* (2021) and Sahu *et al.* (2020) [5, 13, 14, 21].

Post-harvest observations

Number of capsules plant^{-1}

Capsule formation was significantly influenced by sowing dates and varieties. The second week of November sowing (56.67) produced the highest number of capsules, statistically at par with the last week of October (53.33), while the last week of November recorded the lowest (47.78). Among varieties, RLC-92 (57.67) outperformed R-552 (53.00) and RLC-143 (47.11), reflecting its higher branching and reproductive efficiency. Similar findings were reported by Hasan *et al.* (2022), Singh (2018), Gupta *et al.* (2021) and Sahu *et al.* (2020) [5, 6, 13, 16].

Number of seeds capsule^{-1}

The maximum seeds capsule^{-1} (7.84) were observed under second week of November sowing, at par with the last week of October (7.64), while the last week of November recorded the minimum (6.98). Varietal differences were significant, with RLC-92 (7.93) performing better than R-552 (7.59) and RLC-143 (6.94). These results are in agreement with those obtained by Shaikh *et al.* (2009), Tzudir *et al.* (2023), Gupta *et al.* (2021) and Sahu *et al.* (2020) [5, 13, 14, 21].

Test weight (g)

Sowing in the second week of November recorded the highest test weight (7.27 g), at par with the last week of October (6.88 g), both significantly superior to late November (6.47 g). Among varieties, RLC-92 (7.31 g) maintained the maximum test weight, followed by R-552 (6.87 g) and RLC-143 (6.43 g). Higher seed weight under timely sowing and RLC-92 was also reported by Katoch *et al.* (2023), Maurya *et al.* (2017) and Gupta *et al.* (2021) [5, 7, 9].

Seed yield (g) plant^{-1}

The highest seed yield plant^{-1} was recorded under the second week of November sowing (2.85 g), at par with last week of October (2.63 g), while the last week of November recorded the lowest (2.41 g). Among varieties, RLC-92 (2.94 g) significantly outperformed R-552 (2.66 g) and RLC-143 (2.28 g), owing to its superior yield components. These results align with Hasan *et al.* (2022), Katoch *et al.* (2023) and Sahu *et al.* (2020) [6, 7, 13].

Seed yield (kg ha^{-1})

The second week of November sowing gave the maximum seed yield (1159.38 kg ha^{-1}), statistically at par with late October (1124.67 kg ha^{-1}), whereas late November sowing was significantly lower (1023.56 kg ha^{-1}). RLC-92 (1260.82 kg ha^{-1}) yielded significantly more than R-552 (1118.67 kg ha^{-1}) and RLC-143 (928.11 kg ha^{-1}). Similar results were reported by Singh (2018), Tripathi *et al.* (2018), Badiyala and Chopra (2015), Kumar *et al.* (2022), Gupta *et al.* (2021) and Sharma *et al.* (2023) [2, 5, 8, 15, 16, 20].

Stover yield (kg ha^{-1})

The second week of November sowing recorded the highest stover yield (2567.33 kg ha^{-1}), at par with late October (2502.67 kg ha^{-1}), while late November sowing had the lowest (2413.67 kg ha^{-1}). Among varieties, RLC-92 (2635.33 kg ha^{-1}) remained superior, followed by R-552 (2520.33 kg ha^{-1}) and RLC-143 (2328.00 kg ha^{-1}). This advantage reflects its higher dry matter accumulation, as also observed by Katoch *et al.* (2023), Patel *et al.* (2019), Gupta *et al.* (2021) and Sahu *et al.* (2020) [5, 7, 12, 13].

Conclusion

Sowing linseed in the second week of November proved most productive, though the last week of October was also suitable. Among varieties, RLC-92 consistently outperformed others in growth and yield, followed by R-552, while RLC-143 lagged behind. Overall, RLC-92 sown in mid-November is recommended for maximizing linseed productivity in the Northern Hills Zone of Chhattisgarh.

Table 2: Plant population (m-^{2}), Plant height (cm) and Number of primary branches plant-^{1} as affected by sowing dates and varieties

Treatment	Plant population (m^{-2})		Plant height (cm)				Number of primary branches plant^{-1}			
	Initial (30DAS)	At harvest	30DAS	60DAS	90DAS	At harvest	30DAS	60DAS	90DAS	At harvest
A. Date of sowing										
D_1- Last week of October	197.89	176.11	14.65	46.59	50.21	52.07	2.20	3.43	3.18	3.11
D_2- Second week of November	200.22	179.67	15.30	50.89	54.20	55.58	2.39	3.78	3.51	3.48
D_3- Last week of November	193.89	174.44	14.17	44.86	47.78	50.94	1.99	3.27	2.96	2.83
SEm(±)	2.84	1.16	0.18	0.88	0.96	0.58	0.05	0.07	0.09	0.09
CD (P=0.05)	NS	NS	0.72	3.44	3.76	2.28	0.21	0.29	0.37	0.36
B. Variety										
V_1 (RLC-143)	196.44	174.67	13.46	40.52	43.24	44.38	1.96	3.04	2.84	2.77
V_2 (R-552)	196.00	176.33	14.86	45.77	49.94	52.30	2.24	3.31	3.11	3.08
V_3 (RLC-92)	199.56	179.22	15.80	56.04	59.00	61.91	2.38	4.12	3.69	3.58
SEm(±)	1.78	1.37	0.13	0.83	0.83	0.30	0.08	0.10	0.06	0.05
CD (P=0.05)	NS	NS	0.39	2.55	2.57	0.93	0.26	0.32	0.18	0.15

Table 3: Dry matter accumulation (g) plant-1, Days to 50% flowering, Days to 50% maturity and Days to maturity as affected by sowing dates and varieties

Treatment	Dry matter accumulation (g) plant^{-1}				Days to 50% flowering	Days to 50% maturity	Days to maturity
	30DAS	60DAS	90DAS	At harvest			
A. Date of sowing							
D_1- Last week of October	0.19	2.72	6.33	6.48	65.22	108.33	123.22
D_2- Second week of November	0.21	2.90	6.72	6.77	62.22	105.00	118.78
D_3- Last week of November	0.15	2.23	5.96	6.21	60.56	103.33	116.00
SEm(±)	0.01	0.05	0.13	0.10	0.35	0.48	0.31
CD (P=0.05)	0.03	0.21	0.51	0.39	1.38	1.90	1.23
B. Variety							
V_1 (RLC-143)	0.13	2.19	5.77	5.86	65.67	108.00	123.56
V_2 (R-552)	0.19	2.60	6.43	6.60	61.89	106.22	118.78
V_3 (RLC-92)	0.23	3.07	6.81	7.00	60.44	102.44	115.67
SEm(±)	0.01	0.13	0.12	0.13	0.38	0.33	0.29
CD (P=0.05)	0.03	0.40	0.36	0.41	1.16	1.03	0.88

Table 4: Number of capsule plant-^{1}, Number of seeds capsule -^{1}, Test weight (g), Seed yield (g) plant-^{1}, Seed yield (kg ha-^{1}) and Stover yield (kg ha-^{1}) as affected by sowing dates and varieties

Treatment	Yield attributing characters					
	Number of capsule plant^{-1}	Number of seeds capsule $^{-1}$	Test weight (g)	Seed yield (g) plant^{-1}	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
A. Date of sowing						
D_1- Last week of October	53.33	7.64	6.88	2.63	1124.67	2502.67
D_2- Second week of November	56.67	7.84	7.27	2.85	1159.38	2567.33
D_3- Last week of November	47.78	6.98	6.47	2.41	1023.56	2413.67
SEm(±)	1.70	0.10	0.12	0.08	14.47	19.72
CD (P=0.05)	6.66	0.38	0.46	0.30	56.83	77.45
B. Variety						
V_1 (RLC-143)	47.11	6.94	6.43	2.28	928.11	2328.00
V_2 (R-552)	53.00	7.59	6.87	2.66	1118.67	2520.33
V_3 (RLC-92)	57.67	7.93	7.31	2.94	1260.82	2635.33
SEm(±)	1.04	0.07	0.13	0.07	12.42	16.96
CD (P=0.05)	3.20	0.23	0.41	0.22	38.27	52.25

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