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EFFECT OF DATE OF SOWING ON YIELD ATTRIBUTES, YIELD AND ECONOMICS OF LINSEED VARIETIES UNDER CHOTA NAGPUR PLATEAU REGION OF JHARKHAND INDIA

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ABSTRACT

A field experiment was conducted during the *rabi* seasons of 2020-21 and 2021-22 at Research Farm of Birsa Agricultural University, Kanke, Ranchi, Jharkhand, to study the "Effect of dates of sowing on yield attributes, yield and economics of linseed varieties under Chota Nagpur Plateau Region of Jharkhand". The experiment was conducted in split plot design which replicated thrice. Main plots comprised of 4 sowing dates, *viz*. D1: 18th November, D2: 8th December, D3: 18th December and D4: 4th January and 4 linseed varieties, *viz*. V1: Priyam, V2: BAU 14-09, V3: Divya and V_4: BAU 14-03 in sub-plots. The experimental results revealed that sowing dates as well as linseed varieties significantly affected yield attributes, yield, and economics of linseed. Analysis of pooled data showed significantly higher number of capsule/plant (34.66), test weight (8.50 g), seed yield (14.99 q/ha), straw yield (27.39 q/ha), harvest index (35.38 %), gross return (68975.00 q/ha), net return (50270.00 q/ha) and B:C (2.69) were recorded in sowing on 18th November (D1). Among linseed varieties, Divya variety (V_3) recorded significantly higher number of capsule/plant (34.20), number of seed/capsule (8.29), test weight (8.34 g), seed yield (15.29 q/ha), straw yield (28.81 q/ha) harvest index (34.65 %), gross return (70541.50 q/ha), net return (51836.50 q/ha) and B:C (2.77).

Key words*: *sowing date, linseed varieties, yield attributes, yield, economics

Introduction

Linseed (*Linum usitatissimum* L. Griesb.) is an important oilseed *rabi* crop next to rapeseed and mustard in India (Badiyala *et al*., 2015). Linseed belongs to Linaceae family and commonly known by different names like *Alsi*, *Chikna* or Linseed in India. It is a great vegetarian source of nutrients which contains 33 to 47% of oil. Out of total oil produced, about 20% is used at farmer's level and the rest 80% oil goes to industries in various purposes such as borated oil, boiled oil, urethane oil, aluminates oil, eposidized oil, isomerizes oil etc. The oil is rich in linolenic acid (>66%) and it is a perfect drying oil. Linseed seeds contain high levels of dietary fiber as well as lignin, an abundance of micronutrient and omega-3 fatty acids. It tastes good and contains 36% protein, 85% of which is digestible. It is also used as organic manure and contains about 5% N, 1.4% P_2O_5 and 1.8% K_2O (J. B. Ganvit *et al*., 2019). Linseed's essential fatty acids have anti-inflammatory properties, offering health benefits to a number of chronic diseases such as Heart disease, Diabetes and Arthritis (Sarkar and Sarkar, 2017).

India holds first position in terms of area under linseed cultivation and third in terms of production in world. In the Indian region, it is cultivated on about 4.68 lakh ha with total production of 1.63 lakh tones (Anonymous, 2012). While in Jharkhand it is cultivated over 0.26 lakh ha with production of 0.16 lakh MT and it's average yield is 6.12 q/ha (Directorate of Economics and Statistics, Ministry of Agriculture & Farmers' Welfare, New Delhi, 2013-16).

There has been a continuous decline in linseed production area in the country during the last four decades

so to sustain linseed production mainly in rainfed area. To obtain higher crop yield, we should evaluate suitable agro technique for different agro climatic zone like optimum sowing time, selection of suitable variety, proper management of soil, soil nutrient and soil moisture to produce higher crop yield in dry land condition are the major research threats for agronomic research worker (Mohammada *et al*., 2012).

One of the most significant agronomic factors that is non-financial in nature yet has a discernible effect on crop productivity is the ideal sowing time. The timing of seeding has a major impact on the growth characteristics, yield, and its constituents as well as the oil production of flax (Al-Doori, 2012). In order to reduce the detrimental effects of high temperatures and moisture stress during the crucial flowering and seed filling phases, the sowing date was a crucial management strategy (Chauhan *et al*., 2008). The timing of sowing has a significant impact on crop output and understanding. This element is essential to develop a plan for increasing the yield of fibre and oil. Delays in seeding cause the environment's temperature to rise when the plant is in its reproductive growth stage (Raj and Gupta, 2020).

In case of variety, it is crucial since, within its genetic range, a variety's potential yield is determined by its surroundings. One significant advancement in attaining higher yield per unit area is the introduction of new linseed cultivars. These cultivars' yields can be increased even more by creating the ideal environment and adjusting agronomic techniques. The production potential of different varieties varies based on numerous physiological processes that are influenced by both environmental factors and genetic composition (Abhishek *et al*., 2021). Among the various techniques, planting at the right time is crucial for utilising a variety's entire genetic potential because it offers the best growing circumstances in terms of humidity, light, temperature, and rainfall.

Materials and Methods

A field experiment was conducted in upland areas of Research Farm of the Birsa Agricultural University, Kanke, Ranchi ($23^0$17' N latitude, $85^0$10' E longitude and 625 m above mean sea level), India during *rabi* season of 2020-21 and 2021-22 to evaluate the "Effect of dates of sowing on yield attributes, yield and economics of linseed varieties under Chota Nagpur Plateau Region of Jharkhand". "Divya" variety of linseed was taken for experimentation. The experiment was laid out in Split Plot Design with three replications. Main plots comprised of 4 sowing dates, *viz*. D_1: 18th November, D_2: 8th December, D_3: 18th December and D_4: 4th January and 4 linseed varieties, *viz*. V_1: Priyam, V_2: BAU 14-09, V_3: Divya and V_4: BAU 14-03 in sub-plots. The soil of experimental plot was sandy loam in texture having low carbon (0.34 %), low nitrogen (178.6 Kg/ha), medium in phosphorous (15.23 Kg/ha) and medium in potassium (184.64 Kg/ha), plot size 5 × 3 m^2 with soil pH 5.6 which is slightly acidic in reaction. The mean minimum and maximum temperature throughout the cropping season ranged from 2.2^0C to 38.1^0C and average rainfall was 10.54 mm during 2020-21 and during 2021-22 the mean minimum and maximum temperature throughout the cropping season ranged from 2.0^0C to 37.6^0C and average rainfall was 11.14 mm. The recommended fertilizer dose was 50 kg N: 50 kg P_2O_5: 50 kg K_2O /ha supplied through urea, single super phosphate and muriate of potash, respectively. The linseed was sown manually in rows at 4-5 cm depth using 25 kg/ha seed rate with 30 cm row spacing. All the recommended package of practices were adopted same in all the treatments during the crop growth periods. All observation on yield attributes (number of capsules per plant, number of seeds per capsule and test weight), yield (seed yield, straw yield and harvest index) and economics were recorded from the marked area of net plot at harvest. Number of capsules per plant was determined by counting the total number of capsules from the same five tagged plants used for growth observations and average was worked out. The total capsule number were counted and divided by number of plants to obtain the capsules number per plant. Number of seed per capsule was worked out by taking five randomly selected capsules from each tagged plant. Each capsule was broken carefully by hand and seeds were counted and average number was computed. Test weight was taken by counting one thousand grains from the representative sample of each treatment drawn from winnowed and clean produce and their weight in grams was recorded by electronic balance. Seed and straw yields were recorded from the net plot area harvest. The plants from the net plot area were harvested, tagged and bundled separately. The harvest was dried under sun to a standard moisture condition and weighed for bundle weight. The harvest was threshed to recorded seed and straw yield. The straw yield was computed by subtracting seed yield from bundle weight. The seed and straw yield per plot were converted to yields quintal per hectare. The harvest index of linseed was obtained by dividing the economic yield (seed yield) by the biological yield (seed and straw yield) and represented in percentage (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain Straw yield)}} \times 100$$

Table 1: Effect of date of sowing on yield attributes of linseed varieties.

Main Date of Sowing (A)	Plot:No. of Capsule per plant			No. of Seeds per capsule			Test weight (g)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
D1:18/11/2021	33.71	35.60	34.66	6.90	7.26	7.08	8.29	8.71	8.50
D2:08/12/2021	31.91	33.54	32.73	7.37	7.71	7.54	8.03	8.39	8.21
D3:18/12/2021	29.34	30.66	30.00	7.81	8.15	7.99	7.52	7.81	7.67
D4:04/01/2022	29.04	30.18	29.61	8.27	8.56	8.42	7.44	7.69	7.57
SEm±	0.88	0.92	0.90	0.14	0.14	0.14	0.15	0.16	0.15
CD (P=0.05)	3.68	3.86	3.77	0.58	0.59	0.59	0.63	0.66	0.65
Sub Plot: Linseed Variety (B)									
V1: PRIYAM	32.23	33.78	33.01	7.72	8.05	7.89	7.98	8.31	8.15
V2: BAU 14-09	29.38	30.79	30.09	7.32	7.64	7.49	7.69	8.01	7.85
V3: DIVYA	33.40	35.00	34.20	8.11	8.47	8.29	8.17	8.51	8.34
V4: BAU 14-03	29.01	30.40	29.70	7.20	7.52	7.36	7.45	7.76	7.61
SEm±	0.55	0.58	0.57	0.16	0.17	0.16	0.11	0.12	0.12
CD (P=0.05)	1.86	1.96	1.91	0.54	0.57	0.55	0.39	0.40	0.39
CV%	6.16	6.17	6.16	7.31	7.34	7.32	5.03	5.02	5.02
Interaction (A × B)									
SEm±	1.30	1.36	1.33	0.31	0.32	0.32	0.24	0.26	0.25
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

The yield of linseed was converted into gross return in q/ha based on current price prevailing in the market and approved for the sale of product at research farm of the Institute. Net profit per hectare was calculated by subtracting total cost of cultivation from gross return. B:C ratio was calculated by dividing net monetary return with cost of cultivation. All the data obtained from the experiment were put to statistical analysis by adopting appropriate method of "Analysis of Variance" as suggested by the Gomez and Gomez (1976). Critical difference (CD) at 5% level of significance was worked out to determine the difference between treatments.

Result and Discussion

Effect of date of sowing on yield attributes of linseed varieties

Capsule per plant

At maturity number of capsules per plant was affected significantly by different treatments during both the years of experimentation (Table 1). Analysis of pooled data revealed that the maximum number of capsules per plant was recorded in crop sown on 18th November (34.66) which was significantly superior to 8th December, 18th December and 4th January sown crops. In case of varieties the highest number of capsules per plant was observed in Divya which was statistically superior over BAU 14-09 and BAU 14-03 while at par with Priyam. Same trend was followed in the year 2020-21 and 2021-22. This might be due to the reason that first planted crop got the favourable weather conditions during whole life cycle and hence the different phases of plant life was accomplished at the proper time, which lead to increased number of branches per plant and finally more number of capsule per plant. The crops planted after 18th November were unable to get favourable weather conditions. Similar findings were obtained by Mohammada (2012), Alam *et al*., (2020) and Maurya *et al*., (2017).

Seed per capsule

The information gathered based on the number of seed per capsule showed that the delayed sowing followed the upward trend (Table 1). Pooled data reflected that crop sown on 4th January exhibited the maximum number of seed per capsule (8.42) which was comparable to 18th December sown crop (7.99) but significantly superior to rest of the crops sown earlier. 18th November sown crop recorded significantly lower number of seed per capsule during both the years (6.90 & 7.26 in 2020-21 & 2021-22 respectively). The number of seed per capsule among varieties also differed significant. Divya variety was observed with significantly higher number of seed per capsule (8.11, 8.47 & 8.29 in 20220-21, 2021-22 & in pooled data respectively)) which was significantly superior over rest of the varieties except Priyam (7.72, 8.05 & 7.89 in 2020-21, 2021-22 & in the pooled data respectively). Sowing time significantly affected the number of seed per capsule in such a way that when sowing was delayed it gradually increased. This might be caused by a number of things, including the temperature that was present throughout the sowing process, the vegetative and reproductive stages, which affected how many seeds were contained in each capsule. The crop sown on November 18th yielded a high yield

Table 2: Effect of date of sowing on yields of linseed varieties.

Main	Seed yields (q/ha)			Straw yield (q/ha)			Harvest index (%)		
Date of Sowing (A)	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
D1:18/11/2021	14.59	15.39	14.99	26.82	27.96	27.39	35.26	35.49	35.38
D2:08/12/2021	13.51	14.21	13.86	25.39	26.55	25.97	34.78	34.92	34.85
D3:18/12/2021	12.30	12.92	12.61	23.56	24.47	24.02	34.28	34.55	34.42
D4:04/01/2022	11.56	12.13	11.85	23.51	24.23	23.87	33.05	33.44	33.25
SEm±	0.32	0.33	0.32	0.68	0.74	0.71	0.44	0.45	0.44
CD (P=0.05)	1.33	1.39	1.36	2.84	3.12	2.97	1.85	1.88	1.86
Sub Plot: Linseed Variety (B)									
V1: PRIYAM	13.34	14.03	13.69	25.30	26.37	25.83	34.48	34.69	34.59
V2: BAU 14-09	12.66	13.32	12.99	24.25	25.25	24.75	34.38	34.61	34.50
V3: DIVYA	14.90	15.68	15.29	28.31	29.30	28.81	34.48	34.82	34.65
V4: BAU 14-03	11.06	11.63	11.35	21.42	22.28	21.85	34.02	34.27	34.15
SEm±	0.37	0.39	0.38	0.94	0.94	0.94	0.43	0.41	0.42
CD (P=0.05)	1.25	1.32	1.28	3.17	3.16	3.16	1.47	1.38	1.42
CV%	9.86	9.86	9.86	13.08	12.57	12.79	4.38	4.08	4.21
Interaction (A × B)									
SEm±	0.714	0.750	0.732	1.76	1.78	1.77	0.87	0.84	0.85
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

because the number of seeds per capsule was the lowest among the sowing dates and the seeds were of fair weight. The crop sown on January 4th was forced to mature by high temperatures during the later stages of reproduction, resulting in an increase in the number of seeds per capsule. However, the test weight indicated that the seeds were not of acceptable quality. Rokade *et al*., (2015) and Yadav *et al*., (2005) also reported findings that were similar.

Test weight (g)

Test weight of linseed was significantly influenced by different date of sowing (Table 1). As the sowing was delayed test weight significantly decreased. Perusal of pooled data showed that test weight of crop sown on 18th November was significantly higher (8.50 g) which was comparable to 8th December (8.21 g) and statistically superior over 18th December and 4th January sown crop. Data based on test weight in both the years (2020-21 and 2021-22) followed the same trend. In case of varieties the best performed variety was Divya (8.34 g) which was followed by Priyam (8.15 g) however, significantly higher than rest of the varieties in both the years and in pooled data also. As stated above that the environmental factors, especially the temperature prevailed at the time of vegetative and reproductive stages influenced the test weight. The reason behind this might be due to the fact that under later sown conditions the grains were pressurized to mature and dry because of sudden rise in temperature along with hot wind. Hence, the grains obtained from 4th January sown crop were not of good quality and eventually resulted in lower test weight. Contrary to this, the timely sown crop got an opportunity to complete the different stages of life cycle properly under favourable temperature. This was in conformity with the finding of Rokade *et al*., (2015), Alam *et al*., (2020) and Kalita *et al*., (2005).

Seed and straw yield (q/ha)

Seed yield of linseed was affected by different date of sowing which was reflected in Table 2. The significantly highest seed yield (Fig. 1) during both the years i.e. 2020-21 and 2021-22 was obtained in the crop sown on November 18th (14.59 q/ha in 2020-21, 15.39 q/ha in 2021-22 & 14.99 q/ha in pooled data) followed by 8th December (13.51 q/ha in 2020-21, 14.21 q/ha in 2021-22 & 13.86 q/ha in pooled data) but it was significantly superior over 18th December and 4th January sown crop. The seed yield was significantly influenced by different varieties and all varieties were noticed with significant difference to each other. In case of varieties the highest seed yield was produced by Divya (14.90 q/ha in 2020-21, 15.68 q/ha in 2021-22 & 15.29 q/ha in pooled data) which statistically performed the best among all the varieties.

However, in case of straw yield it was significantly affected by different sowing date of the crop. It is clear from the pooled data that significantly maximum straw yield was obtained by the crop sown on 18th November (27.39 q/ha) followed by the crop sown on 8th December (25.97 q/ha) but significantly superior to the crop sown on 18th December (24.02 q/ha) and 4th January (23.87 q/ha). On the other hand, a significant difference was also observed in straw yield of linseed varieties. It is apparent

from the pooled data that straw yield of Divya (28.81 q/ha) was found statistically at par with Priyam variety (25.83 q/ha) while superior to BAU 14-09 (24.75 q/ha) and BAU 14-03 (21.85 q/ha). Seed yield followed the decreasing trend as the sowing time was delayed from 18th November. This might be due to the fact that the vegetative growth and yield attributing characters were not exhibited properly by the late sown conditions along with this the high temperature and hot wind forced the maturity of the crop and ultimately resulted in lower seed yield. The early sown crop availed the favourable cool weather conditions and also the availability of long duration for proper development of vegetative and reproductive stages resulted in greater productivity. This is in line with the findings of Singh and Bohra (2006), Raj and Gupta (2020), J.B. Ganvit *et al.*, (2019), Alam *et al.*, (2020) and Kumhare *et al.*, (2022).

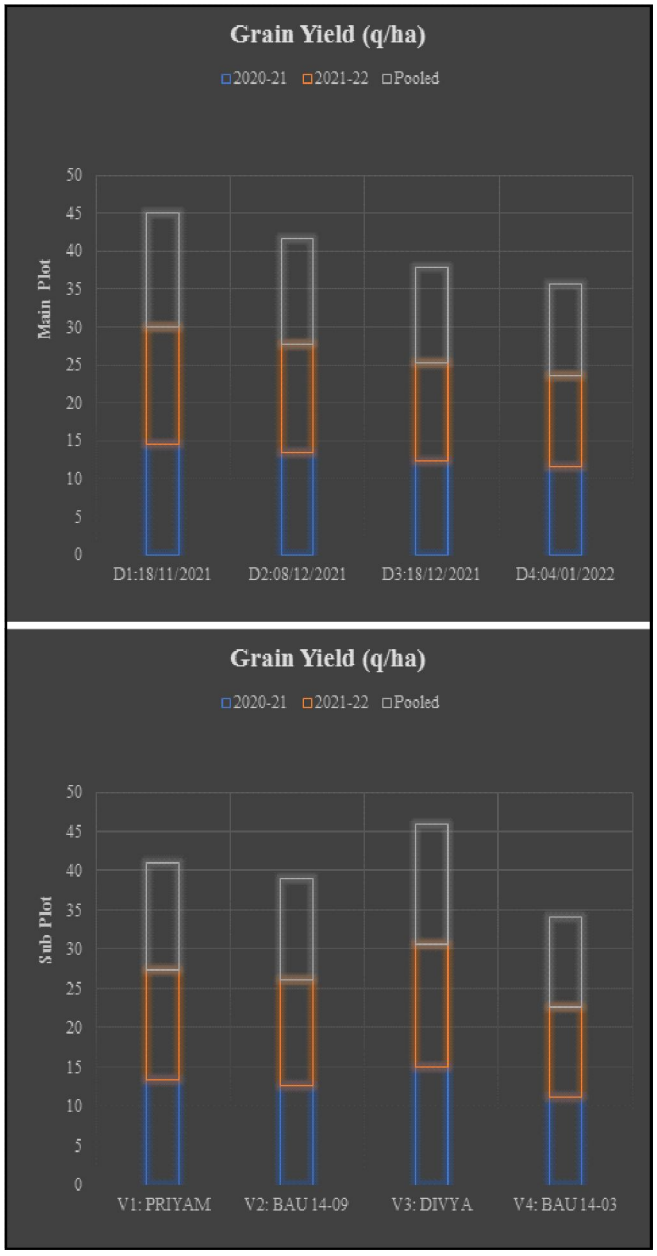

Fig. 1: Grain Yield (q/ha).

Harvest Index (%)

On the basis of pooled data (Table 2) harvest index was higher in the crop sown on 18th November (35.38 %) when compared to 8th December (34.85 %) and 18th December (34.42 %) sown crop but significantly superior to 4th January sown crop (33.25 %). Further, among different varieties highest harvest index was recorded with Divya (34.65 %) which was being at par with rest of the varieties. Seed and straw yields of crop at timely sowing along with the favourable environment condition might be the reason for the maximum harvest index of Divya variety. This is in line with the findings of Alam *et al.*, (2020).

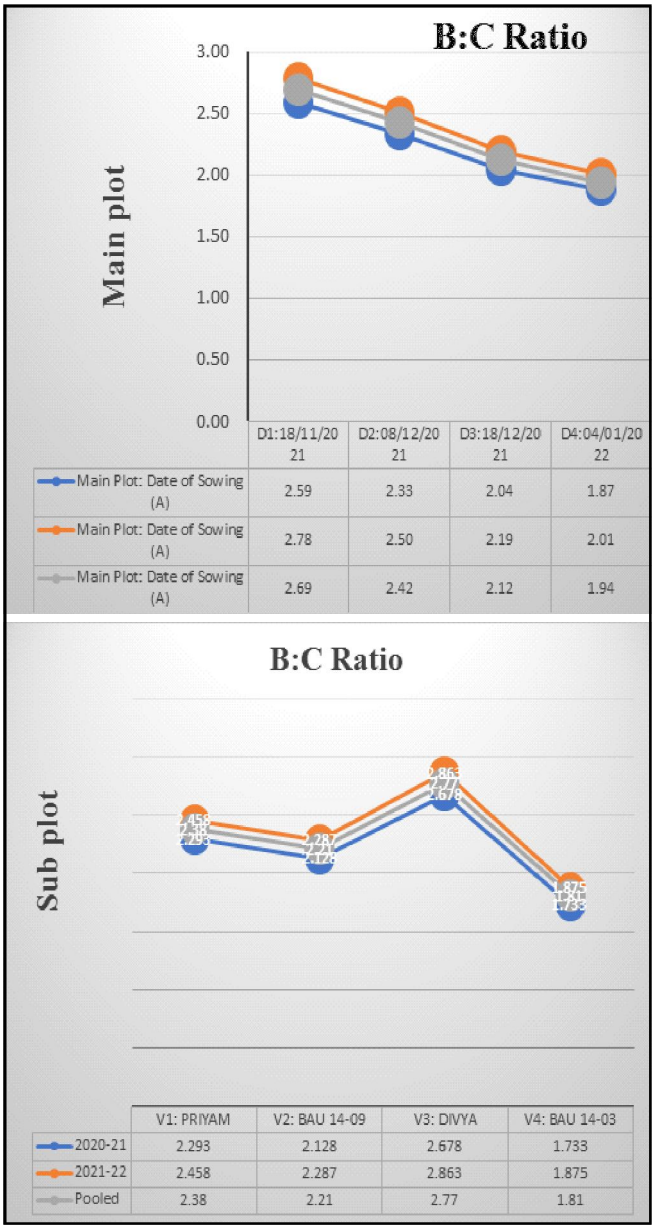

Fig. 2: Benefit Cost Ratio.

Table 3: Effect of date of so wing on economics of linseed varieties.

Main Plot: DOS (A)	Cost of Cultivation (q/ha)			Gross return (q/ha)			Net return (q/ha)			B:C ratio		
				20-21	21-22	Pooled	20-21	21-22	Pooled	20-21	21-22	Pooled
D1:18/11/2021	18705.00	18705.00	18705.00	67164.42	70785.00	68975.00	48459.42	52080.00	50270.00	2.59	2.78	2.69
D2:08/12/2021	18705.00	18705.00	18705.00	62316.75	65521.92	63919.67	43611.75	46816.92	45214.67	2.33	2.50	2.42
D3:18/12/2021	18705.00	18705.00	18705.00	56830.08	59665.67	58248.08	38125.08	40960.667	39543.08	2.04	2.19	2.12
D4:04/01/2022	18705.00	18705.00	18705.00	53737.42	56279.17	55008.50	35032.42	37574.17	36303.50	1.87	2.01	1.94
SEm±				1431.95	1509.76	1470.79	1431.95	1509.76	1470.79	0.08	0.08	0.08
CD (P=0.05)				6014.49	6341.32	6177.63	6014.49	6341.32	6177.63	0.32	0.34	0.33
Sub Plot: Linseed Variety (B)												
V1: PRIYAM	18705.00	18705.00	18705.00	61586.33	64727.25	63157.00	42881.33	46022.25	44452.00	2.29	2.46	2.38
V2: BAU 14-09	18705.00	18705.00	18705.00	58503.75	61485.42	59994.92	39798.75	42780.42	41289.92	2.13	2.29	2.21
V3: DIVYA	18705.00	18705.00	18705.00	68802.08	72280.25	70541.50	50097.08	53575.25	51836.50	2.68	2.86	2.77
V4: BAU 14-03	18705.00	18705.00	18705.00	51156.50	53758.83	52457.83	32451.50	35053.83	33752.83	1.73	1.88	1.81
SEm±				1729.60	1814.14	1771.85	1729.60	1814.14	1771.85	0.09	0.10	0.10
CD (P=0.05)				5845.99	6131.73	5988.79	5845.99	6131.73	5988.79	0.31	0.33	0.32
CV %				9.98	9.97	9.97	14.51	14.17	14.33	14.54	14.18	14.34
Interaction (A × B)												
SEm±				3320.39	3486.07	3403.17	3320.39	3486.07	3403.17	0.18	0.19	0.18
CD (P=0.05)				**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

DOS: Date of Sowing; **Note:** Selling price of linseed = Rs. 4200/- per quintal & selling price of straw = Rs. 220 /- per quintal

Economics

It is evident from the Pooled data in Table 3 and Fig. 2 that highest gross return (Rs. 68975.00 /ha), net return (Rs. 50270.00 /ha) and benefit cost ratio (2.69) were maximum on 18th November sown crop which was being at par with 8th December (Rs. 63919.67 /ha, Rs. 45214.67 /ha & 2.42 respectively) while significantly superior over 18th December and 4th January sown crop. Moreover, among different varieties, the highest gross return (Rs. 70541.50 /ha), net return (Rs. 51836.50 /ha) and benefit cost ratio (2.77) were obtained in Divya which was statistically superior over all the varieties. The best performance of Divya was due to the highest yield attributing characters and seed yield production in comparison to other varieties. These findings are substantiated with those reported by Ganga *et al.*, (2015) and Maurya *et al.*, (2017), Alam *et al.*, (2020) and Kumhare *et al.*, (2022).

Conclusion

Finally, it can be said that the timing of the sowing was a crucial management tool for reducing the adverse effects of high temperatures during the crucial flowering and seed filling phases. Two year of experimentation showed that November 18th is the best day to sow for the good production of linseed. Therefore, a thorough study of the environmental parameters that affect growth, development, yield, and economics should be the foundation for selecting the ideal sowing date. Additionally, the timing of sowing reveals a critical element that determines the crop's success. The present study's findings can be useful in recommending the best time to plant linseed in the Chota Nagpur Plateau Region of Jharkhand. Furthermore, the linseed variety Divya was sown on November 18th, during the second fortnight of November showed that the pooled analysis of data produced the highest number of capsules per plant (34.20), test weight (8.34 g), seed yield (15.29 q/ha), straw yield (28.81 q/ha), net monetary return (Rs. 51836.50 /ha), and benefit cost ratio (2.77).

Conflict of interests

The authors declare that the research was conducted in the absence of any potential conflict of interest.

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