Original Research Article

Effect of sowing dates on yield attributes, yield and economics of linseed (*Linum usitatissimum* L.) varieties

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ABSTRACT

A field experiment was conducted during the *rabi* season of 2020-2021 at Agronomy farm, College of Agriculture, Nagpur to study the effect of sowing dates on yield attributes, yield and economics of linseed varieties. The treatment comprised of four sowing dates, *i.e.,* 43rd MW (meteorological week) (22nd October - 28th October), 44th MW (29th October - 4th November), 45th MW (5th November - 11th November) and 46th MW (12th November - 18th November) in main plots and three varieties *i.e.,* PKV-NL-260, PKV-NL-97 and JLS-73 in sub-plots, replicated three times in a split plot design. Sowing dates as well as varieties significantly affect yield attributes, yield and economics of linseed. The result of the experiment showed significantly higher number of capsule plant^{-1} (52.89), number of seed capsule^{-1} (8.11), seed yield (9.13 q ha^{-1}), biological yield (25.45 q ha^{-1}) and harvest index (35.87%), gross monetary return (Rs. 44688 ha^{-1}) and net monetary return (Rs. 23436 ha^{-1}) with benefit cost ratio (2.10) were recorded when crop sown during 44th MW. The variety PKV-NL-260 recorded significantly higher number of capsule plant^{-1} (48.08), number of seed capsule^{-1} (8.25), seed yield (8.85 q ha^{-1}), biological yield (24.92 q ha^{-1}) and harvest index (35.52%), gross monetary return (Rs. 43478 ha^{-1}) and net monetary return (Rs. 22226 ha^{-1}) with benefit cost ratio (2.04). The sowing date on 44th MW along with variety PKV-NL-260 was found significantly higher seed yield (9.95 q ha^{-1}), gross monetary return (Rs. 48225 ha^{-1}) and net monetary return (Rs. 26973 ha^{-1}). Linseed crop sown during 44th MW along with variety PKV-NL-260 performed better than variety PKV-NL-97 and JLS-73.

Key words: Sowing dates, growth, linseed, variety, yield

1. INTRODUCTION

Linseed (*Linum usitatissimum* L.) is one of the oldest cultivated *rabi* oilseed and fiber crop locally known as *tisi, jawas* or *alsi*. It has been grown from ancient time for flax and seed purpose which is rich in oil. Linseed oil possesses high content of omega-3 fatty acid, alfa linoleic acid (ALA). It contains 35 to 45% oil with the (ALA) making up about 57% of the total fatty acids and 11 to 32% protein [1]. Every part of this plant is extensively used, either directly or after processing. Linseed has different industrial value and linseed oil is mainly used in paint industries as a medium for paints, varnishes, pad ink and printing ink.

Linseed is produced mostly in India, China, Canada, USA, Argentina and Russia. Linseed stands next to rapeseed-mustard in *rabi* oilseeds in area and production. It is grown under rainfed (63%), utera (20%)

and irrigated (17%) conditions [2]. In India, its cultivation is mostly confine to Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Bihar, Jharkhand, Nagaland and Assam. India contributes about 10.81% and 5.30% to world area and production respectively. In India linseed occupies an area of 1.72 lakh ha yielding 99 thousand tones with an average productivity of 5.74 q ha^{-1} [3]. Madhya Pradesh premier position in India with respect to both area (1.16 lakh ha) and production (0.55 lakh tones) with 4.74 q ha^{-1} productivity of linseed [4]. In Maharashtra state, the total area under linseed crop is 8.7 thousand ha with 2.6 thousand tones production. Average productivity of this crop in Maharashtra is 2.99 q ha^{-1} [5].

The average productivity of this crop is very low as compare to other oilseed crops. The productivity of linseed in Maharashtra is below the national productivity. There are many factors responsible for low productivity but sowing time and variety have prominent factors responsible for low productivity of linseed. Delay in sowing leads to an increase in environmental temperature during reproductive growth of crop resulting lower seed yield, seed quality and increased economical cost of cultivation. It is reported that high temperature above 32^0C accompanied with drought during flowering reduced yield, oil content and the quality of crop. Linseed may be damaged or destroyed at a temperature between -8^0C and 3^0C at seedling stage [6]. Varieties play an important role in determining the yield of a crop, the potential yield of varieties within its genetic limit is set by its environment.

There is large scope for increasing the productivity of linseed crop for getting higher crop yield per unit area by adopting improved agronomic practices. Production potentiality of linseed can be fully exploited with suitable agronomic technique such as optimum sowing time and selection of high yielding varieties as it provides optimum growing conditions under varying climatic conditions.

2. MATERIAL AND METHODS

A field experiment was conducted during *rabi* season of 2020-2021 at Agronomy farm, College of Agriculture, Nagpur. The experimental area was geographically positioned at 79^0 7' East longitude and 21^0 8' North latitude with an altitude of 321 meter above mean sea level. Soil of the experimental site was clayey in texture, low in available nitrogen, medium in phosphorous and rich in available potash. Organic carbon content was medium and soil reaction was slightly alkaline. The total rainfall during crop growth period *i.e.,* October, 2020 to March, 2021 was 101 mm received in 7 rainy days. The maximum temperature ranged from 27.3 to 41.5 ^{0}C, the minimum temperature ranged from 11.3 to 24.1^{0}C, the morning relative humidity ranged from 26 to 85%, the evening relative humidity ranged from 16 to 69% and total evaporation was 101 mm. The experiment was laid out in split plot design with twelve treatment combinations and three replications consisting of four levels of meteorological weeks *i.e.,* 43rd MW, 44th MW, 45th MW, 46th MW and three varieties *i.e.,* PKV-NL-260, PKV-NL-97 and JLS-73. The gross and net plot size were 4.8 m x 3.6 m and 4.2 m x 3.0 m, respectively. A spacing of 30 cm x 5 cm was adopted by using 30 kg seed per hectare. Three varieties of linseed were sown (drilling of seeds manually) in four

different dates to evaluate the optimum sowing dates for linseed varieties. Physiological and economical parameters used in this experiment are given below.

2.1 Yield attributes

2.1.1 Numbers of capsules plant^{-1}

The numbers of capsules plant^{-1} from the five observational plants were counted. Average number of capsules plant^{-1} was worked out.

2.1.2 Numbers of seed capsules^{-1}

The numbers of seed capsules^{-1} from the five observational plants were counted. Average number of numbers of seed capsules^{-1} was worked out.

2.2 Yield of linseed

2.2.1 Biological yield (q. -ha^{-1})

The plants from net plot were cut close to the ground and tied into bundles. The bundles were dried in the sun and their weight was recorded before threshing as per treatments. From this biological yield q ha^{-1} was worked out.

2.2.2 Seed yield (q. ha^{-1})

After harvesting, produce from every net plot was sun dried weighed and then threshed. After cleaning seed yield net plot^{-1} was recorded and seed yield q ha^{-1} was calculated.

2.2.3 Harvest index (%)

Harvest index of linseed was obtained by dividing the economic yield with the biological yield and represented in percentage [7].

2.3 Economics

2.3.1 Cost of cultivation (Rs. ha^{-1})

The total cost of cultivation was calculated considering the inputs used in each treatment with prevailing market rates.

2.3.2 Gross monetary return (Rs. ha^{-1})

The total production of crop including both seed and straw yield in terms of rupees is known as gross monetary return. It was estimated on per ha basis.

2.3.3 Net monetary return (Rs. ha^{-1})

The net production of crop after reducing the total cost of cultivation from gross monetary return in terms of rupees is known as net monitory return. It was estimated on ha^{-1} basis.

2.3.4 Benefit cost ratio

The benefit cost ratio was worked out by dividing the gross monetary return with total cost of cultivation**.**

2.4 Statistical analysis

Standard method of analysis, known as Analysis of Variance was used for statistical analysis [8]. The Critical Difference was worked out at 5% level of significance and F value used to differentiate significant or non-significant effects. The treatment effects are presented by preparing tables of means with appropriates Standard Error of Means (SE(m) ±) and Critical Difference (CD) values, in respect of various aspects studied. Important effects are illustrated by graphs [9].

3. RESULT AND DISCUSSION

3.1 Yield attributes

The data pertaining to yield attributes like number of capsules $plant^{-1}$, number of seed $capsule^{-1}$ as influenced significantly by different sowing dates and varieties are presented in Table 1.

3.1.1 Number of capsules $plant^{-1}$

Effect of sowing dates

Sowing taken on 44^{th} MW recorded higher number of capsules $plant^{-1}$ (52.89) which was significantly superior over sowing carried out on 43^{rd} MW, 45^{th} MW and 46^{th} MW respectively. The higher number of capsules $plant^{-1}$ was due to timely sowing of seeds and exposure to favorable weather during the entire growth period. Similar results were reported earlier [10, 11, 12]

Effect of varieties

The variety PKV-NL-260 recorded significantly higher number of capsules $plant^{-1}$ (48.08) than variety PKV-NL-97 (45.08). The variety PKV-NL-97 was found at par with variety JLS-73 (43.83). It was found that the significant difference in number of seed per capsule might be due to number of branches $plant^{-1}$ and genetic potential of variety. Similar results were reported earlier [2, 13].

3.1.2 Number of seed $capsule^{-1}$

Effect of sowing dates

Sowing of linseed on 44^{th} MW recorded significantly higher number of seed $capsule^{-1}$ (8.11) than rest of the sowing dates. However, it was found at par with sowing done during 43^{rd} MW (7.78). The higher number of seeds per capsule might be due to prevalence of favorable climatic factors such as temperature and light energy, which provide the plant full chance to develop well canopy and biomass

and its increased capacity to absorb enough water and nutrients during the entire growth period with sowing on 44th MW. Similar results were reported earlier [10, 12, 14].

Table 1: Yield attributes and yields of linseed as influenced by sowing dates and varieties

Treatments	Number of capsule plant^{-1}	Number of Seed capsule^{-1}	Seed yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
Sowing dates					
D_1 - 43rd MW	48.11	7.78	8.71	24.32	35.81
D_2 - 44th MW	52.89	8.11	9.13	25.45	35.87
D_3 - 45th MW	43.00	7.33	8.07	23.07	34.98
D_4 - 46th MW	38.67	7.22	7.43	21.93	33.98
SE(m)±	0.71	0.18	0.10	0.22	-
CD at 5%	2.45	0.62	0.37	0.77	-
Varieties					
V_1 - PKV-NL-260	48.08	8.25	8.85	24.92	35.52
V_2 - PKV-NL-97	45.08	7.42	8.44	23.84	35.41
V_3 - JLS-73	43.83	7.17	7.71	22.32	34.55
SE(m)±	0.53	0.28	0.09	0.14	-
CD at 5%	1.61	0.86	0.29	0.42	-
Interaction					
SE(m)±	1.07	0.57	0.19	0.28	-
CD at 5%	NS	NS	0.58	NS	-
GM	45.67	7.61	8.33	23.69	35.16

Effect of varieties

The variety PKV-NL-260 recorded significantly higher number of seed capsules^{-1} (8.25) which was found at par with variety PKV-NL-97 (7.42). Lowest number of seeds capsule^{-1} was recorded by variety JLS-73 (7.17). It was found that the significant difference in number of capsules plant^{-1} was might be due to

genetically makeup of these varieties were different for seed settling and seed development in capsule. Similar results were also reported earlier [2, 13].

3.2 Yield of linseed

The data related to seed yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) as significantly influenced by sowing dates and varieties are presented in Table 1.

3.2.1 Seed yield (q ha^{-1})

Effect of sowing dates

Sowing taken on 44th MW had recorded significantly higher seed yield (9.13 q ha^{-1}) which was significantly superior over rest of the sowing dates. Lowest seed yield (7.43 q ha^{-1}) was recorded under 46th MW. This might be due to timely sown crop received favorable weather conditions for longer duration and recorded better growth and yield attributes and resulted in greater productivity. Similar results were reported earlier [2, 12, 15].

Effect of varieties

The variety PKV-NL-260 produced higher seed yield (8.85 q ha^{-1}) which was significantly superior over variety PKV-NL-97 (8.44 q ha^{-1}) and JLS-73 (7.71 q ha^{-1}). This might be due to the less flower drop and more number of branches $plant^{-1}$ which helped in increased seed yield per hectare. Similar results were reported earlier [11, 16].

Interaction effect

The interaction effect between sowing dates and varieties were found significant for seed yield per hectare at harvest in Table 2. The sowing date 44th MW along with variety PKV-NL-260 found to be significantly higher seed yield (9.95 q ha^{-1}) which was found at par with treatment combination of 43rd MW along with variety PKV-NL-260 and 44th MW along with variety PKV-NL-97. However, it was found significantly superior over rest of the combination. The results showed timely sowing of linseed varieties, could able to assimilate the more biomass and resulted in increased seed yield of linseed.

Table 2: Seed yield of linseed as influenced by interaction of sowing dates and varieties

Varieties / Sowing dates	Seed yield (q ha^{-1})		
	V_1 -PKV-NL-260	V_2 -PKV-NL-97	V_3 -JLS-73
D_1 - 43rd MW	9.39	8.78	7.94
D_2 - 44th MW	9.95	9.38	8.04
D_3 - 45th MW	8.39	8.15	7.65
D_4 - 46th MW	7.65	7.44	7.18
SE(m) ±	0.19		
CD at 5%	0.58		

3.2.2 Biological yield (q ha^{-1})

Effect of sowing dates

The crop sown at 44th MW recorded significantly higher biological yield (25.45 q ha^{-1}). However, it was significantly superior over sowing taken on 43rd, 45th and 46th MW. Lowest biological yield was recorded under 46th MW (21.93 q ha^{-1}). Sowing on 44th MW has accumulated higher photosynthates which helped in higher accumulation of dry matter which resulted in higher biological yield. Similar results were reported earlier [1, 13, 14].

Effect of varieties

The variety PKV-NL-260 produced significantly higher biological yield (24.92 q ha^{-1}) than the variety PKV-NL-97 (23.84 q ha^{-1}) and JLS-73 (22.32 q ha^{-1}). This might be due to genetic makeup of variety PKV-NL-260. Similar results were reported earlier [1, 13].

3.2.3 Harvest index (%)

Effect of sowing dates

The data represented in Table 1 revealed that sowing on 44th MW recorded comparatively higher harvest index (35.87%) as compare to all other sowing dates. Similar results were reported earlier [13, 17].

Effect of varieties

The harvest index was comparatively higher in linseed variety PKV-NL-260 (35.52 %) than variety PKV-NL-97 (35.41%) and JLS-73 (34.55 %). This might be due to genetic makeup of variety PKV-NL-260. Similar results were reported earlier [13]

3.3 Economic studies

The data related to cost of production, gross monetary return, net monetary return and benefit cost ratio as significantly influenced by sowing dates and varieties are presented in Table 3.

3.3.1 Gross monetary return (Rs. ha^{-1})

Effect of sowing dates

Sowing done during 44th MW recorded highest gross monetary return (Rs. 44688 ha^{-1}) which was found at par with 43rd MW (Rs. 42705 ha^{-1}) and was significantly superior over sowing carried out on 45th MW (Rs. 39768 ha^{-1}) and 46th MW (Rs. 36974 ha^{-1}). Increase in gross monetary return is due to significant increase in seed and straw yield of linseed. Similar results were reported earlier [11].

Effect of varieties

Variety PKV-NL-260 recorded highest gross monetary return (Rs. 43478 ha^{-1}) resulted significantly superior over variety PKV-NL-97 (Rs. 41483 ha^{-1}) and JLS-73 (Rs. 38140 ha^{-1}). Increase in gross monetary return is due to significant increase in seed and straw yield of linseed variety. Similar results were reported earlier [2].

Interaction effect

The interaction effects of sowing dates and linseed varieties were found significant for gross monetary return in Table 4. The sowing date on 44th MW along with variety PKV-NL-260 was found to be significantly higher gross monetary return (Rs. 48225 ha^{-1}) which was found at par with treatment combination of sowing on 43rd MW along with variety PKV-NL-260 (Rs. 46983 ha^{-1}) and sowing on 44th MW along with variety PKV-NL-97 (Rs. 45816 ha^{-1}). However, it was found significantly superior over rest of the combination.

Table 3: Cost of cultivation, gross monetary return, net monetary return and benefit cost ratio of linseed as influenced by sowing dates and varieties

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross monetary return (Rs. ha^{-1})	Net monetary return (Rs. ha^{-1})	B:C ratio
Sowing dates				
D_1 - 43rd MW	21252	42705	21453	2.00
D_2 - 44th MW	21252	44688	23436	2.10
D_3 - 45th MW	21252	39768	18516	1.87
D_4 - 46th MW	21252	36974	15722	1.73
SE(m)±	-	457.86	457.86	-
CD at 5%	-	1584.23	1584.23	-
Varieties				
V_1 - PKV-NL-260	21252	43478	22226	2.04
V_2 - PKV- NL-97	21252	41483	20231	1.95
V_3 - JLS-73	21252	38140	16888	1.79
SE(m)±	-	399.34	399.34	-
CD at 5%	-	1197.09	1197.09	-
Interaction				
SE(m)±	-	798.68	798.68	-
CD at 5%	-	2394.18	2394.18	-
GM	21252	41033	19781	1.93

3.3.2 Net monetary return (Rs. ha^{-1})

Effect of sowing dates

Sowing taken on 44th MW was recorded highest net monetary return (Rs. 23436 ha^{-1}) and was significantly superior over sowing carried out on 43rd MW (Rs. 21453 ha^{-1}), 45th MW (Rs. 18516 ha^{-1}) and 46th MW (Rs. 15722 ha^{-1}).

Table 4: Gross monetary return as influenced by interaction of sowing dates and varieties

Varieties / Sowing dates	Gross monetary return (Rs. ha^{-1})		
	V_1 -PKV-NL-260	V_2 -PKV-NL-97	V_3 -JLS-73
D_1 - 43rd MW	45983	42776	39355
D_2 - 44th MW	48225	45816	40023
D_3 - 45th MW	41523	40098	37683
D_4 - 46th MW	38181	37243	35498
SE(m) ±	798.68		
CD at 5%	2394.18		

Table 5: Net monetary return as influenced by interaction of sowing dates and varieties

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Varieties / Sowing dates	Net monetary return (Rs. ha^{-1})		
	V_1 -PKV-NL-260	V_2 -PKV-NL-97	V_3 -JLS-73
D_1 - 43rd MW	24731	21524	18103
D_2 - 44th MW	26973	24564	18771
D_3 - 45th MW	20271	18846	16431
D_4 - 46th MW	16929	15991	14246
SE(m) ±	798.68		
CD at 5%	2394.18		

Effect of varieties

The variety PKV-NL-260 was recorded highest net monetary return (Rs. 22226 ha^{-1}) resulted significantly superior over variety PKV-NL-97 (Rs. 20231 ha^{-1}) and JLS-73 (Rs.16888 ha^{-1}).

Interaction effect

The interaction effects of sowing dates and linseed varieties were found significant for net monetary return in Table 3. The sowing date on 44th MW along with variety PKV-NL-260 was found to be significantly higher net monetary return (Rs. 26973 ha^{-1}) which was found at par with combination of sowing on 43rd MW along with variety PKV-NL-260 (Rs. 24731 ha^{-1}) and sowing on 44th MW along with variety PKV-NL-97 (Rs. 24564 ha^{-1}). However, it was found significantly superior over rest of the combination.

3.3.3 B: C ratio

Effect of sowing dates

Highest benefit cost ratio (2.10) was recorded with sowing on 44th MW as compare to other sowing dates. Lowest benefit cost ratio was observed under 46th MW (1.73). Increase in benefit cost ratio was due to significant increase in gross monetary return under sowing taken on 44th MW. Similar results were reported earlier [2].

Effect of varieties

Comparatively higher benefit cost ratio (2.04) is recorded with variety PKV-NL-260 over variety PKV-NL-97 (1.95) and JLS-73 (1.79). Increase in benefit cost ratio was due to significant increase in gross monetary return by variety PKV-NL-260 [13].

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To make linseed cultivation sustainable, it is essential to combine technologies, management techniques and adjust the management of the agricultural system. The opportune selection of the planting date is essential to obtain high yields, which does not generate an extra expense in the production cost of the crop. A delay in the sowing date generates negative effects on the formation and development of the capsules, as well as on the number and weight of the grain [18]~~(Maich, 2021)~~.

In warm weather, various plant species of great interest can be planted, both in summer and winter, the latter being irrigated. Thus, during the year, linseed, like other crops, is subject to changes in solar radiation [19], temperature [20], and evaporative air demand measured through crop evapotranspiration (ETc) [21], which influence its growth and yield.

As confirmed by a study in the northern hemisphere (April), early planting of the linseed crop gives the highest yields [22]~~(Maich, 2021)~~. Similar results were reached by [~~2318~~]~~Mirshekari et al. (2012)~~. Always in the northern hemisphere and in autumn sowings, sowing during the first fortnight of November was the

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one that provided the highest yields. In the southern hemisphere, particularly in Argentina, the optimal planting date for Gallardo [243]~~Gallardo et al. (2014)~~ corresponded to the first half of June, likewise other trials indicated that of four planting dates (April 12, May 3 and 24, and June 14, 2012), the highest yields were recorded in the first two planting dates.

Various studies [24, 25, 26] indicated that, although the growth of a crop is affected by a complex group of environmental factors, those with the greatest impact are: rainfall [27, 28, 29], radiation and seasonal temperature [30, 31]. The relationship between these factors and the growth and yield of the crop will depend on the climate in which it is developed [32, 33]. Of these three factors, water can be considered the first in importance and is the most decisive for agricultural production. One evidence of this is the linear relationship between water supply and crop yield.

Finally, it is considered appropriate to mention that the grain yield of linseed per surface unit in the studies reviewed fluctuated between one and two tons per hectare. Based on the above, it is postulated that plantings during 44th MW along with variety PKV-NL-260 performed better than variety PKV-NL-97 and JLS-73.

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4. Conclusion

In present investigation it has been concluded that sowing time and variety has immense effect on yield attributes, yield and economic of linseed. Results reveal that sowing of linseed during 44th MW and variety PKV-NL-260 recorded highest number of capsules plant^{-1}, number of seed capsule^{-1}, seed yield, biological yield, harvest index, gross and net monetary return with B: C ratio as compare to early and delayed sowing. Sowing of linseed during 44th MW along with variety PKV-NL-260 obtained significantly higher seed yield with the highest gross and net monetary returns.

5. References

I suggest the authors update the bibliography, many of the citations are more than 10 years old, therefore I suggest adding recent references which address the issue in question. Suggested citations are for genuine scientific reasons that emphasize the current topic of study in context

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