Effect of sowing dates and crop spacing on growth, yield and quality of linseed under south Gujarat condition

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Abstract
A field experiment was conducted during the rabi season of 2016-17 at College Farm, Navsari Agriculture University, Navsari, Gujarat to study the Effect of sowing dates and crop spacing on growth, yield and quality of linseed. The treatments comprised of 4 sowing dates, Viz. D1: 3rd week of October, D2: 4th week of October, D3: 1st week of November and D4: 2nd week of November in main plots and 3 spacing (S1: 20 cm x 5 cm, S2: 30 cm x 5 cm and S3: 40 cm x 5 cm) in sub-plots, replicated four times in a split plot design. Sowing dates as well as spacing significantly affected growth characters, yield attributes, yield, oil yield and Economics. The results of the experiment showed significantly higher plant height (59.62 cm), number of branches/plant (9.78), number of seeds/capsule (6.62), test weight (6.61 g), seed yield (1272 kg/ha), stover yield (2908 kg/ha), oil yield (476 kg/ha) and accrued highest net realization (₹ 73,252/ha) with BCR (4.47) were recorded in sowing on 1st week of November (D3). Sowing of linseed with narrow spacing (S1: 20 cm x 5 cm) was recorded significantly higher plant height (59.62 cm), seed yield (1262 kg/ha), stover yield (2976 kg/ha), oil yield (471 kg/ha) and also reported maximum net realization (₹ 72,565/ha) with BCR (4.43).

Keywords: Sowing dates, growth, spacing, linseed, yield, quality, economics

Introduction
Linseed (Linum usitatissimum L.), also known as flax is a member of genus Linum in the family Linaceae. It is commonly known as Alashi or Alsi. Every part of the linseed plant is utilized commercially, either directly or after processing. On a very small scale seed is directly used for edible purposes. It contains 33 to 47% of oil. About 20% of the total oil produced is used at farmer’s level and the rest 80% oil goes to industries in various forms such as boiled oil, borated oil, epoxidized oil, aluminates oil, urethane 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 is good in taste and contains 36% protein, 85% of which is digestible. It is also used as organic manure and contains about 5% N, 1.4% P₂O₅ and 1.8% K₂O.

India is an important linseed growing country in the world and it contributes 7 per cent to the world linseed pool. At present, linseed is cultivated in about 2.63 lakh hectares with contribution of 1.26 lakh tons to the annual oilseed production of the country. The average productivity of linseed is 477 kg/ha (2015-16). Major linseed growing states in India are Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Bihar, Rajasthan, Orissa and Karnataka. Madhya Pradesh has largest growing area (1.16 lakh ha) and production (0.55 lakh tones) with 474 kg/ha productivity (Anonymous 2015-16) [1].

Optimum sowing time is one of the most important agronomic factor and non-monetary input but has noticeable impact on productivity of crop. Planting dates significantly affect growth character, yield and its components as well as oil yield in flax (Al-Doori, 2012) [1]. Sowing dates have been shown to provide differential growth conditions such as temperature, precipitation and growth periods. The appropriate sowing date is very important since it ensures good seed germination, as well as timely appearance of seedling and optimum development of root system.

Spacing plays an important role in increasing production per unit area. It is well known fact that spacing plays an important role in production of field crops. Spacing is dependent upon the expected growth of a particular crop and variety in a given agro-climatic condition. Therefore, optimum plant spacing is one of the most important factors in increasing the yield per hectare.
Materials and Methods
The present study was conducted on plot No. D-16 of the College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari during rabi season of 2016-17. The soil of experimental plot was clayey in texture, low in organic carbon (0.44%) and available nitrogen (206.50 kg/ha), medium in available phosphorus (38.20 kg/ha) and high in available potassium (323.18 kg/ha). The soil was found slightly alkaline (pH 7.8) with normal electric conductivity. The experiment was laid out in split plot design with four levels of sowing dates, i.e. D₁: 3rd week of October, D₂: 4th week of October, D₃: 1st week of November and D₄: 2nd week of November in the main plots and three levels of spacing, viz. S₁: 20 cm x 5 cm, S₂: 30 cm x 5 cm and S₃: 40 cm x 5 cm in the sub plots, replicated four times. Required quality of seed as per treatment was calculated for experimental area. The seeds were drilled 3-4 cm deep in previously opened furrows as per treatments and covered properly with soil. Five plants were selected randomly from each net plot and tagged for recording growth and yield attributing parameters. Oil content of seed was determined by soxhlet apparatus as per the method suggested by Tiwari et al., 2011 [16]. The statistical analysis of data recorded for different characters during the course of investigation was carried out through the procedure appropriate to the Split plot design as described by Cochran and Cox, 1967 [4]. The economics was calculated on the basis of different inputs and output.

Result and Discussion
Effect of sowing dates
Effect on growth parameters
Plant height
The significantly taller plant (59.62 cm) was observed under the treatment D₁ (1st week of November). This is probably due to timely sowing which might have enjoyed favourable climatic conditions in terms of temperature and other parameters during crop growth and also on account of better availability of mineral nitrogen to the plants due to favourable soil temperature which have resulted in better utilization of carbohydrates to form more protoplasm resulting in more cell division and enlargement. These results lend support to those reported by Al-Doori (2012) [1] at Mosul and Ganga et al. (2015) [6] at Varanasi (Table 1).

Number of branches/plant
Significantly higher number of branches/plant (9.78) recorded under treatment D₁ (1st week of November). This might be due to favourable weather during entire crop period coupled with nutrient absorption at appropriate time. These results also corroborate with the findings of Kalita et al. (2005) [8] at Assam and Ganga et al. (2015) [6] at Varanasi (Table 1).

Effect on yield and attributes and yield
Number of capsules/plant
Significantly higher number of capsules/plant (53.85) was recorded under treatment D₁ (1st week of November). This was possibly due to timely planting and crop exposure to favourable weather during the whole growth period and thus different phases of crop were completed at appropriate timings, which ultimately resulted in production of more number of branches/plant providing more sites for reproductive structures viz., number of capsules/plant. This also confirms the results of Ganga et al. (2015) [6] at Varanasi and Maurya et al. (2017) [13] at Varanasi (Table 1).

Number of seeds/capsule
Treatment D₁ (1st week of November) produced significantly higher number of seeds/capsule (6.62). This might be because of favourable environment particularly that of temperature that prevailed during the time of sowing and at vegetative and reproductive stages. The results obtained by Raundal et al. (2015) [14] at Pune and Maurya et al. (2017) [13] at Varanasi also confirm the findings of present investigation (Table 1).

1000 seed weight
Treatment D₁ (1st week of November) recorded significantly higher 1000 seed weight (6.61). This due to timely sown crop got an advantage because after having completed its vegetative growth satisfactorily it came in the reproductive stage when the temperature was quite favourable. The results lend support to those reported by; El-Mohsen et al. (2013) [5] at Egypt and Ganga et al. (2017) [13] at Varanasi (Table 1).

Seed yield
The treatment D₁ recorded significantly higher seed yield (1272 kg/ha) of linseed by 6.35 and 11.19 per cent over D₂ and D₃, respectively. Higher seed yield might be the result of cumulative effect of improvement in growth and yield attributes such as number of branches/plant, number of capsules/plant, number of seeds/capsule as well as 1000 seed weight. The timely sown crop received favourable weather conditions for longer duration and recorded better growth and yield attributes and resulted in greater productivity. Superiority of timely planting might be due to prevalence of favourable 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, and consequently possessed more effective productive organs. The results lend support to those reported by El-Mohsen et al. (2013) [5] at Egypt; Ganga et al. (2015) [6] at Varanasi and Maurya et al. (2017) [13] at Varanasi (Table 1).

Stover yield
Significantly higher straw yield (2908 kg/ha) was recorded under the treatment D₁ which superseded by 13.46 per cent over D₂. Higher straw yield under treatment D₁ might be due to more favorable period for vegetative growth in terms of plant height obviously resulted into more straw yield. These findings are in cognizance with the results of El-Mohsen et al. (2013) [5] at Egypt and Ganga et al. (2015) [6] at Varanasi (Table 1).

Effect on quality
Varying sowing dates failed to produce significant effect on quality of linseed in terms of oil content. However, numerically higher oil content (37.53 %) in linseed was observed under the treatment D₁ (1st week of November). Significantly higher oil yield (476 kg/ha) was recorded under the treatment D₁ (1st week of November). The higher oil yield obtained under the above treatment was the resultant of perceptibly higher seed along with the higher oil content which were directly responsible for higher oil yield. The timely sown crop experienced favourable weather conditions for longer duration recorded better growth and seed yield resulted in more oil productivity. These results lend support to those reported by Al-Doori (2012) [1] at Mosul and Ganga et al. (2015) [6] at Varanasi (Table 1).
Effect on economics
Among various sowing dates D3 recorded the highest net returns of ₹ 73,252/ha with BCR of 4.47. These findings are substantiated with those reported by Gohil et al. (2016) [7] at Navsari and Maurya et al. (2017) [13] at Varanasi (Table 1).

Effect of spacing
Effect on growth parameters
Plant height
The significantly tallest plant (59.73 cm) was observed under the treatment S1 (20 cm x 5 cm). Higher plant height might be due to unavailability of sufficient space and sunlight which forced the plants to grow vertically rather than horizontally. The present results are in close conformity with those of Kushwaha et al. (2006) [11] at Kanpur and Gohil et al. (2016) [7] at Navsari (Table 1).

Number of branches/plant
Significantly higher number of branches/plant (9.76) recorded under treatment S1 (40 cm x 5 cm). This might be due to sufficient availability of sunlight and nutrient which increased plant growth and development. The present results are in cognizance with those of Khan et al. (2005) [9] at Multan and Gohil et al. (2016) [7] at Navsari (Table 1).

Effect on yield and attributes and yield
Number of capsules/plant
Significantly higher number of capsules/plant (50.49) was recorded under treatment S2 (30 cm x 5 cm). This was possibly due to less competition between plants for nutrient, soil moisture, space and solar radiation etc. in wider spacing than closer spacing. This also confirms the results of Kushwaha et al. (2006) [7] at Kanpur and Chaudhary (2009) [3] at Kanpur and (Table 1).

Number of seeds/capsule
Treatment S2 (30 cm x 5 cm) produced significantly higher number of seeds/capsule (6.46). This was due to plants grown wider spacing produce more branches, which stimulate the formation of a larger number of capsules and seeds on the stems. The result obtained by Saoji et al. (2007) [15] at Gondia (M. S.) and Gohil et al. (2016) [7] at Navsari also confirm the findings of present investigation (Table 1).

1000 seed weight
An appraisal of results in respect of weight of 1000 seeds (test weight) was found to be non significant due to various spacing, however, the numerically higher test weight (6.46 g) was observed in treatment S1 (40 cm x 5 cm). These results lend support to those reported by Khan et al. (2005) [9] at Multan; Chaudhary (2009) [3] at Kanpur and Gohil et al. (2016) [7] at Navsari (Table 1).

Seed yield
The treatment S1 (20 cm x 5 cm) recorded significantly higher seed yield (1262 kg/ha) of linseed by 9.17 percent over S1. Higher seed yield might be more number of plants per unit area resulted in higher yield per unit area. As narrow spacing sown crop have more number of plants per unit area and reduction in yield per plant might be compensated with yield from more number of plants per unit area. But there is a optimum plant population level at which yield per plant decrease with narrow spacing is compensated with yield from more number of plants per unit area. This equilibrium plant population where yield per unit area is higher with given plant population is considered optimum crop spacing. These results lend support to those reported by Kushwaha et al. (2006) [12] at Kanpur; Saoji et al. (2007) [15] at Gondia (M. S.) and Gohil et al. (2016) [7] at Navsari (Table 1).

Effect on stover yield
Significantly higher straw yield (2976 kg/ha) was recorded under the treatment S1 (20 cm x 5 cm). Higher straw yield might be due to healthy vegetative growth in terms of plant height obviously resulted into more straw yield. These findings are in cognizance with the results of Kushwaha et al. (2006) [12] at Kanpur; Chaudhary (2009) [3] at Kanpur and Gohil et al. (2016) [7] at Navsari (Table 1).

Effect on quality
Oil content was not influenced significantly due to spacing. The narrow spacing of S1 (20 cm x 5 cm) recorded significantly higher oil yield (471 kg/ha). The higher oil yield achieved under this treatment was due to the higher seed yield, which is directly responsible for higher oil yield. Almost similar findings were also reported by Kumar et al. (2012) [13] at Pantnagar (Uttarkhand) and Gohil et al. (2016) [7] at Navsari (Table 1).

Effect on economics
In case of spacing highest net returns (₹ 72565/ha) was recorded under the treatment S1 (20 cm x 5 cm) with 4.43 BCR. These findings are substantiated with those reported by Kumari et al. (2012) [10] at Pantnagar (Uttarkhand) and Gohil et al. (2016) [7] at Navsari (Table 1).

Interaction effect
Seed yield
Interaction effect between sowing dates and spacing was found to be significant in terms of seed yield (kg/ha) in linseed. However significantly higher values of seed yield (1429 kg/ha) was observed in treatment combination of D3S1 (1st week of November and 20 cm x 5 cm) and remained at par with D3S1. These results are in conformity with those reported by Saoji et al. (2007) [15] at Gondia (M. S.); Gohil et al. (2016) [7] at Navsari (Table 2).

Economics
Highest net returns (₹ 84,240/ha) and BCR of 5.14 were obtained with treatment combination of D3S1 (1st week of November and 20 cm x 5 cm) followed by D3S1 (₹ 76,448/ha) with BCR 4.67. The lowest net returns (₹ 60,571/ha) with BCR value of 3.70 were realized in D3S2 (1st week of October and 40 cm x 5 cm) treatment. Higher net gain/ha under 1st week of November sowing (D3) and 20 cm x 5 cm (S1) was due to higher yield. These findings are substantiated with those reported by Ganga et al. (2015) [6] at Varanasi and Maurya et al. (2017) [13] at Varanasi (Table 2).
### Table 1: Effect of sowing dates and spacing on growth parameters, yield attributes, yield, quality and economics of linseed

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Number of branches/plant</th>
<th>Number of capsules/plant</th>
<th>Number of seeds/Capsule</th>
<th>Test weight (g)</th>
<th>Seed Yield (kg/ha)</th>
<th>Stover Yield (kg/kg)</th>
<th>Oil content (%)</th>
<th>Oil yield (kg/ha)</th>
<th>Total cost of cultivation (₹/ha)</th>
<th>Net realization (₹/ha)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sowing dates (D)</strong></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>D1</td>
<td>55.86</td>
<td>9.16</td>
<td>45.55</td>
<td>6.08</td>
<td>6.13</td>
<td>1144</td>
<td>2563</td>
<td>36.39</td>
<td>416</td>
<td>16370</td>
<td>64223</td>
<td>3.92</td>
</tr>
<tr>
<td>D2</td>
<td>56.23</td>
<td>9.39</td>
<td>46.61</td>
<td>6.20</td>
<td>6.23</td>
<td>1196</td>
<td>2798</td>
<td>36.90</td>
<td>441</td>
<td>16370</td>
<td>67910</td>
<td>4.15</td>
</tr>
<tr>
<td>D4</td>
<td>57.77</td>
<td>9.67</td>
<td>47.33</td>
<td>6.34</td>
<td>6.38</td>
<td>1248</td>
<td>2817</td>
<td>37.20</td>
<td>466</td>
<td>16370</td>
<td>71553</td>
<td>4.37</td>
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**Spacing (S)**

<table>
<thead>
<tr>
<th>S</th>
<th>Number of seeds/Capsule</th>
<th>Test weight (g)</th>
<th>Seed Yield (kg/ha)</th>
<th>Stover Yield (kg/kg)</th>
<th>Oil content (%)</th>
<th>Oil yield (kg/ha)</th>
<th>Total cost of cultivation (₹/ha)</th>
<th>Net realization (₹/ha)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.67</td>
<td>0.87</td>
<td>0.11</td>
<td>0.11</td>
<td>22</td>
<td>73</td>
<td>0.55</td>
<td>11</td>
<td>-</td>
</tr>
<tr>
<td>C,D at 5%</td>
<td>2.13</td>
<td>2.78</td>
<td>0.37</td>
<td>0.34</td>
<td>70</td>
<td>234</td>
<td>NS</td>
<td>35</td>
<td>-</td>
</tr>
</tbody>
</table>

**Interaction (D x S)**

<table>
<thead>
<tr>
<th>S, Em. ±</th>
<th>Number of seeds/Capsule</th>
<th>Test weight (g)</th>
<th>Seed Yield (kg/ha)</th>
<th>Stover Yield (kg/kg)</th>
<th>Oil content (%)</th>
<th>Oil yield (kg/ha)</th>
<th>Total cost of cultivation (₹/ha)</th>
<th>Net realization (₹/ha)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>S, Em. ±</td>
<td>1.91</td>
<td>2.52</td>
<td>0.28</td>
<td>0.28</td>
<td>60</td>
<td>207</td>
<td>2.32</td>
<td>28</td>
<td>-</td>
</tr>
<tr>
<td>C,D at 5%</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>Sig.</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(D1: Third week of October, D2: Forth week of October, D3: First week of November, D4: Second week of November, S1: 20 cm × 5 cm, S2: 30 cm × 5 cm, S3: 40 cm × 5 cm)

### Table 2: Seed yield and economics of linseed influenced by interaction effect of sowing dates and spacing

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Seed Yield (kg/ha)</th>
<th>Total cost of cultivation (₹/ha)</th>
<th>Net realization (₹/ha)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>D,S1</td>
<td>1140</td>
<td>16370</td>
<td>64029</td>
<td>3.91</td>
</tr>
<tr>
<td>D,S2</td>
<td>1198</td>
<td>16370</td>
<td>67998</td>
<td>4.15</td>
</tr>
<tr>
<td>D,S3</td>
<td>1093</td>
<td>16370</td>
<td>60571</td>
<td>3.70</td>
</tr>
<tr>
<td>D,S1</td>
<td>1163</td>
<td>16370</td>
<td>65680</td>
<td>4.01</td>
</tr>
<tr>
<td>D,S2</td>
<td>1227</td>
<td>16370</td>
<td>70035</td>
<td>4.28</td>
</tr>
<tr>
<td>D,S1</td>
<td>1197</td>
<td>16370</td>
<td>67955</td>
<td>4.15</td>
</tr>
<tr>
<td>D,S1</td>
<td>1429</td>
<td>16370</td>
<td>84240</td>
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</tr>
<tr>
<td>D,S2</td>
<td>1242</td>
<td>16370</td>
<td>71144</td>
<td>4.35</td>
</tr>
<tr>
<td>D,S3</td>
<td>1146</td>
<td>16370</td>
<td>64439</td>
<td>3.94</td>
</tr>
<tr>
<td>D,S1</td>
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<td>16370</td>
<td>76448</td>
<td>4.67</td>
</tr>
<tr>
<td>D,S2</td>
<td>1239</td>
<td>16370</td>
<td>70892</td>
<td>4.33</td>
</tr>
<tr>
<td>D,S3</td>
<td>1188</td>
<td>16370</td>
<td>67379</td>
<td>4.12</td>
</tr>
<tr>
<td>S, Em. +</td>
<td>44</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C,D at 5%</td>
<td>129</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Conclusion

Finally it is concluded that for obtaining potential yield and profit from linseed local variety could be obtained by sowing of linseed either during 1st week of November or 2nd week of November along with spacing 20 cm × 5 cm.

### References


