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Research Paper

Effect of sowing environments and genotypes on growth and yield of linseed (*Linum usitatissimum*)

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ABSTRACT

An experiment was conducted during the winter *(rabi)* season of 2010–11 and 2011–12 at Chatha, Jammu, to study the effect of genotypes and sowing time on yield, yield components and development rates of linseed (*Linum usitatissimum* L.). The treatments comprised of 4 sowing dates, viz. 20 October, 30 October, 10 November and 20 November in main plots and 4 varieties ('LC 2023', 'LC 2063', 'LC 54' and 'Local variety') in sub-plots, replicated thrice in a split-plot design. Sowing dates as well as varieties significantly affected growth characters; yield attributes and yields in both the years. Sowing on 20 October during both the seasons was the most optimum time, as it recorded the maximum seed yield of 1.11 t/ha. Sowing on 20 October also gave the highest net returns (₹11,701/ha) and benefit: cost ratio of 1.47. Sowing of linseed on 20 October remained superior to later sowing dates by recording 9.9, 21.9 and 33.7% higher seed yield. Linseed varieties differed significantly for yield attributes and yield in both the seasons. The highest number of capsules/plant, seeds/capsule and 1,000-seed weight, seed and stover yields were given by 'LC 2063' in both the seasons. The results indicated that variety 'LC 2063' exceeded 'LC 2023', 'LC 54' and 'Local' ones in terms of seed yield by 9.0, 17.2 and 31.3%, respectively. All yield components were significantly influenced by weather as represented by the year of sowing. The environmental factors most likely to affect yields were temperature and sunshine hours due to their effect on development rate. Highly significant positive correlation was observed in linseed seed yield with capsules/plant, seeds/capsule, 1,000-seed weight, biological yield and harvest index. The character like biological yield had maximum positive direct effect on economic yield followed by seeds/capsule.

***Key words*:** Linseed, Sowing dates, Yield components

Linseed is globally cultivated for its fibres and is called flax. Its fibre is used for the manufacture of linen. Flax fibres are amongst the oldest fibre crops in the world after silk (Narayan, 1987). The stem yields fibre of good quality having high strength and durability. Weather-resistant fibre is lustrous and blends very well with wool, silk, cotton, *etc*. Strong twines, canvas, suiting, shirting and various indispensable products for defense purposes are manufactured from it. Woody matter and short fibres may be used as raw pulp for making paper of quality comparable with that of currency notes (Husain *et al.,* 2009). The rough and strong linseed fibre can effectively be used for low-cost roofing tiles based on convertible polymers and for fibre-reinforced plastic (FRP). Every part of the linseed plant is utilized commercially, either directly or after processing. Linseed seeds contain 33–47% of oil. On a very small scale, the seed is directly used for edible purposes. About 20% of the total oil produced is used at farmers' level, and the rest 80% oil goes to industries in various forms. The oil is rich (>66%) in linolenic acid, and is a perfect drying oil. Hence it is utilized in the manufacture of paints, oil cloth, varnish, pad-ink, printed ink, linoleum, *etc*. Linseed oil is the richest plant source of linoleic (omega-6) and linolenic (omega-3) polyunsaturated fatty acids (PUFA), which are essential fatty acids for humans since they cannot be synthesized in the organism and must be obtained from food and has several human health benefits (Saghayesh *et al.*, 2014).

Linseed is one of the important crops of the world cultivated on over 2.49 million ha during 2012–13. The important linseed-growing countries are India, Canada, China, the USA and Ethiopia. India occupies second position in area after Canada in the world, but stands at third place in production, with poor productivity of 502 kg/ha

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(CSAUAT, Kanpur, 2013). It is grown in our country under both rainfed and irrigated conditions, as an important winter (*rabi*) season oilseed crop, next to rapeseed and mustard in economic importance.

In Jammu region of Jammu and Kashmir state, the area under linseed cultivation is very meagre with poor productivity of 565 kg/ha (Anonymous, 2014). The reason for low productivity is poor management practices and lack of knowledge among the farming community regarding various sowing dates. However, this trend of poor productivity can be reversed by adopting improved agronomic practices like substitution of traditional varieties with new high-yielding ones, knowing the optimum time of sowing, using proper seed rate and other inputs like fertilizers and manures, *etc*. Linseed crop under semi-arid region when sown earlier encountered favorable environmental conditions resulting in significantly high economic yield as compared to other sowing dates (Saghayesh *et al*., 2014). Optimal sowing time is a great management option to lessen the negative aspects of temperature (Mirshekari *et al.,* 2012). In Jammu region not much work has been done on linseed crop, as generally the farming communities raise low yielding local variety. Therefore, it becomes imperative to undertake the study to find out the optimum sowing time for new improved varieties.

MATERIALS AND METHODS

A field experiment was conducted during the rainy *(kharif)* and winter *(rabi)* seasons of 2010–11 to 2011–12, at Research Farm of Sher-E-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus, Chatha (32°40', longitude of 74°58' and at an altitude of 320 meters above mean sea level). The mean annual rainfall of Jammu is 1,147 mm and more than 80% generally occurs during south-west *monsoon* season (July–September). The rainfall received during 2010–11 crop season was slightly higher than that received during 2011–12. The soil of the experimental field was sandy clay loam, slightly alkaline in nature (*p*H 7.8), low in organic C and available N (214 kg/ha) and medium in available P (13.8 kg/ha) and K (129.8 kg/ha). The experimental layout was under fodder crop for 2 seasons before sowing of experimental crop.

Maize crop 'Kanchan 517' was raised during *kharif* seasons of 2010 and 2011, as a uniform blanket crop without any treatments imposed. In the succeeding *rabi* seasons, linseed crop was taken up. The treatment combinations comprised of 4 dates of sowing, i.e. 20 October, 30 October, 10 November and 20 November in the main plots and 4 linseed varieties, viz. 'LC 2023', 'LC 2063', 'LC 54' and 'Local', in the subplots. The experiment was arranged in split-plot design with 3 replications. Maize and linseed crops were sown with seed rates of 15 and 25 kg/ha respectively. The spacing adopted were 60 cm × 20 cm for maize and 30 cm × 10 cm for linseed. The recommended dose of N: P: K fertilizer for linseed crop was 50:30:20 kg/ha, whereas maize crop was fertilized with N: P: K @ 90:60:30 kg/ha respectively, using urea, diammonium phosphate and muriate of potash as source of fertilizers. Full dose of P and K along with half of N were applied as basal to both the crops and remaining N was applied in 2 splits at 30 and 60 days after sowing (DAS) to linseed crop and at 25 and 45 DAS to maize crop. The different weather parameters were recorded during crop-growth period in both the years. The maximum and minimum temperatures recorded were in the range of 15 to 35°C and 3 to 20°C, respectively. The total evaporation observed was 547.0 and 487.2 mm, while total rainfall of 290.0 and 214.4 mm was recorded in the crop-growth season during 2010–11 and 2011–12, respectively. Relative humidity in the morning (RH1) found to be in the range of 54–97 and 68–93%; however, evening (RH2) were found to be in the range of 25–83 and 25–69% during 2010–11 and 2011–12, respectively. Data on various yield attributes, seed and stover yields of maize and linseed were calculated as per the standard procedures. Both the crops were irrigated as and when required.

To have better insight of the impact of different weather variables like temperature, relative humidity, vapour pressure, evaporation, sunshine hours and rainfall on different crop growth stages; a correlation study was done and the correlation coefficient of the weather variables, prevailed at different phenophases, viz. PS1-Emergence to flowering; PS2-flowering to capsule formation and PS3-capsule formation to maturity were assessed and tabulated. Similarly, correlation among the growth and yield attributes, seed yield, biological yield and harvest index was also done and correlation coefficient were assessed and tabulated.

RESULTS AND DISCUSSSION

Growth and yield-attributing characters

The linseed sown on 20 October showed better growth and yield-attributing characters, resulting in significantly higher yield over the other sowing dates in comparison. Yield- attributing characters like capsules/plant, seeds/capsule and 1,000-seed weight were significantly more when linseed sown on 20 October than other delayed sowing dates, *i.e.* 10 and 20 November, but remained at par with the linseed sown on 30 October, during both the years (Table 1). Mohapatra *et al.* (2009) also reported similar results.

The better growth of linseed which resulted in higher values of yield-attributing characters under earlier sowing dates, *i.e*. 20 and 30 October, may be on account of

favourable meteorological factors like temperature, relative humidity, rainfall, *etc*. during early sowing dates. Flax grows best under moderate to cool conditions, particularly during seed filling. High temperature during the ripening phase reduces the number of seeds/capsule, seed weight, but also decreases oil yield and quality (Dybing and Zimmerman, 1965). Hence, temperature was the main environmental factor that reduced linseed yield. Temperature has pronounced effect on the agronomic factors-sowing time and seed rates. Hence, sowing time is certainly among the key agronomic decisions which results in producing higher growth and yield of linseed.

Among the varieties, 'LC 2063' recorded significantly more capsules/plant, seeds/capsule and 1,000-seed weight than the other varieties (Table 1).

Seed and stover yields

Seed and stover yields of linseed were found to be superior when the linseed was sown on 20 October than 10 and 20 November sown linseed but remained statistically at par with linseed sown on 30 October. The higher yield under earlier sowing dates may be because of better growth and yield attributes which ultimately resulted in higher seed and stover yields (Table 2). These findings are corrugrous with those of Al-Doori (2012). Mathur *et al.* (1984) also reported that good crop of linseed was obtained when sowing was done during the last week of October to mid-November. This may be because crop gets sufficient time for its growth and development under suitable climatic conditions. However, late-sown conditions had shorter growing periods and hence fewer numbers of

Table 1. Effect of sowing dates and varieties on growth and yield attributes of linseed (pooled data of 2 years)

Treatments	Plant height (cm)	Branches/ plant	Capsules/ plant	Seeds/ capsule	1,000-seed weight (g)
Dates of sowing					
20 October	71.3	8.16	44.76	7.22	8.31
30 October	68.5	7.57	42.28	6.89	8.30
10 November	62.1	7.06	37.41	6.08	7.66
20 November	60.2	6.08	35.59	5.52	7.14
SEm±	2.8	0.20	0.75	0.11	0.15
CD (P=0.05)	8.6	0.68	2.58	0.37	0.52
Variety					
'LC 2023'	66.4	7.38	40.87	6.70	7.97
'LC 2063'	70.0	7.92	43.17	6.97	8.35
'LC 54'	63.7	7.00	39.29	6.19	7.70
'Local'	59.5	6.56	36.70	5.85	7.39
SEm±	0.8	0.07	0.32	0.03	0.05
CD (P=0.05)	2.5	0.20	0.93	0.10	0.14

Table 2. Effect of sowing dates and varieties on yield and economics of linseed (pooled data of 2 years)

Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Dates of sowing						
20 October	1.10	2.12	34.4	11,217	15,843	1.41
30 October	1.02	1.90	34.7	11,217	13,610	1.21
10 November	0.91	1.62	36.3	11,217	11,376	1.01
20 November	0.83	1.50	35.5	11,217	9,517	0.85
SEm±	0.03	0.08	0.57	–	441	–
CD (P=0.05)	0.09	0.26	NS	–	1,522	–
Variety						
'LC 2023'	1.00	1.87	34.9	11,273	13,342	1.18
'LC 2063'	1.09	2.05	34.8	11,273	15,305	1.36
'LC 54'	0.93	1.72	35.2	11,273	11,949	1.06
'Local'	0.83	1.48	35.9	11,050	9,751	0.88
SEm±	0.03	0.02	0.58	–	394	–
CD (P=0.05)	0.08	0.08	NS	–	1151	–

capsules. The shorter period from first flowering to harvest may have resulted in insufficient time for proper grain filling and development.

Regarding the varieties, 'LC 2063' gave significantly higher seed and stover yields than the other varieties tested, *viz*. 'LC 2023', 'LC 54' and 'Local'. Better seed and stover yields of variety 'LC 2063' may be on account of better growth and yield attributes of this variety, which may be genotypic character of this variety, suitable for sub-tropical conditions of Jammu (Table 2).

Economics

Significantly higher net returns were obtained from linseed sown on 20 October than that sown on 10 and 20 November, but were statistically similar with the linseed sown on 30 October (Table 2). This was owing to higher seed and stover yields from the same treatment which finally led to higher income. Mohapatra *et al.* (2009) and Husain *et al.* (2009) also reported higher net returns from earlier sowing date.

Correlation

The correlation coefficient between yield and yield parameters were highly significant and positive (Table 3). Highly significant and positive correlation was observed in seed yield with capsules/plant, seeds/capsule, biological yield and harvest index. These findings are in the agreement with the results of Mirshekari *et al.* (2012). Jain (2011) also observed positive correlation of 1,000-seed weight with biological yield, economical yield and harvest index on linseed crop.

The correlation analysis of relations among seed yield and weather parameters during different phenophases, *viz*. emergence to flowering (PS1), flowering to capsule formation (PS2) and capsule formation to maturity (PS3) revealed that seed yield had a significantly positive correlation with all the maximum and minimum temperature, vapour pressure during PS1 and PS2 but was negatively correlated during PS3 stage. The negative correlation during PS3 stage clearly indicates that high temperature during this stage significantly inhibited the import of photosynthates and thereby decreased the sink strength (Table 4).

Thus based on the study it was found that optimum sowing time for linseed crop is 20 October which can be extended up to 30 October without significant reduction in yield, however, further delay in sowing to 10 and 20 November recorded significant reduction in yield to the tune of nearly 21.9 and 33.7%, respectively. Among the varieties tested 'LC 2063' performed better than other varieties and recorded approximately 31.3% increase in yield over 'Local'.

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Table 3. Correlation coefficients for the effect of sowing dates and varieties on yield attributes and yield of linseed crop

	Plant height	Primary branches	Capsules/ plant	Seeds/ capsule	1,000 seed weight	Seed yield	Biological yield	Harvest index
Plant height	1.00							
Primary branches	–0.28	1.00						
Capsules/plant	–0.13	0.45*	1.00					
Seeds/capsule	–0.007	0.65**	0.61**	1.00				
1,000-seed weight	0.57**	0.20	0.06	0.05	1.00			
Seed yield	0.40*	0.50*	0.90**	0.83**	0.46*	1.00		
Biological yield	0.72**	0.59**	0.59**	0.72**	0.68**	0.85**	1.00	
Harvest index	–0.22	0.43*	0.81**	0.84**	0.47*	0.88**	0.63**	1.00

* P=0.05; ** P=0.01

Table 4. Correlation coefficients for effect of weather parameters during different phenophases on seed yield of linseed crop

Pheno Phase	Max. Temperature	Min. Temperature	Relative humidity (Morning)	Relative humidity (Afternoon)	Vapour pressure (Morning)	Vapour pressure (Afternoon)	Pan evaporation	Sunshine hours	Rainfall
PS1	0.89**	0.93**	–0.75**	–0.62**	0.76**	0.68**	0.81**	0.92**	0.79**
PS2	0.81**	0.87**	–0.26	–0.59*	0.81**	0.73**	0.76**	0.19	–0.87**
PS3	–0.63**	–0.74**	–0.81**	–0.71**	–0.67**	–0.82**	0.85**	–0.73**	0.89**

PS1, Emergence to flowering; PS2, flowering to capsule formation; PS3, capsule formation to maturity

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