EFFECT OF SPACING AND PLANT GROWTH REGULATORS ON GROWTH AND YIELD OF LINSEED (*Linum usitatissimum*)

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ABSTRACT: The field experiment was conducted during *rabi* season of 2021 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), low in organic carbon (0.91%), available N (301.26 kg/ha), available P (37.23 kg/ha) and available K (271.47 kg/ha). The treatments consisted of two spacings (20 cm x 5 cm and 30 cm x 5 cm) and two plant growth regulators with twolevels each (Gibberellic acid at 125 ppm and 250 ppm; Indole acetic acid at 1 ppm and 3 ppm) and one control plot, respectively. The experiments were laid out in randomized block design with nine treatments and were replicated thrice. Results defined that maximum plantheight (52.25 cm), dry weight per plant (8.93 g), capsules/plant (49.93), test weight (7.14 g),seed yield (1.48 t/ha), stover yield (3.19 t/ha) and harvest index (35.69%) were recorded withapplication of 20 cm x 5 cm + GA_3 at 250 ppm. However, crop growth rate (10.31 g/m^2/day)and seeds/capsule (8.13) was obtained maximum values in 30 cm x 5 cm + GA_3 at 250 ppmand relative growth rate (0.0160 g/g/day) was in 30 cm x 5 cm + IAA at 3 ppm. Maximum gross returns (INR. 94,198.71/ha), net returns (INR. 66,698.71/ha) and benefit: cost ratio (2.43) was obtained highest in the treatment combination of 20 cm x 5 cm + GA_3 at 250 ppm. Whereas, lowest gross returns (INR. 75,588.31/ha), net returns (INR. 49,663.31/ha) and benefit: cost ratio (1.92) was noticed in control plot, respectively.

Keywords: Economics, GA_3, IAA, Seed yield, Stover yield

In the world, linseed occupies an area of 26.25 lakh hectares with production of 26.54lakh tonnes with an average productivity of 1011 kg/ha (Annual Report 2016-17). Canada is the largest producer of linseed shares approximately 33% followed by China (20%), United States (16%) and India (11%). In the world, India ranks third and fourth with respect to area (10.81%) and production (5.31%) of linseed, respectively (Annual report 2016-17). In India, linseed is chiefly grown under rainfed (63%), Utera (25%) and irrigated (12%) with limited input. At present, linseed occupying about 2.63 lakh hectares area with a contribution of 1.25 lakh tonnes production and its average productivity is 477 kg/ha (Annual report 2016-17). Yield is influenced by many factors viz. temperature, atmospheric humidity, soil conditions etc. and agronomy is the science of providing favourable environment to crop production by manipulation of micro climates in the crop field by soil preparation, fertilization, irrigation, spacing, etc. Among them, row spacing plays an important role in increasing production per unit area. Spacing is dependent upon the expected growth of a particular crop and variety in a given agro-climatic condition.

MATERIAL AND METHODS

The details of the experimental materials and methods were summarized here under the following headings.

Experimental site, Weather and climate, Soil properties, Cropping history of experimental site, Experimental details, Details of raising the test crop, Cultural operations, Pre-harvest observations, Post-harvest observations, Economic analysis and Statistical analysis were worked out.

Experimental site

The field experiment was carried out during *rabi* season of 2021 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25.57^0 N latitude, 87.19^0 E longitude and at an altitude of 98 m above mean sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Prayagraj city. All the facilities required for crop cultivation were available.

Soil properties

The soil of the experimental field constituting a part of central Gangetic alluvium andis neutral and deep. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorus and low in potassium. The soil samples were collected randomly from 5 spots at 0 to 15 cm depth of the experimental field just before layout of experiment. Field layout plan of experimental field is indicated below.

Details of layout

Design of experiment	:
Total number of treatments	:
Total number of replications	:
Total number of plots	:
Size of each plot	:
Width of main irrigation channel	:
Width of sub-irrigation channel	:
Width of each bund	:
Total length of experimental field	:
Total width of experimental field	:
Gross cultivated area	:
Net cultivated area	:

Experimental factorsFactor I: Spacing

- 20 cm x 5 cm
- 30 cm x 5 cm

Factor II: Plant growth regulators

- Gibberellic acid – 125 ppm
- Gibberellic acid – 250 ppm
- Indole acetic acid – 1 ppm
- Indole acetic acid – 3 ppm

Treatment combinations

1. 20 cm x 5 cm + GA_3 at 125 ppm
2. 30 cm x 5 cm + GA_3 at 125 ppm
3. 20 cm x 5 cm + GA_3 at 250 ppm
4. 30 cm x 5 cm + GA_3 at 250 ppm
5. 20 cm x 5 cm + IAA at 1 ppm
6. 30 cm x 5 cm + IAA at 1 ppm
7. 20 cm x 5 cm + IAA at 3 ppm
8. 30 cm x 5 cm + IAA at 3 ppm
9. Control

Statistical analysis

The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance (Skeleton). The significance and non- significance of the treatment effect were judged with the help of 'F' variance ratio test. Calculated 'F' value (variance ratio) was compared with the table value of 'F' at 5% level ofsignificance.

RESULTS AND DISCUSSION

The mean data of plant height of linseed recorded at 20, 40, 60, 80, 100 DAS and atharvest stage as influenced by different spacing and plant growth regulators were presented in Table 4.1. Plant height gradually increased with the advancement of crop age and reached maximum till harvest stage.

At 20 DAS, highest plant height (13.30 cm) was observed in 20 cm x 5 cm + GA_3 at 125 ppm and the lowest was obtained in 20 cm x 5 cm + IAA at 1 ppm (10.70 cm). There was no significant difference among the treatments.

At 40 DAS, no significant difference was found in all of the treatments. However, highest plant height (11.83 cm) was observed in 1.5 kg B/ha + 1 kg Mo/ha and lowest plant height (19.31 cm) was observed in 30 cm x 5 cm + GA_3 at 250 ppm.

At 60 DAS, significantly higher plant height (37.38 cm) was recorded in 20 cm x 5 cm + IAA at 3 ppm. However, treatment 20 cm x 5 cm + GA_3 at 250 ppm (36.73 cm) were noticed statistically at par with treatment 20 cm x 5 cm + IAA at 3 ppm.

At 80 DAS, a significant difference found among the treatments. Significantly higher plant height (43.86 cm) was observed in 30 cm x 5 cm + GA_3 at 250 ppm and at par was observed in 20 cm x 5 cm + IAA at 3 ppm and 30 cm x 5 cm + IAA at 3 ppm (41.21 and 41.52 cm).

At 100 DAS, higher plant height (48.67 cm) was obtained in 20 cm x 5 cm + GA_3 at 250 ppm significantly. However, at par value of plant height (46.05 and 45.26 cm) was obtained in 30 cm x 5 cm + GA_3 at 250 ppm and 20 cm x 5 cm + IAA at 3 ppm, respectively.

At final harvest stage, obviously maximum plant height (52.25 cm) is recorded in 20 cm x 5 cm + GA_3 at 250 ppm and at par values was noticed in the treatment 30 cm x 5 cm + GA_3 at 250 ppm (51.78 cm), respectively.

Higher plant height might be due to unavailability of sufficient space and sunlight might be make the plant longer in search of sunlight, which make the plant longer in narrow spaced crops. Increased in plant height might be along with GA_3 which stimulate organ growth through enhancement of cell elongation and cell division by inducing mitotic division and auxin positively influence GA_3, to promote cell elongation and increase plant length. Saied *et al.* (2018) also observed that mixture of more than one growth hormone increased plant height (8.3%). Almost same result was found by Mukadam and Chandrashekar (2015).

Dry weight (g)

The data pertaining to dry weight of a plant which was recorded at 20, 40, 60, 80, 100 DAS and at harvest were depicted in Table 4.2. Initially at 20 and 40 DAS interval, dry weight was found non-significant. However, dry weight from 60 DAS onwards obtained a significant difference.

At 20 DAS, highest dry weight (0.75 g) was observed in 20 cm x 5 cm + IAA at 3 ppm and the lowest dry weight (0.64 g) was obtained in 30 cm x 5 cm + GA_3 at 125 ppm. There was no significant difference among the treatments.

At 40 DAS, the highest dry weight (1.79 g) was observed in 30 cm x 5 cm + IAA at3 ppm and the lowest dry weight (1.49 g) was obtained in 20 cm x 5 cm + GA_3 at 125 ppm.

At 60 DAS, the significantly higher dry weight (3.82 g) was observed in 20 cm x 5 cm + IAA at 3 ppm and which was at par with 20 cm x 5 cm + GA_3 at 250 ppm and 30 cm x 5 cm + GA_3 at 250 ppm (3.61 and 3.58 g).

At 80 DAS, there was a significant increase in dry weight. The maximum dry weight(5.51 g) was observed in 20 cm x 5 cm + GA_3 at 250 ppm. However, treatments of 30 cm x 5cm + GA_3 at 250 ppm and 20 cm x 5 cm + IAA at 3 ppm (5.19 and 5.03 g) was found to be atpar with the treatment of 20 cm x 5 cm + GA_3 at 250 ppm.

At 100 DAS, dry weight was significantly higher in 20 cm x 5 cm + GA_3 at 250 ppm(6.90 g). However, treatments with 30 cm x 5 cm + GA_3 at 250 ppm and 20 cm x 5 cm + IAAat 3 ppm (6.26 and 6.37 g) were statistically at par to the

treatment of 20 cm x 5 cm + GA_3 at 250 ppm.

At harvest, significantly higher dry weight (8.93 g) was observed in 20 cm x 5 cm +GA_3 at 250 ppm where 30 cm x 5 cm + GA_3 at 250 ppm, 20 cm x 5 cm + IAA at 3 ppm and 30 cm x 5 cm + IAA at 3 ppm (8.58, 8.27 and 8.11 g) was found to be at par with the 20 cmx 5 cm + GA_3 at 250 ppm.

The significant improvement in the biomass per plant at each of the growth stage seems to be due to profuse branching indicating the ability of plant to generate leaf area continuously for longer period. These improvements might have increased leaf area index thereby greater photosynthetic activity and finally dry matter accumulation. It is generally considered that all over growth of the plant is the balance between photosynthesis and respiration. Adequate moisture supply under higher rate and frequent application of irrigation which ultimately increased plant height and dry matter accumulation and the result is in close conformity with Ram *et al.* (2001), Chauhan *et al.* (2008), Ahlawat and Gangaiah (2010) and Mirshekari *et al.* (2012). Increase in dry matter accumulation under foliar application of GA_3 at 250 ppm might be due to GA_3 which enhanced the source-sink relationship in the plant and induced photo-assimilate translocation in the plant. Khan and Khan (2016) also reported applications of IAA on soybean increased stem and total dry weight. The similar outcome was corroborated by Khan *et al.* (2009). Same study done by Saied *et al*. (2018) on mustard (cv. BINAsarisa-6) and revealed that application of GABA is a mixture of more than one growth hormone) increased total dry mass (22.2%) over the control.

Table-1: Effect of spacing and plant growth regulators on plant height of linseedTreatments

	Plant height (cm)					
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**At harvest**
20 cm x 5 cm + GA_3 at 125 ppm	13.30	20.88	32.91	38.19	42.20	47.09
30 cm x 5 cm + GA_3 at 125 ppm	12.54	21.07	34.08	37.33	40.44	46.65
20 cm x 5 cm + GA_3 at 250 ppm	11.98	22.51	36.73	38.99	48.67	52.25
30 cm x 5 cm + GA_3 at 250 ppm	12.89	19.31	34.63	43.86	46.05	51.78
20 cm x 5 cm + IAA at 1 ppm	10.70	21.55	32.51	38.07	42.18	49.41
30 cm x 5 cm + IAA at 1 ppm	12.06	24.00	34.98	37.56	40.43	47.41
20 cm x 5 cm + IAA at 3 ppm	12.09	24.73	37.38	41.21	45.26	49.85
30 cm x 5 cm + IAA at 3 ppm	11.00	20.34	34.38	41.52	42.51	49.45
Control	12.77	23.55	31.71	34.84	39.37	45.00
F-Test	NS	NS	S	S	S	S
SEm±	0.80	1.46	0.49	1.61	1.84	0.69
CD (P=0.05)	-	-	1.47	4.83	5.51	2.07

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