

**ENHANCEMENT OF PRODUCTION AND PROFITABILITY OF FLAX BY  
FOLIAR APPLICATION OF PLANT GROWTH REGULATING  
HORMONES**

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**ABSTRACT**

**Aims:** An agricultural experiment was carried out to study the effect of growth hormones. Linseed is commonly known as flax or Alsi or Tissi is a important rabi oilseed crop next to rapeseed-mustard in India. Linseed is a hardy crop which requires less amount of additional fertilization as compared to rapeseed-mustard. Proper use of nutrients along with foliar spray of growth regulating hormones can boost up the productivity of the crop as they help in biochemical processes of the plant and stimulates stem elongation, increases dry weight and yield.

**Study design:** The experiment was laid out in randomized block design with eight different treatments in three replications.

**Place and Duration of Study:** The experiment was carried out during rabi season of 2018-19, 2019-20 and 2020-21 at Experimental unit of Zonal Research Station, Shillongani, Assam.

**Methodology:** In our study we incorporated eight different treatment combinations of plant growth regulating hormones mainly auxin, gibberellic acid, salicylic acid, Tebuconazole and including control i.e. water spray.

**Results:** Amongst all the treatments foliar application of 1.0 ppm Auxin + 200 ppm Gibberellic acid resulted in better seed yield (985 kg/ha) and gave higher net monetary return (Rs. 35915.6/ha) and benefit cost ratio (2.9) in all the three consecutive years of experiment as well as in pooled result.

*Keywords: Auxin, Flax, Foliar application, Hormone*

**1. INTRODUCTION**

Linseed (*Linum usitatissimum*) is an erect annual herbaceous rabi oilseed crop next to rapeseed-mustard in India. It belongs to Linaceae botanical family. It has higher nutritional value because it contains fat (41%), protein (20%), dietary fibres (28%), linoleic and omega-3 fatty acids, which regulate blood flow, lower cholesterol, prevent coronary complications and provide the body with anti-carcinogenic properties. Linseed oil has a high percentage of unsaturated fatty acids and used in paints varnishes, printed inks, coating oils, and soaps due to quick-drying properties. Linseed fibre is used in making high quality writing paper, cigarette paper, currency paper. India's ranks 4th in terms of total area coverage and 3rd in total production followed by Canada and Russia (Annual Report, AICRP

on linseed, 2019-20). The total area of linseed in Assam is around 5000 ha with a productivity of 628 kg/ha (Agril. Statistics of Assam).

An increase in demand of flax seed or oil and by-products was seen in last few years, which has increase in present times due to its importance in industrial uses and health benefits. It has been noticed that the productivity of the crop is not up to the mark. The main reason of low yield is may be non-availability of high yielding variety to different agro-climatic zones. It requires very less amount of fertilizer but to cope up the global demand of linseed approaches to be made to increase the production and productivity. To tackle such global issue so as to increase productivity of flax the principal direction is the study of plant growth regulators, which are an integral part of the complex chemistry of crop production (Ahmad *et al.*, 2019).

Plant growth regulators (PGRs) are organic substance produced naturally by plant to regulate their growth and development at very low concentration. It is produced by plant itself but production of plant growth regulator is affected by biotic and abiotic factor, which cause constraint in the growth and development of plant through physiological process. Plant growth regulators can be successfully working to enhance the yield in the economically important oil seed crops (Harish *et al.*, 2021). Application of plant growth hormones to crop helps in metabolic processes and lead to visible changes in the course of development phases, shoot growth, the formation of an assimilation surface and the rhizosphere formation (Rohach *et al.*, 2020). They activate the main life processes of plants like membrane processes, cell division, respiration and nutrition processes. Furthermore, they contribute to increasing the biological and economic efficiency of crop production (Koutroubas and Damalas, 2016, Zhou *et al.*, 2020). The ultimate objective of our study was to set up a valid conclusion that by applying plant growth hormones there is a possibility of increasing productivity of linseed crop.

## 2. MATERIAL AND METHODS

The experiment was conducted at Research Farm of Zonal Research Station, Shillongani, Nagaon district of Assam during 2018-19, 2019-20 and 2020-21 under the affiliation of Assam Agricultural University, Jorhat, Assam. The experimental site was sandy loam in texture, lies within 26<sup>o</sup>21' N latitude and 90<sup>o</sup>45' E longitude with an elevation of 50.2 m mean sea level. The experiment was designed by choosing 'Shekhar' a high yielding variety of linseed. The experiment was conducted at the experimental field of AICRP on Linseed, Zonal Research Station, Shillongani, Assam during rabi season of 2018-19, 2019-20 and 2020-21. The highest rainfall was received during the year 2018-19 and maximum temperature was attained in 2020-21 (Fig1). The seeds were sown in three replications with randomized block design with seed rate of 20 kg/ha and spaced 25 cm between rows and 10 cm between plants. Four growth hormones auxin (IBA), salicylic acid, Tebuconazole and Gibberellic acid (GA) were used individually and in

combinations. The hormones were dissolved in water in different concentrations. The experiment was consisted of eight treatments as follows; G<sub>1</sub>: 1.0 ppm Auxin, G<sub>2</sub>: 1.0 ppm Auxin + 200 ppm GA, G<sub>3</sub>: 200 ppm GA, G<sub>4</sub>: 400 ppm GA, G<sub>5</sub>: 75 ppm Salicylic acid, G<sub>6</sub>: 0.1% Tebuconazole, G<sub>7</sub>: 2.0 ppm Auxin and G<sub>8</sub>: Control (water spray). Each experimental unit was size of 5.0 m x 3.0 m. Fertilizers 40:20:10 N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O kg/ha was applied as basal. Intercultural operations and plant protection measures were given as an when required. The hormonal treatments were sprayed to the crop at vegetative and at reproductive stages.

The growth characters like plant height in cm were recorded in randomly selected five numbers of plants from each unit and plant height was measured from base of the plant to tip of the plant and average was taken out. Accordingly, number of branches per plant was measured in randomly selected five numbers of plant from each unit at maturity stage and average was taken out. The plant population was recorded in three randomly selected 1 m<sup>2</sup> size spots from each unit and average was taken out and finally converted it to hectare.

Yield attributing character number of capsules per plant was recorded from five randomly selected plants at maturity stage and average was taken out. Number of seeds per capsule was measured at harvesting stage in ten randomly selected capsules and average was recorded. The seed yield (kg/ha) were computed based on seed weight per plot and computed for hectare. Economics of foliar application of growth hormones were worked out by using the current market price of inputs and linseed. The net return per hectare was worked out for all the treatments by subtracting the cost of cultivation from the gross return. B: C ratio was also calculated as ratio of gross return (Rs/ha) over cost of cultivation (Rs/ha). Statistical analysis of the recorded data was done by using OPSTAT (free online statistical software). The critical difference (CD) at the 0.05 level of probability was determined after two-way analysis of variance (ANOVA) in each case to compare the treatment means.

### **3. RESULTS AND DISCUSSION**

#### **1.1. Growth Attributes**

The data in table 1 revealed that the maximum plant height (68.2 cm) was attained under foliar application of 1.0 ppm Auxin + 200 ppm GA at flower initiation stage, in all three seasons. The minimum was recorded under control (60.9 cm). An observation of number of branches per plant under foliar application of 1.0 ppm Auxin + 200 ppm GA at flower initiation stage were recorded highest number (4.1 no./plant) and lowest branches were showed under control (3.1 no./plant). Plant growth regulators, foliar application of auxin 1 ppm and gibberellic acid 200 ppm at flower initiation stage were recorded maximum number of plant population per hectare (688.6 thousand/ha). However, the morphological characters did not show any significant variation. Plant growth regulator helps in several physiological processes within plant including stem elongation, shoot development. Hence, our research results testify to the fact that application of auxin and gibberellic acid helps

in increasing plant morphological characters, which is in close proximity with research findings of Sajjad *et. al.* 2014.

### **1.2. Yield attributes, Yield and Economics of the study**

Better yield attributes were accumulated from integrated use of auxin and gibberellic acid which resulted in better seed yield of linseed. The highest number of capsules per plant (97.3), number of seeds per capsule (9.2) and seed yield (985.9 kg/ha) were recorded in treatment receiving foliar application of 1.0 ppm Auxin + 200 ppm GA at flower initiation stage in all three seasons as well as in pooled estimation as shown in the table 2. The minimum average was recorded in control. The results are compatible with the research work of Harshit *et. al.* 2021. They also reported that during flower initiation stage one spray of 1.0 ppm Auxin + 200 ppm GA resulted in maximum yield attributes which ultimately increases the seed yield. The variation found in yield might be due to the fact that it was strongly influenced by various growth components, i.e., plant height, seeds/capsule, capsules/plant and branches/ plant. Combined doses of auxin and gibberellins were effective for the enhancement of tillers, secondary branches and capsules per plant, while auxin alone was effective for seeds per capsule (Faizanullah, B. A. and Nosheen, A. 2010 and Rahimi *et. al.* 2011).

Maximum net monetary return (Rs. /ha 35915.6) and benefit cost ratio (2.9) were recorded in treatment receiving foliar application of 1.0 ppm Auxin + 200 ppm GA at flower initiation stage in all three seasons as well as in pooled estimation as shown in the table 3. Moreover, the lowest value was recorded in control. This is due the seed yield was maximum in this treatment combination.

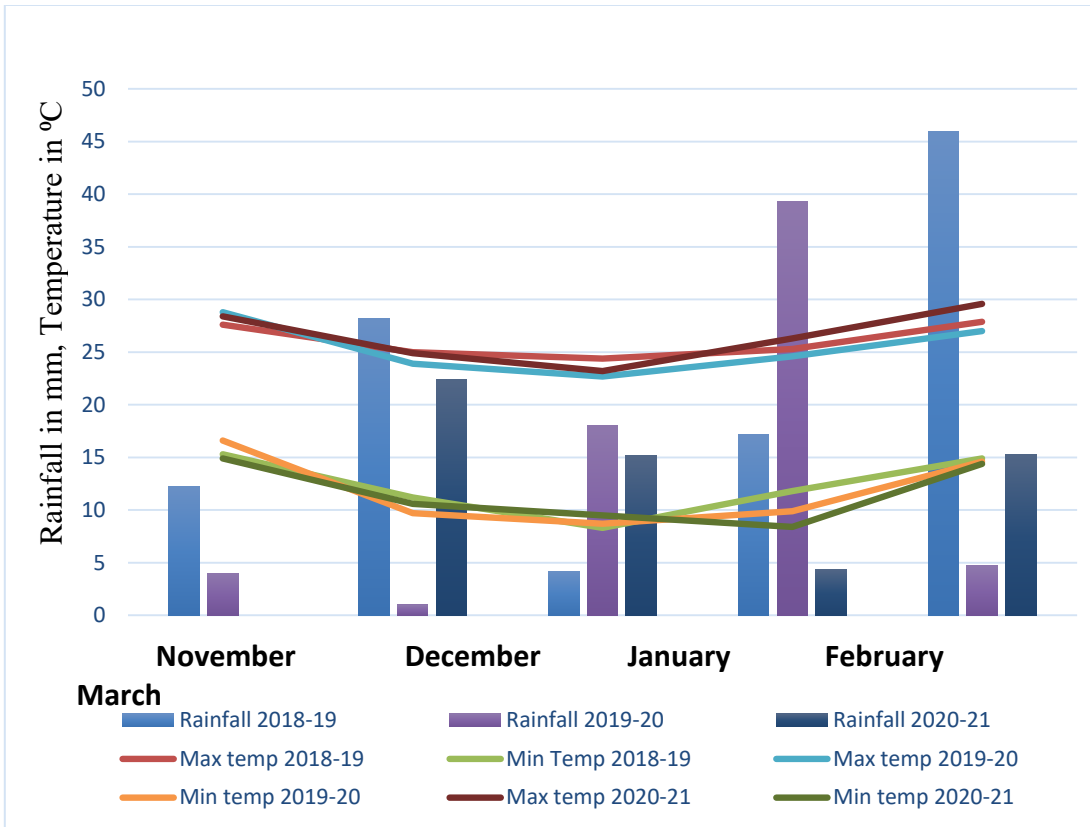


Fig 1: Weather parameters of three consecutive years during the crop season

UNDER REVIEW

**Table 1: Effect of growth regulating hormones in vegetative growth of linseed at Assam condition (3 years pooled)**

Treatment	Plant Height (cm)			Pooled	No. of branches/Plant			Pooled	Plant population'000/ha			Pooled
	2018-19	2019-20	2020-21		2018-19	2019-20	2020-21		2018-19	2019-20	2020-21	
	G <sub>1</sub>	70.7	53.5	70.0	64.7	3.3	2.1	5.8	3.7	766.0	607.0	515.0
G <sub>2</sub>	73.7	59.9	71.0	68.2	3.7	2.6	5.9	4.1	823.0	689.0	554.0	688.6
G <sub>3</sub>	70.8	55.3	68.0	64.6	3.2	2.6	5.8	3.9	722.0	624.0	491.0	612.3
G <sub>4</sub>	67.9	58.3	70.0	65.9	2.9	2.5	5.6	3.7	793.0	630.0	508.0	643.6
G <sub>5</sub>	69.7	49.1	68.0	62.3	2.9	2.2	4.8	3.3	700.0	654.0	522.0	625.3
G <sub>6</sub>	69.7	54.2	70.0	64.6	3.6	2.4	4.8	3.6	772.0	597.0	537.0	635.3
G <sub>7</sub>	71.1	52.7	68.0	63.6	3.4	2.3	5.5	3.7	730.0	669.0	520.0	639.6
G <sub>8</sub>	68.9	48.9	65.0	60.9	2.3	2.0	5.1	3.1	682.0	576.0	454.0	570.6
SEm±	2.7	3.7	1.4	1.5	0.5	0.2	0.8	0.3	41.4	33.3	37.8	21.5
CD 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV	6.7	11.8	3.6	7.0	15.7	15.9	14.7	15.1	9.6	9.2	12.7	10.2

**Table 2: Yield attributes and Yield of linseed influenced by growth regulating hormones (3 years pooled)**

Treatment	No. of capsule/Plant				No. of seed/capsule				Seed Yield (kg/ha)			Pooled
				Pooled				Pooled				
	2018-19	2019-20	2020-21		2018-19	2019-20	2020-21		2018-19	2019-20	2020-21	
G1	95.3	55.3	102.7	84.4	9.4	7.8	9.5	8.9	878.0	774.0	679.0	776.8
G2	100.0	64.5	127.3	97.3	9.4	8.5	9.6	9.2	1178.0	876.0	924.0	985.9
G3	97.5	49.3	101.0	82.6	9.4	7.9	9.5	8.9	850.0	609.0	617.0	692.0
G4	75.5	41.6	124.4	80.5	9.3	7.6	9.4	8.8	945.0	649.0	667.0	753.8
G5	86.7	44.3	112.7	81.2	9.3	7.8	9.5	8.9	889.0	679.0	732.0	766.7
G6	82.8	50.2	107.9	80.3	9.4	7.6	9.4	8.8	1023.0	749.0	711.0	828.0
G7	98.0	45.8	102.8	82.2	9.3	8.0	9.6	8.9	874.0	717.0	753.0	781.1
G8	64.3	38.3	88.7	63.7	9.2	7.4	9.4	8.6	639.0	567.0	513.0	573.0
SEm±	14.5	5.4	7.4	5.1	0.1	0.3	0.1	0.1	38.2	28.7	36.8	19.5
CD5%	NS	NS	22.4	14.0	NS	NS	NS	NS	115.8	86.8	111.6	54.1
CV%	28.7	19.2	11.7	18.9	1.5	6.2	2.0	3.5	7.1	7.1	9.1	7.5

**Table3: Effect of growth regulating hormones on NMR and B:C of linseed (3 years pooled)**

Treatment	Net Monetary Return (Rs/Ha)				Pooled	B:C			Pooled
	2018-19	2019-20	2020-21	2018-19		2019-20	2020-21		
	G1	29730.0	24010.0	18785.0		24175.0	2.6	2.3	
G2	46109.0	29499.0	32139.0	35915.6	3.5	2.6	2.7	2.9	
G3	27650.0	14395.0	14835.0	18960.0	2.4	1.7	1.8	1.9	
G4	32545.0	16265.0	17255.0	22021.6	2.6	1.8	1.9	2.1	
G5	29015.0	17465.0	20380.0	22286.6	2.4	1.8	2.0	2.1	
G6	36595.0	21525.0	19435.0	25851.6	2.8	2.0	1.9	2.2	
G7	28080.0	19445.0	21425.0	22983.3	2.4	1.9	2.1	2.1	
G8	17325.0	13365.0	10395.0	13695.0	1.9	1.7	1.5	1.7	
SEm±	1912.0	1283.0	1806.0	984.0	0.2	0.1	0.1	0.05	
CD5%	5792.0	1857.6	5472.0	4720.0	0.5	0.2	0.3	0.16	
CV%	15.1	22.5	31.3	21.3	12.5	6.8	9.6	8.3	

#### 4. CONCLUSION

The present research work clearly distinguished that growth regulating hormones alone or in combination have a positive effect on increasing seed yield as well as overall plant growth of linseed. Based on the three years of experimentation it can be concluded that foliar application of 1.0 ppm Auxin + 200 ppm GA at flower initiation stage is recommended for increasing productivity and profitability of linseed in Assam condition.

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