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Peddaveeri Pravalika Reddy
Department of Plantation, Spices, Medicinal and Aromatic Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

JK Hore
Department of Plantation, Spices, Medicinal and Aromatic Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Corresponding Author:
JK Hore
Department of Plantation, Spices, Medicinal and Aromatic Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Effect of growth substances on growth and yield of fenugreek (*Trigonella foenum-graecum* L.)

Peddaveeri Pravalika Reddy and JK Hore

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Abstract
The investigation was carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, during *rabi* season of two consecutive years *i.e.* 2016-17 and 2017-18. The variety 'Hissar Sonali' was selected for this study. The experiment comprising of three concentrations of five growth substances namely GA_3 (50,100 and150 ppm), NAA (25, 50 and 75 ppm), ethrel (100,150 and 200 ppm), maleic hydrazide (500, 1000 and 1500 ppm), thiourea (250,500 and 750 ppm) and control (water spray) were applied as foliar spray at 30 and 60 days after sowing. The experiment was laid out in Randomized block design with three replications. Among different treatments, shortest duration for 50% pod formation (61.28 days), maximum yield plot^{-1}(652.39g 3m^{-2}) and projected yield ha^{-1} (16.31q) were observed with NAA 75 ppm. Plants treated with GA_3 100 ppm recorded maximum number of seed pod^{-1} (15.18) and test weight (14.75 g). Maximum plant height (73.35cm) and primary branches (6.84) at 75 DAS were recorded with GA_3 150 ppm. thiourea 500 ppm recorded longest pod (12.56 cm). The control plants recorded projected yield of 12.38 q ha^{-1}. From yield maximization point of view the most effective treatment was NAA 75 ppm (16.31q ha^{-1}) followed by thiourea 250 ppm (15.69 q ha^{-1}) and ethrel 200ppm (15.46 q ha^{-1}) under alluvial plains of West Bengal for fenugreek production.

Keywords: Fenugreek, growth substances, growth, yield

Introduction
Fenugreek (*Trigonella foenum-graecum* L.) is an annual herbaceous multipurpose crop grown during winter season in North India. The seed is mainly used as condiment and in the pharmaceutical industry especially in preparation of ayurvedic medicines, while young plants are used as a vegetable and forage. In addition to high medicinal, pharmaceutical values fenugreek can be used as a high quality forage legume, a nitrogenous fixing cover crop and green manure in agricultural plantation [1, 2]. It is probably indigenous to eastern Mediterranean, West Asia and India [3]. Ethiopia is known to be the original homeland for fenugreek [4]. The major fenugreek producing countries are India, Pakistan, Bangladesh, Argentina, Egypt, France, Spain, Turkey, Morocco, Iran, Nepal, Ukraine and China [5]. Lack of proper management practices and good high yielding varieties, inadequate access of the seed of available HYVs to the growers leads to low productivity of these crops. The productivity can be increased, if a proper combination of the varieties and management are available to the growers. Plant growth regulators present a new possibility to break yield barrier, particularly imposed by the environment [6]. Application of tricontanol and naphthalene acetic acid (NAA) induces higher physiological efficiency including photosynthetic ability of plants. It leads to better growth and yield of several vegetables and agronomic crops without substantial increase in cost of production [7]. Effectiveness of plant growth regulators depends on several factors *viz*., concentration, method and time of application etc. Therefore, it is established fact that plant growth regulators in small quantity regulate various physiological processes [8] but information regarding the suitability of various plant growth regulators and their time of application for fenugreek is not available. Keeping *in view* the importance of plant growth regulators, the present investigation was undertaken to find out the suitable growth regulators and optimum concentration for maximization of yield of fenugreek.

Material and methods

The present research work was conducted at Horticultural Research Station, Mandouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during winter season of two consecutive years *i.e.*, 2016-17 and 2017-18. The climatic condition of the experimental site falls is sub-tropical sub-humid. The soil type was gangetic alluvial (Entisol) having soil pH 6.9, sandy clay loam texture with good water holding capacity, well drained with moderate soil fertility status. The experiment was laid out in randomized block design with three replication. Five growth regulators were included with three concentration namely GA_3 (50, 100 and 150 ppm), NAA (25, 50 and 75 ppm), ethrel (100, 150 and 200 ppm), maleic hydrazide (500, 1000 and 1500 ppm) and thiourea (250, 500 and 750 ppm). The control plots were sprayed with distilled water. The seeds were sown in the first week of November in the plots of 2 x 1.5 m at a spacing of 30 x 20 cm. A manurial dose of 15 t ha^{-1} of farmyard manure and 20 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1} were applied**.** Nitrogen was applied in two equal split dose *i.e.*, half basal and remaining dose at 30 days after the first application. The entire phosphorus and potassium were applied as basal. Growth regulators were applied as foliar spray as per the treatments at 30 and 60 days after sowing. The data were recorded on the morphological and yield attributing characters like plant height, primary branches at 75 days after sowing (DAS), days to 50% pod formation, length of pod, number of seeds pod^{-1}, test weight, seed yield $plot^{-1}$ and projected yield ha^{-1}.

Results and discussion

The growth and yield components of fenugreek as influenced by growth substances were presented in Table.1 and revealed that foliar application showed significant variation over control in all the observations recorded. The maximum plant height at 75 DAS (73.35 cm) was recorded in $GA_3$150 ppm followed by NAA 75 ppm (69.86 cm) and $GA_3$100 ppm (69.43 cm) as compared to minimum plant height (48.62 cm) under maleic hydrazide at 1500 ppm (shown in Fig.1). Since maleic hydrazide is an inhibitor, a reduction in plant height may be attributed due to reduction in cell division, cell enlargement, osmotic solute concentration in the cell, permeability of water, cell wall pressure and other activities [9] causing retardness. At 75 DAS, number of branches increasing with increasing of concentration in five growth substances. As represented in Table.1, Fig.2, maximum number of primary branches was recorded with GA_3 150 ppm (6.84 cm) followed by NAA 75 ppm (6.82 cm) and GA_3 100 ppm (6.58) against the lowest number of branches (5.49) in ethrel 100 ppm. Highest number of secondary branches was recorded in ethrel 200 ppm (6.24) followed by NAA 75 ppm (6.17) and maleic hydrazide 1000 ppm (6.12) as compared to lowest branches in thiourea 750 ppm (4.59). The data indicated that plants under NAA 75 ppm required minimum duration of 62.35 days for 50% pod formation while longest duration of 78.14 days in maleic hydrazide 1500 ppm followed by thiourea 750 ppm (76.32 days).

Table 1: Effect of growth substances on growth and yield attributes of fenugreek (pooled of two years)

Treatment	Plant height (cm)	No. of primary branches $plant^{-1}$	No. of secondary branches $plant^{-1}$	Days to 50% pod formation	Length of pod (cm)	No. of seeds pod^{-1}	Test weight (g)	Seed yield g $3m^{-2}$	Projected seed yield (q ha^{-1})
GA_3-50 ppm	64.48	6.24	5.26	64.13	8.93	14.26	13.65	542.08	13.55
GA_3-100 ppm	69.43	6.58	5.94	63.25	9.86	15.18	14.75	594.25	14.85
GA_3-150 ppm	73.35	6.84	5.76	67.29	9.24	14.64	14.52	532.96	13.32
NAA-25 ppm	61.56	6.16	5.81	64.92	8.68	14.05	13.56	518.35	12.96
NAA-50 ppm	63.24	6.57	6.05	62.35	9.68	14.82	14.12	611.23	15.28
NAA-75 ppm	69.86	6.82	6.17	61.28	10.29	15.06	14.46	652.38	16.31
Ethrel-100 ppm	58.24	5.49	5.32	67.25	8.72	13.74	13.26	529.68	13.24
Ethrel-150 ppm	61.79	5.86	5.76	63.16	9.45	14.36	13.92	590.75	14.76
Ethrel-200 ppm	67.35	6.12	6.24	64.92	10.41	14.64	14.38	618.47	15.46
MH-500 ppm	59.38	5.68	5.36	73.64	8.85	12.98	12.54	552.64	13.82
MH-1000 ppm	52.75	6.21	6.12	72.95	8.46	12.14	12.16	486.75	12.17
MH-1500 ppm	48.62	6.54	5.84	78.14	8.12	11.76	11.76	428.76	10.72
Thiourea-250 ppm	56.48	5.78	4.59	64.15	10.18	13.86	13.81	627.52	15.69
Thiourea-500 ppm	59.41	6.02	4.85	68.24	12.56	14.45	14.65	573.65	14.33
Thiourea-750 ppm	52.64	6.54	5.32	76.32	9.45	11.82	12.6	437.26	10.93
Control	57.83	5.62	4.69	67.38	8.32	12.62	12.34	495.36	12.38
S.Em (±)	0.567	0.058	0.053	0.636	0.089	0.129	0.127	5.086	0.127
CD (P=0.05)	2.266	0.227	0.207	2.54	0.511	0.355	0.503	20.333	0.503

Longest pod of 12.56 cm was recorded in thiourea 500 ppm followed by ethrel 200 ppm, NAA 75 ppm (10.29 cm) and ethrel 250 ppm (10.18cm) as compared to minimum pod length (8.12cm) under maleic hydrazide 1500 ppm. Maximum number of seeds pod^{-1} was recorded under $GA_3$100 ppm (15.18cm) followed by NAA 75 ppm (15.06) and NAA 50 ppm (14.82) as compared to minimum number of seeds per pod with maleic hydrazide 1500 ppm (11.76). The plants under control recorded the seed number of 12.62 per pod. The maximum test weight of 14.75g was recorded in GA_3 100 ppm followed by thiourea 500 ppm (14.65g) and $GA_3$150 ppm (14.52g) as compared to the lowest test weight of 11.76g under maleic hydrazide 1500 ppm. The maximum plot yield (652.38 g $3m^{-2}$) was recorded in NAA 75 ppm followed by thiourea 250 ppm (627.52 g $3m^{-2}$) and ethrel 200 ppm (618.47 g $3m^{-2}$) as compared to lowest yield of 428.76 g $3m^{-2}$ under maleic hydrazide 1500 ppm. The plants grown under NAA 75 ppm recorded maximum yield (16.31 q ha^{-1}) followed by thiourea 500 ppm (15.69q ha^{-1}) and ethrel 200 ppm (15.46q ha^{-1}) as compared to control (11.23q ha^{-1}). The lowest yield was recorded in maleic hydrazide 1500 ppm (shown in Fig.4).

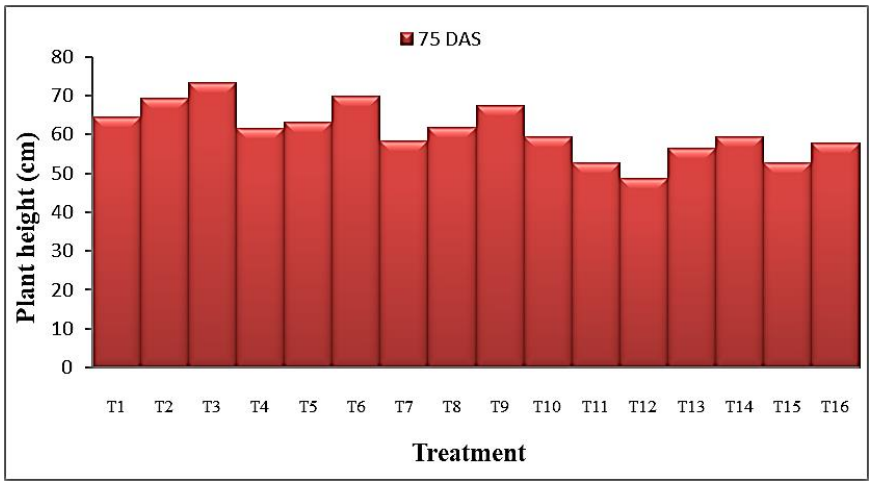

Fig 1: Effect of growth substances on plant height of fenugreek

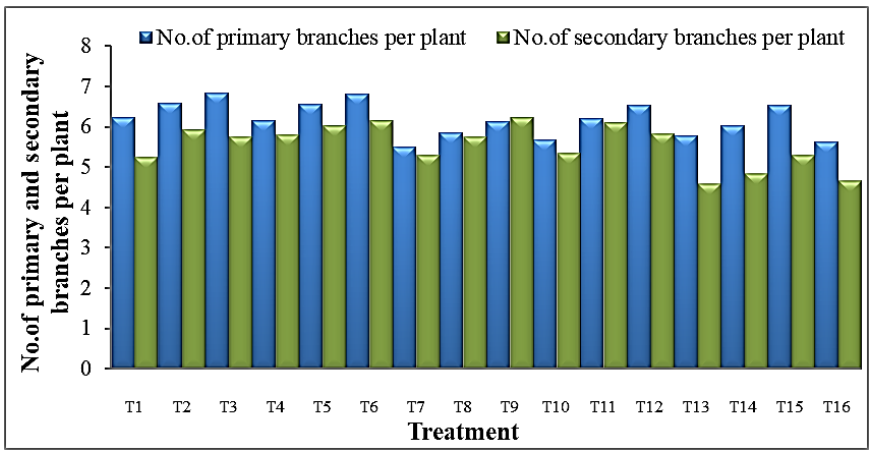

Fig 2: Effect of growth substances on number of primary branches and number of secondary branches of fenugreek

T_1 - GA_3 50 ppm
T_2 - GA_3 100 ppm
T_3 - GA_3 150 ppm
T_4 - NAA 25 ppm
T_5 - NAA 50 ppm
T_6 - NAA 75 ppm
T_7 - Ethrel 100 ppm
T_8- Ethrel 150 ppm
T_9 - Ethrel 200 ppm
T_{10} - MH 500 ppm
T_{11} - MH 1000 ppm
T_{12} - MH 1500 ppm
T_{13} - Thiourea 250 ppm
T_{14} - Thiourea 500 ppm
T_{15} -Thiourea 750 ppm
T_{16} – Control

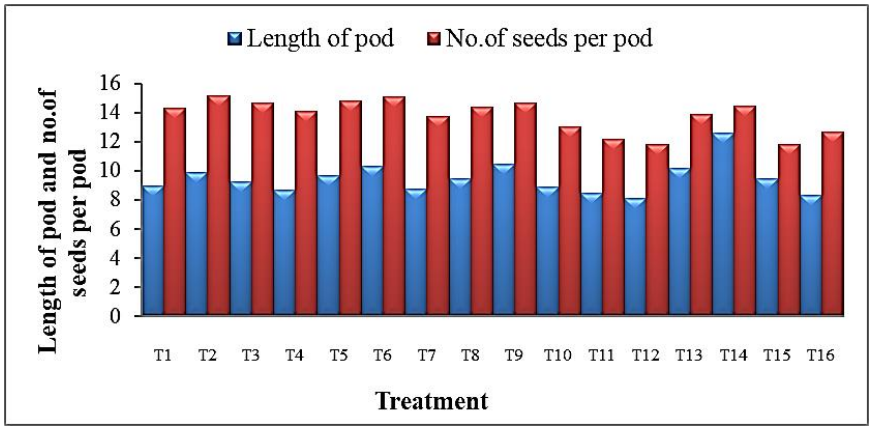

Fig 3: Effect of growth substances on length of pod and number of seeds per pod of fenugreek

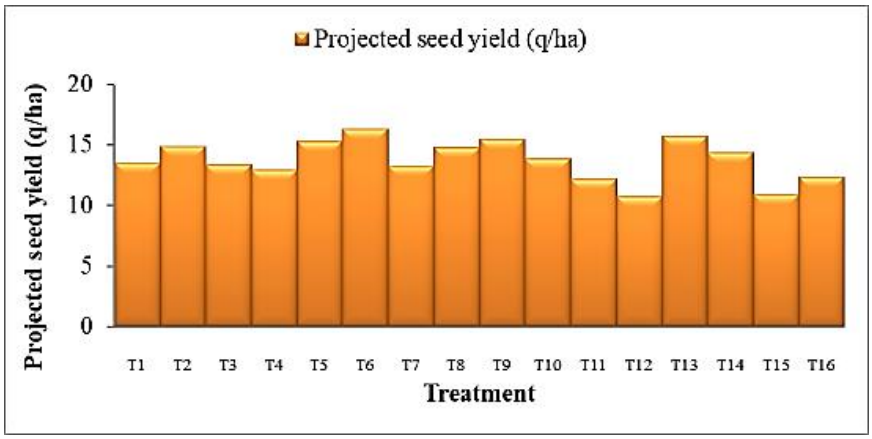

Fig 4: Effect of growth substances on projected yield (q/ha) of fenugreek

T_1 - GA_3 50 ppm	**T_9** - Ethrel 200 ppm
T_2 - GA_3 100 ppm	**T_{10}** - MH 500 ppm
T_3 - GA_3 150 ppm	**T_{11}** - MH 1000 ppm
T_4 - NAA 25 ppm	**T_{12}** - MH 1500 ppm
T_5 - NAA 50 ppm	**T_{13}** - Thiourea 250 ppm
T_6 - NAA 75 ppm	**T_{14}** - Thiourea 500 ppm
T_7 - Ethrel 100 ppm	**T_{15}** -Thiourea 750 ppm
T_8- Ethrel 150 ppm	**T_{16}** – Control

The results of the present investigation were in good agreement with [10]. Plants sprayed with maleic hydrazide 1000 and 1500 ppm recorded lesser value which might have caused detrimental effect on growth due to higher dose. The positive influence of plant growth substances in the present study were due to increasing photosynthetic activity, efficient translocation and utilization of photosynthates causing rapid cell division and cell elongation in growth pattern of the plant on stimulation of growth besides increasing the uptake of nutrients. Beneficial effect of growth regulators also reported by [10, 11, 12, 13, 14] in fenugreek which are similar to the present study.

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