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Influence of pinching and plant growth regulators on flowering, yield and economics of fenugreek (*Trigonella foenum-graecum* L.)

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Abstract

A field experiment was conducted to evaluate the effect of pinching and plant growth regulators on flowering and seed yield of fenugreek cv. *APHU Methi-1*. Minimum time to 50% flowering and seed maturity and maximum test weight were recorded with no pinching (P_0) treatment. Single pinching at 25 days after sowing (DAS) (P_1) recorded significantly maximum number of pods, length of pod, number of seeds pod^{-1} and seed yield. Among the plant growth regulators, foliar spray of GA_3 50 ppm (G_1) thrice (25, 45 and 65 DAS) resulted in best performance of the yield parameters like number of pods plant^{-1}, length of pod, number of seeds pod^{-1} and seed yield plant^{-1}. Early flower initiation and early maturity was observed with application of GA_3 75 ppm (G_2). Among the interactions of pinching and plant growth regulators (PGRs), the treatment combination of no pinching with application of GA_3 50 ppm (P_0G_1) resulted in maximum test weight. Maximum yield attributes like number of pods plant^{-1}, length of pod and seed yield plant^{-1} were recorded with single pinching at 25 DAS and application of GA_3 50 ppm (P_1G_1). However, pinching at 25 DAS with application of NAA 50 ppm (P_1G_3) gave highest B: C ratio (1.88).

Keywords: fenugreek, flowering, growth regulators, pinching, yield

Introduction

Fenugreek, the multi-use and commercially important spice crop is extensively grown almost in every part of the country for its seeds, tender shoots and fresh leaves. In India, area under fenugreek is 93,090 ha with production of 1,12,845 tonnes (Anon 2013). The value added products of fenugreek such as fenugreek powder and oleoresins are exported. Among several seed production approaches, apical bud pinching is practiced to enhance flower bearing branches by curbing vegetative growth. Cutting management or pinching practice greatly influences the growth and yield attributes in fenugreek (Baboo 1997). Cutting of herbage at early stages of growth induces uniformity in growth, flowering and seed setting in fenugreek (Pandita & Randhawa 1994). The role of plant growth regulators (PGRs) in enhancing the production and quality of crops has long been recognized and emerged as a boon for enhancing the

production in many crops. Gibberellins (GA_3) have been used in increasing stalk length and vegetative growth, flower initiation, increasing fruit size, hastening maturity and improving fruit quality in horticultural crops (Swamy 2012; Haq *et al*. 2013). Gibberellins play an important role in enhancing the growth and yield in fenugreek (Badge *et al.* 1993). The role of NAA in enhancing the growth, fruit set and yield attributes in fenugreek has been reported by Alagukannan & Vijayakumar (1999). The present investigation was carried out keeping in view the importance of plant growth regulators and pinching in improving the flowering and yield of fenugreek.

Materials and methods

The present study was conducted at Vegetable Research Station, Rajendranagar, Hyderabad during *rabi* season of 2013–14 with 3 replications in a Factorial Randomized Block Design. The experiment was carried out with fenugreek cv. *APHU Methi-1* and consisted of four pinching treatments *viz.*, no pinching (P_0), single pinching at 25 days after sowing (P_1), single pinching at 45 days after sowing (P_2), double pinching at 25 and 45 days after sowing (P_3) and five plant growth regulator treatments *viz*., control (water spray) (G_0), 50 ppm GA_3 (G_1), 75 ppm GA_3 (G_2), 50 ppm NAA (G_3) and 75 ppm NAA (G_4). The seeds were sown manually in rows at a spacing of 30 cm and the plants were thinned to 10 cm at 20 DAS. Pinching was done manually without causing damage to the plant parts. The plant growth regulators were sprayed thrice at 25, 45 and 65 DAS. A uniform basal dose of 25 kg N ha^{-1}, 20 kg P ha^{-1} and 20 kg K_2O ha^{-1} was applied in the form of urea, single super phosphate and muriate of potash respectively. Plant protection measures were taken. The data was recorded on flowering and yield parameters *viz.*, number of days taken to 50% flowering, percent of pod setting, number of pods $plant^{-1}$, length of pod (cm), number of seeds pod^{-1}, seed yield $plant^{-1}$ (g), seed yield $plot^{-1}$ (g), number of days to seed maturity, test weight (g) and B:C ratio. Seed yield ha^{-1} (q) was calculated based on the seed yield $plot^{-1}$.

Results and discussion

The result of effect of pinching and plant growth regulators on number of days taken to 50% flowering (Table 1). Minimum time to 50% flowering (45.94) was recorded with no pinching (P_0) and was at par (45.98) with pinching at 45 DAS (P_2). Late flowering (49.35) was recorded with pinching at 25 DAS (P_1). The effect of PGRs on days to 50% flowering was not significant while interaction effect of pinching and PGRs was found to be significant. The treatment combination of pinching at 45 DAS with application of NAA 50 ppm (P_2G_3) resulted in significantly less number of days to 50% flowering (45.40) and at par with treatment of P_2G_4, P_0G_2, P_0G_1, P_0G_4, P_0G_0, P_2G_2, and P_2G_0. From the data it is clear that less time to 50% flowering (45.94 days) was recorded with no pinching. Contrary to this, pinched plants took relatively more days to 50% flowering as compared to no pinching. The advancement of days to 50% flowering may be related to alter in source-sink relationship thereby advancing the reproductive phase (Vasudevan *et al.* 2008).

Maximum number of pods $plant^{-1}$ (22.15) was recorded with pinching at 25 DAS (P_1) and was found to be at par (21.69) with pinching at 45 DAS (P_2) (Table 1). The minimum number of pods $plant^{-1}$ (20.36) was recorded with double pinching at 25 and 45 DAS (P_3). The main effect of pinching is to restrict the vertical growth and enhance the lateral growth which results in production of more number of branches and in turn more number of pods $plant^{-1}$. Single pinching showed superior results over no pinching and double pinching. Similar results were also reported by Thapa & Maity (2004) in fenugreek. Significantly higher number of pods $plant^{-1}$ (22.65) was recorded with application of GA_3 50 ppm (G_1). The minimum number of pods $plant^{-1}$ (20.20) was recorded with control (G_0). This might be due to the production of more number of flowers $plant^{-1}$. The results are in conformity with Pariari *et al.* (2007). Vasudevan *et al.* (2008) also noted the beneficial effect of GA_3 on fenugreek to produce maximum number of pods $plant^{-1}$. The interaction effect of pinching and PGRs on number of pods $plant^{-1}$ was non significant.

Table 1. Effect of pinching and plant growth regulators on number of days taken to 50% flowering and number of pods plant^{-1} in fenugreek cv. *APHU Methi-1*

Treatments	Number of days taken to 50% flowering						Number of pods plant^{-1}					
	G_0	G_1	G_2	G_3	G_4	Mean	G_0	G_1	G_2	G_3	G_4	Mean
P_0	46.00	45.86	45.80	46.13	45.93	45.94	20.26	22.53	20.83	21.40	20.60	21.12
P_1	50.40	49.53	49.36	48.60	48.86	49.35	20.60	23.26	22.10	23.06	21.73	22.15
P_2	46.33	46.20	46.33	45.40	45.66	45.98	20.56	22.80	21.43	22.60	21.06	21.69
P_3	47.85	47.47	47.20	50.40	48.46	48.27	19.40	22.03	20.10	20.73	19.56	20.36
Mean	47.64	47.26	47.17	47.63	47.23		20.20	22.65	21.11	21.95	20.74	
	P	G	P×G		P	G	P×G					
SEm±	0.15	0.17	0.34		0.17	0.19	0.37					
CD (P<0.05)	0.43	NS	0.96		0.48	0.53	NS					

P_0=No pinching; G_0=Control (Water spray); P_1=Single pinching at 25 DAS; G_1=GA_3 50 ppm; P_2=Single pinching at 45 DAS; G_2=GA_3 75 ppm; P_3=Double pinching at 25 and 45 DAS; G_3=NAA 50 ppm; G_4=NAA 75 ppm

The result of length of pod and number of seeds pod^{-1} are presented in Table 2. Maximum length of pod (11.37 cm) was recorded with pinching at 25 DAS (P_1) while minimum length of pod (10.59 cm) was recorded with double pinching at 25 and 45 DAS (P_3). Pinching of apical bud will influence the yield contributing characters like number of pods plant^{-1}, number of seeds pod^{-1}, length of pod and finally seed yield. Similar findings are reported by Gill *et al.* (2001) in fenugreek. Length of pod decreased with increased number of pinching treatments. Similar results were reported by Thapa & Maity (2004) in fenugreek. Among PGR treatments, maximum length of pod (11.38 cm) was recorded with application of GA_3 50 ppm (G_1) and was at par (11.25) with NAA 50 ppm (G_3). The minimum length of pod (10.41 cm) was recorded with control (G_0). These results are supported by the findings of Cristina *&* Jose (1995) who confirmed the role of GA_3 in pod development of pea. The results of Rita & Vrinda (2007) also suggested the role of GA_3 in pod development of pigeon pea varieties.

The interaction between pinching and PGRs on length of pod was found to be significant. Minimum length of pod (10.02 cm) was recorded with treatment combination of double pinching at 25 and 45 DAS with control (P_3G_0) and was found to be at par (10.10 cm) with pinching at 45 DAS with control (P_2G_0), no pinching with application of NAA 75 ppm (P_0G_4) (10.32 cm) and double pinching at 25 and 45 DAS with application of GA_3 75 ppm (P_3G_2) (10.34 cm).

Maximum number of seeds pod^{-1} (14.66) was recorded with pinching at 25 DAS (P_1) (Table 2). This increase was statistically significant. The minimum number of seeds pod^{-1} (12.88) was recorded with double pinching at 25 and 45 DAS (P_3). Superiority of single pinching and significant reduction with double pinching and no pinching was observed from the present study. The results are in conformity with Thapa & Maity (2004) and Vasudevan *et al.* (2008). Maximum number of seeds pod^{-1} (14.60) was recorded with application of GA_3 50 ppm (G_1) and was at par with GA_3 75 ppm (G_2) (14.26).

Table 2. Effect of pinching and plant growth regulators on length of pod (cm) and number of seeds per pod in fenugreek cv. *APHU Methi-1*

Treatments	Length of pod (cm)						Number of seeds pod^{-1}					
	G_0	G_1	G_2	G_3	G_4	Mean	G_0	G_1	G_2	G_3	G_4	Mean
P_0	10.46	11.44	10.81	11.22	10.32	10.85	12.70	14.86	14.06	13.33	12.73	13.54
P_1	11.04	11.70	11.67	11.25	11.20	11.37	14.40	15.06	15.20	15.06	13.60	14.66
P_2	10.10	11.54	11.21	11.58	10.71	11.03	13.80	15.06	14.66	13.86	13.26	14.13
P_3	10.02	10.84	10.34	10.96	10.80	10.59	12.50	13.40	13.13	12.86	12.50	12.88
Mean	10.41	11.38	11.01	11.25	10.76		13.35	14.60	14.26	13.78	13.02	
	P	G	P×G		P	G	P×G					
SEm±	0.06	0.07	0.14		0.18	0.20	0.40					
CD (P<0.05)	0.17	0.19	0.39		0.52	0.58	NS					

P_0=No pinching; G_0=Control (Water spray); P_1=Single pinching at 25 DAS; G_1=GA_3 50 ppm; P_2=Single pinching at 45 DAS; G_2=GA_3 75 ppm; P_3=Double pinching at 25 and 45 DAS; G_3=NAA 50 ppm; G_4=NAA 75 ppm

Minimum number of seeds pod^{-1} (13.02) was recorded with application of NAA 75 ppm (G_4) and was at par (13.35) with control (G_0). Similar results were obtained by Pariari *et al.* (2007). Interaction effect of pinching and plant growth regulators was found to be non significant.

The pinching at 25 DAS (P_1) has produced maximum seed yield plant^{-1} (4.14 g) (Table 3). Whereas, double pinching at 25 and 45 DAS (P3) produced a minimum seed yield of 3.51 g plant^{-1} and it was at par with no pinching (P_0) (3.69 g). Significantly maximum seed yield plant^{-1} (4.25 g) was recorded with application of GA_3 50 ppm (G_1) and was at par with GA_3 75 ppm (G_2) (4.00 g). The minimum seed yield plant^{-1} (3.38 g) was recorded with control (G_0) and was at par with NAA 75 ppm (G_4) (3.47 g). Interaction effect of pinching and PGRs was non significant.

The result revealed that the crop left for seed production after single pinching at 25 DAS gave significantly higher seed yield than other treatments. It is well established that pinching of apical bud in several flower and vegetative crops resulted in sprouting of axillary branches which in turn produce more number of flowers and pods plant^{-1} as reported Gill *et al.* (2001) and Vasudevan *et al.* (2008) in fenugreek. Adverse effect of more than one cutting on seed yield might be due to injurious effects causing delay in flowering and seed setting (Thakral *et al*. 1991). Verma & Sen (2006) in coriander and Pariari *et al.* (2007) in fenugreek reported that seed yield was found to be maximum with GA_3 at 50 ppm. Involvement of growth regulating substances with sink efficiency in influencing the yield potential has been reported by Evans *et al*. (1972). Probably under the influence of GA_3 foliar sprays, better efficacy of sink resulted in higher yield. Chatterjee & Choudhury (2012) reported that foliar application of GA_3 was highly efficient in production and translocation of assimilates to the developing sink in cowpea. The spray of GA_3 during the active growth phase of the crop triggers judicious utilization of resources and results in a better source-sink relationship (Shah *et al*. 2006).

Table 3. Effect of pinching and plant growth regulators on seed yield plant^{-1} (g), seed yield plot^{-1} (g) and seed yield ha^{-1} (q) in fenugreek cv. *APHU Methi-1*

Treatments	Seed yield plant^{-1} (g)						Seed yield plot^{-1} (g)						Seed yield ha^{-1} (q)					
	G_0	G_1	G_2	G_3	G_4	Mean	G_0	G_1	G_2	G_3	G_4	Mean	G_0	G_1	G_2	G_3	G_4	Mean
P_0	3.30	4.37	3.76	3.70	3.35	3.69	331.9	439.1	378.2	372.1	336.6	371.5	8.30	10.89	9.45	9.30	8.41	9.27
P_1	3.66	4.45	4.40	4.40	3.79	4.14	368.1	447.5	442.5	442.2	381.2	416.3	9.20	11.18	11.06	11.05	9.53	10.40
P_2	3.45	4.43	3.82	3.79	3.41	3.78	347.4	445.5	383.9	381.5	342.7	380.2	8.68	11.13	9.59	9.53	8.56	9.49
P_3	3.11	3.75	4.02	3.35	3.36	3.51	312.5	377.5	404.6	336.6	338.0	353.8	7.81	9.43	10.11	8.41	8.45	8.84
Mean	3.38	4.25	4.00	3.81	3.47		339.9	427.4	402.3	383.1	349.6		8.49	10.65	10.05	9.57	8.74	
	P	G	P×G				P	G	P×G				P	G	P×G			
SEm±	0.09	0.10	0.20				8.93	9.98	19.95				0.22	0.25	0.50			
CD (P<0.05)	0.25	0.28	NS				25.55	28.56	57.13				0.64	0.71	1.42			

P_0=No pinching; G_0=Control (Water spray); P_1=Single pinching at 25 DAS; G_1=GA_3 50 ppm; P_2=Single pinching at 45 DAS; G_2=GA_3 75 ppm; P_3=Double pinching at 25 and 45 DAS; G_3=NAA 50 ppm; G_4: NAA 75 ppm

Table 4. Effect of pinching and plant growth regulators on number of days to seed maturity and test weight (g) in fenugreek cv. *APHU Methi-1*

Treatments	Number of days to seed maturity						Test weight (g)					
	G_0	G_1	G_2	G_3	G_4	Mean	G_0	G_1	G_2	G_3	G_4	Mean
P_0	94.10	92.33	92.10	93.03	93.36	92.98	1.33	1.35	1.31	1.34	1.34	1.33
P_1	93.86	93.03	92.86	93.60	93.63	93.40	1.27	1.33	1.34	1.34	1.27	1.31
P_2	94.16	93.10	93.13	93.80	93.83	93.60	1.29	1.27	1.26	1.29	1.29	1.28
P_3	95.16	93.20	93.43	94.30	94.40	94.10	1.27	1.30	1.29	1.25	1.24	1.27
Mean	94.32	92.91	92.88	93.68	93.80		1.29	1.31	1.30	1.31	1.29	
	P	G	P×G				P	G	P×G			
SEm±	0.02	0.02	0.05				0.01	0.01	0.02			
CD (P<0.05)	0.06	0.07	NS				0.03	NS	NS			

P_0=No pinching; G_0=Control (Water spray); P_1=Single pinching at 25 DAS; G_1=GA_3 50 ppm; P_2=Single pinching at 45 DAS; G_2=GA_3 75 ppm; P_3=Double pinching at 25 and 45 DAS; G_3=NAA 50 ppm; G_4=NAA 75 ppm

Data pertaining to number of days to seed maturity as influenced by pinching, plant growth regulators and their interaction (Table 4) showed that among effects of pinching, significantly minimum time to seed maturity (92.98) was recorded with no pinching (P_0). Late maturity (94.10) was recorded with double pinching at 25 and 45 DAS (P_3). Pinched plants took relatively more number of days to 50% flowering compared to no pinching. This may be ascribed to delay in days to 50% flowering and pod formation leading to late maturity of the crop. The results are in agreement with Datta *et al.* (2005) in fenugreek. Significantly minimum time to seed maturity (92.88) was recorded with application of GA_3 75 ppm (G_2) and was at par (92.91) with application of GA_3 50 ppm (G_1). Late maturity (94.32) was recorded with control (G_0). It clearly indicated the involvement of GA_3 in transition of vegetative apices to floral apices.

Pinching influenced the test weight (100 seed weight) significantly (Table 4). Maximum test weight (1.33 g) was recorded with no pinching (P_0) and was at par with pinching at 25 DAS (P_1) (1.31 g). The minimum test weight (1.27 g) was recorded with double pinching at 25 and 45 DAS (P_3) and was on par (1.28 g) with pinching at 45 DAS (P_2). Increase in number of pinching showed decrease in test weight of seed. This might be due to reduction in overall vegetative growth under more pinching treatments. Similar results were reported by Kumar & Singh (2007) in fenugreek.

The benefit cost ratio was calculated based on the economics involved in different treatments and worked out in terms of cost of cultivation,

Table 5. Effect of pinching and plant growth regulators on benefit cost ratio of fenugreek cv. *APHU Methi-1*

Treatments	Yield (q ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
P^0G_0	8.30	36380	83000	46620	1.28
P_0G_1	10.89	40180	108900	68720	1.71
P_0G_2	9.45	41680	94500	52820	1.26
P_0G_3	9.30	37355	93000	55645	1.48
P_0G_4	8.41	37443	84100	46657	1.24
P_1G_0	9.20	37380	92000	54620	1.46
P_1G_1	11.18	41180	111800	70620	1.71
P_1G_2	11.06	42680	110600	67920	1.59
P_1G_3	11.05	38355	110500	72145	1.88
P_1G_4	9.53	38443	95300	56857	1.47
P_2G_0	8.68	37380	86800	49420	1.32
P_2G_1	11.13	41180	111300	70120	1.70
P_2G_2	9.59	42680	95900	53220	1.24
P_2G_3	9.53	38355	95300	56945	1.48
P_2G_4	8.56	38443	85600	47157	1.22
P_3G_0	7.81	38380	78100	39720	1.03
P_3G_1	9.43	42180	94300	52120	1.23
P_3G_2	10.11	43680	101100	57420	1.31
P_3G_3	8.41	39355	84100	44745	1.13
P_3G_4	8.45	39443	84500	45057	1.14

P_0=No pinching; G_0=Control (Water spray); P_1=Single pinching at 25 DAS; G_1=GA_3 50 ppm; P_2=Single pinching at 45 DAS; G_2=GA_3 75 ppm; P_3=Double pinching at 25 and 45 DAS; G_3=NAA 50 ppm; G_4=NAA 75 ppm

gross returns and net returns ha^{-1}. Data pertaining to cost of cultivation (Rs ha^{-1}), gross returns (Rs ha^{-1}), net returns (Rs ha^{-1}) and B: C ratio of fenugreek as influenced by pinching, PGRs and their interaction are presented in Table 5. The treatment combination of pinching at 25 DAS with application of GA_3 50 ppm (P_1G_1) recorded maximum gross returns (Rs. 111800 ha^{-1}). While minimum gross returns (Rs. 78100 ha^{-1}), net return (Rs. 39720 ha^{-1}) and B:C ratio (1.03) were obtained from double pinching at 25 and 45 DAS with control (P_3G_0). The treatment combination of pinching at 25 DAS with application of NAA 50 ppm (P_1G_3) recorded maximum net returns (72145 Rs ha^{-1}). The treatment combination of pinching at 25 DAS with application of NAA 50 ppm (P_1G_3) recorded maximum benefit cost ratio (1.88).

On the basis of present research findings, it could be concluded that the pinching treatments and application of plant growth regulators influenced the growth and yield of fenugreek cv. *APHU Methi-1*. Among the treatments, single pinching at 25 DAS and foliar spray of GA_3 50 ppm at 25, 45 and 65 DAS proved advantageous for higher seed yield, whereas the highest benefit cost ratio (1.88) could be obtained with pinching at 25 DAS in combination with application of NAA 50 ppm thrice in Southern Telangana region.

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