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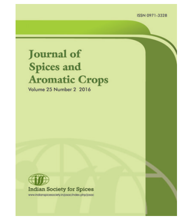

Response of fenugreek (*Trigonella foenum graecum* L.) to plant growth regulators and their time of application

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Abstract

The effect of plant growth regulators and their time of application on growth, yield and economics of fenugreek were studied during three winter seasons (*Rabi*) of 2005–06 to 2007–08. Plant growth regulators used were Naphthalene Acetic Acid (NAA) 50 ppm, Triacontanol 1000 ppm & Triacontanol 500 ppm with three times of spray *viz*., one (40 DAS), two (40 & 60 DAS) and three (40, 60 & 80 DAS) along with absolute control laid out in factorial randomized block design replicated thrice. Based on three years study it was observed that growth regulator treatments significantly influenced growth, yield attributes, yield & economics of fenugreek. The highest pods plant^{-1}, test weight, seed yield (1494 kg ha^{-1}), straw yield (3381 kg ha^{-1}), gross returns (Rs. 51582 ha^{-1}), net returns (Rs.35586 ha^{-1}) and benefit : cost ratio (2.25) were recorded with NAA 50 ppm which was significantly superior to Triacontanol 1000 ppm & 500 ppm & water spray. The seed yield was increased by 27.80%, 23.70% & 16.08% and net returns by 44.20%, 36.71% & 25.25% with application of NAA 50 ppm, Triacontanol 1000 ppm & 500 ppm over spray of water, respectively. Further, significantly maximum number of branches plant^{-1}, test weight, seed yield (1409 kg ha^{-1}), gross returns (Rs. 48546 ha^{-1}), net returns (Rs. 32331 ha^{-1}) and benefit : cost ratio (1.99) were recorded with three sprays at 40, 60 & 80 DAS closely followed by two sprays at 40 & 60 DAS over single spray at 40 DAS. Hence, the application of NAA 50 ppm twice at 40 & 60 DAS or thrice at 40, 60 & 80 DAS was found beneficial in terms of increased growth, yield and monetary returns of fenugreek.

Keywords: economics, fenugreek, growth, NAA, plant growth regulators, triacontanol, yield

Introduction

Fenugreek commonly known as "*methi*" is an important seed spice crop utilized as leafy vegetable, fodder and condiment. It is mainly cultivated in Rajasthan, Gujarat, Madhya Pradesh, Tamil Nadu and Uttar Pradesh under semi-arid conditions. Plant growth regulators present a new possibility to break yield barrier, particularly imposed by the environment (Witter 1971). The plant growth regulators act as chemical catalysts in plants and improve physiological and reproductive efficiency in the plants. The plant growth regulators possibly improve the gene expression for efficient sucrose transport and increase dry matter partitioning for seed production. Application of Triacontanol and Naphthalene Acetic Acid (NAA) induce 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 the cost of production (Sumeriya *et al.* 2000). These increase ethylene formation in plants, which facilitates the efficient translocation of photosynthates from source to sink. Foliar application of Triacontanol is known to enhance dry matter accumulation resulting in higher seed yield of crops (Naeem *et al.* 2012). Application of NAA is known to induce higher physiological efficiency including photosynthetic ability of plants (Gour *et al*. 2012). Effectiveness of plant growth regulators depends upon 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 (Saxena 1989) 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 various plant growth regulators for higher crop productivity, this field experiment was conducted with the objective to determine most effective plant growth regulator with proper time of application for higher productivity of fenugreek.

Materials and methods

The field experiment was conducted during three winter seasons (*Rabi*) of 2005–06 to 2007–08 on a loamy sand soil at Agronomy farm, SKN College of Agriculture, Jobner (Rajasthan) situated at latitude of $26^{o}05^{1}$ N, longitude of $75^{o}20^{1}$ E and at an altitude of 427 m above mean sea level. The soil was low in organic carbon (0.28%), available N (133.3 kg ha^{-1}), available P_2O_5 (17.5 kg ha^{-1}) and medium in available K_2O (180.6 kg ha^{-1}) and was slightly alkaline in reaction (pH 8.2) having 1.53 mg/m^{-3} bulk density, 2.64 mg/m^{-3} particle density, 12.79% field capacity and 4.75% permanent wilting point at the beginning of the experiment. The treatments were laid out in factorial randomized block design with 3 replications. The experiment comprised of 13 treatment combinations consisting of sprays of plant growth regulators as one factor (NAA 50 ppm, Triacontanol 1000 ppm & 500 ppm & water spray) and number of sprays as another factor (spraying once at 40 days after sowing (DAS), twice at 40 & 60 DAS and thrice at 40, 60 & 80 DAS) along with one absolute control. Fenugreek Rmt 351 was sown directly using seed rate of 20 kg ha^{-1} with seed drill in 4.0 m × 3.0 m size plots at row spacing of 30 cm. The crop was sown in first week of November during all the three years. A general recommended basal dose of 40 kg N ha^{-1} & 45 kg P_2O_5 ha^{-1} through DAP & Urea was applied. One light irrigation just after sowing and five irrigations at different growth stages were applied to the crop. Need based cultural and plant protection operations were taken up to harvest good crop. The data collected for three years was subjected to statistical analysis individually year wise as well as pooled over three years by the procedure described by Panse & Sukhatme (1978).

Results and discussion

Growth parameters

Growth regulators significantly influenced the plant height and number of branches $plant^{-1}$ as compared to control (Table 1). Among the different growth regulators used under the investigation, NAA 50 ppm recorded maximum plant height (59.2 cm) and number of branches $plant^{-1}$ (5.84) which was on par with Triacontanol 1000 ppm but significantly superior to Triacontanol 500 ppm & water spray. Triacontanol 1000 ppm also significantly increased plant height and number of branches $plant^{-1}$ over Triacontanol 500 ppm & water spray. Significantly higher number of branches $plant^{-1}$ (5.71) were recorded with three sprays at 40, 60 & 80 DAS over single spray at 40 DAS and it was comparable with two sprays at 40 & 60 DAS. These results are in agreement with findings of Verma & Sen (2006) & Meena *et al.* (2006) in coriander. The increment in plant growth might be due to stimulation of cell division and cell elongation, while increasing plasticity of cell wall. The primary physiological effect of plant

Table 1. Effect of plant growth regulators on growth & yield attributes of fenugreek (Pooled data of 2005–06 to 2007–08)

Treatments	Plant height(cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Test weight(g)
Plant growth regulators					
Triacontanol 500 ppm	57.1	5.62	21.4	16.7	9.86
Triacontanol 1000 ppm	59.0	5.84	22.8	16.7	10.17
NAA 50 ppm	59.2	5.84	23.5	16.8	10.38
Water spray	54.7	5.14	20.3	15.9	9.47
S Em. ±	0.6	0.07	0.2	0.2	0.07
CD (P=0.05)	1.9	0.19	0.6	0.5	0.21
Time of application					
One (40 DAS)	57.2	5.52	21.3	16.3	9.79
Two (40 & 60 DAS)	57.3	5.58	22.2	16.6	10.04
Three (40, 60 & 80 DAS)	58.0	5.71	22.5	16.6	10.09
S Em. ±	0.6	0.06	0.2	0.2	0.07
CD (P=0.05)	NS	0.17	NS	NS	0.19
Control vs. rest					
Control	54.6	5.00	19.0	15.5	8.97
Rest	57.5	5.61	22.0	16.5	9.98
S Em. ±	0.8	0.08	0.3	0.2	0.09
CD (P=0.05)	2.3	0.24	0.8	0.6	0.27

growth regulators is to stimulate the elongation of cells due to increased enzymatic activities, permeability of cell wall and formation of energy rich phosphates (Idrees *et al.* 2010). Another possible explanation for better growth might be due to the increased osmotic uptake of water and nutrients under the influence of plant growth regulators and in turn improving nutrient metabolism of plant system. These observations are quite in line with those reported by Singh *et al.* (2012) in coriander and Shivran & Jat (2013) in cumin.

Yield attributes

The data on absolute control with rest of treatments application indicated that growth regulator treatments significantly influenced yield attributes (Table 1). Number of pods plant^{-1} (23.5) and test weight (10.38 g) were highest with application of NAA 50 ppm which was significantly superior over Triacontanol 1000 ppm, Triacontanol 500 ppm & water spray. Application of Triacontanol 1000 ppm also recorded significantly higher pods plant^{-1} (22.8) and test weight (10.17 g) over Triacontanol 500 ppm & water spray. The maximum number of seeds pod^{-1} (16.8) was recorded with application of NAA 50 ppm which was comparable with Triacontanol 1000 ppm & 500 ppm but significantly superior to water spray. Significantly more test weight (10.09 g) was recorded with three sprays at 40, 60 & 80 DAS over single spray at 40 DAS, but remained at par with two sprays at 40 & 60 DAS. The increase in yield attributing characters due to application of plant growth regulators may be due to the stimulatory effect of growth regulators which induces large number of reproductive sinks leading to greater activity of carboxylating enzyme (ribose-1,5-di phosphate carboxylase) thus resulting in higher photosynthetic rates with greater translocation and accumulation of metabolites in the sink. The favourable hormonal balance maintained at cellular level on NAA application might also have greater photosynthetic efficiency and enzymatic activity through the production of endogenous auxin (Sarkar *et al.* 2002). Such a mechanism may be operating in fenugreek also. Higher yield attributes as a result of application of plant growth regulators were also reported by Nehara *et al*. (2006) in fenugreek and Panda *et al*. (2007) in coriander.

Yield

The yield of fenugreek increased significantly with the application of plant growth regulators. The seed yield obtained with growth regulator treatments was16.30, 26.59, 15.50 and 19.39% higher than the absolute control during 1st, 2nd, 3rd year of experimentation and in pooled data, respectively (Table 2). In pooled data over three years, significantly maximum seed and straw yields were recorded with NAA 50 ppm (1494 & 3381 kg ha^{-1}) over Triacontanol 1000 ppm (1446 & 3239 kg ha^{-1}), Triacontanol 500 ppm (1357 & 3085 kg ha^{-1}) and water spray (1169 & 2719 kg ha^{-1}). During individual years of experimentation, maximum seed yield was also obtained with application of NAA 50 ppm. The application of Triacontanol 1000 ppm and 500 ppm also recorded significantly higher seed yield during all the years of experimentation and seed and straw yields in pooled data over spray of water. The seed yield was increased by 27.80, 23.70 & 16.08% with application of NAA 50 ppm, Triacontanol 1000 ppm & 500 ppm over spray of water, respectively in pooled data. With reference to number of sprays, significantly higher seed yield was recorded with three sprays at 40, 60 & 80 DAS over single spray at 40 DAS and remained at par with two sprays at 40 & 60 DAS during 1st and 2nd year of experimentation and in pooled data. However, during 3rd year of experimentation, seed yield was not influenced significantly by number of sprays. Three and two sprays increased seed yield by 7.96% & 6.21% over single spray at 40 DAS in pooled analysis. There was no significant influence of number of sprays on straw yield. These findings are in close conformity with results obtained by Verma & Sen (2006) in coriander, Nehara *et al*. (2006) in fenugreek, Meenaria & Maliwal (2007) in fennel who reported higher vegetative growth and increased yield attributes resulting in maximum seed yield due to plant growth regulators application. The possible reason for increased yield was due to higher photosynthetic activity of treated plants as compared to control. This may be due to greater accumulation of photosynthate in plant body owing to higher photosynthesis and better efficacy of sink, which would have enhanced the yields. The another possible reason may be explained in the light of the sole function of fertilized ovules or seeds in relation to growth of fruits is to synthesize one or more hormones, which initiate and maintain a metabolic gradient along which foods can be translocated from parts of plants towards the sink (Idrees *et al.* 2010; Godara *et al.* 2013). Therefore higher seed yield was obtained with foliar spray of NAA 50 ppm followed by Triacontanol. It is evident from the study that water spray and control registered significantly lower yields than growth regulator sprays which indirectly indicated that seed yield is the manipulation of morphological, physiological and growth parameters as reported by Channakesava *et al*. (2007). Similar higher yields of fenugreek as a result of application of growth regulators were also reported by Gour *et al*. (2012).

Economics

Growth regulator treatments application gave remarkably higher monetary returns, registering 19.66%, 30.49% & 26.45% increase in gross returns, net returns and benefit : cost ratio, respectively over the absolute control (Table 2). Amongst the different growth regulators, NAA 50 ppm recorded maximum gross returns (Rs. 51582 ha^{-1}), net returns (Rs. 35586 ha^{-1}) and benefit : cost ratio (2.25) which were significantly higher over Triacontanol 1000 ppm, Triacontanol 500 ppm & water spray. Triacontanol 1000 ppm also recorded significantly higher gross returns (Rs. 49858 ha^{-1}), net returns (Rs. 33738 ha^{-1}) and benefit : cost ratio (2.09) over Triacontanol 500 ppm & spray of water. The application of Triacontanol 500 ppm had also fetched significantly higher gross returns (Rs. 46880 ha^{-1}), net returns (Rs. 30910 ha^{-1}) and benefit : cost ratio (1.94) over spray of water. The net returns were increased by 44.20%, 36.71% & 25.25% with application of NAA 50

Table 2. Effect of plant growth regulators on yield & economics of fenugreek (Pooled data)

Treatments	Seed yield (kg ha^{-1})				Straw yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
	2005–06	2006–07	2007–08	Pooled				
Plant growth regulators								
Triacontanol 500 ppm	1251	1375	1446	1357	3085	46880	30910	1.94
Triacontanol 1000 ppm	1331	1502	1506	1446	3239	49858	33738	2.09
NAA 50 ppm	1360	1612	1511	1494	3381	51582	35586	2.25
Water spray	1051	1167	1288	1169	2719	40508	24678	1.56
S Em. ±	28	32	24	16	42	590	482	0.03
CD (P=0.05)	82	91	71	47	121	1705	1394	0.08
Time of application								
One (40 DAS)	1150	1345	1451	1305	3050	45250	29512	1.87
Two (40 & 60 DAS)	1266	1446	1447	1386	3129	47838	31861	1.99
Three (40, 60 & 80 DAS)	1330	1451	1446	1409	3138	48546	32331	1.99
S Em. ±	25	27	21	14	39	509	416	0.02
CD (P=0.05)	71	79	NS	41	NS	1472	1207	0.07
Control vs. rest								
Control	1073	1117	1245	1145	2557	39464	23964	1.55
Rest	1248	1414	1438	1367	3106	47222	31272	1.96
S Em. ±	34	38	30	20	52	726	589	0.04
CD (P=0.05)	101	112	88	58	149	2090	1707	0.09

ppm, Triacontanol 1000 ppm & Triacontanol 500 ppm over water spray, respectively. With regard to number of sprays, maximum gross returns (Rs. 48546 ha^{-1}), net returns (Rs. 32331 ha^{-1}) and benefit : cost ratio (1.99) were recorded with three sprays at 40,60 & 80 DAS closely followed by two sprays at 40 & 60 DAS over single spray at 40 DAS. Three and two sprays increased net returns by 9.55% & 7.96% over single spray at 40 DAS. Thus, increased seed yield with low cost of inputs gave higher monetary returns as also reported by Sarada *et al.* (2008) & Singh *et al.* (2012) in coriander. Overall, the application of NAA 50 ppm thrice at 40, 60 & 80 DAS or twice at 40 & 60 DAS was found beneficial in terms of increased growth, yield and monetary returns of fenugreek.

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