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## Responses of crop geometry, bio-fertilizers, and phytohormones on seed yield and quality traits of fenugreek (*Trigonella foenum graecum* L.)

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### Abstract

Present investigation on 'Responses of crop geometry, bio-fertilizers, and phytohormones on seed yield and quality traits of fenugreek (*Trigonella foenum graecum* L.). Carried out during winter season (2020-21 and 2021-22) at research field of Department of horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior Madhya Pradesh. The field experiment consists twelve treatments combinations of two spacing (30 cm × 10 cm and 25 cm × 15 cm), three Bio-fertilizer (*Rhizobium*, *Phosphate Solubilizing Bacteria* and *Potassium Mobilizing Bacteria*) and two levels of phytohormones (GA<sub>3</sub>@200 ppm and NAA @100 ppm). The work was conducted in FRCB Design with three replications. The significantly maximum value of yield attributes viz., No. of pods / plant (50.68), Pod length (21.20 cm), Pod weight (0.3174 g), No. of seeds / pod (16.21), Test weight of seeds (16.04 g) Seed yield (0.96 kg/plot) and Seed yield (21.22 q/ha) under the S<sub>1</sub>- (30 cm × 10 cm) spacing. Whereas significantly maximum value of quality traits viz., Protein (24.82%), Carbohydrate content (47.41%), Vitamin-A (61.09 IU), Ascorbic acid (4.98 mg/100 g), Fat (7.55 g/100 g) also recorded under the S<sub>1</sub> (30 cm × 10 cm) spacing. The highest value of yield attributes viz., No. of pods / plant (51.58), Pod length (21.49 cm), Pod weight (0.3183 g), No. of seeds/pod (16.68), Test weight of seeds (16.49 g) Seed yield (0.97 kg/plot) and Seed yield (21.59 q/ha) were found to be significantly maximum with seed inoculation with *Rhizobium*. The significantly highest value of quality traits viz., Protein (24.93%), Carbohydrate content (47.55%), Fat (7.88 g/100 g) also were found to be significantly when seeds inoculation with *Rhizobium*, while Vitamin-A (61.13 IU) and Ascorbic acid (5.14 mg/100 g) significantly maximum when seeds inoculation with *Phosphate Solubilizing Bacteria*. Foliar spray of GA<sub>3</sub> @200 ppm was significant higher in yield attributes viz., No. of pods / plant (51.66), Pod length (21.17 cm), Pod weight (0.3186 g), No. of seeds/pod (16.91), Test weight of seeds (16.51 g) Seed yield (1.00 kg/plot) and Seed yield (22.11 q/ha). Foliar spray of GA<sub>3</sub> @200 ppm also was found significant higher in yield attributes viz., Protein (24.54%), Carbohydrate content (47.53%), Vitamin-A (61.12 IU), Ascorbic acid (5.01 mg/100g), Fat (7.83 g/100 g). All interaction effects were non-significant, except spacings x growth regulators (A x C) which were significant for yield and quality traits- No. of pods / plant and Carbohydrate content %.

**Keywords:** Fenugreek, geometry, *Rhizobium*, *Phosphate solubilizing bacteria*, *Potassium mobilizing bacteria*, GA<sub>3</sub>, NAA

### Introduction

Fenugreek (*Trigonella foenum graecum* L.) is an annual self-pollinated leafy vegetable crop and grow up to the height of 30-65cm with light green to dark green leaves. It is belonging to the fabaceae. *Trigonella foenum graecum* L. is a diploid species which have 2n=16 chromosome number. Its dry seeds are generally used as spice and condiment, while the leaves as well as seeds have ayurvedic medicinal uses. There are only two important species of fenugreek which know as common methi and champa methi. Common methi is one of the most important winter spices crop in India. It is native of South Eastern Europe and West Asia. The area of fenugreek, In India is 2 lakh, 18 thousand ha with production of 2 lakh 20 thousand MT (Anonymous, 2017) [6]. Rajasthan has maximum area and production of fenugreek. Rajasthan also known as "fenugreek bowl" of the country (Anitha *et al.*, 2018) [5]. Fenugreek seeds are used in preparation of traditional Ayurvedic medicines and cosmetics. Fenugreek seed revealed that it contains 13.7 percent water, 26.2 percent protein, 5.8 percent fat, 3.0 percent mineral matter, 7.2 percent fibers, 4.41 per cent carbohydrates, 0.16 per cent calcium, 0.37 per cent phosphorus, 14.1 mg iron, 333 calories and 160 IU carotene per 100 gm. (Agrawal *et al.*, 2001) [2].

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One of the significant subjects increasing yield and quality is to regulate the optimum plant density on the field. Plant density varies according to the cultivar, yield capacity of the soil, irrigation condition and cultivation objectives (Tunçturk, 2011) [16]. Plant growth regulators present a new possibility to break yield barrier, particularly imposed by the environment (Witter, 1971) [17]. Gibberellins play an important role in enhancing the growth and flowering in fenugreek (Pariari *et al.*, 2007) [13]. The role of NAA in enhancing the growth and yield attributes in fenugreek has been reported by Alagukannan and Vijay Kumar (1999) [4]. Use of biofertilizers i.e. *Rhizobium* and *Phosphate solubilizing bacteria* affects on the growth, yield and quality of fenugreek crops. In previous years, higher dose of chemical fertilizers with little or no use of organic fertilizers is leading to poor growth and yield of crops. This situation promotes to enhance cost of production. Hence it has become an important to use other resources of fertilizer of biological origin for INM in fenugreek and manage plant population through adopting different spacings. The application of bio-fertilizer including *Rhizobium*, *Phosphate Solubilizing Bacteria* as well as potassium mobilizing bacteria has been found superior to improve soil health, growth and yield characteristics of fenugreek.

## Materials and Methods

### Investigation site and location

The field investigation was carried out during winter season at research field of Department of horticulture, College of Agriculture, Gwalior (M.P.). The experimental field is located at the 26° 13' North latitude and 76° 14' East longitude with an altitude of 211.52 meters higher Mean Sea Level.

### Climate and Weather Condition

The maximum temperature reaches up to 46 °C during last May to mid-June, while minimum goes up to 2 °C during last December to mid-January. The annual average rainfall ranges between 700 to 800 mm, generally which is occurring during July to August. The maximum and minimum temperature during the growing period as 28.05 °C and 12.2 °C respectively.

### Treatment details

Details of the experimental treatments are as under:

(A) Spacing

S1– 30 cm ×10 cm

S2– 25 cm ×15 cm

(B) Bio –fertilizers (seed inoculation with bio-fertilizer)

B1– *Rhizobium*

B2– PSB

B3– KMB

(C) Growth regulators (foliar spray at 20 and 40 DAS)

G1 – GA<sub>3</sub>@200 ppm

G2 – NAA @100 ppm

The treatments included in the investigation comprised of the twelve combinations of two spacing, three bio fertilizers and two growth regulators. The investigation laid out in the Factorial Randomized Complete Block Design

### Observational details

The data noted on the various yield and quality traits were

divided into different categories during the period of investigation. The data were noted as per standard procedure. The observation on yield characteristics viz. No. of pods / plant, Pod length (cm), Pod weight (g), No. of seeds / pod, Test weight of seeds (g), Seed yield / plot (kg), Seed yield q/ha. Observation on quality viz. Protein content in seed was calculated by multiplying nitrogen content of seed (%) with the conversion factor 6.25. Vitamin – A content, carotenoid were calculated by using the following formula

$$\text{Carotene (mg/100g)} = \frac{\text{O.D.} \times 13.9 \times 10^4 \times 100}{\text{Weight of sample (g)} \times 560 \times 1000}$$

Ascorbic acid, the ascorbic acid content in the juice was determined titrimetric ally using 2, 6- dichlorophenol indophenol dye described. Fat content, Carbohydrate content, determined by Anthrone Method.

## Results and Discussion

### A. Yield Parameters

**The data on different yield and yield attributing traits of fenugreek have been presented in Table no. 1.**

**No. of pods / plants:** The calculated pooled data significantly maximum No. of pods / plants were recorded (50.68) in S<sub>1</sub> (30 cm ×10 cm) spacing, (51.58) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (51.66) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Pod length (cm):** The calculated pooled data significantly maximum pod length was recorded (21.20 cm) in S<sub>1</sub> (30 cm ×10 cm) spacing, (21.49 cm) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (21.17 cm) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Pod weight (g):** The calculated pooled data significantly maximum pod weight was recorded (0.3174 g) in S<sub>1</sub> (30 cm ×10 cm) spacing, (0.3183 g) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (0.3186 g) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**No. of seeds per pod:** The calculated pooled data significantly maximum no. of seeds per pod was recorded (16.21) in S<sub>1</sub> (30 cm ×10 cm) spacing, (16.68) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (16.91) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Test weight of seeds (g):** The calculated pooled data significantly higher Test weight of seeds was recorded (16.04) in S<sub>1</sub> (30 cm ×10 cm) spacing, (16.49) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (16.51) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Seed yield/plot (kg):** The calculated pooled data significantly maximum Seed yield / plot was recorded (0.96) in S<sub>1</sub> (30 cm ×10 cm) spacing, (0.97) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (1.00) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Seed yield q/ha:** The calculated pooled data significantly maximum Seed yield /ha was recorded (21.22) in S<sub>1</sub> (30 cm ×10 cm) spacing, (21.59) in B<sub>1</sub> (*Rhizobium*) bio-fertilizer and (22.11) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**The closely investigation on same yield parameters of fenugreek are**

Pawan *et al.* (2018) [14] and Krishana *et al.* (2018) [10]. Reported that the spacing 30 X 10 cm<sup>2</sup> provide sufficient

spacing for growth and development of fenugreek plant. Abdelgani *et al.* (1999) [1], Yadav and Kumawat (2003) [18] and Jat (2004) [9]. reported that the seed treatment with rhizobium increasing greater number of root nodule and synthesised more nitrogen might responsible for increasing a greater number of pods per plant and a greater number of pods per plant increase the yield and yield parameters. Kumar and sundareswaran (2011) [11], Chatterjee and Choudhuri (2012) [7] and Rohamare *et al.* (2013) [15]. Reported that obtained similar significant effect of growth regulators on

increasing the yield and yield parameters of fenugreek.

## B. Quality Parameters

The data on different quality characteristics of fenugreek seeds have been presented in Table no.2.

### Protein Content %

The calculated pooled data significantly higher Protein Content was recorded (24.82%) in S<sub>1</sub> (30 cm × 10 cm) spacing, (24.93%) in B<sub>1</sub> (Rhizobium) bio-fertilizer and (24.54%) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Table 1:** Effect of different spacing, bio-fertilizes and growth regulators on yield characteristics of fenugreek (pooled data of two years)

Treatment	No. of pods per plant	Pod length (cm)	Pod weight (g)	No. of seeds per pod	Test weight of seeds (g)	Seed yield / plot (kg)	Seed yield q/ ha
<b>(A) Spacings</b>							
S1– 30 cm × 10 cm	50.68	21.20	0.3174	16.21	16.04	0.96	21.22
S2–25 cm × 15 cm	45.80	19.26	0.3173	15.67	14.23	0.91	20.30
SEm(±)	1.58	0.55	0.0005	0.18	0.54	0.02	0.37
C.D. at 5%	4.64	1.62	NS	0.53	1.59	0.05	1.09
<b>(B) Biofertilizers (seed inoculation with bio-fertilizer)</b>							
B1– Rhizobium	51.58	21.49	0.3183	16.68	16.49	0.97	21.59
B2– PSB	48.99	20.10	0.3172	15.91	15.01	0.95	21.16
B3– KMB	44.14	19.11	0.3165	15.23	13.91	0.88	19.54
SEm(±)	1.94	0.68	0.0006	0.22	0.66	0.02	0.45
C. D. at 5%	5.68	1.98	NS	0.65	1.95	0.06	1.33
<b>(C) Growth regulators (foliar spray at 20 and 40 DAS)</b>							
G1 –GA <sub>3</sub> @200 ppm	51.66	21.17	0.3186	16.91	16.51	1.00	22.11
G2–NAA @ 100 ppm	44.81	19.29	0.3161	14.97	13.76	0.87	19.42
SEm(±)	1.58	0.55	0.0005	0.18	0.54	0.02	0.37
C. D. at 5%	4.64	1.62	0.0014	0.53	1.59	0.05	1.09
A x B	NS	NS	NS	NS	NS	NS	NS
A x C	S*	NS	NS	NS	NS	NS	NS
B x C	NS	NS	NS	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS	NS	NS	NS

DAS: Days after sowing, (A x B): Spacings x Biofertilizers, (A x C): Spacings x growth regulators, (B x C): Biofertilizers x growth regulators, (A x B x C): Spacings x Biofertilizers x growth, S\*: Significant, NS: Non significant

**Table 2:** Effect of different spacing, bio-fertilizes and growth regulators on quality characteristics of fenugreek seeds (pooled data of two years)

Treatment	Protein %	Carbohydrate content (%)	Vitamin-A (IU)	Ascorbic acid (mg/100g)	Fat (g/100g)
<b>(A) Spacings</b>					
S1– 30 cm × 10 cm	24.82	47.41	61.09	4.98	7.55
S2–25 cm × 15 cm	22.73	45.46	58.88	4.11	6.48
SEm(±)	0.45	0.60	0.68	0.24	0.28
C.D. at 5%	1.33	1.75	2.00	0.70	0.81
<b>(B) Bio - fertilizers (seed inoculation with bio-fertilizer)</b>					
B1– Rhizobium	24.93	47.55	60.12	4.49	7.88
B2– PSB	24.07	46.26	61.13	5.14	6.86
B3– KMB	22.32	45.49	58.71	4.01	6.32
SEm(±)	0.56	0.73	0.83	0.29	0.34
C. D. at 5%	1.63	2.15	2.45	0.86	1.00
<b>(C) Growth regulators (foliar spray at 20 and 40 DAS)</b>					
G1 –GA <sub>3</sub> @200 ppm	24.54	47.53	61.12	5.01	7.83
G2–NAA @ 100 ppm	23.01	45.34	58.85	4.09	6.21
SEm(±)	0.45	0.60	0.68	0.24	0.28
C. D. at 5%	1.33	1.75	2.00	0.70	0.81
A x B	NS	NS	NS	NS	NS
A x C	NS	S*	NS	NS	NS
B x C	NS	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS	NS

DAS: Days after sowing, (A x B): Spacings x Biofertilizers, (A x C): Spacings x growth regulators, (B x C): Biofertilizers x growth regulators, (A x B x C): Spacings x Biofertilizers x growth, S\*: Significant, NS: Non significant

### Carbohydrate content (%)

The calculated pooled data significantly higher Carbohydrate content was recorded (47.41%) in S<sub>1</sub> (30 cm × 10 cm) spacing,

(47.55%) in B<sub>1</sub> (Rhizobium) bio-fertilizer and (47.53%) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.



**Vitamin-A (IU)**

The calculated pooled data significantly maximum vitamin-A content was recorded (61.09%) in S<sub>1</sub> (30 cm ×10 cm) spacing, (61.13%) in B<sub>2</sub> (PSB) bio-fertilizer and (61.12%) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Ascorbic acid (mg/100g)**

The calculated pooled data significantly maximum Ascorbic acid content was recorded (4.98%) in S<sub>1</sub> (30 cm ×10 cm) spacing, (5.14%) in B<sub>2</sub> (PSB) bio-fertilizer and (5.01%) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**Fat (g/100g)**

The calculated pooled data significantly maximum Fat content was recorded (7.55%) in S<sub>1</sub> (30 cm ×10 cm) spacing, (7.88%) in B<sub>2</sub> (PSB) bio-fertilizer and (7.83%) in G<sub>1</sub> (GA<sub>3</sub>@200 ppm) growth regulator.

**The closely finding on same quality parameters of fenugreek seeds are**

Ganvit *et al.*, (2019)<sup>[8]</sup>. Reported that the spacing 30X10 sq cm provided sufficient space for their growth and development of linseed plants. This is also support for formation of higher quality parameters. Abdelgani *et al.* (1999)<sup>[1]</sup>, Aishwath *et al.* (2010)<sup>[3]</sup> and Mishra *et al.* (2011)<sup>[12]</sup>. Studies that the micro-organism rhizobium synthesised more nitrogen in the root nodules and might also help to synthesis of other nutrient. The maximum nitrogen might increase the formation of amino acids, synthesis of DNA and RNA. These amino acids increase the synthesis of proteins and other quality parameters compare to other biofertilizers.

**Conclusion**

The from the present experiment showed that S<sub>1</sub> (30X10cm) spacing positively responded under the subtropical condition of the Grid region on the basis of the yield and quality parameters of fenugreek seeds. The evaluated that the seed inoculation with B<sub>1</sub> (rhizobium) bio-fertilizer significantly superior to B<sub>2</sub> (PSB) and B<sub>3</sub> (KBM) in respect to yield and quality traits of fenugreek seeds. It is also revealed that the foliar application of Gibberellic acid at the rate of 200 ppm maximization yield and quality characteristic of fenugreek seeds. During the of the interaction effect of the all factors, it is resulted that the treatment S1G1 superior in respect of yield and quality parameters.

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