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Effect of bio-fertilizers and plant growth regulators on growth and yield of fenugreek (*Trigonella foenum-graecum* L.)

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ABSTRACT

A field experiment on effect of bio-fertilizers and plant growth regulators on growth and yield of fenugreek was carried out at NRCSS, Ajmer. The experiment comprising of four levels of bio- fertilizers (no inoculation, *Rhizobium*, PSB and *Rhizobium*+PSB) and five levels of plant growth regulators (GA_3 50 and 100 ppm and NAA 10 and 20 ppm and water) was conducted in factorial randomelly bock design with three replication. The results indicated that superiority of dual inoculation of seed with *Rhizobium*+PSB recorded significantly higher plant height, no of branches/plant, number of nodules/plant and dry weight of nodules per plant at 45 DAS and harvest stage over rest treatment. Dual inoculation of seed with *Rhizobium*+PSB also recorded significantly higher yield components *(viz.)*, number of pods/plant, pod length, pod weight, number of seeds/pod and shelling percentage) and consequently increase seed and biological yield (*i.e.*, 18.02 and 63.96 q ha^{-1}) over control (15.62 and 57.55 q ha^{-1}), respectively.The growth parameters, yield components and seed yield showed positive response to foliar application of plant growth regulators. The maximum dry matter accumulation, number of pods/plant, numbers of seeds/pod, pod length, pod weight, and shelling percentage was recorded in 20 ppm NAA treatment followed by 10 ppm NAA application. The productivity of fenugreek crop in terms of seed, biological yield and harvest index were recorded highest (17.62, 65.65 q ha^{-1} and 27.45%) in 20 ppm foliar spray of NAA.

Key words: Bio-fertilizers, Fenugreek, Growth, Plant growth regulators, Yield.

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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. Its fresh tender leaves, pods and shoots are rich in iron, calcium, protein, vitamin and essential amino acids, being a legume spices it has high nutritive value and used in the middle and far East countries in preparation of meatless diets during social and religious functions. Both leaves and seeds are extensively used for medicinal purposes and prescribed in treatment of chronic dysentery, diarrhoea, chronic cough. Dropsy, dyspepsia enlargement of leaver and spleen, arthritis, diabetes, colic troubles, abscesses, ulcers and rickets (Pruthi, 16). Fenugreek is considered to have originated in South Eastern Europe and far West Asia, has been grown in India, part of North African counties, Argentina, France, Morocco, Lebanon. India is the one of major producer of fenugreek; its production is concentrated mainly in the state of Rajasthan, Madhya Pradesh, Maharashtra, Haryana, Punjab, Gujarat and Uttar Pradesh. The current productivity of fenugreek is 70.05 q/ha. In recent years, continued and imbalance application of chemical fertilizers with little or no use of organic manure is leading to poor nutrient use efficiency and low yield of crops. At the same time its increasing cost of production, changing trend towards increase environmental sensitivity and consumer's preference towards organic products are commonly realized now a days. Hence it has become important to search for other complementary resources and fertilizer of biological origin for integrated nutrient management in fenugreek. In this approach, microbial fertilization including *Rhizobium* as well as phosphate solubilizing bacteria has been found promising to improve soil health and crop production. Fenugreek belongs to sub-family *Papilionaceae* of the family *Leguminaceae.* It has the capacity to fix atmospheric nitrogen symbiotically. But as most of the soils of Rajasthan are low in organic matter and poor in nitrogen content, introduction of N efficient strain of bio-inoculants in such soil through seed inoculation may help in boosting up the production. The seed inoculation with Rhizobium has been reported to boost the growth, yield and quality attributes in green gram and fenugreek (Jat and Shaktawat, 10). Soils of India are low to medium in available phosphors. The fertilizer use efficiency of phosphatic fertilizer is very low (20-25percent) due to chemical fixation in soil. Phosphorus deficiency is usually the most important single factor which is responsible for poor yield of legume crops on all types of soil. In recent years, several strains of phosphate solubilizing bacteria (PSB) and fungi have been isolated which have shown to possess the ability to solubilise sparingly soluble phosphate, growth promotion and uptake of P by plants (Whitelaw, 22). Phosphatic biofertilizer is an important group of biological software containing some heterotypic bacteria and fungi which are known to have the ability to solubilise inorganic Phosphorus from insoluble sources by the production of organic acid. The mechanism of action of these microorganisms (PSM) involves secretion of organic acid, which lowers the pH and increase the availability of sparingly soluble phosphorus sources. The role of plants bio-regulators in enhancing the production of crop has long been recognized and now this low cost technology has emerged as a boon for enhancing the agriculture production at an unprecedented rate. It has been observed that synthesis and translocation of photosynthetic into sink is very poor at later stages of the crop besides poor vegetative growth and flowering. Plant hormones play important role as the small quantities, regulate the various physiological processes and balance the source and sink thereby increase the productivity. Gibberellins (GA_3) have been used in increasing stalk length and vegetative growth, flowers initiation, increasing fruit size, hastening maturity, improving fruit quality and controlling fruit cracking in horticultural crops. GA_3 play an important role in enhancing the growth and yield in fenugreek (Geore and Bharud, Badge *et al.,* 3). The role of NAA in enhancing the fruit set, growth and yield attributes in fenugreek (Alagukannan and Vijay Kumar, 1) and in french been (Medhi, 13) have been reported. In lack of information on these aspects with respect to fenugreek and considering the importance of fenugreek for human health and national economy. Hence, the present study was under taken to find out the effect of bio-fertilizers and plant growth regulators on growth and seed yield of fenugreek.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2010-011 at the research farm of National Research Centre on Seed Spices, Ajmer, Rajasthan. The soil of the experimental area was sandy loam having low organic matter (0.23%), available nitrogen (178.5 kg ha^{-1}), phosphorus (12 kg ha^{-1}) and potassium (85 kg ha^{-1}), slightly alkaline having pH (8 to 8.3) and EC (0.072 dSm^{-1}). The experiment comprising of four levels of bio-fertilizers (no inoculation, *Rhizobium*, PSB and

Rhizobium+PSB) and four levels of plant growth regulators (GA_3 50 and 100 ppm and NAA 10 and 20 ppm) and water were sprayed thrice during the crop growth and development. These treatments were evaluated under random block design with three replications. The seed of variety Ajmer Fenugreek-1 were sown keeping seed rate of 20 kg ha^{-1}. Recommended dose of fertilizers as well as other standard agro-techniques was used for raising good crop. 30 kg nitrogen, 40 kg phosphorus and 20 kg potassium per ha were supplied through urea, DAP and muriatic of potash, respectively. Full dose of phosphorus, potash and half dose of nitrogen were applied as basal at the time of sowing and remaining nitrogen was given at 45 DAS. Spraying of PGRs was done three times by hand sprayer as per treatment the first spraying was done at 25 days after sowing, the second was at 50% flowering and third was at 20 days after 2nd spray to wet both sides of the leaves. The control plots were sprayed by distilled water. Seeds of fenugreek (variety Ajmer Methi-1) were treated with bio-fertilizer and after drying in the shade they were sown at row to row spacing of 30 cm. Weeds are controlled by manual hand weeding as per need of the crop. Harvesting of the crop was done manually by pulling the dry plants out of the soil and removing the roots. In the study, fenugreek was evaluated for vegetative growth attributes, yield attributes and seed yield. Statistical analysis of data was done by standard procedure suggested by Panse and Sukhatme (15).

RESULTS AND DISCUSSION

Bio-fertilizers

Perusal of data in (Table 1 and 2) reveals that bio-fertilizer significantly influenced the plant height at harvest, dry matter accumulation, number of primary branches per plant, number of nodules per plant, dry weight of nodules per plant, number of pods per plant, pod length, pod weight, number of seeds per pod and seed yield kg ha^{-1}. Seed inoculation with *Rhizobium* + PSB recorded the maximum plant height (89.91 cm), dry matter accumulation (337.35) at harvest, number of primary branches per plant (6.68), number of nodules per plant (24.35), dry weight of nodules per plant (0.16), number of pods per plant (89.62), pod length (12.05cm), pod weight (4.72g), number of seeds per pod(17.81), seed yield ha^{-1} and straw yield ha^{-1} respectively as compared to control. Phosphate solubilizing organisms have been reported to solubilize inorganic fixed form of P by excreting organic acids that directly dissolves fixed phosphatic materials of soil (Gaur, 8 and Balchandran and Nagarajan, 4). These bacterial are also capable to secret some biologically active compounds such as auxin, gibberellins, vitamins etc. which are considered to be important for proper growth and development of plant (Whitelaw, 22). The results corroborate with the findings of Shinde and Saraf (17) in chickpea, Dubey (7) in soybean, Yadav and Srivastava (23) in gram. Thus, concomitant effect of *Rhizobium* and PSB inoculation led to the enhanced nitrogen and phosphorus availability which might have utilized by plants in synthesis of protein, carbohydrates, starch and its partitioning towards formation of flowers and increases in sink capacity both in size and numbers (Jat , 10), which seems to have improved yield attributes and consequently yield of the fenugreek crop. Similar beneficial effect of *Rhizobium* culture in fenugreek (Baboo and Sharma, 2, Shivran *et al*., 18, Kumawat, 12) was also reported. These findings are increase agreement with those of Yadav and Srivastava (23) in gram, Bothe *et al*. (5) in fenugreek.

Plant growth regulators

Growth Characteristics

The results revealed that foliar application of plant growth regulators significantly improved the growth characters. Among different plant growth regulators applied, 100 ppm GA_3 resulted in the highest plant height (90.98 cm), number of branches/plant (6.80) at harvest and dry weight of nodules / plant (0.14g) followed by other treatments. It may be noted that irrespective of the concentration, GA_3 proved more effective in increasing the plant height than other treatments. The maximum dry matter accumulation of 329.54 mg/plant and number of nodules/plant (22.08) were recorded in 20 ppm NAA followed by rest treatment (Table 1). The effectiveness of GA_3 to enhance the vegetative characteristics of fenugreek crop might be due to rapid cell elongation and division in growing portion of plants and increased uptake of nutrients. The characteristic property of NAA in delaying senescence process and retention of flower and fruits probably resulted in more dry matter accumulation per plant at later stage of plant growth (Kalitaet *et al*., 11). The results are in close conformity with findings reported by Deore and Bharud (6) and Mishriky *et al*. (14) in fenugreek.

YIELD ATTRIBUTES AND YIELD

Critical examination of (Table 2) revealed that foliar spray of plant growth regulators significantly increased the number of pods/plant, pod length, pod weight, number of seeds/pod, seed yield and straw yield q/ ha in comparison to control. Foliar application of 20 ppm NAA

recorded the maximum number of pods/plant (86.37), pod length (12.12 cm) highest pod weight (i.e.,4.85mg), number of seeds/pod (18.0), seed yield (17.99q ha^{-1}) and straw yield (47.48q ha^{-1} which was closely followed by 10 ppm NAA. The overall improvement in plant growth by cell division, cell enlargement and production of sufficient photosynthesis through increased chlorophyll content of leaves on one hand and efficient utilization/ immobilization photosynthesis towards development of flowers and fruits on the other hand, might have been responsible for increased yield attributes. Thus, remarkable improvement in different yield component along with seed yield of fenugreek crop primarily appears to be a function of greater photosynthetic efficiency per unit land area, maintenance of its higher rate for longer period, especially during post- flowering period and at the late pod filling stage leads to increase greater accumulation of dry matter which resulted in higher productivity of crop. Significant improvement in yield components and yield of fenugreek crop under the foliar application of plant growth regulators is in close accordance with the findings of Singh and Sharma (20), Singh *et al*. (21), Geetha and Nair (9), Sanna *et al*. (19) and Medhi and Borbora (13) with NAA. Thus foliar spray of NAA 20 ppm is the best treatment for realized highest yield attributes and seed yield of fenugreek in comparison to rest treatment.

Table 1. Effect of bio-fertilizers and plant growth regulators on growth attributes of fenugreek

Treatment	Plant height at harvest (cm)	Dry matter accumulation/ plant at harvest (mg)	No. of primary branches $plant^{-1}$	No. of nodules $plant^{-1}$	Dry weight of nodules $plant^{-1}$ (g)
Bio-fertilizer					
Control	85.75	296.40	6.60	17.07	0.07
Rhizobium	86.45	331.27	6.67	21.13	0.12
PSB	85.79	333.41	6.61	20.20	0.11
Rhizobium + PSB	89.91	337.35	6.68	24.35	0.16
S.Em+	0.12	10.81	0.15	0.46	0.01
CD (P = 0.05)	0.33	30.96	0.44	1.31	0.01
Plant growth regulators					
Water spray	82.01	311.44	6.32	18.33	0.12
GA_3 50 ppm	89.27	326.15	6.75	20.33	0.14
GA_3 100 ppm	90.98	327.52	6.80	20.94	0.12
NAA 10 ppm	89.85	328.40	6.65	21.08	0.12
NAA 20 ppm	82.77	329.54	6.66	22.08	0.08
S.Em+	0.10	9.67	0.14	0.41	0.01
CD (P = 0.05)	0.30	27.69	0.39	1.18	0.01

Table 2. Effect of bio-fertilizers and plant growth regulators on growth attributes of fenugreek

Treatment	Number of pods plant^{-1}	Pod length (cm)	Pod weight (mg)	Number of seeds pod^{-1}	Seed yield ha^{-1}	Straw yield ha^{-1}
Bio-fertilizers						
Control	76.55	11.40	4.53	16.99	13.89	42.62
Rhizobium	85.24	11.87	4.68	17.68	16.07	44.54
PSB	85.23	11.85	4.63	17.60	16.31	55.27
Rhizobium + PSB	89.62	12.05	4.72	17.81	17.43	46.68
S.Em+	1.84	0.28	0.11	0.38	0.24	0.88
CD (P = 0.05)	5.28	0.80	0.31	1.09	0.75	2.70
Plant growth regulators						
Water spray	80.03	11.58	4.29	17.06	13.36	39.31
GA_3 50 ppm	84.56	11.80	4.66	17.41	16.29	45.63
GA_3 100 ppm	84.89	11.62	4.68	17.45	16.59	46.45
NAA 10 ppm	84.97	11.86	4.71	17.68	17.65	46.78
NAA 20 ppm	86.37	12.12	4.85	18.00	17.99	47.48
S.Em+	1.65	0.25	0.10	0.34	0.21	1.10
CD (P = 0.05)	4.72	0.71	0.28	0.98	0.85	3.09

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