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Growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.) as influenced by nitrogen, phosphorus and bio-fertilizers

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ABSTRACT

A field experiment was conducted at Sardarkrushinagar (Gujarat) during 2006-07 and 2007-08 to study response of nitrogen, phosphorus and bio-fertilizers on fenugreek with 16 treatment combinations in factorial RBD with three replications. The soil of the experimental field was low in organic carbon, available nitrogen, medium in phosphorus and good in respect to available potassium. Application of 20 kg N and 40 kg P_2O_5/ha gave significantly higher plant height at all the growth stages, and seed, straw and biological yields as well as protein content in seed and straw over 10 kg N and 20 kg P_2O_5 / ha, respectively. Combined inoculation of seed with *Rhizobium* and PSB and their sole application significantly gave higher plant height over control at all the growth stages but significantly the highest seed, straw and biological yield as well as protein content in seed and straw was recorded with combined inoculation of seed with *Rhizobium* and PSB, which was higher over their individual application and control. Sole application of both *Rhizobium* and PSB was found at par in respect to seed, straw and biological yield. Harvest index was not significantly influenced with N, P and bio-fertilizer levels.

Key words: Bio-fertilizers, fenugreek, plant height, quality nutrient, yield.

INTRODUCTION

Fenugreek(*Trigonella foenum-graecum* L.) commonly known as *methi* is a multipurpose crop grown during winter season in northern India. It is an annual herb belonging to sub-family Papilliaceae of the family Fabacae. It is one of the important major seed spices in the country cultivated in an area of 35,737 ha producing 35,737 tonnes of seed with a productivity of 1,000 kg/ ha. Rajasthan and Gujarat are the main fenugreek producing states in India. Being a leguminous crop, the root nodules enrich the soil with atmospheric nitrogen. Intensive agriculture involving use of high input for increasing production resulted heavy removal of nutrients from the soil. However fertilizer application generally remained much below as compared to removal. Thus there is wide gap between nutrients removed from soil and nutrient supplied. This gap can be bridged with use of chemical fertilizers along with application of low cost inputs like bio-fertilizer. Information on cost effective nutrient management in semi-arid climatic conditions in fenugreek are needed to be worked out. Integrated use of chemical fertilizers as well as bio-fertilizers in fenugreek can be more efficient than chemical fertilizers alone. Therefore, the present study was undertaken to see the effect of nitrogen, phosphorus and bio-fertilizers on growth characters of fenugreek.

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MATERIALS AND METHODS

A field experiment was carried during 2006-07 and 2007-08 on loamy sand soil at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat). The experiment was laid out on different sites during both the years. The soil had pH 7.75 and 7.73 and electrical conductivity 0.12 and 0.11 dS/m, respectively during 2006-07 and 2007-08. The soil of the experimental field of both the sites were low in organic carbon (0.17 & 0.22%), available nitrogen (152.75 & 165.25 kg /ha), medium in available P_2O_5 (40.75 and 47.6 kg /ha) and good in respect to available K_2O (260.25 and 264.7 kg /ha). Total 16 treatment combinations of two nitrogen (10 and 20 kg N /ha), two phosphorus (20 and 40 kg P_2O_5 /ha) and four bio-fertilizers (control, *Rhizobium,* Phosphorus Solublising Bacteria (PSB) and *Rhizobium* + PSB) levels were laid in Factorial Randomized Block Design (RBD) with three replications. Full dose of nitrogen and phosphorus as per treatment was applied through SSP and urea at the time of sowing. Inoculation of seeds of fenugreek with respective bio-fertilizer was done before sowing and after drying in shade, sowing was done at 30 cm row to row spacing using 20 kg seed/ha. The fenugreek variety Gujarat Methi-2 was sown on 18th of November during both the years. Recommended cultural practices were adopted for raising healthy crop. Five plants were selected randomly from each plot for recording of plant height. Protein content in seed and straw was determined by

multiplying N content with factor 6.25. Similar trend of response of treatments during both the years was observed. Analysis of variance of design was carried out according to standard procedure suggested by Panse and Sukhamte (5).

RESULTS AND DISCUSSION

The different N, P and bio-fertilizer combinations influenced the plant growth, yield and quality of fenugreek (Tables 1, 2 & 3).Plant height at different growth stages, number of branches/plant, days to 50% flowering and maturity, protein content in seed and straw as well as seed, straw and biological yields were recorded significantly higher with application of 20 kg N over 10 kg N/ha during both the years as well as in pooled but harvest index was not significantly influenced with nitrogen levels. This might be due to early and abundant availability of N leading to better nutritional environment in the root zone for growth and development of plant. In addition to its role in the formation of protein, N is an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. Under the present investigation, profound influence of increased N fertilization on crop growth seems to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media. These results corroborate with the findings of Detroja *et al*. (2).

Application of 40 kg P_2O_5 / ha gave significantly higher plant height at all the growth stages but delayed for days to 50% flowering and maturity. Protein content in seed and straw as well as seed, straw and biological yields were also recorded higher with application of 40 kg P_2O_5 over 20 kg P_2O_5 / ha. But harvest index was not significantly affected with phosphorus levels. (Tables 1 & 2). An application of 40 kg P_2O_5 / ha resulted 13.4, 11.7 and 12.2 per cent higher seed , straw and biological yield, respectively over 20 kg P_2O_5 / ha. Phosphorus plays an important role in root development and proliferation as well as it also improves root nodule formation and biological N fixation by supplying assimilates to the roots. It is the main constituent of energy rich phosphate molecules like ATP. Thus, phosphorus influences photosynthesis, biosynthesis of protein and phospholipids, nucleic acid synthesis, membrane transport and cytoplasm streaming. Increased availability of phosphorus owing to its application in the soil, improved nutrient availability. The applied phosphorus increased nitrogenase activity of roots, which enhanced the root nodulation and created congenial environment for plant rhizosphere that resulted in increasing physiological growth parameters. Increase in growth parameters like plant height, dry matter accumulation, branches per plant and nodulation due to application of 40 to 60 kg P_2O_5 / ha in fenugreek have been

Table 1. Plant growth, flowering and maturity as influenced with different levels of nitrogen, phosphorus and bio-fertilizers (pooled data).

Treatment	Plant height (cm)				No. of branches /plant	Days to 50% flowering	Days to maturity
	30 DAS	60 DAS	90 DAS	Maturity			
(A) Nitrogen (kg/ha)							
10	6.9	36.3	47.0	55.2	4.14	50.65	114.66
20	8.3	41.3	54.3	63.0	4.80	54.06	120.05
$CD_{0.05}$	0.3	1.5	2.0	2.3	0.16	1.99	3.91
(B) Phosphorus (kg/ha)							
20	7.1	36.4	47.5	55.4	4.28	50.99	114.48
40	8.1	41.2	53.8	62.7	4.65	53.71	120.23
$CD_{0.05}$	0.3	1.5	2.0	2.3	0.16	1.99	3.91
(C) Bio-fertilizer							
Without inoculation	7.1	36.3	47.4	55.3	4.18	51.72	115.94
Rhizobium inoculation	7.7	39.6	51.7	60.3	4.56	52.56	117.82
PSB inoculation	7.6	39.0	50.9	59.4	4.49	52.35	117.35
R*hizo.* + PSB inoculation	7.9	40.2	52.5	61.3	4.63	52.77	118.29
$CD_{0.05}$	0.3	1.7	2.3	2.7	0.19	2.29	NS
Interaction between N × P	S	S	S	S	NS	NS	NS

Table 2. Seed, straw and biological yield as well as quality of fenugreek as influenced with different levels of nitrogen, phosphorus and bio-fertilizers (pooled data).

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Biol. yield (kg/ha)	Harvest index (%)	Protein content (%)	
					Seed	Straw
(A) Nitrogen (kg/ha)						
10	1156	2398	3554	32.54	19.43	19.43
20	1367	2778	4145	32.98	21.63	21.63
$CD_{0.05}$	50.2	116.9	156.9	0.73	0.63	0.63
(B) Phosphorus (kg/ha)						
20	1182	2445	3627	32.61	19.90	19.90
40	1340	2730	4070	32.91	21.15	21.15
$CD_{0.05}$	50.2	116.9	156.9	0.73	0.63	0.63
(C) Bio-fertilizer						
Without inoculation	1171	2402	3573	32.74	19.24	19.24
Rhizobium inoculation	1262	2589	3851	32.76	20.80	20.80
PSB inoculation	1246	2556	3802	32.77	20.45	20.45
R*hizo.* + PSB inoculation	1366	2802	4169	32.77	21.62	21.62
$CD_{0.05}$	57.9	135.0	181.2	0.84	0.72	0.72
Interaction between N × P	S	S	S	S	NS	NS

Table 3. Plant height seed, straw and biological yields as affected by interaction effect between nitrogen and phosphorus (Pooled data).

Nitrogen/ phosphorus (kg/ha)	Plant height (cm)								Seed yield (kg/ha)		Straw yield (kg/ha)		Biological yield (kg/ ha)	
	30 DAS		60 DAS		90 DAS		Maturity							
	20	40	20	40	20	40	20	40	20	40	20	40	20	40
10	6.7	7.1	35.2	37.4	45.56	48.38	53.50	56.80	1121	1190	2338	2457	3458	3648
20	7.5	9.0	37.5	45.0	49.40	59.18	57.33	68.66	1244	1490	2553	3002	3797	4492
$CD_{0.05}$	0.3		1.7		2.31		2.71		57.9		135.0		181.2	

reported by Shivkumar *et al*. (6), and Bhunia *et al*. (1).

An appraisal of the data (Tables 1 & 2) reveals that sole as well as combined application of both *Rhizobium* and PSB was found at par to each other with respect to plant height at all the growth stages but significantly better over control in both the years and in pooled data. However, seed, straw as well as biological yield were recorded significantly higher with combined inoculation of seed with *Rhizobium* and PSB over their sole application and control. *Rhizobium* and PSB improves the N and P availability of soil which are major plant nutrients and combined inoculation of both N_2 fixer and PSB benefit plants than either group of organisms alone and may have an added advantage. Furthermore, some of the bacteria involved might be interacting on more metabolic levels, *i.e.* P solublizer may also be auxin, IAA and gibberellins producer and N_2 fixer may also solublize P. This was probably due to more N_2 fixation by the bacteria, which in turn helped in better absorption and subsequent utilization of N for synthesis of chlorophyll molecules, as N is an integral part of the chlorophyll molecules. This results higher photosynthesis thereby producing more photosynthates leading to more plant height and ultimately to higher seed, straw and biological yields. These results are in accordance with the findings of Jain *et al*. (8), and Bhunia *et al*. (1).

Critical examination of the data in Table 3 revealed that plant height at all the growth stages as well as seed, straw and biological yield were significantly

influenced with interaction effect between N and P. Application of 20 kg N with 40 kg P_2O_5 resulted the highest plant height at all the growth the stages and seed, straw as well as biological yields. The lowest values of these attributes were recorded by application of 10 kg N with 20 kg P_2O_5 /ha. Application of N enhances absorption of P because it increases CEC of roots and helped in vigorous root development and proliferation. Thus, combined application of N and P created favorable environment which increased uptake of nutrients from the soil for better growth and development. Synergistic effects of both N and P improved nutrient levels and enhanced plant growth by promoting the merismetic activity, which favour plant growth and finally higher seed, straw and biological yields. Similar results were reported by Verma *et al*. (7), and Mavi *et al*. (4).

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