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Effect of Nitrogen, Phosphorus and Bio-fertilizers on Yield and Profitability of Fenugreek (*Trigonella foenum-graecum* L.)

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Field experiments were conducted at Sardarkrushinagar during *Rabi* 2006-07 and 2007-08 to find out optimum levels of nitrogen, phosphorus and bio-fertilizer. The experiment comprising of sixteen treatment combinations with two levels each of nitrogen (10 and 20 kg N / ha) and phosphorus (20 and 40 kg P_2O_5 / ha) as well as four levels of bio-fertilizer (control, inoculation of seed with *Rhizobium*, inoculation of seed with PSB and inoculation of seed with *Rhizobium* +PSB) was laid in factorial randomised block design with three replications. Results revealed that increasing levels of N and P_2O_5 significantly increased yield attributes, yield, net return and BCR over their respective lower levels. Inoculation of seed with *Rhizobium* and PSB resulted in the higher pod length (12.2 cm), number of pods per plant (27.95), number of seeds per pod (14.27), 1000-seed weight (12.02 g) and seed yield per plant (5.56 g). Seed (1366 kg /ha), straw (2802 kg /ha) and biological yield (4169 kg /ha) as well as gross return (Rs. 45871/ ha), net return (Rs.25,289/ha) and BCR (1.23) were the highest with inoculation of seed by *Rhizobium* and PSB followed by seed inoculation with *Rhizobium* only.

Key words: BCR, fenugreek, gross return, net return, yield

Fenugreek is an important multipurpose rabi season seed spice crop mainly grown in Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Haryana, Punjab, Bihar and Andhra Pradesh. The seeds of fenugreek are used as a condiment and seasoning agent for garnishing and flavourings dishes. Being a leguminous crop, the root nodules enrich the soil with atmospheric nitrogen. Intensive agriculture involving use of high input for increasing production resulted in heavy removal of nutrients from the soil. Thus, there is a wide gap between the nutrients removed from the soil and the nutrient supplied. This gap can be bridged with use of chemical fertilizers along with application of low cost input like bio-fertilizer. Nitrogen plays a key role in the synthesis of chlorophyll. Nitrogen is an essential constituent of compounds like amino acids, proteins, nucleic acids, prophyrin, flavin, pyridines, nucleotides, enzymes, coenzymes and alkaloids which contributes to the growth of plant. The general role of phosphorus on plant metabolism is known to enhance the symbiotic nitrogen fixation. Information on cost effective nutrient management in semi arid climatic condition in fenugreek are very meagre. Integrated use of chemical fertilizers as well as bio-fertilizers in fenugreek can be a more efficient, economical and judicious approach than chemical fertilizers alone. Therefore, the study was undertaken to evaluate the effect of nitrogen, phosphorus and bio-fertilizers on yield, yield attributes and profitability in fenugreek.

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Materials and Methods

The field experiments were conducted during 2006-07 and 2007-08 on loamy sand soil of research farm of S.D. Agricultural University, Sardar krushinagar (Gujarat).The experiment was laid out on different sites during both the years. The soil had pH of 7.75 &7.73, electrical conductivity 0.12 and 0.11 dSm^{-1}. The soil was low in organic carbon (0.17 & 0.22) available nitrogen (152 & 165 kg /ha), medium in available P_2O_5 (40 and 47 kg /ha) and good in respect to available K_2O (260 & 264 kg /ha) respectively during 2006-07 and 2007-08. Sixteen treatment combinations consisting of two levels each of nitrogen (10 and 20 kg N / ha) and phosphorus (20 and 40 kg P_2O_5/ha) as well as four levels of bio-fertilizers(Control, *Rhizobium,* PSB and *Rhizobium* + PSB) were laid in factorial RBD with three replications. Full dose of nitrogen and phosphorus as per treatment was applied manually 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. It was sown manually at 30 cm row to row spacing keeping 20 kg seeds per ha. The fenugreek variety GM-2 was sown on 15th and 28th November during 2006-07 and 2007-08,respectively at 30 cm row to row spacing keeping seed rate of 20 kg per

ha. Standard agronomic practices were adopted for raising healthy crop. Profitability of nutrient application in fenugreek was determined by calculating economic parameters like cost of cultivation, gross return, net return and BCR. The trend of response of all the treatments under study remained the same during both the years.Hence results were discussed as per pooled analysis.

Results and Discussion

Effect of nitrogen

The higher value of yield attributes *viz*. pod length, number of pods per plant, number of seeds per pod, 1000-seed weight and seed yield per plant as well as seed, straw and biological yields and net return and BCR in fenugreek were recorded with application of 20 kg nitrogen /ha (Table 1&2). Application of 20 kg N /ha increased seed and straw yield to magnitude of 18 and 15 per cent, respectively and net return and BCR by 37 and 35 per cent respectively, over 10 kg N/ha. Harvest index was not significantly affected with varying levels of nitrogen. Application of nitrogen increased the photosynthetic activity and translocation of photosynthates from source to sink and this might be the cause of higher yield attributes at higher levels of nitrogen. Adequate supply of N plays a vital role in various metabolic processes which resulted in increased flowering and fruiting thereby improving pods per plant due to favourable effect of these nutrients on growth

Table 1. Yield attributes of fenugreek as influenced by N,P and bio-fertilizer (Pooled data of 2006-07 and 2007-08)

Treatment	Length of pod (cm)	Pods per plant	Seeds per pod	1000 Seed weight (g)	Seed yield per plant (g)
Nitrogen levels					
N_1:10 (kg /ha)	10.4	24.20	12.21	10.30	4.79
N_2:20 (kg/ ha)	12.2	27.43	14.14	11.90	6.48
CD(P=0.05)	0.45	1.02	0.54	0.44	0.25
(B) Phosphorus levels					
P_1 : 20 (kg/ ha)	10.6	24.22	12.35	10.65	5.27
P_2 : 40 (kg/ ha)	12.0	27.41	13.99	11.55	5.99
CD(P=0.05)	0.45	1.02	0.54	0.44	0.25
(C) Bio-fertilizer					
B_1 : Without inoculation	10.5	23.97	12.23	10.30	5.22
B_2 : :Rhizobium inoculation	11.3	25.83	13.18	11.11	5.64
B_3 : PSB inoculation	11.2	25.50	13.01	10.96	5.56
B_4 : Rhizo.+PSB inoculation	12.2	27.95	14.27	12.02	6.10
CD (P=0.05)	0.52	1.18	0.62	0.50	0.29
N x P interaction	Sig.	Sig.	Sig.	NS	Sig.

parameters. Seed yield of a crop is a function of yield attributes such as pods per plant, number of seeds per pod, 1000-seed weight, seed yield per plant and length of pod. Increase in yield attributes due to increasing levels of N had direct and positive effect on seed, straw and biological yields of fenugreek. These findings are similar with those of Detroja *et al*. (1996) and Shivaran *et al*. (1995) in fenugreek. The application of increasing levels of N resulted in higher yield attributes, thereby giving more seed yield, which fetched higher net return. The magnitude of increase in yield was higher as compared to cost incurred on application of 20 kg N/ ha, hence resulted in higher BCR over10kg N / ha.

Effect of phosphorus

Length of pod, number of pods per plant, number of seeds per pod, 1000-seed weight and seed yield per plant as well as seed, straw and biological yields and gross return, net return and BCR were signi ficantly higher with application of 40 kg P_2O_5 /ha (Table1&2). Application of 40 kg P_2O_5 / ha increased seed and straw yield by 13 and 12 per cent, respectively over 20 kg P_2O_5. Similarly, net return and BCR were also increased by 25 and 23 per cent respectively over lower level but harvest index was not significantly affected by phosphorus levels. Adequate supply of phosphorus plays a vital role in various metabolic processes, which resulted in increased flowering and fruiting thereby improving pods per plant. Phosphorus also involved in transformation of energy in biological reaction. These processes might be favourably improved with phosphorus application and finally resulted in higher yield attributes. Beneficial effect of phosphorus fertilization on yield attributes and yield of grain legumes is universally accepted. Seed yield of a crop is a function of yield attributes such as number of pods per plant, number of seeds per pod, seed

Table 2. Yield, return and BCR as influenced by N,P and bio-fertilizer levels (Pooled data of 2006-07 and 2007-08)

Treatments	Seed yield (kg /ha)	Straw yield (kg/ ha)	Biological yield (kg/ ha)	Harvest Index (%)	Gross return (Rs./ha	Net return (Rs./ha	BCR
(A) Nitrogen levels							
N_1 : 10 (kg /ha)	1156	2398	3554	32.54	38839	18344	0.90
N_2 : 20 (kg /ha)	1367	2778	4145	32.98	45860	25257	1.22
CD(P=0.05)	50.2	116.9	156.9	0.73	1685	875	0.04
(B) Phosphorus levels							
P_1 : 20 (kg /ha)	1182	2445	3627	32.61	39728	19379	0.95
P_2 : 40 (kg /ha)	1340	2730	4070	32.91	44971	24221	1.17
CD(P=0.05)	50.2	116.9	156.9	0.73	1685	875	0.04
(C) Bio-fertilizer							
B_1 : Without inoculation	1171	2402	3573	32.74	39307	18815	0.92
B_2 : Rhizobium inoculation	1262	2589	3851	32.76	42379	21817	1.06
B_3 : PSB inoculation	1246	2556	3802	32.77	41841	21279	1.04
B_4 : Rhizo.+PSB inoculation	1366	2802	4169	32.77	45871	25289	1.23
CD (P=0.05)	57.9	135.0	181.2	0.84	-	-	-
N x P interaction	Sig.	Sig.	Sig.	NS	-	-	-

yield per plant and 1000-seed weight. Increase in growth and yield attributes due to increasing levels of P will have direct and positive effect on seed, straw and biological yields of fenugreek. These results confirm the findings of Bhunia *et al.* (2006). Higher net return and BCR with application of increasing levels of P were obtained on account of higher seed yield which resulted in higher net return because of less cost involved in application of additional dose of P_2O_5 as compared to additional yield obtained. These results corroborate with the findings of Chaudhary (1999) who reported that maximum net return and BCR in fenugreek was obtained with application of 40 kg P_2O_5 /ha. Parmar and Thanki (2007) in gram also reported that increasing level of P increased net return and BCR.

Interaction effect between nitrogen and phosphorus

Most of the yield attributes *viz.* length of pod, number of pods per plant, number of seeds per pod and seed yield per plant and seed, straw as well as biological yields were significantly influenced by the interaction effect between nitrogen and phosphorus. Combined application of 20 kg N + 40 kg P_2O_5 /ha exhibited significantly higher length of pod, number of pods per plant, number of seeds per pod, seed yield per plant, seed yield, straw yield, biological yield, gross return, net return and BCR over rest of the treatment combinations and the lowest values of these parameters were obtained with application of 10 kg N + 20 kg P_2O_5 /ha. Combined application of 20 kg N + 20 kg P_2O_5/ ha and 10 kg N + 40 kg P_2O_5

Table 3. Yield attributes of fenugreek as influenced by interaction effect between N and P (Pooled data of 2006-07 and 2007-08)

Nitrogen/ Phosphorus levels (kg/ ha)	Length of pod (cm)		Number of pods / plant		Number of seeds per pod (g)		Seed yield per plant (g)	
	P_1: 20	P_2: 40	P_1: 20	P_2: 40	P_1: 20	P_2: 40	P_1: 20	P_2: 40
N_1:10	10.09	10.71	23.47	24.93	11.84	12.58	4.64	4.93
N_2:20	11.11	13.31	24.96	29.89	12.86	15.41	5.89	7.06
CD (P=0.05)	0.52		1.18		0.62		0.62	

Table 4. Yield, return and BCR of fenugreek as influenced by interaction effect between N and P (Pooled data of 2006-07 and 2007-08)

Nitrogen/ Phosphorus levels (kg/ ha)	Seed yield (kg /ha)		Straw yield (kg/ ha)		Biological yield (kg/ ha)		Gross return (Rs./ha)		\Net return (Rs./ha)		BCR	
	P_1: 20	P_2: 40	P_1: 20	P_2: 40	P_1: 20	P_2: 40	P_1: 20	P_2: 40	P_1: 20	P_2: 40	P_1: 20	P_2: 40
N_1:10	1121	1190	2338	2457	3458	3648	37689	39989	17394	19293	0.86	0.93
N_2:20	1244	1490	2553	3002	3797	4492	41768	49953	21364	29149	1.05	1.40
CD (P=0.05)	57.9		135.0		181.2							

/ha resulted at par yield attributes and yields. Improved growth and development under combined influence of N and P increased the yield attributes and seed yield significantly, probably by improving source and sink relationship. Rathore and Manohar (1989) and Chaudhary,(1999) reported similar results in fenugreek.

Effect of bio-fertilizer

Combined inoculation of seed with *Rhizobium* and PSB resulted in significantly higher yield attributes, yield, gross return, net return and BCR in fenugreek over their sole application and control (Table1&2). Inoculation of seed with *Rhizobium* and PSB separately also gave significantly higher yield attributes and yield over control. Harvest index was not significantly affected by bio-fertilizers levels. Inoculation of seed with *Rhizobium* and PSB increased seed and straw yield by 16 and 17 per cent, respectively over control. This might be due to the fact that *Rhizobium* inoculation increased root through better root development, nodulation, more nutrient availability resulting in vigorous plant growth and dry matter production which in turn resulted in better flowering and pod formation thereby giving higher yield attributes and yield over control. These results corroborated with the findings of Chaudhary (1999) in fenugreek, Singh and Chauhan (2005) in lentil. Synergistic effect of *Rhizobium* and PSB might have increased the growth and yield attributes which ultimately increased seed, straw and biological yields of fenugreek due to higher nitrogenase activity and available P status of soil. Meena and Pareek (2001) in chick pea have also reported similar type of effect of *Rhizobium* and PSB as alone or in combination on yield attributes and yield. Higher net return and BCR with combined inoculation with *Rhizobium* and PSB was obtained due to higher seed yield coupled with very less cost involved in inoculation. These results are in conformity with those of Chaudhary (1999) who reported that maximum net return of Rs.15407 /ha and BCR of 1.63 in fenugreek was obtained by inoculation of seed with *Rhizobium*.

Thus, higher seed, straw and biological yield as well as net return and BCR in fenugreek can be obtained by application of 20 kg nitrogen and 40 kg phosphorus /ha with seed inoculation by *Rhizobium* and PSB

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