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Influence of nitrogen, phosphorus and bio-fertilizers on growth characters and yield of fenugreek (*Trigonella foenum-graecum* L.)

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Abstract

A field experiment was carried out at Sardarkrushinagar (Gujarat) to find out the optimum levels of nitrogen and phosphorus with bio-fertilizers for obtaining higher yield in fenugreek (*Trigonella foenum-graecum*). Sixteen treatment combinations of two nitrogen levels (10 and 20 kg N ha^{-1}), two phosphorus levels (20 and 40 kg P_2O_5 ha^{-1}) and four bio-fertilizer levels (Control, *Rhizobium* sp., Phosphate solublising bacteria (PSB) and *Rhizobium* sp. + PSB) were evaluated in the experiment. Application of 20 kg N and 40 kg P_2O_5 ha^{-1} produced higher plant height, dry matter and leaf $plant^{-1}$, leaf area index and seed and straw yields over 10 kg N and 20 kg P_2O_5 ha^{-1}. Individual and combined application of both *Rhizobium* sp. and PSB was at par with each other with respect to plant height but significantly better over control during both the years. Dry matter accumulation, leaf area index seed and straw yields were higher with inoculation of seed with *Rhizobium* sp. and PSB over their individual application as well as control at all growth stages during both the years. Thus, application of 20 kg N and 40 kg P_2O_5 ha^{-1} with seed inoculation by *Rhizobium* sp. and phosphorus solublizing bacteria is better for higher growth and yield of fenugreek.

Keywords: fenugreek, growth, *nutrition, Trigonella foenum-graecum.*

Introduction

Information on integrated nutrient management in fenugreek (*Trigonella foenum-graecum* L.) grown under semi-arid conditions in India is less. Pareek & Manohar (2004) reported higher seed yield of fenugreek with application of 20 kg N + 40 kg P_2O_5 ha^{-1} under Rajasthan condition. Hence, the present study was undertaken to see the effect of nitrogen, phosphorus and bio-fertilizers on growth and yield of fenugreek under semi-arid climatic condition of Gujarat.

Materials and methods

The field experiment was carried out for two consecutive years (2006-07 and 2007-08) on loamy sand soil of research farm of

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Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat). The experiment was laid out in different fields during the two years under study. The soil had pH 7.75 and 7.73 and electrical conductivity 0.12 and 0.11 dSm^{-1}, respectively during 2006-07 and 2007-08. The soil of the experimental field was low in organic matter (0.17% and 0.22%), available nitrogen (152.75 and 165.25 kg ha^{-1}), and medium in phosphorus (40.75 and 47.6 kg ha^{-1}) and good with respect to available potassium (260.25 and 264.70 kg ha^{-1}). During 2006-07 and 2007-08, 16 treatment combinations of two nitrogen levels (10 and 20 kg N ha^{-1}), two phosphorus levels (20 and 40 kg P_2O_5 ha^{-1}) and four bio-fertilizer levels (control, *Rhizobium* sp., phosphate solublising bacteria (PSB) and *Rhizobium* sp. + PSB) were laid in a factorial randomized block design with three replications. Full dose of nitrogen and phosphorus as per treatment was drilled manually through urea and SSP at the time of sowing. Inoculation of seeds of fenugreek with respective bio-fertilizers was done before sowing and after drying in shade; sowing was done manually at 30 cm row to row spacing maintaining a seed rate of 20 kg seeds ha^{-1}.

The fenugreek variety GM-2 was sown during the second week of November during both the years. Recommended cultural practices were adopted for raising a healthy crop. Five plants were selected randomly from each plot for recording plant height, dry matter accumulation $plant^{-1}$ and leaf area at periodical growth stages (30, 60, 90 days after sowing and at maturity). Seed and straw yield were recorded at harvest. The samples were first dried under shade for 48 h and then in oven at 70°C till constant weights were obtained. The mean value of leaf area $plant^{-1}$

Table 1. Influence of nitrogen, phosphorus and bio-fertilizers on plant height and dry matter accumulation in fenugreek

Treatment	Plant height (cm)				Dry matter accumulation $plant^{-1}$ (g)			
	30 DAS	60 DAS	90 DAS	Maturity	30 DAS	60 DAS	90 DAS	Maturity
Nitrogen								
10 (kg ha^{-1})	6.9	36.3	47.0	55.2	0.375	3.045	9.795	11.950
20 (kg ha^{-1})	8.3	41.3	54.3	63.0	0.400	3.650	12.400	15.680
SEm ±	0.1	0.5	0.7	0.8	0.004	0.040	0.192	0.278
CD (P=0.05)	0.3	1.5	2.0	2.3	0.013	0.113	0.543	0.802
Phosphorus								
20 (kg ha^{-1})	7.1	36.4	47.5	55.4	0.364	2.999	9.666	11.809
40 (kg ha^{-1})	8.1	41.2	53.8	62.7	0.411	3.696	12.529	15.821
SEm ±	0.1	0.5	0.7	0.8	0.004	0.040	0.192	0.278
CD (P=0.05)	0.3	1.5	2.0	2.3	0.013	0.113	0.543	0.802
Bio-fertilizer								
Without inoculation	7.1	36.3	47.4	55.3	0.363	3.041	9.541	11.678
Rhizobium sp.	7.7	39.6	51.7	60.3	0.387	3.366	11.327	13.993
PSB	7.6	39.0	50.9	59.4	0.382	3.307	10.985	13.637
Rhizobium sp. + PSB	7.9	40.2	52.5	61.3	0.418	3.676	12.537	15.952
SEm ±	0.1	0.6	0.8	1.0	0.005	0.046	0.222	0.393
CD (P=0.05)	0.3	1.7	2.3	2.7	0.015	0.131	0.627	1.134
N X P interaction	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Values indicate mean of 2 years; DAS=Days after sowing PSB=Phosphorus solublizing bacteria

Table 2. Interaction effect between nitrogen and phosphorus levels on plant height in fenugreek

Nitrogen level (kg ha^{-1})	Phosphorus level (kg ha^{-1})							
	30 DAS		60 DAS		90 DAS		Maturity	
	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
20	7.5	9.0	37.5	45.0	49.40	59.18	57.33	68.66
SEm±	0.1		0.6		0.82		0.96	
CD (P=0.05)	0.3		1.7		2.31		2.71	

Values are means of 2 years; DAS=Days after sowing

Table 3. Interaction effect between nitrogen and phosphorus levels on dry matter accumulation in fenugreek

Nitrogen level (kg ha^{-1})	Phosphorus level (kg ha^{-1})							
	30 DAS		60 DAS		90 DAS		Maturity	
	20	40	20	40	20	40	20	40
10	0.364	0.386	2.831	3.259	8.88	10.71	10.58	12.82
20	0.364	0.436	3.167	4.133	10.45	14.35	12.80	17.73
SEm±	0.005	0.005	0.046	0.046	0.22	0.22	0.27	0.27
CD (P=0.05)	0.015	0.015	0.131	0.131	0.63	0.63	0.76	0.76

Values are means of 2 years; DAS= Days after sowing

was computed to work out leaf area index by using the formula suggested by Watson (1947).

Results and discussion

Effect of nitrogen

Plant height, dry matter accumulation plant^{-1}, leaf area and leaf area index (LAI), seed yield and straw yields were significantly affected by application of varying levels of nitrogen (Tables 1 and 4). Application of 20 kg N ha^{-1} resulted in significantly higher plant height, dry matter accumulation, leaf area, LAI, seed and straw yields over 10 kg N ha^{-1} during both the years. This might be due to early and abundant availability of nitrogen leading to better nutritional environment in the root zone for growth and development of the crop as reported earlier by Detroja *et al*. (1996).

Effect of phosphorus

Application of varying levels of phosphorus influenced plant height, dry matter accumulation, leaf area, LAI, seed and straw yields during both the years of study. Application of 40 kg P_2O_5 ha^{-1} resulted in higher plant height, dry matter accumulation plant^{-1}, leaf area plant^{-1}, LAI, seed and straw yields over 20 kg P_2O_5 (Tables 1 and 4). The applied phosphorus probably increased the nitrogenase activity of roots which enhanced root nodulation and created a congenial environment in the rhizosphere that resulted in increasing physiological growth parameters. Increase in growth parameters like plant height, dry matter accumulation and branches plant^{-1} due to application of 40 to 60 kg P_2O_5 ha^{-1} in fenugreek have also been reported by Detroja *et al*. (1995) and Bhunia *et al*. (2006).

Interaction effect of nitrogen and phosphorus

The interaction effect between nitrogen and phosphorus was significant with respect to plant height, dry matter accumulation, leaf area plant^{-1}, LAI, seed and straw yields during both the years. Application of 20 kg N with

Table 4. Influence of nitrogen, phosphorus and bio-fertilizers on leaf area, leaf area index, seed and straw yields in fenugreek

Treatment	Leaf area per plant (dm^2)				Leaf area index				Seed yield	Straw yield
	30 DAS	60 DAS	90 DAS	Maturity	30 DAS	60 DAS	90 DAS	Maturity	(kg ha^{-1})	(kg ha^{-1})
Nitrogen										
10 (kg ha^{-1})	0.378	1.475	3.400	1.415	0.126	0.492	1.133	0.472	1156.0	2398.0
20 (kg ha^{-1})	0.432	1.665	3.825	1.600	0.144	0.555	1.275	0.533	1367.0	2778.0
SEm±	0.005	0.019	0.047	0.020	0.002	0.006	0.016	0.007	17.7	41.3
CD (P=0.05)	0.014	0.054	0.133	0.056	0.005	0.018	0.044	0.019	50.2	116.9
Phosphorus										
20 (kg ha^{-1})	0.380	1.473	3.389	1.414	0.127	0.491	1.130	0.471	1182.0	2445.0
40 (kg ha^{-1})	0.430	1.667	3.836	1.601	0.143	0.556	1.279	0.534	1340.0	2730.0
SEm±	0.005	0.019	0.047	0.020	0.002	0.006	0.016	0.007	17.7	41.3
CD (P=0.05)	0.014	0.054	0.133	0.056	0.005	0.018	0.044	0.019	50.2	116.9
Bio-fertilizer										
Without inoculation	0.379	1.470	3.383	1.412	0.127	0.490	1.128	0.471	1171.0	2402.0
Rhizobium sp.	0.413	1.602	3.686	1.538	0.138	0.534	1.229	0.513	1262.0	2589.0
PSB	0.407	1.578	3.632	1.516	0.136	0.526	1.211	0.505	1246.0	2556.0
Rhizobium sp. + PSB	0.420	1.629	3.749	1.564	0.140	0.543	1.250	0.521	1366.0	2802.0
SEm±	0.006	0.022	0.054	0.023	0.002	0.007	0.018	0.008	20.5	47.7
CD (P=0.05)	0.016	0.062	0.153	0.064	0.005	0.021	0.051	0.021	57.9	135.0

Values indicate mean of 2 years; DAS=Days after sowing PSB=Phosphorus solubilizing bacteria

Table 5. Interaction effect between nitrogen and phosphorus levels on leaf area (dm^2) in fenugreek

Nitrogen level (kg ha^{-1})	Phosphorus level (kg ha^{-1})							
	30 DAS		60 DAS		90 DAS		Maturity	
	20	40	20	40	20	40	20	40
10	0.367	0.389	1.431	1.519	3.30	3.50	1.37	1.46
20	0.393	0.471	1.515	1.815	3.48	4.17	1.46	1.74
SEm±	0.006	0.006	0.022	0.022	0.05	0.05	0.02	0.02
CD (P=0.05)	0.016	0.016	0.062	0.062	0.15	0.15	0.06	0.06

Values are means of 2 years; DAS=Days after sowing

Table 6. Interaction effect between nitrogen and phosphorus levels on leaf area index, seed and straw yields in fenugreek

Nitrogen level (kg ha^{-1})	Phosphorus level (kg ha^{-1})											
	Leaf area index								Yield (kg ha^{-1})			
	30 DAS		60 DAS		90 DAS		Maturity		Seed		Straw	
	20	40	20	40	20	40	20	40	20	40	20	40
10	0.122	0.130	0.477	0.506	1.099	1.167	0.458	0.486	1121.0	1190.0	2338.0	2457.0
20	0.131	0.157	0.505	0.605	1.160	1.390	0.485	0.581	1244.0	1490.0	2553.0	3002.0
SEm±	0.002		0.007		0.018		0.008		20.5		47.7	
CD (P=0.05)	0.005		0.021		0.051		0.021		57.9		135.0	

Values are means of 2 years

40 kg P_2O_5 resulted in significantly highest plant height, dry matter accumulation, leaf area $plant^{-1}$, LAI, seed and straw yields as compared to all other treatment combinations (Tables 2, 3, 5 and 6). Thus combined application of nitrogen and phosphorus created a favourable environment which increased the uptake of nutrients from the soil for better growth and development. Plant height, dry matter accumulation, leaf area $plant^{-1}$, LAI, seed and straw yields were highest with application of 20 kg N + 40 kg P_2O_5 ha^{-1}. Similar results were also reported by Verma *et al*. (1991) and Mavi *et al*. (2000).

Effect of bio-fertilizers

Individual and combined application of both *Rhizobium* sp. and PSB was at par with each other and resulted in higher plant height over control at all growth stages during both the years but dry matter accumulation, leaf area $plant^{-1}$, LAI, seed and straw yields was significantly higher with combined inoculation of seed with *Rhizobium* sp. and PSB over their individual application and control (Tables 1 and 4). Nitrogen and phosphorus are major plant nutrients and combined inoculation of *Rhizobium* sp. and PSB benefit plants more than either group of organisms alone and may have an added advantage. These results are in conformity with the findings of Bhunia *et al*. (2006).

Thus it is inferred that application of 20 kg N and 40 kg P_2O_5 ha^{-1} with inoculation of seed by *Rhizobium* sp. and PSB is better for realizing higher growth, development and yield of fenugreek under semi-arid conditions in Gujarat.

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