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Effect of integrated phosphorus management on yield, uptake and quality of fenugreek [*Trigonella foenum-graecum* L.]

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ABSTRACT

A field experiment was conducted during *rabi* 2014-15 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, to study the 'Effect of integrated phosphorus management on yield, uptake and quality of fenugreek'. The experiment consisted of 10 different treatments of integrated phosphorus management practices for application of recommended dose of phosphorus (RDP) to fenugreek i.e. 40 kg/ha through different sources *viz.*, control, organic [vermicompost (VC) and castorcake (CC)], inorganic fertilizer alone or in combination with organic sources and PSB. Results revealed that integration of 50% RDP through vermicompost + 50% RDP through inorganic fertilizer along with seed inoculation of PSB recorded higher seed yield and straw yield as well as significantly improved the microbial population of *rhizobium* and PSB in the soil after harvest of the crop as compared to rest of the treatments. Combined application of 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB inoculation registered higher P content, total uptake of nitrogen and phosphorus by fenugreek over control and application of organic manure and inorganic fertilizer alone surpassed rest of the treatments. It was also proved best treatment for getting maximum net profit and BCR. Different phosphorus management treatments failed to produce significant influence on protein content.

Key words : Castor cake, economics, rhizobium, vermicompost

Fenugreek popularly known as by its vernacular name "methi' is an important condiment legume crop grown in Northern India concentrated in Rajasthan and Gujarat states. The seeds of fenugreek are used in chronic dysentery, chronic diarrhea and cough, enlargement of lever, diabetic, spleen and rickets. Its seeds are also used to induce lactation during post natal period. Looking to the importance of fenugreek among spices and condiments, it may be called as queen of seed spices.

Phosphorus is backbone of energy related activities and development of root system. Most of the Indian soils have inadequate supply of phosphorus hence need to supplement P in the form of fertilizer for optimum crop production. Application of organic manure in conjunction with inorganic fertilizer in an integrated manner appears to be the best alternative.

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Integrating chemical fertilizer with organic manures has been found to be quiet promising not only in maintaining higher productivity but also in providing great stability in crop production (Nambiar and Abrol, 1989).

Integrated phosphorus management has assumed greater significance in the recent past mainly because of two reasons. First, the continuous increase in agricultural production with shrinking land resources requires increased level of fertilizer and present level of fertilizer production in India is not enough to meet the total plant nutrients requirement. The gap between demand and supply of fertilizers was about 3.5 million tonnes in 2012-13. Secondly, the results of large number of experiments on manure and fertilizers conducted in the country revealed that neither chemical fertilizers nor organic manures alone exclusively can achieve the production sustainability of soil as well as crop. Even balanced use of chemical fertilizer will not be able to sustain high productivity due to the emerging deficiency of one or more of

secondary and micronutrients (Hedge and Sarkar, 1990). The combined use of organic and inorganic sources of nutrients in an integrated way found superior to the use of each component separately. Keeping in view present study was undertaken to study the effect of integrated phosphorus management on yield, uptake and quality of fenugreek (*Trigonella foenum-graecum* L.)

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2014-15 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of integrated phosphorus management on yield, uptake and quality of fenugreek (*Trigonella foenum-graecum* L.)". The soil of the experimental plot was loamy sand containing 149, 39.60 and 188 kg/ha available nitrogen, phosphorus and potassium, respectively in 0-15 cm soil depth with pH 8.0 and organic carbon 0.27 per cent. There was 10 treatments *viz.*,T_1: control i.e. 20 kg N/ha through inorganic fertilizer (urea), T_2 : 100 % RDP through vermicompost, T_3 : 100% RDP through castor cake, T_4:100 % RDP through inorganic fertilizer, T_5: 50% RDP through vermicompost + 50% RDP through castorcake, T_6: 50% RDP through vermicompost + 50% RDP through castor cake + PSB, T_7: 50% RDP through vermicompost + 50% RDP through inorganic fertilizer, T_8: 50% RDP through castor cake + 50% RDP through inorganic fertilizer,T_9 : 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB and T_{10}: 50% RDP through castor cake + 50% RDP through inorganic fertilizer + PSB were evaluated in randomized block design with four replications. The recommended dose of nitrogen (20 kg/ha) was applied through urea at basal. While phosphorus through single super phosphate, vermicompost and castor cake were applied at basal as per treatments. Castor cake was applied 10 days before sowing of fenugreek in previously opened furrow as per treatments. Quantity of castor cake and vermicompost added in treatments was determined by considering the phosphorus content in castor cake (0.8 %) and vermicompost (1.3 %). For studying the growth and yield attributes five plants were tagged randomly in the net plot. Yield and yield attributes were recorded at harvest under different treatments. The cost of cultivation and returns were calculated by taking into account the prevailing cost of inputs and prices of produce.

Estimation of N and P content in seed and straw of fenugreek was done by using Kjeldhal method (Waranke and Barber, 1974) and Vanado molydophosphoric acid yellow colour method (Jackson, 1973), respectively. The uptake of nitrogen and phosphorus in seed and straw were determined by using the following formula.

Total nutrient uptake (kg/ha) = [Nutrient content in seed (%) x Seed yield (kg/ha)] + [Nutrient content in straw (%) x Straw yield (kg/ha)]

The protein content in seed was calculated by multiplying nitrogen content of the seed (per cent) with the factor 6.25 as reported by Gupta *et al.,* (1972) and was expressed as percentage of protein content. Count of *rhizobium* and PSB in soil after harvest of crop were analyzed by Spread (Pour) plate method.

RESULTS AND DISCUSSION

Seed and straw yields

The application of phosphorus through various sources along with biofertilizer (PSB) significantly influenced seed and straw yields over control (Table 1). The maximum seed (1895 kg/ha) and straw (3638 kg/ha) yields of fenugreek were recorded by the application of 50% RDP through vermicompost + 50 % RDP through inorganic fertilizer + PSB inoculation (T_9) and was found statistically at par with 50% RDP through castor cake + 50% RDP through inorganic fertilizer with and without PSB (T_8 & T_{10}) but significantly superior over rest of the treatments (Table 1). In comparison to control and sole application of organic manures and inorganic fertilizer, an additional seed yield of 464 to 776 kg/ha and straw yield of 990 to 1475 kg/ha were obtained with conjunctive use of organic manure + inorganic fertilizer with biofertilizer i.e. 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB, which might be due to direct application of an appreciable amount of essential plant nutrients through organic manures and improvement in physical properties of the soil (Nambiar and Abrol, 1989). Higher yield in this treatment might be due to cumulative effect of elevated growth as well as yield structure. The results supported by the findings of Wagadre *et al.*, (2010).

Nitrogen and Phosphorus content and uptake

Integrated application of phosphorus failed to reach the level of significance with respect to nitrogen content in seed and straw and P content in straw

Table 1 Yield, protein content, microbial population and economics as influenced by different treatments

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Protein content (%)	Rhizobium (CFU x 10^6/g soil)	PSB (CFU x 10^6/ g soil)	Cost of cultivation (₹ /ha)	Net return (₹ /ha)	BCR
T_1 : Control (20 kg N/ha through urea)	1119	2163	19.74	4.78	5.18	28194	39840	2.41
T_2 : 100% RDP through vermicompost	1431	2648	19.95	5.47	5.49	44323	42326	1.95
T_3:100% RDP through castorcake	1188	2259	19.66	5.46	5.48	47878	24239	1.51
T_4 : 100% RDP through inorganic fertilizer	1361	2499	20.11	5.52	6.52	29619	52733	2.78
T_5 : 50% RDP through vermicompost + 50% RDP through castorcake	1606	3139	20.18	6.08	6.58	46101	51646	2.12
T_6 : 50% RDP through vermicompost + 50% RDP through castor cake +PSB	1570	2928	20.20	6.24	6.75	46181	48953	2.06
T_7 : 50% RDP through vermicompost + 50% RDP through inorganic fertilizer	1577	3209	20.49	6.20	6.71	36864	59498	2.61
T_8 : 50% RDP through castorcake + 50% RDP through inorganic fertilizer	1753	3374	20.61	6.16	6.66	38641	67896	2.76
T_9 : 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB	1895	3638	21.05	6.64	7.19	36944	78195	3.12
T_{10}: 50% RDP through castorcake + 50% RDP through inorganic fertilizer + PSB	1786	3526	21.03	6.31	6.83	38722	70086	2.81
S.Em. ±	54.7	138.8	0.39	0.27	0.21	-	-	-
CD (P = 0.05)	158.7	402.8	NS	0.78	0.60	-	-	-
CV (%)	7.16	9.43	3.83	9.10	6.53	-		
Initial microbial population	-	-	-	4.91	4.23	-	-	-

Table 2 Nutrient content and uptake by fenugreek as influenced by different treatments

Treatment	N content (%)		P content (%)		Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)		
	Seed	Straw	Seed	Straw	Seed	Straw	Total	Seed	Straw	Total
T_1 : Control (20 kg N/ha through urea)	3.16	0.42	0.19	0.14	35.36	9.08	44.48	2.12	3.02	5.25
T_2 :100% RDP through vermicompost	3.19	0.42	0.21	0.14	45.64	11.12	56.93	3.00	3.70	6.77
T_3 : 100% RDP through castor cake	3.15	0.43	0.21	0.15	37.42	9.71	46.98	2.49	3.38	5.75
T_4 : 100% RDP through inorganic fertiliizer	3.22	0.43	0.21	0.15	43.82	10.49	54.44	2.85	3.74	6.51
T_5 : 50% RDP through vermicompost + 50% RDP through castor cake	3.23	0.43	0.21	0.14	51.87	13.49	65.24	3.37	4.39	7.92
T_6 : 50% RDP through vermicompost + 50% RDP through castor cake + PSB	3.23	0.43	0.21	0.15	50.71	12.59	63.27	3.29	4.39	7.71
T_7 : 50% RDP through vermicompost + 50% RDP through inorganic fertilizer	3.28	0.43	0.22	0.15	51.72	13.79	65.56	3.46	4.81	8.16
T_8 : 50% RDP through castor cake + 50% RDP through inorganic fertilizer	3.30	0.44	0.22	0.15	57.84	14.83	72.60	3.85	5.06	8.90
T_9 : 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB	3.37	0.44	0.23	0.15	63.86	16.09	80.23	4.35	5.45	9.98
T_{10} : 50% RDP through castor cake + 50 % RDP through inorganic fertilizer + PSB	3.37	0.44	0.22	0.15	60.18	15.51	75.71	3.92	5.28	9.27
S.Em. ±	0.06	0.01	0.004	0.003	2.01	0.64	2.29	0.19	0.23	0.32
CD (P = 0.05)	NS	NS	0.01	NS	5.84	1.87	6.65	0.38	0.68	0.93
CV (%)	3.83	2.98	3.53	3.45	8.11	10.13	7.33	7.99	10.84	8.39

(Table 2). Marked differences were observed in P content of seed due to different P management treatments. Application of 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB noted significantly higher P content (0.23) in seed being at par with treatments T_7, T_8 and T_{10}. Increase in P content was to the tune of 15.78 per cent over control These findings are in agreement with those reported by Wagadre *et al.* (2010) and Mehta *et al.* (2012).

Total nitrogen and phosphorus uptake by plant were significantly influenced due to different integrated phosphorus management treatments (Table 2). An application of 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB considerably increased total nitrogen uptake (80.23 kg/ha) and phosphorus uptake (9.98 kg/ha) being found at par with treatment T_{10}. As compared to control, the per cent increase in total nitrogen uptake was 80.37 and 70.21 per cent due to treatments T_9 and T_{10}, respectively. Similarly phosphorus uptake was higher by 90.09 and 76.57 per cent under treatments T_9 and T_{10}, respectively against control treatment. These results are in close conformity with the findings of Khiriya and Singh (2003), Singh *et al.* (2010), and Mehta *et al.* (2012).

The application of vermicompost and castor cake resulted in the formation of carbon dioxide which plays an important role in the solubilization of native P and reduces phosphate fixing capacity of the soil. These action of organic manures resulted into higher P content in seed of fenugreek. It is established fact that nutrient uptake by the crop depends primarily on dry matter accumulation and secondarily on the nutrient content at cellular level. The increased total dry matter production and nutrient content seems to be the major cause responsible for higher N and P uptake of integrated nutrient management.

Protein content

Different integrated phosphorus management treatment did not differ significantly with respect to protein content in seed. This might be due to no significant improvement in nitrogen content (Table 1)) in seed due to different P management treatments in present study. On the contrary to these results, Wagadre *et al.* (2010) observed significant increase in protein content in fenugreek seed.

Microbial population of rhizobium and PSB

Population of soil microbes *viz.*, *rhizobium* and PSB after harvest of crop were improved significantly due to different treatments of integrated phosphorus management (Table 1). Among different treatments, an application of 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB (T_9) exerted its notable impact on increment of population of *rhizobium* (6.64 CFU x 10^8/g soil) and PSB (7.19 CFU x 10^8/g soil) after harvest of crop over control (T_1) and sole application of organic manures (T_2 & T_3) and inorganic fertilizer (T_4) but statistically remained at par with treatments T_5, T_6, T_7, T_8 and T_{10}. The percent increase in population of *rhizobium* and PSB after harvest were 38.91 and 37.24 per cent under treatment T_9 over control treatment (T_1). Integration of sources of nutrients viz; organic, inorganic and biofertilizers application facilitated robust growth of plants and soil health and thereby increased in nodulation. Increasing in nodulation is directly related to increase in microbial population in soil. Similar findings have been reported by Bhatt (2011).

Economics

Integrated management of phosphorus had significant influence on economics of fenugreek. The maximum monetary net return of ₹ 78195/ha with BCR (3.12) were obtained with application of 50% RDP through vermicompost + 50% RDP through inorganic fertilizer + PSB (Table 1) closely followed by application of 50% RDP through castor cake + 50% RDP through inorganic fertilizer + PSB. This could be attributed due to higher seed and straw yield received in these treatments. These findings are in accordance with those reported by Singh *et al.* (2010) and Mehta *et al.* (2012).

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