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Performance of fenugreek (*Trigonella foenum-graecum* L.) varieties at various fertilizer levels and biofertilizers inoculation

D. SINGH[1], V. NEPALIA AND A.K. SINGH[2]

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan 313 001

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ABSTRACT

A field study was conducted during winter seasons of 2003-04 and 2004-05 at Udaipur to assess the performance of two fenugreek (*Trigonella foenum-graecum*) cultivars (RMt-1 and RMt-303) at 3 fertilizer levels (control, 20 + 8.6 kg N + P/ha and 40 + 17.2 kg N + P/ha) and 4 biofertilizer inoculations (uninoculated control, *Rhizobium* alone, PSB alone and *Rhizobium* + PSB). Application of 40 + 17.2 kg N + P/ha proved optimum for fenugreek as it significantly improved growth, yield attributes, yield (1.76 tonne/ha), N, P uptake, net returns (Rs 25,640/ha) and B:C ratio (2:49) over 20 + 8.6 kg N + P/ha and control and also favours soil N and P status. With significant higher seed yield (1.56 tonne/ha), net returns (Rs 22,680/ha) B:C ratio (2:31) and with higher N and P status of soil, the variety 'RMt-303' proved superior when compared with 'RMt-1'. Dual inoculation showed superiority by retaining higher available N and P in soil, higher yield, net returns and B:C ratio compared to *Rhizobium*, PSB alone and uninoculated control.

Key words: Fertilizers, Inoculation, Nitrogen, Phosphorus, *Rhizobium, Trigonella foenum-graecum*

Fenugreek (*Trigonella foenum-graecum*) is an important condiment crop. The crop has immense medicinal value and is a good source of vitamins, protein and essential oils. The crop also plays a very important role in agricultural economy as it has bright export potential and is earning valuable foreign currency for the country. Rajasthan occupies prime position in fenugreek production (56.8 thousand tonnes). However, productivity (1,128 kg/ha) in the state is below the national average and in the North-West part of the state, it is further lower than the state average (GOR, 2006). This needs to be bridged out by removing research gap at micro-farming level. Amongst the production constraints, imbalanced and inadequate nutrition, low cost technology and lack of suitable genotypes were considered to be the most important limiting factors (Khariya and Singh, 2003). Identification of high-yielding adaptable varieties is considered to be first and foremost step for increasing productivity. Then to sustain the productivity of land and sustainability in the productivity of crop, judicious use of fertilizer with integration of bio-fertilizers is important (Bhunia *et al.,* 2006). Therefore the present investigation was carried out to study performance of fenugreek varieties at various fertilizer levels and biofertilizer inoculations.

[1]**Corresponding author**: (E mail: dilipagron@yahoo.com).
[2]NBSS&LUP, University Campus, Udaipur 313001

MATERIALS AND METHODS

Field experiments were conducted during *rabi* seasons of 2003-04 and 2004-05 on clay loam soils at Udaipur. The soil had pH 7.8, organic carbon 0.64%, 268.4-18.5-280.3 kg/ha available N-P-K . The experiment was laid out in split plot design with 3 replications at fix site during both the years. The main plot treatments included combination of 3 N + P fertilizer levels (control, 20 + 8.6 and 40 + 17.2 kg/ha) and 2 varieties ('RMt-1' and 'RMt-303'). The sub-plot treatments included seed inoculation with biofertilizers (uninoculated control, *Rhizobium* alone, PSB alone and *Rhizobium* + PSB combined). As per treatments, full dose of N and P were applied at sowing by drilling in furrows 5 cm below the seeding depth. After seed inoculation with biofertilizers as per treatment, the seeds were sown on same day. The crop was sown on second fortnight of November in 5 × 3 m plots in furrows at 30 cm × 10 cm apart by placing seed at depth of 3 - 4 cm using a seed rate of 25 kg/ha. The crop was harvested in first week of April during both the years. Besides a presowing irrigation, five post-sowing irrigations were given to crop during both the years. The crop was sprayed with monocrotophos (35 EC) 0.05 % in first week of February each year as prophylactic measure against common pests. The nodules which were pinkish in colour were counted separately and considered as effective nodules/plant. The

standard methods were used for determination of N and P from plant as well as soil. N and P uptake were calculated by multiplying nutrient concentration with yield and dividing by 100.The variety 'RMt-1' with yellow seed have semi-erect type of plant and matures in 140-150 days. The variety can give yield up to 1.0-1.8 tonne/ha. The varieties 'RMt-303' has bold and dark yellow seed, has semi erect type of plant and matures in 135 - 145 days. It is mutant progeny of variety 'RMt-1' and can give yield up to 1.6 - 2.2 tonne/ha. To find out economic viability of treatment, the gross realization was worked out on basis of grain and straw yield/ha of each treatment on basis of prevailing market prices. The net monetary returns were calculated by deducting the total cost of cultivation from the gross realization for each treatment. The data were subjected to homogeneity test and upon finding the data homogenous pooling was done. Interaction effects were non-significant, hence only results of main effect were presented.

RESULTS AND DISCUSSION

Growth and yield

Addition of graded dose of N-P fertilizers resulted in significant increase in effective nodules/plant and branches/plant. Application of 40 + 17.2 kg N + P/ha recorded highest nodules and branches/plant which were significantly higher over 20 + 8.6 kg N + P/ha and control. Likewise, highest crop growth rate (CGR) at successive stages were recorded under 40 +17.2 kg N + P/ha which was significantly higher over 20 + 8.6 kg N + P ha and control. At the same time aforesaid parameters were significantly higher under 20 + 8.6 kg N + P/ha over control. The significant improvement in N and P status of soil resulted in better availability of nutrient for growth and development of effective nodules/plant, which helps in absorption and translocation of nutrients from vegetative to reproductive parts. The better nutritional environment in plant seems to have promoted CGR, branches/plant and growth of individual leaves by way of active cell division and elongation. Results corroborated with findings of Havlin *et al.* (2003) and Ali *et al.* (2009). A significant variation in pods/plant, seeds/pod and test weight of fenugreek were recorded with each increment in rate of N and P. All these yield attributes were maximum at 40 + 17.2 kg N + P/ha. Favorable effects of yield attributes resulted in significant yield increase at each rate of N and P application. The maximum seed and straw yield were recorded at 40 + 17.2 kg N + P/ha. Physiological role of N and P in enhancing growth parameter might have led to increased yield attributes and thereby yield of crop at higher rates of N and P application. Mavai *et al.* (2001) and Bhunia *et al* . (2006) also reported similar results.

The variety 'RMt-303' had higher effective nodules and branches/ plant. The CGR between 30-60 DAS and 90 DAS- harvest was significantly higher in 'RMt-303' over 'RMt-1', while at 60-90 DAS, the CGR was almost similar in both varieties. Pods/plant and seeds/pod of 'RMt-303 were higher by 11.04% and 6 78% over 'RMt-1', however, test weight was at par in both the varieties. Higher pods/plant and seeds/pod resulted in significant increase in seed yield of 'RMt-303' by 11.42% over 'RMt-1'. Alike, the 'RMt -303' recorded significantly higher straw yield (Table 1) over 'RMt-1'. The marked variation in growth of 'RMt-303' over 'RMt-1' could be ascribed on account of its genetic capabilities to exploit available resources for growth and development.

Amongst inoculation, *Rhizobium* and PSB alone and their dual inoculation improved growth and yield parameters over control. The highest nodules and branches/plant were recorded under dual inoculation which was significantly higher over single inoculation of PSB, *Rhizobium* and control. At the same time branches/plant and nodules/ plant recorded under single inoculation with PSB and *Rhizobium* were almost equal and proved significantly superior over control. The highest CGR at initial stages was recorded under dual inoculation, which was significantly higher over PSB, *Rhizobium* and control. At initial stage PSB and *Rhizobium* alone proved equally efficient and recorded significantly higher CGR over control, while at later stage, highest CGR was recorded under dual inoculation which was significantly higher over control, however, was at par with *Rhizobium* and PSB alone. At 60-90 DAS inoculation failed to influence CGR. Combined inoculation, PSB and *Rhizoboum* alone recorded significantly higher pods/plant and seeds/pod over control, however, highest value of these parameters (35.85 pods/ plant and16.57 seeds/pod) was recorded under dual inoculations. Similarly highest test weight was recorded under dual inoculations which was significantly higher over PSB alone and control by 2.55% and 3.14% but proved at par with *Rhizobium* alone. Inoculation with PSB + *Rhizobium* resulted in highest seed and straw yield which were significantly higher over PSB, *Rhizobium* alone and control by 6.7, 6.0, 17.7% and 6.3, 12.5, 14.3%, respectively. At the same time single inoculation proved equally efficient and both proved significantly superior over control in seed yield. However, PSB alone treated plant recorded significantly higher straw yield over *Rhizobium* and control. The straw yield recorded under control and *Rhizobium* treated plot was at par. The better performance of dual inoculation might be on account of associative effect of both symbiotic and asymbiotic bacteria. Similar findings have been reported by Ali *et al.* (2009).

Table 1. Effect of fertilizer levels, varieties and bio-fertilizer inoculation on growth, yield attributes, yield, N and P status of soil and economics of fenugreek (pooled over two years)

Treatment	Effective nodules/ plant	Branches/ plant	CGR(g/m²/day) 30-60 DAS	CGR(g/m²/day) 60-90 DAS	CGR(g/m²/day) 90 – harvest	Pods/ plant	Seed/ pod	Test weight (g)	Yield (t/ha) Seed	Yield (t/ha) Stover	Net returns (10^3Rs/ha)	B:C ratio	Uptake (kg/ha) N	Uptake (kg/ha) P	Nutrient (kg/ha) balance in soil N	Nutrient (kg/ha) balance in soil P
Fertilizer level (kg N + P/ha)																
Control	20.7	5.7	2.77	9.94	12.28	31.02	13.80	11.01	1.19	4.20	16.11	1.76	69.4	11.9	273.1	18.6
20 + 8.6	23.8	6.6	3.35	11.83	14.37	35.20	14.45	12.31	1.50	4.74	21.31	2.19	94.7	15.5	290.6	21.0
40 +17.2	26.6	7.3	4.01	12.88	16.44	36.70	16.02	13.43	1.76	5.23	25.64	2.49	110.0	18.8	296.8	22.0
SEm±	0.32	0.08	0.06	0.27	0.41	0.31	0.24	0.12	0.02	0.08	0.46	0.05	1.2	0.2	1.2	0.2
CD (P=0.05)	0.94	0.25	0.19	0.82	1.21	0.93	0.73	0.36	0.08	0.25	1.37	0.14	3.5	0.6	3.5	0.8
Fenugreek variety																
'RMt-1'	22.8	6.3	3.19	11.24	13.68	32.51	14.60	12.12	1.40	4.47	19.37	1.97	84.0	14.2	288.5	20.6
'RMt-303'	24.6	6.9	3.57	11.86	15.05	36.10	15.59	12.38	1.56	4.98	22.68	2.31	96.7	16.5	285.2	20.4
SEm±	0.26	0.07	0.05	0.22	0.33	0.25	0.20	0.10	0.02	0.06	0.38	0.04	1.0	0.2	1.2	0.2
CD (P=0.05)	0.77	0.20	0.16	NS	0.99	0.76	0.59	NS	0.07	0.20	1.12	1.12	2.9	0.5	NS	NS
Biofertilizer																
Control	22.2	6.0	2.48	11.24	12.91	33.00	13.71	12.07	1.35	4.40	18.40	1.89	79.2	13.2	277.7	19.8
Rhizobium	23.7	6.5	3.38	11.79	14.57	34.21	15.16	12.33	1.50	4.47	21.33	2.18	94.1	14.6	292.5	20.0
PSB	23.6	6.5	3.33	11.72	14.50	34.17	14.92	12.14	1.49	4.73	21.11	2.16	87.0	16.2	280.3	21.1
Rhizobiun+PSB	25.3	7.2	4.33	11.45	15.48	35.85	16.57	12.45	1.59	5.03	23.19	2.36	101.1	17.5	296.3	21.2
SEm±	0.39	0.09	0.07	0.23	3.92	0.30	0.26	0.11	0.02	0.08	0.49	0.04	1.4	0.2	1.4	0.2
CD (P=0.05)	0.96	0.26	0.21	NS	1.10	0.86	0.74	0.31	0.08	0.25	1.37	0.15	3.9	0.7	4.0	0.4

Sale price: fenugreek seed: Rs 15,500 (2004) and Rs16,000/tonne (2005) straw: Rs 500 (2004) and Rs 600/t (2005). Common cost of cultivation: Rs 7,635/ha

Economics

There was marked improvement in net returns and B:C ratio with each successive increase in fertilizer level from control to 40 +17.2 kg N + P/ha. It has resulted in higher net returns of Rs 4,329/ha and Rs 9,528/ha and B:C ratio by 13 7 and 41.4% over 20 + 8.6 kg N + P/ha and control, respectively.

The highest net returns and B:C ratio were realized with 'RMt-303' indicating net gains of Rs 3,326/ha and B:C ratio of Rs 0.34 over 'RMt-1'.

Dual inoculation with PSB and *Rhizobium* recorded significantly higher net returns and B:C ratio, over PSB, *Rhizobium* alone and control. At the same time PSB and *Rhizobium* alone proved equally efficient in terms of net returns and B:C ratio and both of these proved significantly superior over control. The results conforms the findings of Purbey and Sen (2005) and Ali *et al.* (2009).

Nutrient uptake

Highest N and P uptake was recorded under application of 40 +17.2 kg N + P/ha which was significantly higher over its lower dose and unfertilized control. "RMt-303' accumulated significantly higher N and P over 'RMt-1'. Amongst biofertilizers, highest N and P uptake were recorded under dual inoculation which was significantly higher over PSB and *Rhizobium* alone. At the same time *Rhizobium* alone treated plot recorded significantly higher N uptake over control and PSB alone, while PSB alone treated plant recorded significantly higher P uptake over *Rhizobium* alone and control. The results conforms findings of Ali *et al.* (2009).

Nutrient balance

Available N and P status of soil increased with increasing level of fertilizer obliviously due to addition of fertilizer. The content of actual N and P showed significant increasing trend with enhancement of N and P fertilizer levels. More N gain was worked out at 40 +17.2 kg N + P/ha. This might be due to profound role of fixing N through root nodules and addition of inorganic fertilizer. Ali *et al* . (2009) also reported similar findings. Contrary P gain decreased with increasing fertilizer might be on account of higher uptake of P by plants and its fixation in soil.

Amongst varieties even after significant higher uptake of N and P by plant, the net gain of N and P was higher under 'RMt-303'. Higher N might be on account of better nodulation in 'RMt-303' when compared with 'RMt-1'.

Highest N and P were retained under dual inoculation with PSB and *Rhizobium.* The next best treatment in retaining higher N and P were single inoculation with *Rhizobium* and PSB, respectively, further conform the role of *Rhizobium* in fixation of N and PSB in solublizing insoluble P from soil. The results are in close conformity with findings of Ali *et al.* (2009).

On the basis of productivity and economics of two years pooled data it is concluded that application of 40 17.2 kg N + P/ha proved optimum for fenugreek. 'RMt-303' variety of fenugreek and dual inoculation *Rhizobium* + PSB proved promising.

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