

Yield and economics of fenugreek (*Trigonella foenum-graecum* L.) as influenced by fertility levels, biofertilizers and brassinosteroid

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ABSTRACT

A field study was conducted during *rabi* seasons of 2012-13 and 2013-14 to assess the yield and profitability of fenugreek as influenced by fertility levels, biofertilizers and brassinosteroid. Three fertility levels [60, 80 and 100 % RDF (40 kg N + 40 kg P₂O₅ + 10 kg S/ha)] and three biofertilizer inoculations (*Rhizobium*, PSB and *Rhizobium* + PSB) in main plot and three concentrations of brassinosteroid (water spray, BR 0.25 ppm and BR 0.50 ppm) in sub plot were studied in split plot design with three replications. The highest values of yield attributes, seed yield (2245 kg/ha), haulm yield (5236 kg/ha), net returns (₹ 56200) and B:C ratio (1.88) were recorded with application of 100 % RDF. Dual inoculation of seed with *Rhizobium* + PSB gave significantly higher yield attributes, seed yield (2085 kg/ha), net return (₹ 50690) and B:C ratio (1.71) over their alone application. Interaction of fertility levels and biofertilizers was also found significant in yield attributes and consequently in yields and economics. Application of 100 % RDF + dual inoculation, being on a par with 80 % RDF + dual inoculation, gave the highest seed yield (2287 kg/ha) and net return (₹ 57939). Foliar spray of brassinosteroid 0.50 ppm brought about 14.6 and 6.2 per cent higher seed yield over water spray and BR 0.25 ppm, respectively. Thus, integration of 80 % RDF with dual inoculation and supplemented with foliar spray of brassinosteroid 0.50 ppm at 50 and 70 DAS is better for realizing higher yield and net return in fenugreek.

Key words: Biofertilizers, Brassinosteroid, Fenugreek, Fertility levels.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) vernacularly known as methi is a multipurpose crop grown during winter season in northern India. It is an annual herb belonging to sub-family Papilliacae of the family Fabaceae. It is one of the important major seed spices in the country cultivated in an area of 93,120 ha producing 112870 tonnes of seed with the productivity of 1212 kg/ha (Anonymous, 2013).

Its productivity is much below to potential yield of about 2500 kg/ha. Rajasthan and Gujrat are the main fenugreek producing states in India. It is emerging as a cash crop in semi arid regions of these two States. Being a legume crop, it is generally cultivated not only on poor fertile soils but with lower doses of fertilizers and other inputs also are some reasons of its low yield. Use of recommended dose of fertilizers is becoming a challenge for poor farmers due to regular hike in prices of fertilizers. Besides, recommended dose of fertilizers use of low cost nutritional inputs is a need of hour, the foremost one is biofertilizers, which can supplement or substitute fertilizers to a great extent, which ultimately reduces burden on exchequer as well as improve soil health, and next option is foliar feeding with growth

hormones like brassinosteroid which has vital role in improving physiological efficiency of crop (Mandava, 1988) which ultimately enhances yield. Therefore, the present study was undertaken to see the effect of fertility levels, biofertilizers and brassinosteroid on yield attributes, yield and profitability of fenugreek.

MATERIALS AND METHODS

A field experiment was carried out during 2012-13 and 2013-14 on sandy loam soil at National Research Centre on Seed Spices, Ajmer (Rajasthan). The soil of the experimental site was sandy loam with a pH 8.03 having 0.28 per cent organic carbon and 151.3, 7.8 and 197.1 kg/ha available N, P and K, respectively. The experiment was laid out in split plot design comprising three levels of fertility (F₁-60 % RDF, F₂-80 % RDF and F₃-100 % RDF) and three biofertilizer inoculation (B₁-*Rhizobium*, B₂- PSB and B₃-*Rhizobium*+ PSB) as main plot and three concentrations of brassinosteroid (G₀- water spray, G₁- BR 0.25 ppm and G₂- BR 0.50 ppm) as sub plot treatment replicated thrice. RDF comprised of 40 kg N + 40 kg P₂O₅ and 10 kg S/ha. Sowing of fenugreek (RMt-143) using 20 kg seed/ha was done at 30 cm line to line spacing and plant to plant distance of 10 cm was maintained. Seed treatment with *Rhizobium meliloti*,

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PSB and with both was done as per treatment before sowing. Full dose of nitrogen, phosphorus and sulphur was provided at the time of sowing. The nitrogen, phosphorus and sulphur were supplied through urea, DAP and gypsum, respectively. Brassinosteroid was sprayed twice at 50 and 70 DAS as per treatment under study. Five plants were selected randomly from each plot to count number of pods and average number of pods per plant was recorded. Observations on yield attributing characters viz., pods/plant, pod length, seeds/ pod and seed and haulm yields were recorded. The statistical analysis was done as per procedure suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Yield attributes: The maximum number of pods/plant, seeds/pod, pod length, 1000-seed weight and seed yield/plant was recorded with application of 100 % RDF. The increase in pods/plant, pod length, seeds/pod, 1000-seed weight and seed yield/ plant with 100 % RDF was in order of 13.7 and 4.5, 13.1 and 4.8, 16.0 and 7.0, 11.3 and 4.7, 33.1 and 10.0 per cent, respectively over 60 and 80 % RDF. This might be due to early and abundant availability of nutrients with 100 % RDF which resulted in higher growth and yield attributes. The results corroborate with findings of Kumar *et al.* (2009) and Singh *et al.* (2010).

An appraisal of data (Table 1) reveals that with regard to yield attributes combined application of both *Rhizobium* and PSB was found significantly better over their sole application; however, sole *Rhizobium* was found on a par with PSB. Dual inoculation produced 6.5 and 7.6, 7.2 and 9.7, 5.6 and 8.2, and 8.0 and 11.6 per cent more pods/ plant, seeds/pod, 1000-seed weight and seed yield/plant, respectively over sole *Rhizobium* and PSB. *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 benefits 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. Thus the increased availability of not only N and P but growth hormones also stimulate plant metabolism which resulted in better yield attributes. These results are in accordance with the findings of Purbey and Sen (2007) and Mehta *et al.* (2012). Interaction effect between fertility levels and biofertilizers in respect of pods/plant, seeds/pod, weight of seeds/pod and seed yield/ plant were observed significant during both the years and in pooled data (Table 1a). The maximum values of aforesaid yield attributes were recorded under 100 % RDF + dual inoculation which were found on a par with 80 % RDF and dual inoculation. Statistically equally good performance of combination of 80 % RDF + dual inoculation was might be due to relatively better bacterial activity at lower fertility level. It is well established that N fixation decreases at higher levels of nitrogen.

Foliar spray of brassinosteroid (BR) @ 0.50 ppm resulted in significantly higher yield attributes over water spray and BR 0.25 ppm. Spray of BR 0.50 ppm gave 8.3 and 3.7, 9.7 and 4.0, 3.8 and 1.8, and 16.0 and 6.2 per cent higher pods/plant, seeds/pod, 1000-seed weight and seed yield/plant over water spray and BR 0.25 ppm, respectively. Improvement in yield attributes ascribed to association of brassinosteroid with enhanced photosynthetic efficiency and transport of photosynthates to reproductive parts

Table 1: Effect of fertility levels, biofertilizers and brassinosteroid on yield attributes of fenugreek (Pooled of two years)

Treatments	Seeds/ pod	Pod length (cm)	1000-seed wt.(g)	Wt. of seeds/ pod (g)	Pods/ plant	Seed yield/ plant (g)
Fertility levels						
F ₁ : 60 % RDF	13.59	10.48	13.28	0.178	31.98	5.594
F ₂ : 80 % RDF	14.67	11.36	14.11	0.201	34.80	6.771
F ₃ : 100 % RDF	15.37	12.16	14.78	0.220	36.37	7.445
SEm ±	0.13	0.12	0.14	0.002	0.35	0.074
CD (P=0.05)	0.39	0.35	0.39	0.007	1.00	0.214
Biofertilizers						
B ₁ : <i>Rhizobium</i>	14.31	11.09	13.91	0.198	33.76	6.497
B ₂ : PSB	13.98	10.78	13.58	0.192	33.43	6.293
B ₃ : <i>Rhizobium</i> +PSB	15.33	12.13	14.68	0.210	35.96	7.020
SEm ±	0.13	0.12	0.14	0.002	0.35	0.074
CD (P=0.05)	0.39	0.35	0.39	0.007	1.00	0.214
Interaction (FXB)	Sig	Sig	NS	Sig	Sig	Sig
Brassinosteroid						
G ₀ : Water spray	13.84	10.79	13.79	0.185	32.98	6.091
G ₁ : BR 0.25 ppm	14.60	11.37	14.06	0.201	34.46	6.654
G ₂ : BR 0.50 ppm	15.18	11.84	14.31	0.213	35.72	7.065
SEm ±	0.12	0.10	0.10	0.002	0.29	0.060
CD (P=0.05)	0.33	0.27	0.28	0.006	0.83	0.169

Table 2: Effect of fertility levels, biofertilizers and brassinosteroid on yield and economics of fenugreek (Pooled of two years)

Treatments	Seed yield (kg/ha)	Haulm yield (kg/ha)	Biological yield (kg/ha)	Harvest index	Gross return (₹/ha)	Net return (/ha)	B:C ratio
Fertility levels							
F ₁ : 60 % RDF	1659	3934	5593	29.71	63866	34818	1.20
F ₂ : 80 % RDF	2000	4677	6678	29.99	76849	47321	1.60
F ₃ : 100 % RDF	2245	5236	7480	30.04	86210	56200	1.88
SEm ±	24	62	81	0.18	904	878	0.03
CD (P=0.05)	69	178	234	NS	2603	2528	0.09
Biofertilizers							
B ₁ : <i>Rhizobium</i>	1934	4597	6532	29.60	74485	44979	1.52
B ₂ : PSB	1885	4308	6193	30.46	72185	42670	1.44
B ₃ : <i>Rhizobium</i> +PSB	2085	4941	7026	29.68	80255	50690	1.71
SEm ±	24	62	81	0.18	904	878	0.03
CD (P=0.05)	69	178	234	0.51	2603	2528	0.09
Interaction (FXB)	Sig	Sig	Sig	NS	Sig	Sig	Sig
Brassinosteroid							
G ₀ : Water spray	1831	4320	6151	29.80	70434	41895	1.47
G ₁ : BR 0.25 ppm	1975	4636	6611	29.89	75930	46401	1.57
G ₂ : BR 0.50 ppm	2098	4891	6989	30.04	80562	50043	1.64
SEm ±	12	42	50	0.14	464	452	0.01
CD (P=0.05)	34	118	142	NS	1308	1274	0.04

(Mandava,1988). These results are in close accordance with Farahat (2002) and Bera and Pramanik (2013).

Yield: The highest seed, haulm and biological yields of fenugreek were obtained with 100 % RDF (Table 2). Application of 100 % RDF produced 35.3 and 12.2 per cent higher seed yield over 60 and 80 % RDF, respectively. The corresponding increases in haulm yield were 33.1 and 11.9 per cent. However, the harvest index was not influenced with fertility level. Adequate nutrient availability at 100 % RDF favoured growth and development of plant and thus increased growth and yield attributes which ultimately increased seed and haulm yield of fenugreek over 60 and 80 % RDF. Increase in seed, haulm and biological yield with 100 % RDF was also reported by Kumar *et al.* (2009), Mehta *et al.* (2012) and Dhaker (2014).

Combined inoculation with *Rhizobium* and PSB exhibited 7.8 and 10.6 per cent higher seed yield over their sole application of *Rhizobium* and PSB. The corresponding increases in haulm yield were 7.5 and 14.7 per cent. However, both inoculants were remained on a par with each other w.r.t. yields. Synergistic effect of *Rhizobium* and PSB might have increased the growth and yield attributes which increased seed, haulm and biological yields of fenugreek due to higher nitrogenase activity and available P status of soil. These results corroborated with the findings of Jat and Shaktawat (2001) and Ali *et al.* (2009). Interaction effect between fertility levels and biofertilizers in respect of seed, haulm and biological yields were observed significant (Table 2 a). Application of 100 % RDF + dual inoculation, being on a par with 80 % RDF + dual inoculation, gave the highest seed, haulm and biological yield.

Brassinosteroid significantly influenced the seed, haulm and biological yield. However, harvest index was remained unaffected due to brassinosteroid. Foliar spray of BR 0.50 ppm produced 14.6 and 6.2 per cent higher seed yield and 13.2 and 5.5 per cent higher haulm yield over water spray and BR 0.25 ppm, respectively. These results were in conformity with the findings of Purbey and Sen (2005) and Singh *et al.* (2010).

Economic analysis: Application of 100 % RDF fetched the highest net return (₹56200) with maximum B:C ratio (1.88). Net return was higher by 61.4 and 18.8 per cent over 60 and 80 % RDF, respectively (Table 2). Higher gross as well as net return with B:C ratio was recorded under dual inoculation with *Rhizobium* and PSB. These results are in accordance with the finding of Mehta and Patel (2011). Interaction effect between fertility levels and biofertilizers in respect of gross return, net return and B:C ratio were observed significant (Table 2 a). Application of 100 % RDF + dual inoculation, being on a par with 80 % RDF + dual inoculation, fetched the highest Gross (₹87986) and net return (₹57939), whereas highest B:C ratio (1.96) was recorded under 80 % RDF + dual inoculation. Brassinosteroid 0.50 ppm fetched the highest net return (₹50043) with maximum B:C ratio (1.64). Net return with BR 0.50 ppm was higher by 18.8 and 12.7 per cent over water spray and BR 0.25 ppm, respectively. Purbey and Sen (2005) also found similar results.

Thus, application of 80 % RDF (32 kg N+ 32 kg P₂O₅+10 kg S) along with dual inoculation of seed with *Rhizobium* and PSB and be supplemented with foliar spray of brassinosteroid 0.50 ppm at 50 and 70 DAS is better for realizing higher yield and net return in fenugreek production.

Table 1a: Yield attributes of fenugreek as influenced by interaction effect between fertility levels and biofertilizers

Fertility levels	Pods/plant			Pods length (cm)			Seeds/pod			Seed weigh/pod (g)			Seed yield/plant (g)		
	Biofertilizers			Biofertilizers			Biofertilizers			Biofertilizers			Biofertilizers		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
F ₁ : 60 % RDF	31.59	30.85	34.91	10.57	10.03	10.84	13.68	13.14	13.94	0.183	0.174	0.178	5.658	5.385	5.738
F ₂ : 80 % RDF	34.64	33.57	36.72	10.86	10.50	12.74	14.17	13.84	16.00	0.195	0.184	0.224	6.477	6.212	7.624
F ₃ : 100 % RDF	35.91	36.86	37.08	11.85	11.80	12.84	15.07	14.97	16.06	0.215	0.217	0.229	7.356	7.282	7.697
B at same F	F at same B			F at same B			B at same F			B at same F			F at same B		
SEm ±	0.81	0.82	0.82	0.21	0.18	0.18	0.23	0.23	0.21	0.004	0.004	0.004	0.129	0.113	0.113
CD (P=0.05)	2.65	2.43	2.43	0.92	0.61	0.61	0.53	0.53	0.61	0.97	0.97	0.011	0.011	0.011	0.371

Table 2a: Yields (seed, haulm and biological) and economics of fenugreek as influenced by interaction effect between fertility levels and biofertilizers

Fertility levels	Seed yield (kg/ha)			Haulm yield (kg/ha)			Biological yield (kg/ha)			Net return			B:C ratio		
	Biofertilizers			Biofertilizers			Biofertilizers			Biofertilizers			Biofertilizers		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
F ₁ : 60 % RDF	1672	1609	1697	4045	3696	4060	5717	5305	5757	35528	32609	36317	1.23	1.12	1.25
F ₂ : 80 % RDF	1898	1833	2270	4482	4177	5373	6379	6010	7643	43499	40651	57813	1.48	1.38	1.96
F ₃ : 100 % RDF	2233	2214	2287	5266	5050	5391	7499	7264	7678	55911	54749	57939	1.87	1.83	1.93
B at same F	F at same B			F at same B			B at same F			B at same F			F at same B		
SEm ±	42	29	29	107	86	86	141	141	108	1520	1520	1085	0.05	0.05	0.04
CD (P=0.05)	120	85	85	308	247	247	406	406	312	4378	4378	3127	0.15	0.15	0.10

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