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Evaluation of nutrient management for better growth, yield and economics of fenugreek

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Abstract

A field experiment was conducted to study the effect of nutrient management combinations in fenugreek (*Trigonella foenum-graecum*). Growth as well as seed and straw yields of fenugreek were significantly influenced by different treatments. Application of recommended dose through inorganic form (50%) + neem cake @ 638 kg ha^{-1} + *Rhizobium melilotii* + phosphate solubilising bacteria (PSB) recorded the highest plant height of 34.98 cm, leaves of 82.35 and branches of 5.5 at the final harvest stage. This treatment also recorded significantly highest straw yields. The maximum seed yield, net returns and benefit cost ratio were obtained in the combination of 50% recommended dose of fertilizer (RDF) + poultry manure (PM) @1000 kg ha^{-1} + *Rhizobium* melilotii + phosphate solubilising bacteria (PSB).

Keywords: fenugreek, integrated nutrient management, *Trigonella foenum-graecum*

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is an important seed spice belonging to the family *Fabaceae*. The yield of fenugreek is known to be influenced by different factors such as nutrition, cultural practices etc. Among these, nutrition plays an important role and which has great influence on vegetative growth as well as yield (Sharma *et al.* 2006). However, fertilizer application has generally remained much below as compared to its removal. Thus, balanced nutrition could be achieved through integrated application of organic and inorganic sources of nutrients. Addition of organic manures not only supplies most of the essential plant nutrients, but also improves the soil structure, cation exchange capacity and water holding capacity of soil. Furthermore, the decomposition and mineralisation of organic manure is a slow process which could match the nutrient requirement of the crop. Results of long term experiments have indicated that a suitable combination of organic and inorganic fertilizers will not only sustain soil fertility but also maintain higher level of quality of the produce (Pillai *et al.* 1985). The concept of integrated nutrient management was proved to be successful in many horticultural crops, which reduces the cost of cultivation, improves soil health and reduces chemical residues (Jain & Choudary 2006). An attempt was, therefore, made to evaluate nutrient management combinations in fenugreek.

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Materials and methods

A field experiment was conducted at College Farm, Horticultural College & Research Institute, Venkataramannagudem, Andhra Pradesh during *rabi* season of the year, 2012–13. The location falls under Agro-climatic Zone-10, humid, East Coast Plain and Hills (Krishna-Godavari zone) with an average annual rainfall of 900 mm, located at an altitude of 34 m above MSL. The geographical co-ordinate is 16.83° N latitude and 81.5° E longitude. It experiences hot humid summer and mild winters. The experiment was laid out in a randomized block design (RBD) with three replications and twelve treatments. The treatments comprised of 100% recommended dose of fertilizer (RDF) [60:50:50 N, P_2O_5, K_2O kg ha^{-1}] as control, different combinations of 100%, 75% and 50% recommended dose of fertilizer (RDF) with organic manures (*viz*., poultry manure (PM) @500 and 1000 kg ha^{-1}, vermicompost (VC) @500 and 1000 kg ha^{-1}, farm yard manure (FYM) @3000 and 6000 kg ha^{-1}, neem cake (NC) @319 and 638 kg ha^{-1}) and biofertilizers inoculation [*Rhizobium melilotii* + phosphate solubilising bacteria (PSB)] to seed. Full dose of N, P and K as per treatment were applied through urea, single super phosphate and muriate of potash at the time of sowing. Inoculation of seeds with respective biofertilizer was done before sowing then dried in shade and sowing was done at 30 cm row spacing using 25 kg seed ha^{-1}. All the recommended package of practices were followed during the crop period. From the value of net monetary returns of each treatment and expenditure incurred, cost benefit ratio was worked out.

Results and discussion

Growth

The data on growth characters such as height of plant, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, spread of plant (east west and north south directions) and dry matter production $plant^{-1}$ at 30 days after sowing (DAS) and at final harvest are presented in Tables 1 & 2. It was evident from the data (Table 1) that plant height ranged from 10.27 cm (T_7) to 12.98 cm (T_{11}) with an average of 11.92 cm at 30 DAS. Further, the nutrient combinations did not exert any significant influence on plant height at this stage. Similarly at harvest also, application of 50% RDF + NC + *Rhizobium* + PSB (T_{11}) recorded the highest plant height of 34.98 cm followed by the application of 100% RDF + *Rhizobium* + PSB (T_1) with 34.63 cm as compared to the control (33.83 cm). The lowest plant height (22.18 cm) was recorded with the application of 50% RDF + PM + *Rhizobium* + PSB.

The data on number of leaves at different growth stages is presented in the Table 1. At 30 DAS, the number of leaves ranged from 14.89 (T_4) to 19.13 (T_{11}) with an average of 16.99. There was no significant difference among the treatments for number of leaves at 30 DAS. However significant differences were recorded in number of leaves at other growth stages. At harvest, combination of 50% RDF + NC + *Rhizobium* + PSB (T_{11}) recorded higher number of leaves (82.35) followed by 50% RDF + *Rhizobium* + PSB (T_3) and 100% RDF + *Rhizobium* + PSB (T_1) compared to control (62.40). The lowest number of leaves (31.56) was recorded in 50% RDF + PM + *Rhizobium* + PSB (T_9).

The integration of 50% organic manures and 50% inorganic fertilizers along with biofertilizers resulted in significant effect on plant height and number of leaves. *Rhizobium* lives in root hairs of the legumes forming root nodules, where it fixes atmospheric N which is the major nutrient available for the growth of the plant. The synergistic effect of *Rhizobium* as well as NC resulted in increased vegetative growth (Singhal & Mudgal 1982). The results are in agreement with the findings of Verma *et al.* (1991), Purbey & Sen (2005), Singh *et al.* (2010) in fenugreek.

Results pertaining to number of branches $plant^{-1}$ (Table 1) indicated that at final harvest, average number of branches $plant^{-1}$ was 4.82. The treatment T_{11} with 50% RDF + NC + *Rhizobium* + PSB recorded maximum number of branches $plant^{-1}$ (5.5) which was followed by 50% RDF + *Rhizobium* + PSB (T_3) [5.3]. The lowest number of branches $plant^{-1}$ (4.1) was recorded with 75% RDF + VC @500 kg ha^{-1} + *Rhizobium* + PSB (T_6). The combination of

Table 1. Effect of INM treatments on plant height (cm), number of leaves and branches plant^{-1} of fenugreek (*Trigonella foenum-graecum*)

Treatments	Plant height (cm)		No. of leaves		No. of branches plant^{-1}	
	30 DAS	At final harvest	30 DAS	At final harvest	30 DAS	At final harvest
T_1 - 100% RDF (60: 50: 50 N, P_2O_5, K_2O kg ha^{-1}) + *Rhizobium* + PSB	12.92	34.63	18.79	80.74	2.67	5.13
T_2 - 75% RDF + *Rhizobium* + PSB	12.89	32.89	17.70	53.20	2.57	4.90
T_3 - 50% RDF + *Rhizobium* + PSB	12.97	34.10	18.61	80.85	2.77	5.30
T_4 - 75% RDF + FYM @ 3000 kg ha^{-1} + *Rhizobium* + PSB	11.25	27.76	14.89	40.99	2.60	4.73
T_5 - 50% RDF + FYM @6000 kg ha^{-1} + *Rhizobium* + PSB	11.89	27.09	16.16	40.62	2.33	4.17
T_6 - 75% RDF + VC @500 kg ha^{-1} + *Rhizobium* + PSB	12.84	27.09	17.11	50.62	2.20	4.10
T_7 - 50% RDF + VC @1000 kg ha^{-1} + *Rhizobium* + PSB	10.27	32.11	15.35	49.71	2.43	4.40
T_8 - 75% RDF + PM @500 kg ha^{-1} + *Rhizobium* + PSB	10.55	25.73	15.82	39.54	2.60	4.83
T_9 - 50% RDF + PM @1000 kg ha^{-1} + *Rhizobium* + PSB	11.81	22.18	17.71	31.56	2.53	4.73
T_{10} - 75% RDF + NC @319 kg ha^{-1} + *Rhizobium* + PSB	12.07	30.16	15.50	76.00	2.67	5.07
T_{11} - 50% RDF + NC @638 kg ha^{-1} + *Rhizobium* + PSB	12.98	34.98	19.13	82.35	3.03	5.50
T_{12} - 100% RDF (60: 50: 50) N, P_2O_5, K_2O kg ha^{-1} (Control)	10.57	33.83	17.17	62.40	2.33	5.00
Mean	11.92	30.21	16.99	57.38	2.56	4.82
S.Em ±	0.94	0.31	1.06	1.09	0.16	0.11
CD (P<0.05)	NS	0.90	NS	3.21	NS	0.31

RDF=Recommended dose of fertilizer; PSB=Phosphate solublizing bacteria; FYM=Farm yard manure; VC=Vermicompost; PM=Poultry manure; NC=Neem cake

organic manures and inorganic sources of nutrients ensured readily available nutrients for longer period and biofertilizers improved root nodulation which increased N fixation. Similar combined effect of organic manures, inorganic fertilizers and bio-fertilizers on growth parameters was recorded by Bhunia *et al.* (2006) in fenugreek. The combination of 50% RDF + NC + *Rhizobium* + PSB (T_{11}) recorded significantly higher plant spread of 41.57 cm at final harvest followed by the application of 50% RDF + *Rhizobium* + PSB (T_3) with spread of 33.80 cm. Use of both organic manures and bio-fertilizers created a favourable environment in rhizosphere and increased the microbial population at tremendous rate. The decomposed organic matter in the soil and biological N fixation through biofertilizers and subsequent release of N increased the growth. These results are in agreement with the findings of Smitha *et al.* (2011) in makoi.

The mean dry matter production (g plant^{-1}) of 1.47 g was recorded at the time of harvest (Table 2). The combination of 50% RDF + NC + *Rhizobium* + PSB (T_{11}) recorded higher amount of dry matter of 2.02g followed by the combination of 50% RDF + *Rhizobium* + PSB (T_3) with 1.82 g and was statistically on par with the combination of 100% RDF + *Rhizobium* + PSB (T_1) with 1.71 g. The lowest dry matter content of 1.01g was recorded with 75% RDF + FYM @3000 kg ha^{-1} + *Rhizobium* + PSB (T_4).

Yield

Among the treatments, 50% RDF+ PM + *Rhizobium* + PSB (T_9) recorded significant maximum seed yield (721.4 kg ha^{-1}) followed by 680.75 kg ha^{-1} with the application of 75% RDF + PM + *Rhizobium* + PSB (T_8). The lowest seed yield (532.67 kg ha^{-1}) was recorded in the combination of 75% RDF + *Rhizobium* + PSB (T_2). Among the treatments, application of 50% RDF + NC + *Rhizobium* + PSB (T_{11}) recorded maximum straw yield of 1338.37 kg ha^{-1} followed by the application of 50% RDF + *Rhizobium* + PSB (T_3) with 1285.85 kg ha^{-1} and control (1279.87 kg ha^{-1}).

Highest seed yield in 50% RDF + PM + *Rhizobium* + PSB was due to fact that combined application of 50% RDF through inorganic fertilizers and 50% RDF through organic manures, i.e., poultry manure and bio-fertilizers (*Rhizobium* + PSB) led to enhanced availability of plant nutrients and improved the physical properties of the soil as stated by Nambiar & Abrol (1989). Further, the yield increase might be due to cumulative effect of more grain filling percentage, more shelling percentage, more number of seeds pod^{-1} and maximum test weight of seed due to the increased nutrient uptake by plant. Similar results were reported by Tolanur & Badnur (2003) in chick pea.

Economics

The details of cost of cultivation, gross and net income and benefit cost ratio are presented in Table 3. Cost of cultivation was lowest (Rs.19,966 ha^{-1}) in 50% RDF + *Rhizobium* + PSB due to use of only inorganic fertilizers.

The maximum gross returns (Rs. 53,562.33 ha^{-1}) and the maximum monetary returns (Rs. 32,196 ha^{-1}) was obtained with the application of 50% RDF + PM + *Rhizobium* + PSB (T_9), followed by the application of 75% RDF + PM + *Rhizobium* + PSB (Rs. 29,366 ha^{-1}).

The highest benefit cost ratio was obtained in the treatment T_9 (1:1.51) with the application of 50% RDF + PM + *Rhizobium* + PSB followed by 1:1.35 with the application of 75% RDF + PM + *Rhizobium* + PSB (T_8). The lowest benefit cost ratio (0.78) was recorded in the combination of 50% RDF + NC + *Rhizobium* + PSB (T_{11}).

The lower cost of PM might have resulted in higher net returns of poultry main treatment with PM. The lower quantity of inorganic fertilizer and organic manure in combination is required to fulfil 100% RDF which resulted in lower investment and ultimately gave the highest benefit cost ratio and net returns. Similar results were also reported by Choudhary *et al.* (2011) and Sahne *et al.* (2011) in fenugreek. From the above findings, it can be concluded that the highest B:C ratio of 1:1.51 was recorded with the application of 50% RDF + PM + *Rhizobium* + PSB (T_9).

Table 2. Effect of INM treatments on plant spread (cm), dry matter (g plant^{-1}) and yield of fenugreek (*Trigonella foenum-graecum*)

Treatments	Plant spread (cm)		Dry matter production (g plant^{-1})		Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
	30 DAS	At final harvest	30 DAS	At final harvest		
T_1 - 100% RDF (60: 50: 50 N, P_2O_5, K_2O kg ha^{-1}) + *Rhizobium* + PSB	9.24	32.54	0.93	1.71	635.33	1290.31
T_2 - 75% RDF + *Rhizobium* + PSB	9.08	29.91	0.24	1.32	532.67	1267.60
T_3 - 50% RDF + *Rhizobium* + PSB	10.25	33.80	0.95	1.82	562.67	1285.85
T_4 - 75% RDF + Farm yard manure @3000 kg ha^{-1} + *Rhizobium* + PSB	8.44	27.86	0.20	1.01	586.64	1187.25
T_5 - 50% RDF + Farm yard manure @6000 kg ha^{-1} + *Rhizobium* + PSB	9.00	30.01	0.89	1.68	615.39	1169.07
T_6 - 75% RDF + Vermicompost @500 kg ha^{-1} + *Rhizobium* + PSB	9.80	32.82	0.32	1.34	640.40	1163.50
T_7 - 50% RDF + Vermicompost @1000 kg ha^{-1} + *Rhizobium* + PSB	9.69	32.22	0.39	1.46	665.71	1245.40
T_8 - 75% RDF + Poultry manure @500 kg ha^{-1} + *Rhizobium* + PSB	9.57	33.12	0.39	1.34	680.75	1147.47
T_9 - 50% RDF + Poultry manure @1000 kg ha^{-1} + *Rhizobium* + PSB	9.26	32.95	0.42	1.39	721.40	1139.17
T_{10} - 75% RDF + Neem cake @319 kg ha^{-1} + *Rhizobium* + PSB	8.93	29.52	0.44	1.42	637.17	1236.90
T_{11} - 50% RDF + Neem cake @638 kg ha^{-1} + *Rhizobium* + PSB	11.28	41.57	1.16	2.02	660.70	1338.37
T_{12} - 100% RDF (60: 50: 50) N, P_2O_5, K_2O kg ha^{-1} (Control)	8.64	25.87	0.29	1.16	636.04	1279.87
Mean	9.43	31.85	0.55	1.47	631.24	1223.67
S.E m ±	0.62	2.24	0.05	0.05	6.25	14.21
CD (P<0.05)	N.S.	6.61	0.15	0.16	18.46	41.94

RDF=Recommended dose of fertilizer; PSB=Phosphate solublizing bacteria; FYM=Farm yard manure; VC=Vermicompost; PM=Poultry manure; NC=Neem cake

Table 3. Effect of INM treatments on cost of cultivation (Rs. ha^{-1}), gross income (Rs. ha^{-1}), net income (Rs. ha^{-1}) and benefit cost ratio (BCR) of fenugreek (*Trigonella foenum-graecum* L.)

Treatments	Cost of cultivation(Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
T_1 (100% RDF + *Rhizobum* + PSB)	22,182	48,700.63	26,519	1.20
T_2 (75% RDF + *Rhizobum* + PSB)	21,074	42,495.20	21,421	1.02
T_3 (50% RDF + *Rhizobum* + PSB)	19,966	44,331.71	24,366	1.22
T_4 (75% RDF + FYM @3000 kg ha^{-1} + *Rhizobium* + PSB)	22,574	45,572.89	22,999	1.02
T_5 (50% RDF + FYM @6000 kg ha^{-1} + *Rhizobium* + PSB)	21,966	47,261.35	25,295	1.15
T_6 (75% RDF + VC @500 kg ha^{-1} + *Rhizobium* + PSB)	21,924	48,751.00	26,827	1.22
T_7 (50% RDF + VC @1000 kg ha^{-1} + *Rhizobium* + PSB)	21,666	50,433.20	28,767	1.33
T_8 (75% RDF + PM @500 kg ha^{-1} + *Rhizobium* + PSB)	21,774	51,140.15	29,366	1.35
T_9 (50% RDF + PM @1000 kg ha^{-1} + *Rhizobium* + PSB)	21,366	53,562.33	32,196	1.51
T_{10} (75% RDF + NC @319 kg ha^{-1} + *Rhizobium* + PSB)	25,234	48,704.20	23,470	0.93
T_{11} (50% RDF + NC @638 kg ha^{-1} + *Rhizobium* + PSB)	28,286	50,318.73	22,033	0.78
T_{12} (100% RDF (60: 50: 50 N, P_2O_5, K_2O kg ha^{-1}) - Control)	22,032	48,722.13	26,690	1.21

RDF=Recommended dose of fertilizer; PSB=Phosphate solublizing bacteria; FYM=Farm yard manure; VC=Vermicompost; PM=Poultry manure; NC=Neem cake

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