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Effect of integrated nutrient management on productivity and economics of fenugreek (*Trigonella foenum-graecum*)

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ABSTRACT

A field experiment was conducted during the winter seasons of 2007-08 to 2009-10 at Jobner, India on loamy sand soil to evaluate the effect of integrated nutrient management on growth, productivity and economics of fenugreek (*Trigonella foenum-graecum*). The experiment consisted of fourteen combinations of integrated nutrient management practices for application of recommended dose of nitrogen (RDN) to fenugreek *i.e.*, 40 kg/ha, through different sources, *viz.*, control, inorganic or organic [farmyard manure (FYM), poultry manure (PM), vermicompost (VC) and neem cake (NC)] alone or in combinations was laid out in randomized block design with three replications. Based on three years of study the results revealed that application of all nutrient management treatments through organic and inorganic sources alone or in combination brought significant effect on growth, yield and economics of fenugreek. Further the results revealed that integration of 50% RDN through vermicompost (VC) + 50% RDN through inorganic source to fenugreek recorded higher plant height, branches/plant, pods/plant, seeds/pod, test weight, seed yield (1781 kg/ha), stover yield (3392 kg/ha), biological yield (5173 kg/ha) and net returns (Rs. 52151/ha). However, maximum benefit cost ratio was fetched with application of 100% RDN through inorganic source.

Key words: Farm yard manure, Fenugreek, Integrated nutrient management, Neem cake, Poultry manure, Vermicompost

INTRODUCTION

Fenugreek is a multipurpose crop whose every part is utilized as leafy vegetable, fodder and condiment (Khiriya and Singh, 2003) and is cultivated worldwide under semi-arid agro-climatic conditions having potential to fix atmospheric nitrogen and tolerant to mild salinity (Habib *et al.*, 1971). More than 80 per cent area and production of the crop in India is contributed by Rajasthan state alone as fenugreek is fairly tolerant to salinity which makes it suitable for cultivation in major parts of the state. The crop has immense medicinal value and is a good source of vitamins, protein and essential oils.

For realizing the inherited yield potentials of high yielding varieties, recourse must be taken through the application of manures and fertilizers. In recent years, there has been increasing recognition of the importance of organics as the global consumers are showing inclination towards health cautiousness with their day to day diet. Crops grown using organic inputs having less or no chemicals are being preferred over conventionally produced food by the end users, especially medicinally useful crops. Recently, there has been increasing importance of organic sources of plant nutrients due to growing ecological concern and depleting inherent soil fertility leading to multiple deficiencies of essential plant nutrients. The results of long-term fertilizer experiments have emphasized that sustainability can only be maintained by integration of inorganic and organic sources of nutrients (Chettri and Bandhopadhya, 2005). Addition of organic manures like farm yard manure, vermicompost, neem cake, poultry manure, etc., not only supplies most of the essential plant nutrients, but also improves the soil structure by providing binding substance to soil aggregates leading to increase in cation exchange capacity and water holding capacity of the soil. Organic manures produce food of high quality, encourage and enhance biological cycles within the farming system involving micro-organisms, soil flora and fauna, plants and animals and maintain and increase the long term fertility of soils (Mahapatra *et al.*, 2009). Hence, the replacement of external inputs *viz.*, chemical fertilizer by farm-derived organic inputs normally leads to a reduction in variable input costs under organic management. Therefore, the present study was undertaken to evaluate different organic

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inputs, nutrient sources and to compare the chemical and integrated treatments in fenugreek.

MATERIALS AND METHODS

The field experiment was carried out during three winter seasons of 2007-08, 2008-09 and 2009-10 at S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) situated at latitude of $26^0$05' N, longitude of $75^0$20'E and at an altitude of 427 m above mean sea level. The soil was loamy sand, low in organic carbon (0.22 %), available N (134.5 kg/ha), available P (6.7 kg/ha) and medium in available K (131.6 kg/ha) with alkaline (pH 8.3) in reaction having 1.5 Mg/m^3 bulk density, 2.65 Mg/m^3 particle density, 12.70 % field capacity and 4.67 % permanent wilting point at the beginning of the experiment. The experiment was laid out in randomized block design with three replications for three years. The treatments comprised of fourteen combinations of integrated nutrient management for application of recommended dose of nitrogen (RDN) through different sources *viz.*, control, 100% RDN though inorganic, 100% RDN through farmyard manure (FYM), 100% RDN through poultry manure (PM), 100% RDN through vermicompost (VC), 100% RDN through neem cake (NC), 50% RDN through FYM + 50% RDN through inorganic, 50% RDN through PM + 50% RDN through inorganic, 50% RDN through VC + 50% RDN through inorganic, 50% RDN through NC + 50% RDN through inorganic, 75% RDN through FYM + 25% RDN through inorganic, 75% RDN through PM + 25% RDN through inorganic, 75% RDN through VC + 25% RDN through inorganic and 75% RDN through NC + 25% RDN through inorganic. Nitrogen content was estimated in these organic sources on dry-weight basis and their quantities required for a specific amount of N as per treatment were calculated. The well decomposed FYM, PM, VC and NC with mean composition (N 0.42, 2.80, 1.54 and 4.80%, P 0.24, 2.22, 1.24 and 1.07% and K 0.51, 1.42, 0.84 and 1.28%, respectively) were applied two weeks before sowing and incorporated in soil as per treatments. 'RMt 351' fenugreek variety was sown in rows 30 cm apart using 20 kg seed/ha in first week of November during all the years. Plant to plant distance was maintained at 10 cm. One light irrigation just after sowing and four irrigations at different growth stages were applied to the crop. All improved package of practices were followed to raise the crop under irrigated conditions. The composite soil sample was analyzed after harvesting of the crop to find out the change in organic carbon and available nitrogen. Data obtained from consecutive three years were statistically analyzed by using the F-test as per the procedure given by Gomez and Gomez (1984). LSD at P = 0.05 were used to determine the significant differences between treatment means.

RESULTS AND DISCUSSION

Growth and yield attributes: The application of all nutrient management treatments through inorganic and organic sources alone or in combination brought significant improvement in growth attributes *viz.*, plant height, except RDN through NC alone, branches per plant and yield attributes *viz.*, pods/plant, except RDN through FYM alone, seeds/ pod and test weight during all the years of experimentation (Table 1). The application of 50% RDN through VC + 50% RDN through inorganic gave higher values of all the growth attributes having significance over 100% RDN through FYM, PM and NC alone and 75% RDN through NC + 25% RDN through inorganic for plant height. The combination of organic and inorganic source of nutrients ensured ready availability of nutrients for initial requirement through inorganic sources and slow pace as long term availability through organic source throughout the crop growth period might have improved adequate biomass production and improvement in growth parameters. Moreover, organics, besides supplying macro and micronutrients, have also solubilizing effect on native soil nutrients due to the action of organic acids produced during decomposition and resulted in higher growth attributes. Similar beneficial combined effect of organic and inorganic sources on growth parameters was also recorded by Singh and Verma (2002).

The yield attributes of fenugreek were profoundly influenced due to combined or sole use of organic and inorganic sources and indicated significant difference with respect to pods/ plant, seeds/ pod and test weight and recorded significantly higher values in pooled data over control. The application of 50% RDN through VC + 50% RDN through inorganic source recorded highest pods/ plant (25.1), seeds/ pod (18.8) and test weight (11.94g) in pooled data over three years. It was closely followed by 100% RDN through inorganic, 75% RDN through VC + 25% RDN through inorganic and 100% RDN through VC and was superior over sole application of FYM, PM and NC. The superiority of organic and inorganic combinations could be attributed to the increase in amount of growth parameters and increased availability of nitrogen throughout the life cycle of the crop. The increased and balanced supply of nitrogen to plants promotes flowering and fruiting and supply of food material and its subsequent partitioning in the sink. The organic manures also improve the availability of phosphorus which plays a unique role in energy conservation and transfer. The balanced supply of nitrogen by integrated nutrient sources throughout the life cycle of the crop reduced leaf senescence and able to furnish the increased assimilate demand of plant sinks which resulted in higher number of pods/ plant, seeds /

TABLE 1: Effect of integrated nutrient management on growth and yield of Fenugreek (Pooled data of 3 years)

Treatment	Plant height (cm)	Branches / plant	Pods / plant	Seeds / pod	Test Weight (g)	Seed Yield (kg/ha)	Stover yield (kg/ha)	Biological Yield (kg/ha)
Control	69.7	4.97	20.2	16.8	10.36	1279	2451	3730
100 % RDN through inorganic	80.1	5.57	24.6	18.4	11.75	1655	3315	4970
100 % RDN through FYM	75.4	5.29	21.3	17.2	11.27	1564	3140	4706
100 % RDN through PM	74.6	5.46	22.3	17.6	11.34	1614	3178	4792
100 % RDN through VC	75.9	5.44	23.3	18.0	11.90	1689	3282	4971
100 % RDN through NC	74.2	5.28	21.7	17.7	11.25	1597	3223	4820
50 % RDN through FYM +50 % RDN through inorganic	76.6	5.36	23.1	17.7	11.33	1648	3152	4800
50 % RDN through PM + 50 % RDN through inorganic	78.2	5.40	24.4	18.0	11.33	1681	3327	5008
50 % RDN through VC + 50 % RDN through inorganic	80.7	5.53	25.1	18.8	11.94	1781	3392	5173
50 % RDN through NC + 50 % RDN through inorganic	78.8	5. 39	23.2	17.9	11.10	1633	3200	4833
75 % RDN through FYM + 25 % RDN through inorganic	79.1	5.28	22.5	17.6	11.42	1648	3254	4902
75 % RDN through PM + 25 % RDN through inorganic	76.8	5.40	23.7	18.0	11.93	1648	3269	4917
75 % RDN through VC + 25 % RDN through inorganic	79.2	5.39	24.4	18.3	11.49	1747	3367	5114
75 % RDN through NC + 25 % RDN through inorganic	75.0	5.29	22.9	18.0	11.13	1575	3060	4635
S.Em $\pm$	1.7	0.09	0.4	0.3	0.19	39	74	116
CD (P=0.05)	4.9	0.26	1.3	0.8	0.55	111	212	330

Where, RDN= Recommended dose of nitrogen, FYM= Farm yard manure, PM= Poultry manure, VC= Vermicompost and NC= Neem cake

pod and test weight due to bold grain formation. The results corroborate the finding of Panwar and Munda (2007).

Seed, stover and biological yields: The yields were significantly improved by application of organic manures or inorganic fertilizer alone or in combination with manures *viz.*, FYM, PM, VC and NC over the control (Table 1). The highest mean seed (1781 kg/ha), stover (3392 kg/ha) and biological yields (5173 kg/ha) were obtained with conjunctive use of 50% RDN through VC + 50% RDN through inorganic fertilizer which was comparable with 75% RDN through VC + 25% RDN through inorganic, 50% RDN through PM + 50% RDN through inorganic and 100% through VC. The stover and biological yields obtained with 50% RDN through VC + 50% RDN through inorganic were also comparable with 100% RDN through inorganic source, 75% RDN through PM + 25% RDN through inorganic and 75% RDN through VC + 25% RDN through inorganic sources. The positive response to combined application of organic manures and inorganic fertilizers might be attributed to the better nutrient availability and its favourable effect on soil physical and biological properties resulting in increased yield attributes and finally higher yields (Nambiar and Abrol, 1989). The increased yield might also be due to better nutritional status of the soil which might have stimulated the rate of various plant physiological processes which led to increased growth and yield attributing characteristics and their cumulative effect resulted in enhanced seed, stover and biological yields of fenugreek. The results on yield thus confirmed the trend observed earlier in the yield attributing characters and upheld the need of supplementing the RDN through inorganic with organic and emphasized the utter need for organic manuring along with chemical fertilizers. The increase in production of the crop due to integrated nutrient management was also reported by Tolanur and Badanur (2003) and Tolanur (2009).

Economics: The integrated nutrient management had significant influence on the economics of fenugreek. The maximum monetary net returns (Rs 52,151) was fetched with the application of 50% RDN through VC + 50% RDN through inorganic source, which was found at par with 75% RDN through VC + 25 % RDN through inorganic, 50% RDN through PM + 50% RDN through inorganic and 100% RDN through inorganic source (Table 2). The highest benefit cost ratio was obtained with the application of 100% RDN through inorganic source which remained at par with rest of the treatments except, 100% RDN through VC as well as NC, 50% or 75% RDN through NC and rest through inorganic source. The lower net returns and benefit cost ratio were obtained with sole NC or its integration with inorganic source that might have resulted from higher cost of NC. The lower quantity of inorganic fertilizer is required to fulfill the 100%

TABLE 2: Effect of integrated nutrient management on economics and soil fertility after harvest of Fenugreek (Pooled data of 3 years)

Treatment	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio	Organic carbon (%)	Available N (kg/ha)
Control	50625	35205	2.28	0.19	126.7
100 % RDN through inorganic	66225	49453	2.95	0.23	140.7
100 % RDN through FYM	62740	45320	2.60	0.29	135.5
100 % RDN through PM	64310	46537	2.62	0.25	133.4
100 % RDN through VC	67080	47374	2.40	0.26	137.0
100 % RDN through NC	64025	42725	2.01	0.22	132.9
50 % RDN through FYM +50 % RDN through inorganic	65200	48104	2.81	0.27	142.7
50 % RDN through PM + 50 % RDN through inorganic	67065	49792	2.88	0.23	138.1
50 % RDN through VC + 50 % RDN through inorganic	70390	52151	2.86	0.25	139.3
50 % RDN through NC + 50 % RDN through inorganic	64990	45954	2.41	0.21	138.0
75 % RDN through FYM + 25 % RDN through inorganic	65710	48452	2.81	0.28	140.3
75 % RDN through PM + 25 % RDN through inorganic	65785	48262	2.75	0.24	140.0
75 % RDN through VC + 25 % RDN through inorganic	69245	50272	2.65	0.26	141.2
75 % RDN through NC + 25 % RDN through inorganic	62550	42382	2.10	0.22	139.8
S.Em $\pm$	1699	1138	0.13	0.01	1.3
CD (P=0.05)	4860	3250	0.37	0.03	3.8

RDN which resulted in lesser investment which ultimately gave the highest benefit cost ratio or higher returns per rupee investment over organic manures but organic manures offer benefits of enhancement of soil physical, chemical and biological properties over long term instead of meeting a part of nutrients need of the crop to sustain high yield. Similar results were also reported for combined application of organic and inorganic manures by Singh and Verma (2002). Singh *et al.* (2013) found that 50% RDN through FYM + 50% through urea, 80% RDN through vermicompost + 20% through urea and 25% RDN through FYM + 75% through urea being at par with each other fetched significantly higher net returns and benefit:cost ratio from pearlmillet. However, in fennel 100% RDN applied through fertilizers exhibited highest net returns (Rs 62,091/ha) and benefit cost ratio (3.01), closely followed by 50% RDN through fertilizers + 50% RDN through vermicompost as recorded by Godara *et al.* (2014).

Soil fertility: After harvest of fenugreek the organic carbon and available nitrogen in soil markedly improved due to integrated nutrient management practices through organic as well as inorganic sources over control during all three years of experimentation (Table 2). Application of 50% RDN through organic + 50% RDN through inorganic, 75% RDN through organic + 25% RDN through inorganic and 100% RDN through organic *i.e.,* FYM, PM, VC and NC enhanced progressively organic carbon content of the soil over the initial content. Contrary to this, available nitrogen increased progressively from 100% RDN through organic sources alone towards integrated use of organic and inorganic sources. Organic manure has got some solubilizing effect on some mineral compounds present in soil and brings about the conversion of a number of chemical elements in available form. The beneficial effect of organic manures on organic carbon content could be attributed to the presence of higher residue and litter and enhanced microbial activity. The improvement in soil fertility after crop harvest due to integrated nutrient management was also recorded by Parihar and Rana (2010). The increase in the availability of nitrogen in soil under the treatments having combination of chemical fertilizers and manures might have enhanced because of built up of organic matter due to application of organic manure, besides reducing losses of nitrogen. Singh *et al*. (2013) reported highest organic carbon and available soil nitrogen in pearlmillet cultivation with 100% RDN through FYM followed by 80% RDN through vermicompost + 20% through urea and integrated use of RDN through FYM + urea in different proportions.

Therefore, it can be concluded that the application of 50% RDN through VC + 50% RDN through inorganic source fetched higher productivity and net monetary returns from fenugreek along with improvement in soil health of loamy sand soils of Rajasthan.

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