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Effect of integrated nutrient management on fenugreek (*Trigonella foenum-graecum*) and its residual effect on fodder pearlmillet (*Pennisetum glaucum*)

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ABSTRACT

A field experiment was conducted during winter 2004-05 and 2005-06 at Jobner, Jaipur on loamy sand soil to evaluate the effect of integrated nutrient management on productivity and nutrient uptake of fenugreek (*Trigonella foenum-graecum* L.) and its residual effect on fodder pearlmillet {*Pennisetum glaucum* (L.) R. Br. Emend. Stutz.}. The experiment consisted of eighteen 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, organic [farmyard manure (FYM), vermicompost (VC) and poultry manure (PM), inorganic] alone or in combinations with or without microbial (*Rhizobium*) inoculation. Results revealed that integration of 50% RDN through poultry manure (PM)+50% RDN through inorganic sources to fenugreek recorded higher growth attributes, *viz.* plant stand/m row length, plant height, branches/plant, dry matter accumulation/m row length, nodules/plant and weight of nodules/plant, yield attributes, *viz.* pods/plant, seeds/pod and test weight, seed yield (1.76 t/ha), biological yield (5.97 t/ha), system productivity (2.95 t/ha) and fodder yield of pearlmillet at all the cuttings. This treatment was also superior in terms of N, P, protein and phenol content (%) in seed as well as in haulm, total N and P uptake and available N and P after the harvest of the crop in both the years over all other combination of integrated nutrient management. However, maximum net returns (₹60,443) and net returns/rupee invested for the system were fetched with integrated application of 50% RDN through VC + 50% RDN through inorganic sources.

Key words *:* Farmyard manure, Fenugreek, Integrated nutrient management, Poultry manure, Profitability, Vermicompost.

Fenugreek is cultivated worldwide under semi-arid agro-climatic conditions having potential to fix atmospheric nitrogen and tolerant to mild salinity (Habib *et al.*, 1971). Both fenugreek and fodder pearlmillet crops are grown under marginal and sub-marginal lands. Thus, the balanced nutrition is needed, which could be achieved through integrated application of inorganic and organic sources of nutrients. Addition of organic manures 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. Besides this, the organic manures improve the efficiencies of applied fertilizers. Furthermore, the decomposition and mineralization of organic manure is a slow process which could match the nutrient requirement of a crop and thus limits the loss of precious plant food. Results of long term experiments have indicated that a suitable combination of organic and inorganic fertilizers will not only sustain the soil fertility but also maintain higher level of quality of the produce (Pillai *et al.,* 1985). Since the crop respond favourably to applied N, through combined sources organic as well as inorganic the major part of N applied by various sources remains unutilized by first crop; its application is invariably reflected in succeeding crop (Parihar *et al*., 2009). An attempt was therefore made to evaluate the effect of integrated nutrient management on productivity and nutrient uptake of fenugreek and its residual effect on fodder pearlmillet.

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MATERIALS AND METHODS

The experiment was conducted during *rabi* 2004-05 and 2005-06 at S.K.N. College of Agriculture, Jobner 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 with pH 8.2 (1:2.5 soil to water), organic carbon 0.17%, available N 128.7, available P 6.4, available K 123.3 and available S 13.5 kg/ha and bulk density 1.5 Mg/m^3, particle density 2.65 Mg/m^3, field capacity 12.50% and permanent wilting point was 6.52% at the beginning of the experiment in 0-15 cm soil layer. The total rainfall re-

corded during crop growth period was 7.1 mm and 6.0 mm, minimum temperature ranges from 2.8 to 15.2 and 1.8 to 14.9 and maximum temperatures 19.2 to 32.5 and 22.0 to 34.4°C and relative humidity varies between 60 and 92% during winter 2004-05 and 2005-06, respectively. During both the years one pre sowing, one light irrigation just after sowing and five irrigations at different growth stages were applied to fenugreek. The experiment was conducted in randomized block design with three replications for two years by changing site at the farm every year in a block having same type of soil and cropping history. The treatment combinations comprised of eighteen nutrient management practices through different sources, *viz.* control, 100% RDN through FYM, 100% RDN through VC, 100% RDN through PM, 50% RDN through FYM + 50% RDN through VC, 50% RDN through FYM + 50% RDN through PM, 50% RDN through VC + 50% RDN through PM, 100% RDN through FYM + *Rhizobium*, 100% RDN through VC + *Rhizobium*, 100% RDN through PM + *Rhizobium*, 50% RDN through FYM + 50% RDN through VC + *Rhizobium*, 50% RDN through FYM + 50% RDN through PM + *Rhizobium*, 50% RDN through VC+ 50% RDN through PM + *Rhizobium*, 100% RDN through inorganic source, 100% RDN through inorganic sources + *Rhizobium*, 50% RDN through FYM + 50% RDN through inorganic sources, 50% RDN through VC + 50% RDN through inorganic sources, 50% RDN through PM + 50% RDN through inorganic sources. The well decomposed farm yard manure (FYM), vermicompost (VC) and poultry manure (PM) with mean composition (N 0.43, 1.54 and 2.82%, P 0.24, 1.22 and 2.20%, and K 0.49,0.83 and 1.42%, respectively) were applied two weeks before sowing and incorporated in soil as per treatments either alone or in combination with other organic as well as inorganic sources of nitrogen. 'RMt 1' fenugreek was sown in rows 30 cm apart using 20 kg seeds/ha on 5 November and 6 November and harvested on 21 March and 22 March in 2004 and 2005, respectively. Other management practices were adopted as per recommendations for crops under irrigated conditions. The soil was analyzed after harvesting of the crop to find out the change in available nutrient (N, P and K) status. The nutrient uptake by the crop was obtained as the product of concentration of nutrient and yield. Data obtained from consecutive two 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 significance differences between treatment means.

RESULTS AND DISCUSSION

Growth and yield attributes

Over the seasons all nutrient management treatments through various sources brought significant improvement in growth attributes, *viz.* plant stand/m row length, plant height, branches/plant, dry matter accumulation/m row length at 40, 80 DAS and at harvest, nodules/plant at 50 DAS and weight of nodules/plant in fenugreek during both the years (pooled data) (Table 1). The application of 50% RDN through organic source + 50% RDN through inorganic source gave higher values of all these growth attributes over sole application of 100% RDN through organic source and 100% RDN through inorganic source with or without *Rhizobium* inoculation during both the years. The combination of organic and inorganic source of nutrients ensured readily availability of nutrients for initial requirement through inorganic source and slow pace as long term availability through organic source and resulted in higher plant stand/m row length, plant height, dry matter accumulation/m row length at 40, 80 DAS and at harvest, branches/plant, number and weight of nodules. 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 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 in both the years. The application of 50% RDN through organic source + 50% RDN through inorganic source was found superior over sole application 100% RDN through organic and inorganic source with or without *Rhizobium* inoculation. Application of 50% RDN through PM + 50% RDN through inorganic fertilizer recorded highest pods/plant (35.50), seeds/pod (12.54) and test weight (13.01 g) in pooled data. It was closely followed by application of 50% RDN through VC + 50% RDN through inorganic fertilizer and 50% RDN through FYM + 50% RDN through inorganic fertilizer. 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 plant 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 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 and test weight due to bold grain formation. The results corroborate with those of Khiriya *et al.* (2003).

Table 1. Effect of integrated nutrient management on growth and growth attributes of fenugreek in fenugreek-fodder pearlmillet sequence (Pooled data of 2 years)

Treatment	Plant stand (per metre row length) At harvest	Plant height (cm) At harvest	Branches/ plant At harvest	Dry matter accumulation (g/m row length) 40 DAS	80 DAS	At harvest	Nodules/plant at 50 DAS	Weight of nodules per plant in mg
Control	10.16	41.7	4.4	24.1	51.8	89.6	2.12	13.84
100% RDN through FYM	10.35	52.3	5.6	25.8	63.6	99.2	3.39	17.03
100% RDN through VC	10.36	53.3	5.8	25.9	64.1	99.5	3.65	17.92
100% RDN through PM	10.50	54.3	6.0	26.1	64.8	100.3	4.10	19.48
50% RDN through FYM + 50% RDN through VC	10.59	55.7	6.9	26.5	66.1	102.1	5.09	20.98
50% RDN through FYM + 50% RDN through PM	10.64	56.5	7.1	26.6	66.6	102.8	5.19	21.59
50% RDN through VC + 50% RDN through PM	10.67	58.1	8.3	26.9	68.0	105.1	5.91	22.23
100% RDN through FYM + *Rhizobium*	10.64	53.5	5.9	26.0	64.2	100.0	3.92	18.04
100% RDN through VC + *Rhizobium*	10.66	54.4	6.3	26.1	64.9	100.6	4.32	19.60
100% RDN through PM + *Rhizobium*	10.67	55.5	6.4	26.5	65.6	101.8	4.84	20.80
50% RDN through FYM + 50% RDN through VC + *Rhizobium*	10.70	57.8	7.5	26.7	67.3	103.8	5.54	22.04
50% RDN through FYM + 50% RDN through PM + *Rhizobium*	10.72	60.6	9.1	27.5	69.1	107.1	6.58	22.38
50% RDN through VC+ 50 % RDN through PM + *Rhizobium*	10.73	61.7	9.3	27.6	70.1	108.6	7.11	23.04
100% RDN through inorganic source	10.56	63.8	10.1	27.9	71.2	110.9	7.76	24.09
100% RDN through inorganic source + *Rhizobium*	10.90	65.7	10.3	28.1	72.2	112.8	8.02	24.96
50% RDN through FYM + 50% RDN through inorganic source	10.80	67.2	10.7	28.3	72.8	115.6	8.34	26.85
50% RDN through VC + 50% RDN through inorganic source	10.81	67.5	10.9	28.4	73.7	117.9	8.93	28.24
50% RDN through PM + 50% RDN through inorganic source	10.98	67.7	11.1	28.6	74.9	120.9	9.12	28.72
SEm±	0.57	0.70	0.1	0.4	0.9	0.7	0.14	0.60
CD (P=0.05)	NS	1.98	0.4	1.2	2.4	2.0	0.39	1.70

DAS, days after sowing; FYM, farmyard manure; VC, vermicompost; PM, pultry maure; RDN, recommended dose of nitrogen

Fenugreek yield and system productivity

The application of nitrogen through various source and their integrations significantly influenced the seed, haulm, biological yield and system productivity over control. System productivity, yield of seed, haulm and biological yields were significantly improved by the application of organic manures and inorganic fertilizer alone or in combination with organic manures i.e. FYM, PM and VC within or with inorganic fertilizer over the control (Table 2). The highest mean seed (1.76 t/ha), haulm (4.20 t/ha), biological yields (5.67 t/ha) and system productivity (2.95 t/ha) were obtained with the conjunctive use of organic manures + inorganic fertilizer, i.e. 50% RDN through PM + 50% RDN through inorganic fertilizer, respectively. In comparison to sole application of organic manures and combined use, an additional seed yield of 117 to 298 kg/ha, haulm yield of 249 to 395 kg/ha and system productivity of 720 to 1290 kg/ha was recorded with the combined application of 50% RDN through inorganic manures, i.e. FYM, VC and PM + 50% RDN through inorganic fertilizer, which might be due to direct addition of an appreciable amount of essential plant nutrients through organic manures and improvement in the physical properties of the soil (Nambiar and Abrol, 1989). The increase in system productivity and yield of individual crops grown in sequence might be due to the better nutritional status of soil as evident from nutrients uptake in plant. The increased nutrient uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased growth and yield attributing characteristics and their cumulative effect resulted in enhanced system productivity and yield of individual crops. The increase in system productivity and yields of individual crops due to integrated nutrient management was also reported by Tolanur and Badanur (2003).

Residual effect of integrated nutrient management on fodder pearlmillet

The sole application of organic manure of 100% RDN through FYM, VC and PM to preceding crop of fenugreek alone as well as with *Rhizobium* inoculation leads to improved mean fodder pearlmillet yield over control. The combined use of FYM, VC and PM alone and along with *Rhizobium* inoculation showed superiority in mean fodder yield of succeeding pearlmillet crop but remained significantly higher over Control, 100% RDN through FYM , 100% RDN through VC and 100% RDN through FYM + *Rhizobium* treatments, respectively over their sole application. The residual effect of 100% RDN through inorganic source alone and with *Rhizobium* inoculated produced significantly higher mean fodder yield of pearlmillet over organic source individually and in integration. Integrated application of 50% RDN through organic source + 50% RDN to preceding fenugreek through inorganic source was found superior over sole application of organic and inorganic source in both the years. The maximum mean fodder yield of pearlmillet recorded in 50% RDN through PM + 50% RDN through inorganic source in first cut (12.67 t/ha) and second cut (16.96 t/ha) during (Table 2) both the years and next best treatments of 50 % RDN through VC + 50% RDN through inorganic sources, 50% RDN through FYM + 50% RDN through inorganic sources, 100 % RDN through inorganic sources + *Rhizobium* and 100% RDN through inorganic source. Similar findings were also reported by Tolanur and Badanur (2003). The increase vigour and growth owing to residual nutrients led to better development of pearlmillet fodder which in turn increased the fodder yield of pearlmillet.

Nutrient content and uptake

Integrated application of nutrients significantly increased the N and P content in seed and haulm (Table 3) and their uptake as well as protein and phenol content in seed by application of nutrients through various sources, *viz.* 50% RDN through organic source + 50% RDN through inorganic source over sole application of 100% RDN through organic and inorganic. The nutrient uptake was significantly higher with the application of 50% RDN through PM + 50% RDN through inorganic fertilizer to the tune of 64.76 kg N/ha and 10.75 kg P/ha over control (Table 4)

Table 2. Effect of integrated nutrient management on yield attributes and yield of fenugreek and fodder yield of pearlmillet in fenugreek-fodder pearlmillet sequence (Pooled data of 2 years)

Treatment	Pods/ plant	Seeds/ pod	Test weight (g)	Seed yield (t/ha)	Haulm yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)	Fodder yield of pearlmillet (t/ha)	
								First cut	Second cut
Control	18.90	7.12	9.44	0.71	1.94	2.65	26.81	10.11	13.84
100% RDN through FYM	23.69	8.41	11.32	1.35	3.58	4.92	27.33	11.15	14.83
100% RDN through VC	24.66	8.71	11.36	1.36	3.64	4.99	27.26	11.20	14.94
100% RDN through PM	25.45	9.16	11.49	1.41	3.68	5.08	27.67	11.32	15.10
50% RDN through FYM + 50% RDN through VC	26.60	10.12	11.58	1.47	3.81	5.27	27.80	11.66	15.45
50% RDN through FYM + 50% RDN through PM	27.12	10.36	11.64	1.49	3.83	5.32	28.00	11.71	15.60
50% RDN through VC + 50% RDN through PM	29.12	10.85	11.74	1.53	3.85	5.38	28.50	11.87	16.02
100% RDN through FYM + *Rhizobium*	24.83	8.85	11.00	1.37	3.66	5.03	27.29	11.22	14.95
100% RDN through VC + *Rhizobium*	25.69	9.38	11.09	1.42	3.73	5.15	27.56	11.39	15.12
100% RDN through PM + *Rhizobium*	26.29	9.72	11.48	1.43	3.75	5.18	27.54	11.42	15.24
50% RDN through FYM + 50% RDN through VC + *Rhizobium*	28.48	10.44	11.80	1.54	3.90	5.44	28.24	11.84	15.66
50% RDN through FYM + 50% RDN through PM + *Rhizobium*	30.01	11.03	11.89	1.56	3.93	5.49	28.33	11.95	16.12
50% RDN through VC+ 50% RDN through PM + *Rhizobium*	30.69	11.33	11.82	1.60	3.95	5.55	28.79	12.08	16.24
100% RDN through inorganic source	31.74	11.47	12.31	1.62	3.99	5.62	28.87	12.19	16.38
100% RDN through inorganic source + *Rhizobium*	32.51	11.59	12.45	1.66	4.03	5.69	29.22	12.30	16.46
50% RDN through FYM + 50% RDN through inorganic source	34.08	11.78	12.80	1.71	4.05	5.76	29.64	12.45	16.78
50% RDN through VC + 50% RDN through inorganic source	34.64	12.12	12.85	1.73	4.09	5.81	29.68	12.56	16.86
50% RDN through PM + 50% RDN through inorganic source	35.50	12.54	13.01	1.76	4.20	5.97	29.54	12.67	16.96
SEm±	0.56	0.22	0.24	0.05	0.1	0.12	0.89	0.12	0.14
CD (P=0.05)	1.59	0.62	0.69	0.13	0.28	0.33	2.51	0.33	0.40

in pooled data in both the years of investigation. It was closely followed by 50% RDN through VC + 50% RDN through inorganic fertilizer and 50% RDN through PM + 50% RDN through inorganic fertilizer which might on account of higher accumulation of N and P and higher crop yields. Decomposition of organic manures is accompanied by the release of appreciable quantities of CO_2, which get dissolved in water to form carbonic acid. Carbonic acid is capable of decomposition of certain primary minerals and release of nutrients and favours higher biomass production and nutrient uptake (Dahama, 2003). The higher content in seed and haulm by combined use of organic and inorganic source might be ascribed due to balanced availability of nitrogen throughout the lifecycle of the crop. The increased N content in grain and haulm could also be attributed to the mineralization effect of nitrogen from organic manure.

The application of FYM, VC and PM resulted in the formation of carbon dioxide which plays an important role in the solubilisation of native P and reduce phosphate fixing capacity of the soil. These actions of organic manures resulted into higher P content in grain and haulm of fenugreek. It is an established fact that nutrient uptake by the crop depends primarily on the dry matter accumulation and secondarily on the nutrient content at cellular level. The increased total dry matter production and nutrient content in plants seems to be the major causes responsible for the higher N and P uptake under the influence of integrated nutrient management. The increased protein content in seed is directly correlated with N content in seed. The increased N content in seed resulted into higher protein content due to integrated nutrient management. The present trend of increased N and P contents in grain and haulm, their uptake and higher protein content in seed under the influence of integrated nutrient management was in line with those of Khiriya *et al.* (2003).

Organic carbon and Soil fertility:

The organic carbon and soil fertility (available N, P and K) in fenugreek-fodder pearlmillet cropping system markedly improved due to integrated application of nutrient management through organic as well as inorganic sources with and without microbial inoculation over control (Table 4) during both the years. Integrated application of poultry manure (PM), vermicompost (VC) and farmyard manure (FYM) along with 50% RDN through chemical fertilizer resulted in improvement in organic carbon content of the soil over the initial content. Meanwhile, integrations of organic manures alone or with *Rhizobium* inoculation enhanced progressively organic carbon content of the soil over control. Similarly, available N, P and K status of soil was noticed in the same trend. Highest available N (142.2 kg/ha), P (8.0 kg/ha) and K (131.1 kg/ha) was recorded with the combined application of 50% RDN through PM + 50% RDN through inorganic fertilizer, which might be due to higher N, P and K content in the poultry manure in

Table 3. Effect of integrated nutrient management on nutrient uptake and quality parameters of fenugreek in fenugreek-fodder pearlmillet sequence (Pooled data of 2 years)

Treatment	N content (%)		P content (%)		Total N uptake (kg/ha)	Total P uptake (kg/ha)	Protein content (%)	Phenol content (%)
	Grain	Haulm	Grain	Haulm				
Control	3.27	0.64	0.271	0.102	35.5	3.9	20.44	8.78
100% RDN through FYM	3.37	0.77	0.370	0.115	72.8	9.1	21.03	9.08
100% RDN through VC	3.37	0.78	0.379	0.118	74.1	9.5	21.07	9.19
100% RDN through PM	3.38	0.78	0.385	0.120	76.3	9.8	21.12	9.51
50% RDN through FYM + 50 % RDN through VC	3.40	0.81	0.400	0.134	80.6	11.0	21.21	10.19
50% RDN through FYM + 50 % RDN through PM	3.40	0.84	0.404	0.138	82.5	11.3	21.26	10.49
50% RDN through VC + 50 % RDN through PM	3.41	0.85	0.410	0.144	86.3	11.9	21.31	10.85
100% RDN through FYM + *Rhizobium*	3.38	0.78	0.381	0.120	74.9	9.6	21.09	9.51
100% RDN through VC + *Rhizobium*	3.38	0.78	0.388	0.123	77.2	10.1	21.13	9.66
100% RDN through PM + *Rhizobium*	3.38	0.79	0.395	0.125	78.0	10.3	21.18	9.99
50% RDN through FYM + 50% RDN through VC + *Rhizobium*	3.41	0.87	0.408	0.141	85.2	11.7	21.29	10.67
50% RDN through FYM + 50% RDN through PM + *Rhizobium*	3.41	0.87	0.414	0.147	87.7	12.2	21.34	10.89
50% RDN through VC+ 50% RDN through PM + *Rhizobium*	3.42	0.87	0.416	0.151	89.7	12.6	21.37	10.92
100% RDN through inorganic source	3.43	0.90	0.419	0.155	91.5	13.0	21.40	10.96
100% RDN through inorganic source + *Rhizobium*	3.45	0.90	0.421	0.157	93.5	13.3	21.45	10.99
50% RDN through FYM + 50% RDN through inorganic source	3.45	0.92	0.427	0.160	95.9	13.8	21.55	11.01
50% RDN through VC + 50% RDN through inorganic source	3.45	0.93	0.433	0.163	97.4	14.2	21.59	11.07
50% RDN through PM + 50% RDN through inorganic source	3.46	0.93	0.436	0.166	100.2	14.7	21.63	11.27
SEm±	0.01	0.01	0.011	0.002	2.5	0.4	0.04	0.15
CD (P=0.05)	0.02	0.04	0.030	0.004	7.1	1.0	0.11	0.43

Table 4. System productivity, economics and post harvest soil nutrient status under fenugreek-fodder pearlmillet sequence (Pooled data of 2 years)

Treatment	System productivity (t/ha*)	Total cost of cultivation (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	B:C ratio	Soil nutrient status (kg/ha)			
					Organic Carbon (%)	Available N	Available P	Available K
Control	1.66	16.88	27.61	1.64	0.15	126.16	6.93	122.95
100% RDN through FYM	2.38	19.60	45.46	2.32	0.23	135.29	7.18	127.69
100% RDN through VC	2.41	18.37	47.31	2.58	0.22	136.63	7.35	128.09
100% RDN through PM	2.46	21.33	45.76	2.15	0.22	137.47	7.40	128.40
50% RDN through FYM + 50% RDN through VC	2.55	20.47	48.98	2.39	0.21	138.46	7.45	129.02
50% RDN through FYM + 50% RDN through PM	2.58	18.98	51.29	2.70	0.22	138.80	7.46	129.10
50% RDN through VC + 50% RDN through PM	2.65	19.85	52.17	2.63	0.21	139.78	7.66	129.46
100% RDN through FYM + Rhizobium	2.42	19.63	46.38	2.36	0.22	136.87	7.37	128.20
100% RDN through VC + Rhizobium	2.48	18.39	49.14	2.67	0.21	137.60	7.42	128.50
100% RDN through PM + Rhizobium	2.49	21.35	46.58	2.18	0.22	138.08	7.42	129.02
50% RDN through FYM + 50% RDN through VC + Rhizobium	2.64	20.49	51.33	2.51	0.22	139.24	7.47	129.15
50% RDN through FYM + 50% RDN through PM + Rhizobium	2.68	19.01	53.84	2.83	0.22	140.13	7.72	129.90
50% RDN through VC+ 50% RDN through PM + Rhizobium	2.73	19.87	54.21	2.73	0.21	140.84	7.78	130.00
100% RDN through inorganic source	2.76	17.62	57.46	3.26	0.16	141.49	7.84	130.29
100% RDN through inorganic source + Rhizobium	2.81	17.64	58.67	3.33	0.16	141.81	7.87	130.38
50% RDN through FYM + 50% RDN through inorganic source	2.87	18.86	59.07	3.13	0.19	141.73	7.93	130.81
50% RDN through VC + 50% RDN through inorganic source	2.90	18.24	60.44	3.31	0.18	142.10	7.96	130.91
50% RDN through PM + 50% RDN through inorganic source	2.95	19.72	60.28	3.06	0.18	142.21	8.02	131.11
SEm +	0.06	-	1,419	0.12	0.01	1.35	0.06	0.37
CD (P=0.05)	0.16	-	4,003	0.35	0.03	3.81	0.17	1.05

*System productivity in terms of fenugreek grain equivalent yield was calculated at market prices by summing of fenugreek grain yield (₹ 25,000/t) and pearlmillet fodder yield (₹1,000/t) equivalent

comparison to other organic source.

Organic manure has got some solubilising effect on some mineral compounds present in soil and brings about the conversion of a number of chemical elements to available form. The beneficial effect of FYM application on soil organic carbon (OC) content might be due to more residue left, the higher OC content by PM application could be attributed to the litter present in PM and improvement in OC content due to VC application could be ascribed to the introduction of earthworms in the field and these could have tilled the soil and made it more porous and loose which resulted in higher decomposition of organic residues. Organic manures on decomposition solubilise insoluble P fractions through release of various organic acids and increase the available P status of soil. It also forms chelates with essential plant nutrients and their fixation which favour availability of nutrient to crop (Parihar and Rana, 2010). The higher P content of PM in comparison to other organic source might have resulted in the higher available P content of the soil. The improvement in soil fertility after crop harvest due to integrated nutrient management was also recorded by Parihar *et al*. (2009).

Economics

Application of integrated nutrient management had significant influence on the economics of fenugreek. The maximum monetary returns (₹60,443) was fetched with the application of 50% RDN through VC + 50% RDN through inorganic source, which was found at par with 50% RDN through FYM + 50% RDN through inorganic source and 50% RDN through PM + 50% RDN through inorganic source (Table 4). The highest benefit cost ratio was obtained with the application of 100% RDN through inorganic source along with *Rhizobium* inoculation, closely followed by 50% RDN through VC + 50% RDN through chemical fertilizer and 100% RDN through inorganic fertilizer. The lower cost of vermicompost as compared to poultry manure might have resulted in higher net returns of VC. The lower quantity of inorganic fertilizer is required to fulfill the 100% RDN which resulted in lower investment and ultimately gave the highest benefit cost ratio or higher returns per rupee investment over organic manures. Addition of vermicompost, although offer the twin benefits of soil quality and fertility enhancement but while meeting a part of nutrients need of crop that only sustain the high yields required these days. Similar results were also reported for combined application of organic and inorganic with *Rhizobium* inoculation by Singh and Verma (2002).

Thus, it can be concluded that the application of 50% RDN through VC + 50% RDN through inorganic source

fetched the highest system productivity and net monetary returns from fenugreek-fodder pearmillet cropping sequence along with improvement in soil health of loamy sand soil under semi-arid eastern plain zone of Rajasthan.

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