



Evaluation of nutritional quality of manures: Impact on yield and uptake of nutrients in fenugreek (*Trigonella foenum-graecum*) and soil properties under Typic Haplustepts

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ABSTRACT

A field study was carried out to assess the effect of different organic manures (Vermi-compost, sheep manure and farmyard manure) and *Rhizobium* inoculation on yield and uptake of nutrients in fenugreek (*Trigonella foenum-graecum* L.) and soil properties during 2011-12 and 2012-13. Result revealed that yield of fenugreek enhanced by the application of organic manures and seed inoculation with *Rhizobium*. However, yield obtained with farmyard manure was highest as compared to other inputs and control. The per cent yield increased with these manures and *Rhizobium* was 11.45, 20.83, 22.22 and 35.42 with *Rhizobium*, sheep manure, vermi-compost and FYM, respectively. Chlorophyll content and uptake of macro and micronutrients in fenugreek and soil available macronutrients were more with FYM. Total chlorophyll content was more at 90 days followed by 30 and 60 days. Uptake pattern of nutrient indicated that N, K, Fe, Mn and Cu accumulation was more in straw than seed. Contrary to it, P and Zn accumulation was more in seed than straw. Straw yield and availability of micronutrients except Mn did not influence either by manures or seed inoculation with *Rhizobium*. Soil organic carbon was only higher with sheep manure and FYM. Regardless, it has been cited in some of the literature that vermi-compost is always better than any other farm manures, however our results are warranted. The nutritional value of FYM was the best and vermi-compost was found poorest among the commercially available manures used in this study.

Key words: Fenugreek, FYM, Manures quality, Organic farming, Sheep manure, Soil available nutrients, *Trigonella foenum-graecum*, Typic haplustepts, Vermi-compost

In developing countries like India, increasing prices of chemical fertilizers along with growing concerns for sustaining soil productivity has led to draw the attention for use of organic manures as fertility-restoring inputs (Ramesh *et al.*, 2010). Organic manures are a vital resource not only for supplying plant nutrients but also for replenishing organic matter content in most of agricultural soils, particularly in the tropics and subtropical regions. This would further emphasize the need to use organic manures alone or in combination with chemical fertilizers for maintenance and improvement of soil fertility for sustainable crop production (Reddy *et al.* 2000). Agricultural wastes of animal and plant origin are one of the major under-utilized resources in many countries. These wastes could not be exploited fully due to the non-availability of a viable technology for their economic recycling. Composting, the biological oxidation

of organic matter, is an important process by which it can be recycled properly at farm. Notwithstanding, nutrient content in manures vary by various reasons like methods of composting, substrate used and loss of nutrients or organic matter (Ketkar 1993). Nitrogen is one of the common plant nutrients which promote vegetative growth and development in plants. This plant nutrient is also important for producing herb, folium and seed yields in medicinal and spice plants (Ceylan 1995). *Rhizobium* spp. are well known group of bacteria that acts as the primary symbiotic fixer of nitrogen. These bacteria infect the roots of leguminous plants, leading to the formation of lumps or nodules where the nitrogen fixation takes place. This symbiosis reduces the requirements for nitrogenous fertilizers during the growth of leguminous crops (Ali *et al.* 2012).

Fenugreek (*Trigonella foenum-graecum* L.) is one of the major seed spice crop belongs to Papilionaceae, a sub family of Fabaceae. Vernacular name of the crop is 'Methi', which is cultivated in the northern parts of India, in the *rabi* season. The major fenugreek cultivating states in India are Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh, Maharashtra and Punjab. Being a leguminous crop, organic cultivation could be successful of this crop. However, there is a malice about

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the manurial quality which depends upon various factors like substrate used for its preparation, methods etc. Therefore, present investigation was carried out to study the nutritional quality of commercially available manures and their impact on yield and uptake of nutrients by fenugreek as well as soil available nutrients. These parameters are essential for removing misconception in input of organic farming system and sustainable crop production.

MATERIALS AND METHODS

The present study was carried out during 2011-12 and 2012-13 at the experimental field of ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer which lies in between 74° 35' 39" to 74° 36' 01" E longitude and 26° 22' 12" to 26° 22' 31" N coordinates. This zone is semi-arid central plain of Rajasthan and receives the rainfall from 500-600mm. Temperature in summer reaches around 42-45°C and in winter minimum goes down to 2°C or sometimes subzero. This place is on 460.17m height above mean sea level and located in Ajmer district of Rajasthan.

The soil of experimental area comprises a member of fine loamy, mixed calcareous, hyperthermic family of Typic Haplustepts. The soil was more than 100 cm deep, brown to dark brown in color, slightly to moderately alkaline, slightly calcareous having approximately 5.0% calcium carbonates. The texture of experimental soil was loamy sand and with subsurface sandy clay loam, which was analyzed by International Pipette method (Piper 1966). Soil samples were analyzed for available nitrogen (Subbiah *et al.* 1983), 0.5M NaHCO₃ extractable phosphorus (Olsen *et al.* 1982), and 1N NH₄OAc (CH₃COONH₄ ammonium acetate) extractable potassium (Jackson 1973). Soil organic carbon (SOC) was estimated by wet digestion method as described by Walkley and Black (1934). Detailed initial soil properties are given in Table 1. Texture of soil was sandy loam having EC (dS/m), pH and SOC (%) of their corresponding values 0.24, 8.8 and 0.23, respectively. The values of soil available N, P and K were 116.7, 6.5 and 135.1 kg/ha, respectively. However, available micronutrient status particularly Fe, Zn, Mn and Cu were estimated by Lindsay and Norvell (1978) method and their values were, 6.4, 2.1, 10.5 and 3.0 mg/kg, respectively.

Table 1 Nutritional value of manures used in experiment

Nutrients content	Farmyard manure	Sheep manure	Vermi-compost
Nitrogen (g/kg)	13.4 (3.2)	10.0 (3.0)	8.6 (2.9)
Phosphorus (g/kg)	3.9 (1.8)	2.7 (2.1)	2.4 (1.9)
Potassium (g/kg)	16.5 (5.5)	8.5 (5.2)	8.0 (4.9)
Zinc (Mg/kg)	99.4 (1.6)	50.9 (5.1)	54.9 (13.7)
Iron (Mg/kg)	551.6 (21.7)	475.2 (21.6)	419.9 (9.2)
Manganese (Mg/kg)	148.7 (79.3)	176.3 (10.8)	209.9 (8.3)
Copper (Mg/kg)	66.2 (7.0)	41.5 (5.1)	44.9 (1.9)

The value given in parenthesis is standard deviation.

In order to make a soil tilth, first ploughing was done, by soil turning plough and afterward 2-3 ploughings with harrow. The field was immediately planked to break clods and leveled to conserve soil moisture. After leveling the field, experiment was laid out in field with five treatments and four replications in Randomized Block Design (RBD). The treatment details were three types of manures (Vermi-compost, sheep manure and FYM) and seed inoculated with *Rhizobium*, which were compared with control plots. The fenugreek variety Rmt-305 was used in the experiment to assess the crop response to manures and bio-fertilizers. Seeds of fenugreek were sown in *rabi* season. Prior to sowing seeds were cleaned and treated with fungicide and also with *Rhizobium* as a treatment. Seeds were sown in field by maintaining spacing, i.e. row to row 30 cm and plant to plant spacing 10 cm and these seeds were covered with soil properly. *Rhizobium* inoculant was prepared by using jaggery solution (20% W/V sugar solution). One kg fenugreek seeds were embedded in jaggery solution for 15 minutes. Seeds were mixed with a packet of *Rhizobium* powder (10 g) before sowing in the field. The manures were procured from commercial production at state department farm, ICAR institute and local farmers.

The chlorophyll contents in leaves was estimated as per the method suggested by Barnes *et al.* (1992). Fully mature open leaves were chosen for chlorophyll content estimation. Accurately weighed 0.1 g clean leaf sample was immersed in 5 ml of dimethyl sulphoxide (DMSO). The sample was incubated at 70°C for four hours in hot air oven. Optical densities of samples were taken by using spectrophotometer at wavelength 625 and 645. Chlorophyll a, b and total were calculated according to the following formula-

$$\text{Chlorophyll 'a' (mg/g)} = \frac{[(12.7 \times 645) - (2.65 \times 625) \times \text{Volume of sample}]}{1000 \times \text{Weight of sample}}$$

$$\text{Chlorophyll 'b' (mg/g)} = \frac{[(22.7 \times 645) - (4.68 \times 645) \times \text{Volume of sample}]}{1000 \times \text{Weight of sample}}$$

$$\text{Total Chlorophyll (mg/g)} = \text{Chlorophyll 'a'} + \text{Chlorophyll 'b'}$$

Plant samples were collected after the harvest of crop. The samples were successively washed with tap water, 0.1 M HCl and distilled water and dried at 70°C. Manures samples were collected randomly from various lots used for the experiments. After proper drying plant and manure samples were powdered in wily mill and using mortar and pestle, respectively. Fine ground sample passed through the 20 mesh steal sieve for acid digestion. Nitrogen was estimated by Kjeldahl method (Piper 1966). The samples were digested in nitric and perchloric acid (10:4) for the estimation of P by Vanado-molybdo yellow colour method (Chapman and Pratt 1962) and K by flame photometer. Micronutrients were estimated by Atomic Absorption Spectrophotometer by taking aliquot from the digested samples used for estimation of P and K.

The data of both the years were pooled and analyzed by ANOVA and treatment differences were expressed for

Least Significant Differences (LSD) at 5% probability to determine the significance among the treatment means (Cochran and Cox 1987).

RESULTS AND DISCUSSION

Nutritional quality of manures

Regardless, it has been cited in some of the literature that vermi-compost is always better than any other farm manures, however following results are warranted. Such vogueish statements distract the attention of researchers from full sense of the original research. The nutritional value of FYM was the best and vermi-compost was found poorest among the commercially available manures used in this study (Table 1). Nitrogen content in FYM was 34% more than sheep manure and 1.6 time more than vermi-compost. Phosphorous and potassium content in both sheep manure and vermi-compost was almost similar. Phosphorous content was 1.4 and 1.6 times more in FYM than sheep manure and vermi-compost, respectively. However, potassium and zinc content was substantially higher in FYM than the rest of manures accounts about to double. Iron content was also more in FYM followed by sheep manure and vermi-compost. Moreover, copper content in FYM was about 1.5 times more than the other two manures. Contrary to other elements, manganese content was more in sheep manure than FYM and it was highest in vermi-compost. This because of substrate used for the preparation of these manures was different consequently product was also differed in quality. Highest fluctuation in Mn content was observed in manures followed by iron as the data on standard deviation are given in parenthesis of Table 2. However, some of the workers reported variation in nutritional quality of vermicomposts those supported by findings of Nagavallema *et al.* (2004) and Sinha (2009).

Yield of fenugreek enhanced by the application of organic manures and seed inoculation with *Rhizobium*. However, seed yield was more with vermi-compost and sheep manure than the seed inoculated with *Rhizobium* and control (Fig 1). Over all yield obtained with farmyard manure was highest as compared to other inputs and control. However, straw yield did not influence statistically with

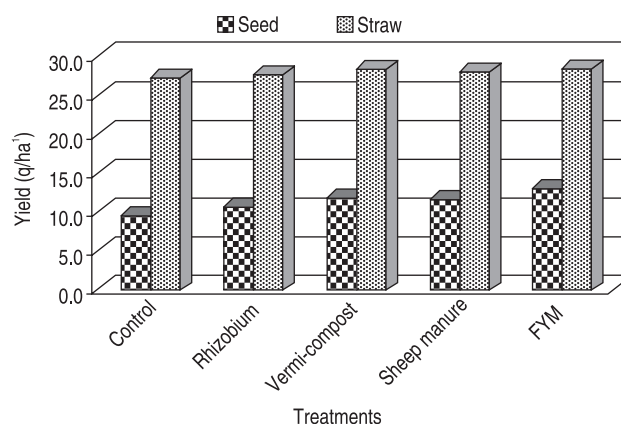


Fig 1 Effect of different organic sources of nutrients on yield of fenugreek

input of organic manures and *Rhizobium* inoculation. The per cent yield increased with *Rhizobium*, sheep manure, vermi-compost and FYM was 11.5, 20.8, 22.2 and 35.4 respectively. The results clearly suggests that seed yield is artifact of several yield components which are dependent on source (photosynthates/metabolites/nutrients) and sink (yield components particularly number of seeds/pod and seed weight/pod) and improvement in all these aspects under the influence of organic fertilization resulted in realization of higher productivity in terms of seed yield. Increase in seed yield of fenugreek due to FYM application was also reported by Choudhary *et al.* (2011). The increase in straw production with addition of FYM seems to be on account of increased photosynthetic efficiency and greater development of vegetative structures. These results are in close conformity with the finding of Khiriya *et al.* (2003). The favorable effects of *Rhizobium* in enhancing the yield of fenugreek was also reported by Purbey and Sen (2007).

Chlorophyll content

In many of crops, chlorophyll content is directly related to soil available N and plant content. Hence, chlorophyll content is an indicator of soil N supply and estimated accordingly. Highest Chlorophyll 'a', 'b' and total content observed with FYM (Table 2). It is because of availability of some nutrients is directly related to the chlorophyll contents

Table 2 Effect of organic manure and *Rhizobium* on chlorophyll content (mg/g) in leaves

Treatment	Chlorophyll content (mg/g)								
	30 DAS			60 DAS			90 DAS		
	Chloro-phyll 'a'	Chloro-phyll 'b'	Total	Chloro-phyll 'a'	Chloro-phyll 'b'	Total	Chloro-phyll 'a'	Chloro-phyll 'b'	Total
Control	0.30	0.40	0.76	0.22	0.36	0.63	0.29	0.43	0.79
<i>Rhizobium</i>	0.31	0.41	0.78	0.25	0.37	0.68	0.31	0.43	0.80
Vermi-compost	0.30	0.42	0.77	0.27	0.39	0.69	0.32	0.47	0.84
Sheep manure	0.32	0.43	0.80	0.26	0.38	0.71	0.32	0.51	0.86
FYM	0.32	0.48	0.86	0.28	0.42	0.74	0.33	0.52	0.91
Mean	0.31	0.43	0.79	0.26	0.38	0.69	0.31	0.47	0.84
CD ($P \geq 0.05$)	NS	0.03	0.04	0.03	NS	0.09	0.03	0.05	0.07

in plants as nitrogen and magnesium are the integral part of Chlorophyll ‘a’ and ‘b’, which were more in FYM. Mean values of chlorophyll indicated that its content in leaves was lower than the initial and later stage of crop, might be due to dilution by peak growth stage of crop. Chlorophyll content was significantly correlated with soil available N ($r^2 = 0.92$) and seed N content ($r^2 = 0.91$) and marginally with straw N content (Fig 2). This is because of N is a structural part of chlorophyll, by weight N and Mg contribute of its total amount about to 6.2 and 2.7 per cent, respectively (Aishwath and Dravid 2004). More of macro and micro nutrients content in plant also have positive impact on chlorophyll content at various stages. Creating congenial condition in rhizosphere by the manures facilitates higher absorption of nutrients and water by plants thereby maintaining favorable water status in leaf which enhances synthesis of chlorophyll. More of the protein content with FYM triggered more of chlorophyll in fenugreek (Naimuddin *et al.* 2013). These results are also in conformity with the work of Abdelgani *et al.* (2012).

Accumulation of macro and micronutrient in seed, straw and total removal by the crop

It is essential to assess the nutrients removal by the crop and their uptake distribution in various parts towards the nutrient economy for plant. Availability in rhizosphere as well as its utilization in the plant system leading to

enhanced translocation to reproductive structures, viz. pods, seed and other parts are quite essential for nutrient budgeting. Nitrogen accumulation in seed was higher with FYM as compared to other treatments (Table 3). Total nitrogen uptake was higher with manures and *Rhizobium* inoculation in comparison to control. This is because of FYM contributed more of N to the soil and ultimately plant content too (Naimuddin *et al.* 2013), as per the data given in Table 2, leading to more N content and uptake of N with FYM. P accumulation in both seed and straw and total uptake was also followed the similar trend as that of nitrogen. However, phosphorus accumulation in seeds was more than the straw, which was divergent to both N and K. More P in FYM leads to more of seed and straw yield. Obviously, it required for energy transfer and storage molecule, regulate cell division, root development and protein formation. Potassium accumulation in both seed and straw as well as total uptake was more with FYM followed by other manures and *Rhizobium* inoculation. Higher P accumulation and uptake with manures may be due to more of AM fungi association with congenial condition created by manures as this crop has very good association under these conditions (Tarafdar *et al.* 2011). However, it is important to note that K accumulated in straw was more than three times than the seed. Which indicated that potassium requirement of fenugreek was more of foliage than seed. This might be due to the fact that potassium play a crucial role of ionic function in plant including stomatal control, maintenance of turgor pressure and charge balance during selective ion uptake across the root membranes. It is obvious that yield was also higher with FYM as well as control. The nitrogen, phosphorus and potassium might have been utilized in greater quantities due to their abundant availability with manurial input. Another reason for higher uptake of nutrients might be due to balanced supply of nutrients during crop growth period through manures and nitrogen through flush of available N by autolysis of microbial cell (Shuman and Hargrover 1985). Higher uptake of N, P and K in seed and straw may also be due to higher yields with treatments (Sharma and Bhandari 2002).

Iron, zinc, manganese and copper accumulation in seed, straw and their total removal by fenugreek was more with manures and *Rhizobium* inoculation as compared to

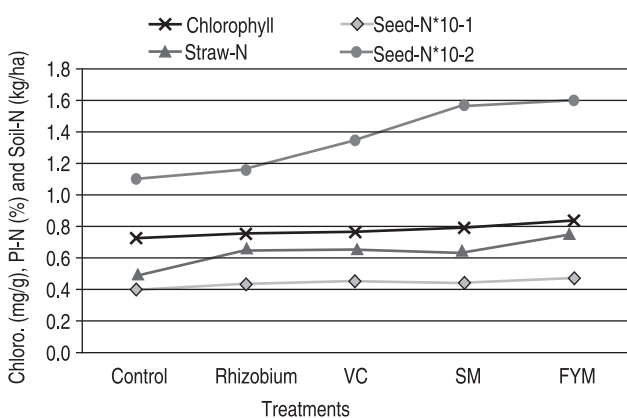


Fig 2 Relationship of chlorophyll content with plant N content and soil available N

Table 3 Effect of organic manures and *Rhizobium* inoculation on accumulation (in seed and straw) and uptake of macro-nutrient (kg/ha)

Treatment	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Control	38.7	53.4	92.1	4.6	4.0	8.7	11.7	43.6	55.3
<i>Rhizobium</i>	46.0	58.0	104.0	7.0	4.7	11.7	13.0	48.0	61.0
Vermi-compost	53.3	57.6	110.9	7.7	5.1	12.8	14.7	48.6	63.3
Sheep Manure	51.2	59.4	110.6	7.4	4.2	11.6	14.2	46.6	60.7
FYM	61.5	59.5	120.9	9.8	4.5	14.2	17.5	49.9	67.4
Mean	50.14	57.58	107.7	7.3	4.5	11.8	14.22	47.34	61.54
CD (P ≥ 0.05)	3.7	NS	11.0	0.8	NS	1.4	1.1	5.7	5.8

Table 4 Effect of organic manures and *Rhizobium* inoculation on accumulation (in seed and straw) and uptake of micronutrient

Treatment	Iron (kg/ha)			Zinc (g/ha)			Manganese (g/ha)			Copper (g/ha)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Control	0.10	0.79	0.89	40.3	37.8	78.1	21.5	113.1	134.7	21.0	40.7	61.7
<i>Rhizobium</i>	0.15	1.02	1.17	48.5	40.6	89.1	23.3	116.1	139.4	26.9	44.9	71.8
Vermi-compost	0.16	1.09	1.25	51.1	48.6	99.7	27.8	117.7	145.5	29.1	50.9	80.0
Sheep manure	0.17	1.10	1.28	52.0	49.1	101.1	31.1	126.2	157.3	32.2	54.7	87.0
FYM	0.17	1.28	1.45	61.2	53.7	114.9	36.3	147.0	183.5	41.8	55.6	97.4
Mean	0.15	1.06	1.21	50.6	45.9	96.6	28.0	124.0	152.08	30.2	49.36	79.6
CD ($P \geq 0.05$)	0.01	0.10	0.10	5.0	4.8	7.1	3.5	15.5	14.8	8.0	15.8	17.8

control (Table 4). However, micronutrient accumulation in seed and straw as well as total removal was highest where FYM applied in fenugreek followed by sheep manure and vermi-compost. Contrary to other field crops, iron, manganese and copper accumulation was more in straw than seed. Iron accumulation in straw was about 7.0 times more than seeds, this might be due to the Fe content was more in leaves than the seed and also higher plant biomass. Irrespective of treatments, manganese and copper accumulation in straw was 4.4 and 1.6 times more than seed. However, zinc accumulation was more in seed than straw, this is because of more of straw accumulation in fenugreek than seed. The manures applied in the field were also having micro-nutrients and contributed to the soil by them as well as some of the organic acid released by them in the soil, mobilized the native micro-nutrient in the soil solution, which enhanced the content and uptake of micro-nutrients. Though *Rhizobium* did not contribute any micro-nutrient either soil or to plant, whereas it improved yield of fenugreek resultant higher uptake. The similar findings have also been reported by Reddy *et al.* (1993) in coriander.

Soil organic carbon and available macro and micro nutrients in post-harvest soil

Soil organic carbon content was highest with the sheep manure as compared to other manures which might due to partially decomposed matter was more in sheep manure, therefore SOC was more in the soil (Table 5). Another probable reason could be a wide C: N ratio (25: 1) of sheep manure which might have result in slow rate

of mineralization process and hence more carbon was left in the soil. Similar findings were also observed by Ramesh *et al.* (2006).

Available nitrogen, phosphorus and potassium were higher with manures as the manures released more of these nutrients in soil solution, resulting more availability (Table 6). The organic manure treated plot showed significantly higher available N and P in post-harvest soil samples as compared to control. This may be ascribed the beneficial role of organic manures in mineralization of own nutrients and mobilization of native pool, thereby increased the available nutrients pool of the soil. As a matter of fact, all the available nutrients are not taken up by the plants but rest of amount remained in the soil which improve availability after the harvest of crop. These results are in conformity with those of Bellaki *et al.* (1997) who had reported increase in availability of nutrients during post-harvest soil with addition of organic manures. Increase in phosphorus availability may be ascribed to the organic acid produced by FYM. The main mode of action of micro-organisms for participating in dissolving insoluble phosphorus is the production of organic acids such as lactic, butyric, acetic, propionic, gluconic, glycolic, oxalic, citric, carbonic acid etc. These acids help in quicker release of locked P from the insoluble calcium phosphate and thereby could have contributed to the availability of phosphorus Rajkhowa *et al.* (2003). They also reported higher N, P and K status of soil after harvest of crop in the plots manured with vermi-compost. Moreover, potassium availability was higher even in control plots than its initial level, might be due to soil having K bearing minerals releases the K by wetting

Table 5 Effect of organic manures and *Rhizobium* inoculation on available macro and micro-nutrient and soil organic carbon (SOC)

Treatment	Macro-nutrient (kg/ha)			SOC (%)	Micro-nutrient (kg/ha)			
	N	P	K		Cu	Mn	Zn	Fe
Control	109.8	5.5	188.7	0.25	2.9	10.6	1.9	6.0
<i>Rhizobium</i>	116.0	6.8	188.2	0.25	3.1	11.8	1.8	5.6
Vermi-compost	134.9	7.4	193.2	0.29	3.1	12.6	1.7	5.7
Sheep manure	156.8	8.3	199.4	0.34	3.0	14.0	1.8	5.4
FYM	159.9	9.4	209.4	0.32	3.0	11.9	1.7	5.8
Mean	135.5	7.5	195.8	0.29	3.02	12.18	1.78	5.7
CD ($P \geq 0.05$)	10.9	10.4	9.2	0.06	NS	2.0	NS	NS

and drying with irrigations and may also be by other cultural activities.

There was no significant variation in available micro-nutrients was observed except manganese, which was highest in sheep manure (Table 5). This may be due to contribution of micro-nutrient by the manures was utilized by the fenugreek and net balance remained almost same in the soil. Somewhat similar findings were also made by Bellakki and Badanur (1997) with *kharif* sorghum. Availability of iron was highest among the micronutrients followed by manganese. Addition of organic manures bearing more of iron under organic farming practice is the cause for such increase in the DTPA extractable iron. Sharma *et al.* (2000) also observed the significant enhancement in DTPA-extractable micronutrients due to incorporation of crop residues and FYM compared to chemical fertilizers application.

The results obtained from the present investigation affirms potential role of organic sources of nutrients for improving productivity of fenugreek. Nutritional value of FYM was superior among the manures and its application recorded highest fenugreek yield, uptake of nutrients and also improved soil chemical properties. Which could remove the misconception about the nutritive value of manures. As in many of the literatures, and deliberations, it is emphasized that vermi-compost is always rich in nutrients among the other farm manures. Yet, it depends on the substrate used. Use of organic manures not only improved the fenugreek yield but also available nutrients, soil organic carbon and ultimately soil health, which will bring the sustainability in fenugreek production organically.

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