

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.702.004>

Effect of Different Organic Sources on Fenugreek (*Trigonella foenum-graecum* L.) under Organic Farming Module

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ABSTRACT

A field experiment on the standardization of organic module for production of fenugreek (*Trigonella foenum graecum* L.) was conducted during *rabi* season of 2007-08 and 2008-09 (two years). The experiment comprising of absolute control and varying proportion of organic and inorganic sources *viz.*, 100 % Recommended Dose of N through FYM, 100 % RDN through castor cake, *Rhizobium* treatment, PSB treatment, *Rhizobium* + PSB treatment, 50 % Recommended Dose of N through FYM + *Rhizobium*, 50 % Recommended Dose of N through CC + *Rhizobium*, 50 % RDN through FYM + *Rhizobium*+ PSB, 50 % Recommended Dose of N through CC + *Rhizobium*+ PSB) and Recommended dose of fertilizer was laid out in randomized block design with four replications. It was found that RDF and varying combinations of organic sources produced significantly higher grain yield over absolute control. The seed and straw yield of fenugreek was found significant due to different treatments, wherein integrated use of organic sources of nitrogen (50 % RDN through castor cake + *Rhizobium* + PSB) recorded significantly higher seed and straw yield of fenugreek as compared to their individual use. Different treatments were failed to produce significant effect on nutrient content in seed and straw of fenugreek, but it was found significant with respect to nutrients uptake, wherein higher removal of nutrients by seed and straw were noticed under integrated use of organic sources of nitrogen as well as chemical fertilizer. The organic carbon and available phosphorus were also found significant due to different treatments, whereas the maximum amount of organic carbon was registered under 100 % RDN through FYM/castor cake. The maximum available phosphorus was recorded with the use of PSB and available potassium was found non-significant due to different treatments. Thus, it can be inferred that application of 50 % RDN through CC + *Rhizobium*+ PSB is better for realizing good soil health and sustainable higher yield levels.

Keywords

Fenugreek, Organic farming, Yield, Nutrients

Article Info

Accepted:

04 January 2018

Available Online:

10 February 2018

Introduction

Fenugreek is an important versatile *rabi* season seed spice crop mainly grown in Rajasthan, Gujarat, Madhya Pradesh Maharashtra and Haryana. The seeds of

fenugreek are used as a condiment and seasoning agent for garnishing and flavourings dishes. Being a leguminous crop, the root nodules enrich the soil with atmospheric nitrogen. Intensive agriculture involving use of high input for increasing production

resulted in heavy removal of nutrients from the soil. Thus, there is a wide gap between the nutrients removed from the soil and the nutrient supplied. This gap can be bridged with the use of chemical fertilizers along with organic sources. Exclusive application of inorganic fertilizers leads to deterioration in soil health and soil structure. Conjunctive use of inorganic and organic sources of nutrients not only supplies nearly all nutrients throughout the growing period of crop but also sustain soil health. Combined use of inorganic fertilizers with organic manures in general enhances microbial activity of soil and biological nitrogen fixation in particularly. Integrated use of chemical fertilizers as well as organic manures in fenugreek can be a more efficient, economical and judicious approach than chemical fertilizers alone. Therefore, the study was undertaken to evaluate the effect of different combinations of organic and inorganic nutrient sources on productivity of fenugreek.

Recent trends in agriculture are centred on reducing the use of inorganic fertilizers by organic manures and biofertilizers (Gyaneshwar *et al.*, 2002 and Darzi *et al.*, 2011). Besides improving soil health, organic manures supply the major nutrients and micronutrients (Palaniappan and Annadurai, 1999). Many studies showed that organic nutrients could enhance the vegetative growth and yield of seed spices like fennel (Darzi *et al.*, 2008) and coriander (Lal and Singh, 2016). The cultivation of seed spices including fenugreek is predominant in the Arid and semi-arid regions of Rajasthan and Gujarat. Seed spices are well adapted to poor resource conditions like water and nutrients since these crops are low input requiring crops. Fenugreek (*Trigonella foenum graecum* L.) is one of the major seed spice crops grown throughout the country. India produces 113000 tonnes of fenugreek annually from 93000 ha area (Tiwari *et al.*, 2013).

Gujarat is the leading state in fenugreek production and it grows mainly in Mehsana, Patan, Sabarkantha, Banaskantha and Kheda districts. The average productivity of fenugreek in the country seems to be very low (1215 kg/ha) which required to be increased (Lal *et al.*, 2015). The main factors responsible for low productivity are poor soil fertility, non-availability of high yielding varieties under organic system and persistence of several biotic and a-biotic factors. Development of location and crop specific organic modules containing required quantity of nutrients, plant protection means for fenugreek cultivation is also necessary. Since, fenugreek is affected by several diseases like root rot, wilt, powdery mildew and insect pests like aphids, thrips, jassids during the cropping season, which are to be managed effectively through organic/ biological means.

Organic products are highly remunerative due to higher demand in domestic market in metro cities and for export earnings. Organic cultivation not only helps in enhancing availability of nutrients to plant, but also reduces dependency upon external inputs as it is near to nature (Lampkin, 1999). Fenugreek crop responds well to the application of both organic manures and inorganic fertilizers. Looking to its medicinal properties, there is great demand for organically produced fenugreek in the domestic and international market. Application of right and appropriate nutritional sources through manures and bio fertilizers and management of diseases and pest by organic sources improve the quality of produce with higher yield without any residual toxicity of pesticides. However, information on this aspect for fenugreek crop is very meagre. Keeping in view the above facts, besides the nutritional strength, medicinal properties and common use of fenugreek, the present study was carried out to standardize organic module for sustainable fenugreek production.

Materials and Methods

A field experiment on “Effect of different organic sources on fenugreek (*Trigonella foenum-graecum* L.) under organic farming” was carried out at Agronomy Instructional Farm, S.D. Agricultural University, Sardarkrushinagar, Gujarat, during ‘rabi’ seasons of 2007-08 and 2008-09 (02 years). The soil had pH 7.8 and electrical conductivity 0.23 dSm⁻¹.

The soil was low in organic carbon (0.26) and available nitrogen (142 kg ha⁻¹), low in available P₂O₅ (45 kg ha⁻¹) and medium in respect to available K₂O (178 kg ha⁻¹).

Ten treatments (T₁: 100 % Recommended Dose of N through FYM, T₂: 100 % RDN through castor cake, T₃: *Rhizobium* treatment, T₄: PSB treatment, T₅: *Rhizobium* + PSB treatment, T₆: 50 % Recommended Dose of N through FYM + *Rhizobium*, T₇: 50 % Recommended Dose of N through CC + *Rhizobium*, T₈: 50 % RDN through FYM + *Rhizobium* + PSB, T₉: 50 % Recommended Dose of N through CC + *Rhizobium*+ PSB and T₁₀: Recommended dose of fertilizer) were laid in randomized block design with three replications.

Full dose of nitrogen and phosphorus and organic manures as per treatment was applied manually through DAP, urea, poultry manure and vermicompost at the time of sowing. It was sown manually at 30 cm row to row spacing keeping seed rate of 20 kg per ha.

The fenugreek variety Gujarat Methi-2 was sown in November during 2007-08 and 2008-09. Standard agronomic practices were adopted for raising healthy crop.

Data of growth and yield attributes were taken from 10 tagged plants. Biological and economic yields were taken from net plot.

Results and Discussion

Grain and straw yield

Data in Table 1 illustrated that the application of different treatments of organic and inorganic fertilizers had significant effect on grain and straw yield of fenugreek during both individual years. The lowest grain (824 and 870 kg ha⁻¹) and straw yield (1557 and 2602 kg ha⁻¹) was observed with the application of PSB treatment during both the years. The maximum grain (1212 and 1106 kg ha⁻¹) and straw yield (2217 and 2895 kg ha⁻¹) was recorded due to application of 50 % RDN through CC + *Rhizobium*+ PSB during both individual years. However, grain yield of fenugreek was at par with treatments T₇, T₈ and T₁₀ during first year but, in case of second year it was at par with treatment T₈ (50 % RDN through FYM + *Rhizobium*+ PSB). On the other hand, straw yield of fenugreek was at par with treatments T₇, T₈ and T₁₀ during first year, and second year it was at par with treatment T₁, T₂, T₅, T₆, T₇ and T₈. The application of PSB enhances root and shoot length, plant biomass and vigour, all leading to a better growth of the plant due to the production of metabolites such as phytohormone and antibiotics which finally promotes the plant growth and grain yield (Balachandran and Nagarajan, 2002). The effect of seed inoculation with *Rhizobium* resulted in increased number of branches and plant height at different growth stages. These parameters have been reported to have significant positive correlation with the acetylene reduction and nitrogen fixation resulting in improved nitrogen nutrient of plant. On the other hand, N₂ fixed by *Rhizobium* translocated to plant system through xylem vessels mainly in the form of asparagines and to same extent as glutamine. These are involved in the synthesis of various enzymatic processes and variety of oxidation and reduction reactions which enhanced the

synthesis of carbohydrates and protein. This might have helped in improved growth parameters with *Rhizobium* inoculation. These findings are in corroboration with the results reported by Nagarajan and Balachandran (2001) and Sibbal and Khurana (2002). Mehta *et al.*, (2010) in cumin also reported increase in plant height, leaf area index and branches per plant with seed inoculation by *Rhizobium* and PSB. Thus balanced nutrients under favourable environment might have helped in production of new tissues and development of new shoots in fenugreek plants, which ultimately increased the yield attributes and grain yield. Similar findings were also reported by Lal and Singh (2016) in coriander.

The increase in yield may be attributed to better utilization of organic N, greater biological N fixation, higher synthesis of plant growth hormones and enhanced availability of P in the presence of biofertilizers. *Rhizobium* and PSB play an important role in the development of meristematic tissues at growing points for promoting growth and also aid in formation of seeds in plant. Increase in seed yield due to inoculation by *Rhizobium*

and PSB has also been recorded in other crops like soybean (Saxena *et al.*, 2001), cumin (Mehta *et al.*, 2010) and fenugreek (Mehta *et al.*, 2011) (Table 2).

Nutrient content and uptake

Different treatments were failed to produce significant effect on nutrient content in seed and straw of fenugreek, but it was found significant with respect to nutrients uptake, wherein higher removal of nutrients by seed and straw were noticed under integrated use of organic sources of nitrogen as well as chemical fertilizer. Significantly, maximum nitrogen uptake by grain (24.88 and 21.32 kg ha⁻¹) was recorded due to application of 50 % RDN through CC + *Rhizobium*+ PSB during both individual years. Significantly, the highest phosphorus uptake by seed (5.55 and 5.16 kg ha⁻¹) was recorded due to application of 50 % RDN through FYM + *Rhizobium*+ PSB as compared to other treatments during both individual years. Significantly, maximum potassium uptake by grain (11.25 kg ha⁻¹) was recorded due to application of recommended dose of fertilizer during first year.

Table.1 Effect of different treatments on seed and straw yield of fenugreek (02 years)

Treatments		Seed Yield (kg ha ⁻¹)		Straw Yield (kg ha ⁻¹)	
		2007-08	2008-09	2007-08	2008-09
T ₁	100 % RDN through FYM	824	870	1557	2602
T ₂	100 % RDN through castor cake	917	859	1700	2621
T ₃	<i>Rhizobium</i> treatment	804	715	1200	2350
T ₄	PSB treatment	784	730	1383	2356
T ₅	<i>Rhizobium</i> + PSB	934	885	1433	2632
T ₆	50% RDN through FYM+ <i>Rhizobium</i>	1019	893	1817	2742
T ₇	50 % RDN through CC + <i>Rhizobium</i>	1079	958	2133	2759
T ₈	50 % RDN through FYM + <i>Rhizobium</i> + PSB	1119	1011	2100	2705
T ₉	50 % RDN through CC + <i>Rhizobium</i> + PSB	1212	1106	2217	2895
T ₁₀	Recommended dose of fertilizer	1058	606	2117	1736
Mean		975	863	1766	2539
S.Em +		61.44	46.67	101.42	173.33
CD 5 %		178.3	126.67	294.32	506.67
CV %		12.60	10.16	11.49	13.77

Table.2 Effect of different treatments on nutrient content in seed of fenugreek (02 years)

Treatments		Nutrient Content in Seed (%)					
		N		P		K	
		2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T ₁	100 % RDN through FYM	2.04	1.93	0.41	0.43	1.02	1.01
T ₂	100 % RDN through castor cake	2.04	1.93	0.41	0.42	1.03	1.01
T ₃	<i>Rhizobium</i> treatment	2.05	1.94	0.42	0.44	0.99	0.97
T ₄	PSB treatment	2.05	1.94	0.46	0.48	1.01	1.00
T ₅	<i>Rhizobium</i> + PSB	2.08	1.96	0.48	0.50	1.03	1.01
T ₆	50% RDN through FYM+ <i>Rhizobium</i>	2.10	1.96	0.49	0.51	1.09	1.07
T ₇	50 % RDN through CC + <i>Rhizobium</i>	2.09	1.97	0.49	0.50	0.97	0.95
T ₈	50 % RDN through FYM + <i>Rhizobium</i> + PSB	2.07	1.96	0.50	0.51	0.92	0.91
T ₉	50 % RDN through CC + <i>Rhizobium</i> + PSB	2.05	1.93	0.44	0.45	0.90	0.89
T ₁₀	Recommended dose of fertilizer	2.13	1.92	0.51	0.52	1.07	1.05
Mean		2.07	1.94	0.46	0.46	1.00	0.99
S.Em ±		0.02	0.04	0.03	0.02	0.04	0.03
CD 5 %		NS	NS	NS	NS	NS	NS
CV %		1.80	1.76	13.8	13.34	7.70	7.81

Table.3 Effect of different treatments on nutrient content in straw of fenugreek (02 years)

Treatments		Nutrient Content in Straw (%)					
		N		P		K	
		2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T ₁	100 % RDN through FYM	0.73	0.78	0.14	0.14	0.38	0.38
T ₂	100 % RDN through castor cake	0.75	0.80	0.17	0.17	0.40	0.40
T ₃	<i>Rhizobium</i> treatment	0.69	0.74	0.16	0.16	0.38	0.38
T ₄	PSB treatment	0.70	0.75	0.16	0.16	0.42	0.42
T ₅	<i>Rhizobium</i> + PSB	0.74	0.79	0.16	0.16	0.42	0.42
T ₆	50% RDN through FYM+ <i>Rhizobium</i>	0.71	0.76	0.17	0.17	0.43	0.43
T ₇	50 % RDN through CC + <i>Rhizobium</i>	0.73	0.78	0.14	0.14	0.39	0.39
T ₈	50 % RDN through FYM + <i>Rhizobium</i> + PSB	0.74	0.79	0.16	0.16	0.42	0.42
T ₉	50 % RDN through CC + <i>Rhizobium</i> + PSB	0.68	0.73	0.16	0.16	0.44	0.44
T ₁₀	Recommended dose of fertilizer	0.87	0.92	0.18	0.18	0.48	0.48
Mean		0.73	0.78	0.16	0.16	0.42	0.42
S.Em ±		0.04	0.03	0.01	0.01	0.02	0.02
CD 5 %		NS	NS	NS	NS	NS	NS
CV %		10.10	9.42	12.80	18.21	10.20	10.15

Table.4 Effect of different treatments on nutrient uptake by seed of fenugreek (02 years)

Treatments		Nutrient Uptake in Seed (kg ha ⁻¹)					
		N		P		K	
		2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T ₁	100 % RDN through FYM	16.80	16.70	3.35	3.76	8.41	8.74
T ₂	100 % RDN through castor cake	18.68	16.48	3.73	3.62	9.42	8.70
T ₃	<i>Rhizobium</i> treatment	16.53	13.86	3.34	3.10	7.98	6.91
T ₄	PSB treatment	16.07	14.14	3.59	3.50	7.97	7.24
T ₅	<i>Rhizobium</i> + PSB	19.36	17.37	4.43	4.41	9.51	9.00
T ₆	50% RDN through FYM+ <i>Rhizobium</i>	21.39	17.50	4.95	4.51	11.06	9.57
T ₇	50 % RDN through CC + <i>Rhizobium</i>	22.50	18.84	5.27	4.78	10.39	9.12
T ₈	50 % RDN through FYM + <i>Rhizobium</i> + PSB	23.19	19.80	5.55	5.16	10.33	9.18
T ₉	50 % RDN through CC + <i>Rhizobium</i> + PSB	24.88	21.32	5.29	4.99	10.91	9.77
T ₁₀	Recommended dose of fertilizer	22.49	11.61	5.36	3.14	11.25	6.40
Mean		20.19	16.76	4.49	4.10	4.10	8.46
S.Em ±		1.29	0.83	0.29	0.34	0.70	0.55
CD 5 %		3.75	2.41	0.84	0.98	2.04	1.66
CV %		12.80	9.91	12.80	16.52	14.5	13.03

Table.5 Effect of different treatments on nutrient uptake by straw of fenugreek (02 years)

Treatments		Nutrient Uptake in Straw (kg ha ⁻¹)					
		N		P		K	
		2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T ₁	100 % RDN through FYM	11.43	20.58	2.23	3.80	5.95	10.00
T ₂	100 % RDN through castor cake	12.86	20.76	2.81	4.31	6.88	10.50
T ₃	<i>Rhizobium</i> treatment	8.24	17.64	1.92	3.89	4.58	8.99
T ₄	PSB treatment	9.63	17.67	2.23	3.86	5.77	9.78
T ₅	<i>Rhizobium</i> + PSB	10.44	20.66	2.23	4.13	5.92	11.05
T ₆	50% RDN through FYM+ <i>Rhizobium</i>	12.77	20.92	3.05	4.60	7.71	11.78
T ₇	50 % RDN through CC + <i>Rhizobium</i>	15.52	21.47	2.97	3.85	8.27	10.67
T ₈	50 % RDN through FYM + <i>Rhizobium</i> + PSB	15.44	21.22	3.27	4.22	8.73	11.20
T ₉	50 % RDN through CC + <i>Rhizobium</i> + PSB	15.03	20.86	3.49	4.51	9.81	12.82
T ₁₀	Recommended dose of fertilizer	18.32	15.89	3.71	3.06	10.17	8.39
Mean		12.97	19.77	2.79	4.02	7.38	10.52
S.Em ±		0.79	1.66	0.24	0.37	0.53	0.96
CD 5 %		2.29	NS	0.68	NS	1.55	NS
CV %		12.30	16.80	16.90	18.21	14.50	18.21

Table.6 Effect of different treatments on organic carbon, phosphorus and potassium content in Soil after harvest of fenugreek (02 years)

Treatments		OC (%)		Available P (kg ha ⁻¹)		Available K (kg ha ⁻¹)	
		2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T ₁	100 % RDN through FYM	0.28	0.31	36.38	36.87	158.71	162.46
T ₂	100 % RDN through castor cake	0.28	0.31	35.09	35.84	154.72	159.22
T ₃	<i>Rhizobium</i> treatment	0.21	0.25	33.67	34.87	142.77	148.39
T ₄	PSB treatment	0.22	0.26	45.51	46.00	153.32	157.07
T ₅	<i>Rhizobium</i> + PSB	0.21	0.26	40.64	41.12	156.12	159.87
T ₆	50% RDN through FYM+ <i>Rhizobium</i>	0.24	0.27	37.26	37.90	158.92	162.67
T ₇	50 % RDN through CC + <i>Rhizobium</i>	0.24	0.27	36.38	36.87	158.71	162.46
T ₈	50 % RDN through FYM + <i>Rhizobium</i> + PSB	0.25	0.28	43.39	44.03	153.43	157.18
T ₉	50 % RDN through CC + <i>Rhizobium</i> + PSB	0.26	0.29	45.26	45.90	165.60	170.85
T ₁₀	Recommended dose of fertilizer	0.26	0.29	43.60	44.08	164.31	172.18
Mean		0.24	0.28	39.72	40.35	156.66	161.24
S.Em ±		0.01	0.01	2.24	2.19	5.66	5.23
CD 5 %		0.04	0.04	6.50	6.34	NS	NS
CV %		10.20	9.33	11.30	10.40	7.20	6.49

But in case of second year significantly maximum potassium uptake by grain (9.77kg ha⁻¹) was recorded due to application of 50 % RDN through CC + *Rhizobium*+ PSB as compared to other treatments.

Significantly, maximum nitrogen uptake by straw (18.32 kg ha⁻¹) was recorded due to application of recommended dose of fertilizer during first year. But in case of second year significantly, maximum nitrogen uptake by straw (21.47 kg ha⁻¹) was recorded due to application 50 % RDN through CC + *Rhizobium* as compared to other treatments. Significantly, the highest phosphorus uptake by seed (3.49 and 4.51 kg ha⁻¹) was recorded due to application of 50 % RDN through CC + *Rhizobium*+ PSB as compared to other treatments during both individual years. Significantly, maximum potassium uptake by grain (10.17 kg ha⁻¹) was recorded due to application of recommended dose of fertilizer during first year. But in case of second year significantly, maximum potassium uptake by grain (12.82 kg ha⁻¹) was recorded due to application 50 % RDN through CC + *Rhizobium*+ PSB as compared to other treatments (Table 3–5).

Soil status after harvest

The organic carbon and available phosphorus were also found significant due to different treatments; whereas the maximum amount of organic carbon (0.28 %) was registered under 100 % RDN through FYM/castor cake, which was found statistically at par with remaining treatments except sole use of biofertilizers. The maximum available phosphorus (45.51 kg ha⁻¹) was recorded with the use of PSB, which was statistically at par with F₅, F₈, F₉ and F₁₀. The available potassium was found non-significant due to different treatments. The use of microbial cultures under different organic modules increased N₂ fixation, solubilisation of P and K. Further the root

system of the legumes has capacity to solubilise soil phosphorus through extraction of amino acid which encourages the growth and multiplication of soil microbes which finally leads to mineralization of unavailable P to available P in soil (Table 6). The results corroborate the findings of Malik *et al.*, 2013 and Singh *et al.*, 2013.

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How to cite this article:

Malav, J.K., J.K. Patel, R.P. Pavaya, B.B. Patel and Patel, V.R. 2018. Effect of Different Organic Sources on Fenugreek (*Trigonella foenum-graecum* L.) under Organic Farming Module. *Int.J.Curr.Microbiol.App.Sci.* 7(02): 17-25.
doi: <https://doi.org/10.20546/ijcmas.2018.702.004>