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Effect of integrated nutrient management on nutrient content and uptake of fenugreek in fenugreek-fodder sorghum cropping sequence

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Abstract
A field experiment entitled "Effect of integrated nutrient management on nutrient content and uptake of fenugreek in fenugreek-fodder sorghum cropping sequence" was conducted at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during the years 2019-20 and 2020-21. The field experiment consisted of integrated nutrient management treatments *viz*., T_1: Biocompost 2.5 t/ha, T_2: Biocompost 5 t/ha, T_3: Biocompost 2.5 t/ha + 50% RDF, T_4: Biocompost 2.5 t/ha + 75% RDF, T_5: Biocompost 2.5 t/ha + 100% RDF, T_6: Biocompost 5 t/ha + 50% RDF, T_7: Biocompost 5 t/ha + 75% RDF, T_8: Biocompost 5 t/ha + 100% RDF to fenugreek in *rabi* season and replicated three times in randomized block design. On the basis of two-year pooled results, the N and P content as well as N, P and K uptake by fenugreek seed and stover was significantly recorded higher values with respect to the treatment T_8 while, K content in fenugreek seed and stover was found to be non significant. However, the treatment T_1 recorded lower values with respect to N, P and K content and uptake by both fenugreek seed and stover. Significantly higher organic carbon content, available N, P_2O_5 and K_2O in soil after harvest of fenugreek was recorded in the treatment consisting of Biocompost 5 t/ha + 100% RDF (T_8) during both the years.

Keywords: Fenugreek**,** integrated nutrient management, biocompost

Introduction
Fenugreek (*Trigonella foenum-graecum* L.) is an annual dicotyledonous plant belonging to the family Fabaceae (subfamily Papilionaceae). The genus name Trigonella means tri angled may be because of triangular shape of its flowers and the word foenum graecum means "Greek hay" indicating its use as a forage crop in the past. Fenugreek known as one of the oldest medicinal plants recognized in recorded history (Lust, 1986) [11]. Chemical analysis of fenugreek seed revealed that it contains 13.7 per cent water, 26.2 per cent protein, 5.8 per cent fat, 3 per cent mineral matter, 7.2 per cent fiber, 4.41 per cent carbohydrate, 0.16 per cent calcium, 0.37 per cent phosphorus, 14.1 mg iron, 333 calories and 160 IU carotene per 100 gm (Agrawal, 2002) [1].

Fenugreek is known for its multipurpose uses. Its seeds are used as spice and condiment to improve the flavour and the nutritive value of foods. Seed are used as seasoning agent for pickles and vegetables. Fenugreek also used as vegetable for human consumption and as a concentrate for cattle. Its green leaves are used as vegetable, while chopped leaves are mixed in flour to prepare delicious preparations. Besides, seeds are bitter in taste due to the presence of two alkaloids 'Trigonellin' and 'Choline', being a legume; its roots are endowed with a mini-factory to synthesize nitrogenous food for the plant. Fenugreek has been referred to as a medicinal herb both in Indian Ayurvedic and traditional Chinese medicines. It was used medicinally from wound-healing to bust enhancement and for promoting lactation in weaning mothers.

In India, fenugreek occupies an area of about 2,11,110 ha, producing 2,99,870 tons of seeds. Gujarat contributes 20 per cent in total production of fenugreek in India. In India it is widely grown in the states of Rajasthan, Gujarat, Tamil Nadu, Himachal Pradesh, Madhya Pradesh and Andhra Pradesh (Saxena and Kumar, 2019) [14]. In Gujarat fenugreek occupies an area of about 7000 ha, producing 13579 tons of seeds (Anon., 2021) [5]. Banaskantha and Mehasana district contributes 80 per cent of total production of the Gujarat (Anon., 2017) [4].

The INM helps to restore and sustain soil fertility and crop productivity. It may also help to

check the emerging deficiency of nutrients other than NPK. It brings economy and efficiency in fertilizer use and favorably affects the physical, chemical and biological environment of soil. Hence, adoption of appropriate integrated nutrient management strategies holds a great potential in boosting the fenugreek crop. Therefore, integrated nutrient management is crucial not only for increasing the yield but also for the improvement of soil health.

Material and Methods

A field experiment was carried out on "Effect of integrated nutrient management on nutrient content and uptake of fenugreek in fenugreek-fodder sorghum cropping sequence" at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during the year 2019-20 and 2020-21. The data of soil analysis revealed that the soil of experimental plot was clay in texture, Low in organic carbon (0.39%) and available nitrogen (198.60 kg/ha), medium in available phosphorus (37.50 kg/ha) and high in available potassium (314.30 kg/ha). The soil was found slightly alkaline (pH 8.1) with normal electric conductivity (0.30 dS/m). The field experiment consisted of integrated nutrient management treatments *viz*., T_1: Biocompost 2.5 t/ha, T_2: Biocompost 5 t/ha, T_3: Biocompost 2.5 t/ha + 50% RDF, T_4: Biocompost 2.5 t/ha + 75% RDF, T_5: Biocompost 2.5 t/ha + 100% RDF, T_6: Biocompost 5 t/ha + 50% RDF, T_7: Biocompost 5 t/ha + 75% RDF, T_8: Biocompost 5 t/ha + 100% RDF to fenugreek in *rabi* season and replicated three times in randomized block design. The recommended dose of fertilizers for *rabi* fenugreek is 20 N + 40 P_2O_5 + 00 K_2O kg/ha.

The fenugreek *cv*. Gujarat Methi-2 was sown with spacing 30 cm between two rows in the month of November and harvested in the month of March during both the years. The required quantity of well decomposed biocompost was incorporated and mixed well within the soil at the time of land preparation during both the years while, nitrogen was applied through urea (46% N) as per the treatments and common dose of 40 kg P_2O_5 was applied through single super phosphate (16% P_2O_5) as well as required quantity of both the fertilizer was applied as a basal dose in previously opened shallow furrows and seeds were inoculated with biofertilizers (*Rhizobium* + PSB each of 10 ml/kg) and dried under shade and were sown as per the treatments during both the years. The observations on N, P and K content (%) N, P and K uptake (kg/ha), Organic carbon (%), Available N, P_2O_5 and K_2O (kg/ha) was recorded. Plant samples of seed and stover of fenugreek collected at harvest form each plot during both the years and were ground in Wiley mill to pass through 40 mesh sieves. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen, phosphorus and potassium content from green pod and stover were estimated using standard procedures given by Jackson (1973).

The nutrient (NPK) uptake of seed and stover of fenugreek was worked out by using following formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)}}{100} \times \text{Yield (kg/ha)}$$

The composite soil samples were drawn from 0-22.5 cm depth before starting of experimentation while, after harvest soil samples were taken separately from each net plots for each crop during both the years. The soil samples were dried under shade, ground and then sieved through 2 mm size sieve. The initial soil samples were analyzed for different physico - chemical properties. The soil samples collected after harvest of fenugreek were used to determine available nitrogen, phosphorus and potassium.

Results and Discussion

That data pertaining to content and uptake of seed and stover of fenugreek are presented in Tables 1 and 2. The results revealed that the N and P_2O_5 content in seed and stover of fenugreek was found to be significant. While, K_2O content was found to be non-significant based on pooled analysis of two years but the significantly higher values of N, P_2O_5 content was observed in treatment T_8 (Biocompost 5 t/ha + 100% RDF) and remained at par with application of Biocompost 5 t/ha + 75% RDF (T_7), Biocompost 5 t/ha + 50% RDF (T_6) and Biocompost 2.5 t/ha + 100% RDF (T_5). Similarly, uptake of N, P_2O_5 and K_2O by seed and stover of fenugreek were significantly influenced by various INM treatments and the higher values of all nutrients were found with treatment T_8 (Biocompost 5 t/ha + 100% RDF). Lower values of N, P_2O_5 and K_2O content and uptake by seed and stover was found under the treatment T_1 (Biocompost 2.5 t/ha).

The results presented in Tables 1 and 2 were observed that the nutrient content improved through the integration of organic and inorganic sources. Among the various INM treatments investigated, treatment T_8 (Biocompost 5 t/ha + 100% RDF) was found to be effective in improving the nutrient content and uptake. The nutrient uptake is a function of yield and nutrient concentration in plant. This might be due to increased growth attributes resulting in higher dry matter accumulation and per hectare yield which enhanced absorption of nitrogen during peak growth period was due to better root spread in the corresponding treatments. It could be due to the increased and sustained availability of nutrients through organic manure and inorganic fertilizers. The increased uptake by fenugreek might be due to improvement in soil physical, chemical and biological health through application of organic manure and inorganic fertilizers under integrated nutrient management. Similar results were reported by Jat *et al.* (2006) [8], Kumawat and Yadav (2009) [9], Choudhary *et al.* (2011) [6], Adak and Sachan (2013) [2], Naher *et al.* (2016) [12], Tagad *et al.* (2016) [15], Amitha (2019) [3] and Thumminkantti (2019) [16].

The data on soil organic carbon and soil nutrient status after the harvest of fenugreek as influenced by different INM treatments are presented in Table 3. Data showed that organic carbon content in the soil was improved significantly due to use of organic manures biocompost and increased with increasing level of manure application over initial level (0.39) and revealed that the higher organic carbon content was recorded with the plot which receiving treatment Bio compost 5 t/ha + 100% RDF (T_8) during 2019-20 (0.480%), 2020-21 (0.488%) and which remained at par with treatments Biocompost 5 t/ha + 75% RDF (T_7), Biocompost 5 t/ha + 50% RDF (T_6) and Biocompost 5 t/ha (T_2) during both year of experimentation. Lower organic carbon content during 2019-20 (0.404%) and in 2020-21 (0.413%) was recorded with treatment Bio compost 2.5 t/ha (T_1). Organic carbon content in soil is directly correlated with the quantity of organic matter in the soil. The treatment which received higher organic manures resulted in higher carbon content in soil.

Similar results were reported by Naher *et al.* (2016) [12], Lunagariya *et al.* (2018) [10] and Safiullah *et al.* (2018) [13].

The available nitrogen, phosphorus and potassium in soil significantly influenced by different INM treatments applied to fenugreek (Table 3) and data revealed that soil available nitrogen, phosphorus and potassium after harvest of fenugreek was found significantly higher with application of Biocompost 5 t/ha + 100% RDF (T_8) during 2019-20 and 2020-21 which remained at par with application of Biocompost 5 t/ha + 75% RDF (T_7), Biocompost 5 t/ha + 50% RDF (T_6) and Biocompost 2.5 t/ha + 100% RDF (T_5). Available status of nutrients after crop harvest during both the years of study was decrease under the treatments *viz.*, T_4: Biocompost 2.5 t/ha +75% RDF, T_3: Biocompost 2.5 t/ha +50% RDF, T_2: Biocompost 5 t/ha and T_1: Biocompost 2.5 t/ha as compared to initial status of soil available nitrogen, phosphorus and potassium and for available potassium was also decrease under the treatments T_5: Biocompost 2.5 t/ha + 100% RDF. From the above results (Table 3), it indicates that the different INM treatments marked their significant influence on available N, P_2O_5 and K_2O status in soil after the harvest of vegetable Indian bean during both the years of experimentation. All treatments of INM were found comparatively good and appreciably improved soil available N, P_2O_5 and K_2O status over its initial status. This is most likely due to the incorporation of organic manures such as biocompost, which contains nitrogen, phosphorous and potassium as well as nitrogen and phosphorous from inorganic sources. These findings are in close conformity with the results of Naher *et al.* (2016) [12], Lunagariya *et al.* (2018) [10] and Safiullah *et al.* (2018) [13] and Amitha (2019) [3] with respect to fenugreek.

Table 1: Nutrient content and uptake of fenugreek seed as influenced by different INM treatments (Two years pooled results)

Treatments	Nutrient content in seed (%)			Nutrient uptake in seed (kg/ha)		
	N	P	K	N	P	K
T_1: Biocompost 2.5 t/ha	2.293	0.224	0.501	27.24	2.67	5.96
T_2: Biocompost 5 t/ha	2.497	0.239	0.509	34.32	3.28	7.01
T_3: Biocompost 2.5 t/ha + 50% RDF	2.988	0.333	0.520	42.84	4.78	7.47
T_4: Biocompost 2.5 t/ha + 75% RDF	3.034	0.336	0.524	45.75	5.08	7.90
T_5: Biocompost 2.5 t/ha + 100% RDF	3.200	0.350	0.532	51.38	5.61	8.53
T_6: Biocompost 5 t/ha + 50% RDF	3.227	0.361	0.539	53.61	5.96	8.96
T_7: Biocompost 5 t/ha + 75% RDF	3.295	0.367	0.543	56.62	6.31	9.30
T_8: Biocompost 5 t/ha + 100% RDF	3.351	0.371	0.549	59.06	6.54	9.69
S.Em±	0.073	0.008	0.01	1.80	0.16	0.33
CD (P=0.05)	0.211	0.022	NS	5.22	0.456	0.95
CV (%)	5.98	5.83	5.06	9.53	7.66	9.94
General mean	2.99	0.323	0.53	46.35	5.03	8.10
Interaction (Y × T)						
S.Em±	0.13	0.013	0.019	3.12	0.27	0.57
CD (P=0.05)	NS	NS	NS	NS	NS	NS
*RDF - Recommended dose of fertilizer CD - Critical Difference, CV – Co-efficient of Variation						

Table 2: Nutrient content and uptake of fenugreek stover as influenced by different INM treatments (Two years pooled results)

Treatments	Nutrient content in stover (%)			Nutrient uptake in stover (kg/ha)		
	N	P	K	N	P	K
T_1: Biocompost 2.5 t/ha	0.882	0.099	0.518	18.11	2.03	10.67
T_2: Biocompost 5 t/ha	0.940	0.104	0.521	21.84	2.42	12.19
T_3: Biocompost 2.5 t/ha + 50% RDF	0.974	0.109	0.528	23.69	2.65	12.78
T_4: Biocompost 2.5 t/ha + 75% RDF	0.995	0.111	0.534	24.95	2.79	13.40
T_5: Biocompost 2.5 t/ha + 100% RDF	1.039	0.116	0.542	27.44	3.06	14.30
T_6: Biocompost 5 t/ha + 50% RDF	1.058	0.117	0.545	29.33	3.27	15.11
T_7: Biocompost 5 t/ha + 75% RDF	1.079	0.120	0.557	30.71	3.41	15.85
T_8: Biocompost 5 t/ha + 100% RDF	1.089	0.123	0.560	31.41	3.53	16.15
S.Em±	0.020	0.002	0.010	0.88	0.12	0.50
CD (P=0.05)	0.059	0.007	NS	2.54	0.34	1.45
CV (%)	4.99	4.91	4.62	8.28	9.91	8.89
General mean	1.01	0.11	0.54	25.93	2.90	13.81
Interaction (Y × T)						
S.Em±	0.036	0.004	0.018	1.52	0.203	0.87
CD (P=0.05)	NS	NS	NS	NS	NS	NS
*RDF - Recommended dose of fertilizer CD - Critical Difference, CV – Co-efficient of Variation						

Table 3: Organic carbon and available nutrient status of soil as influenced by different INM treatments after harvest of fenugreek

Treatments	Organic carbon (%)		Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	0.404	0.413	160.40	161.38	28.78	30.50	249.16	254.51
T_2	0.452	0.451	169.93	172.98	30.84	32.25	272.18	277.38
T_3	0.410	0.418	189.14	194.03	33.74	34.48	285.46	287.28
T_4	0.413	0.421	194.33	197.56	34.32	35.40	291.84	297.40
T_5	0.426	0.435	207.46	207.22	37.40	37.89	306.18	311.50
T_6	0.462	0.465	211.93	214.98	37.88	38.07	312.18	317.18
T_7	0.471	0.473	214.26	217.39	38.44	39.07	320.84	326.56
T_8	0.480	0.488	219.48	220.92	39.08	39.56	329.18	335.51
S.Em±	0.013	0.012	7.69	7.18	1.37	1.29	10.52	10.37
CD (P=0.05)	0.041	0.037	23.33	21.77	4.16	3.92	31.91	31.45
CV (%)	5.27	4.78	6.80	6.27	6.78	6.24	6.16	5.97
General mean	0.440	0.450	195.87	198.31	35.06	35.90	295.88	300.92
Initial status	0.390		198.60		37.50		314.30	

Conclusion

On the basis of two years pooled results, it can be concluded that fenugreek should be fertilized with Biocompost 5 t/ha + 75% RDF (15-30-00 N-P_2O_5-K_2O kg/ha) for getting higher nutrient uptake and to maintain the organic carbon content and nutrient status of soil in fenugreek - fodder sorghum cropping sequence.

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