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Effect of FYM and biofertilizers on growth, yield attributes and yield of fenugreek (*Trigonella foenum-graecum* L.)

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Abstract
A field experiment entitled "Effect of FYM and biofertilizers on growth, yield attribute and yield of fenugreek (*Trigonella foenum-graecum* L.)" was carried out during *rabi* season of 2016-17 on calcareous clayey soil at Junagadh. The experimental results revealed that significantly higher values of growth parameters *viz.*, plant height, number of branches, number and dry weight of root nodules, dry matter production and crop growth rate and yield attributes *viz*., number and length of pods per plant, number of seed per pod, seed yield (1712 kg/ha) and straw yield (2814 kg/ha) were recorded under the treatment T_{10} FYM 4 t/ha + Rhizobium (seed inoculation) + PSB + KSB (soil application), being at par with treatments T_2 (20-40-00 kg N-P_2O_5-K_2O/ha), T_7 (FYM 4 t/ha + *Rhizobium* + PSB), T_8 (FYM 4 t/ha + *Rhizobium* + KSB) and T_9 (FYM 4 t/ha + PSB + KSB).

Keywords: FYM**,** rhizobium, PSB, KSB, fenugreek, yield

Introduction
Fenugreek (*Trigonella foenum-graecum* L.) commonly known as methi belongs to sub-family of papillionaceae of leguminoceae. Chemical analysis of Fenugreek seed revealed that it contains 13.7 percent water, 26.2 percent protein, 5.8 percent fat, 3.0 percent mineral matter, 7.2 percent fibers, 4.41 per cent carbohydrates, 0.16 per cent calcium, 0.37 per cent phosphrous, 14.1 mg iron, 333 calories and 160 IU carotene per 100 gm. (Agrawal *et al.,* 2001) [1] The maximum diosgenin 2.03 per cent was found in cotyledons germinated seeds of fenugreek (Bhavsar *et al.,* 1980) [3]. Fenugreek is one of the important spices of India which is one of the major producer and exporter of fenugreek, with an annual exporter of nearly 1500 tonnes. In India fenugreek occupied an area of about 2, 11,110 hectares producing 2,99,870 tonnes of seeds (Anon., 2017) [2]. In India**,** it is widely grown states are Rajasthan, Gujarat, Tamil Nadu, Utter Pradesh, Himachal Pradesh, Madhya Pradesh and Andhra Pradesh. Gujarat contributes about 20 percent in total production of fenugreek in India. In Gujarat, fenugreek occupied an area of 6250 hectares producing 15129 tonnes of seeds. The major fenugreek growing districts in Gujarat are Banaskantha, Patan and Kheda (Anon., 2017) [2]. Organic materials such as FYM have traditionally been used by farmers. FYM supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. Biofertilizers keep the soil environment rich in all kinds of micro and macro-nutrients *via* nitrogen fixation, phosphate and potassium solubilization or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil providing better nutrient uptake and increased tolerance towards drought and moisture stress.

Materials and Methods
The experiment was conducted in D-4 plot of Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh during *Rabi* 2016-17 to study the "Effect of FYM and biofertilizers on growth, yield attribute and yield of fenugreek (*Trigonella foenum-graecum* L.)". The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with with pH 8.0 and EC 0.56 dS/m. The soil was low in available nitrogen (285 kg/ha), high in available phosphorus (68 kg/ha) and medium in available potash (232 kg/ha). Ten treatments comprising of T_1 (Control), T_2 (20-40-00 kg N-P_2O_5-K_2O/ha), T_3 (FYM 4 t/ha),

T_4 (FYM 4 t/ha + *Rhizobium*), T_5 (FYM 4 t/ha + PSB), T_6 (FYM 4 t/ha + KSB), T_7 (FYM 4 t/ha + *Rhizobium* + PSB), T_8 (FYM 4 t/ha + *Rhizobium* + KSB), T_9 (FYM 4 t/ha + PSB + KSB) and T_{10} (FYM 4 t/ha + *Rhizobium* + PSB + KSB) with three replications. The improved variety "Gujarat Fenugreek-2" was used for sowing with seed rate of 25 kg/ha on 18th November during 2016. The seeds were placed at 3-5 cm depth, keeping inter row spacing of 30 cm and covered with the soil. The crop was uniformly fertilized with 20 kg/ha nitrogen and 40 kg/ha P_2O_5 in the form of urea and di-ammonium phosphate, respectively as a basal application just before sowing. It is applied in only treatment plot.

Results and Discussion

1. Growth parameters

Growth parameters *viz.*, plant height at 30, 60 DAS and at harvest (Table 1); number of branches per plant at harvest, number and weight of root nodules/plant at 60 DAS, dry matter per plant at 30, 60 DAS and at harvest were significantly the highest value observed under the treatment T_{10} (FYM 4 t/ha + *Rhizobium* + PSB + KSB), which remained statistically at par with the treatment T_2 (20-40-00 kg N-P_2O_5-K_2O/ha), T_7 (FYM 4 t/ha + *Rhizobium* + PSB), T_8 (FYM 4 t/ha + *Rhizobium* + KSB) and T_9 (FYM 4 t/ha + PSB + KSB). Among the different treatments, significantly the maximum CGR at 30-60 DAS recorded with treatment T_{10} (FYM 4 t/ha + *Rhizobium* + PSB + KSB) which remain statistically at par with treatment T_2 (20-40-00 kg N-P_2O_5-K_2O/ha).

This may be due to fact that FYM increase the absorptive power of the soil for cation and anion and these ions are released slowly for the entire crop growth period. The FYM also produce hormones and growth promoting substances that help to promote the plant growth. Biofertilizer inoculation like, *Rhizobium* increase the number of such microorganisms in the soil rhizosphere and consequently improve the extent of microbiologically fixed nitrogen for plant growth. They are used either to fix nitrogen or to solubilise plant nutrients like phosphate. Phosphate solubilising microorganism solubilises the unavailable bound phosphate of the soil and makes them available to plants which increase overall plant growth. The increase in growth parameter due to the solubilization of nutrients in the soil by producing organic acids by KSB. Result found which are conformity with the findings of Summauria and Yadav (2009) [9], Meena *et al*. (2015) [7].

Table 1: Effect of different treatments on growth parameter of Fenugreek.

Treatments	Plant height (cm)			No. of branches per plant	No of root nodules at 60 DAS	Weight of root nodules at 60 DAS (mg)	Dry matter per plant (g) at			CGR (g/day) at 30-60 DAS
	At 30 DAS	At 60 DAS	At harvest				At 30 DAS	At 60 DAS	At harvest	
T_1	11.29	31.17	49.46	5.00	26	134.64	0.23	0.92	3.17	0.023
T_2	14.75	37.68	61.80	6.93	31	167.55	0.60	2.70	4.74	0.070
T_3	11.49	31.73	52.93	5.10	27	141.07	0.24	1.10	3.18	0.029
T_4	12.62	33.83	57.03	6.06	30	156.28	0.42	2.15	3.89	0.058
T_5	12.55	33.04	55.85	5.70	29	152.77	0.35	1.88	3.78	0.051
T_6	12.35	32.10	54.54	5.37	28	146.71	0.30	1.35	3.35	0.035
T_7	14.69	36.80	60.90	6.60	31	165.42	0.56	2.40	4.64	0.061
T_8	13.52	35.13	58.93	6.14	30	158.27	0.43	2.21	4.20	0.059
T_9	14.29	35.74	60.01	6.18	30	160.67	0.50	2.25	4.35	0.058
T_{10}	15.25	38.28	62.59	7.15	33	168.41	0.60	3.00	5.53	0.080
S.Em. +	0.73	1.63	2.70	0.33	1.42	7.26	0.02	0.10	0.45	0.001
CD at 5%	2.17	4.84	8.03	0.97	4.22	21.58	0.07	0.30	1.32	0.01
CV %	9.52	8.16	8.15	9.4	8.34	8.11	9.49	8.52	9.62	11.29

Table 2: Effect of different treatments on growth parameter of Fenugreek.

Treatments	Pods per plant	Pod length (cm)	Seeds per pod	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
T_1	19.73	9.34	12.08	1021	1901	2922
T_2	23.43	11.33	15.77	1632	2767	4399
T_3	20.06	9.59	12.32	1254	2124	3378
T_4	21.70	10.31	13.38	1351	2480	3831
T_5	21.23	10.11	12.84	1323	2267	3589
T_6	20.93	9.69	12.49	1285	2198	3483
T_7	23.01	11.19	14.75	1508	2660	4168
T_8	22.10	10.61	13.63	1354	2302	3657
T_9	22.47	10.87	14.35	1402	2540	3942
T_{10}	25.49	11.49	16.29	1712	2814	4525
S.Em. +	1.09	0.49	0.80	82.33	119.59	141.86
CD at 5%	3.24	1.45	2.39	244.61	355.32	421.51
CV %	8.57	8.08	10.09	10.16	8.53	6.41

Treatment details: T_1 (Control), T_2 (20-40-00 kg N-P_2O_5-K_2O/ha), T_3 (FYM 4 t/ha), T_4 (FYM 4 t/ha + *Rhizobium*), T_5 (FYM 4 t/ha + PSB), T_6 (FYM 4 t/ha + KSB), T_7 (FYM 4 t/ha + *Rhizobium* + PSB), T_8 (FYM 4 t/ha + *Rhizobium* + KSB), T_9 (FYM 4 t/ha + PSB + KSB) and T_{10} (FYM 4 t/ha + *Rhizobium* + PSB + KSB)

Note: 1. *Rhizobium* seed treatment @ 30 mL/kg seeds
2. PSB soil application @ 3 L/ha
3. KSB soil application @ 3 L/ha
4. The treatment T_2 was kept outside the organic plot

2. Yield Attributes and Yield

The yield attributes such as number of pod per plant, number of seeds per pod, pod length were significantly the highest value observed under the treatment T_{10} (FYM 4 t/ha + *Rhizobium* + PSB + KSB) and it was found statistically analogous to treatments T_2 (20-40-00 kg N-P_2O_5-K_2O/ha), T_7 (FYM 4 t/ha + *Rhizobium* + PSB) and T_9 (FYM 4 t/ha + PSB + KSB). Seed, stover and biological yield were found significantly higher in treatment T_{10} (FYM 4 t/ha + *Rhizobium* + PSB + KSB), T_2 (20-40-00 kg N-P_2O_5-K_2O/ha), T_7 (FYM 4 t/ha + *Rhizobium* + PSB) and T_9 (FYM 4 t/ha + PSB + KSB). These treatments might be due to application of FYM increased the photosynthetic activity in fenugreek and the translocation of photosynthesis in plant. Improvement of all the yield attributes to be due to better availability of nutrients and their translocation resulted in significantly higher seed and stover yield in fenugreek under *Rhizobium* inoculation and PSB and KSB in soil application. The results corroborated with the findings of Mehta *et al*. (2012) [8], Shivran *et al*. (2016) [10] and Godara *et al*. (2017) [5].

Conclusion

Based on one year experimental results, it seems quite logical to conclude that higher production of fenugreek (Gujarat Fenugreek- 2) can be obtained by application of FYM @ 4 t/ha + Seed treatment of *Rhizobium* @ 30 ml/kg seed + Soil application of PSB + KSB @ 3 L/ha each on medium black calcareous clayey soil under South Saurashtra Agro-climatic Zone.

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