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Response of different organic fertilizers to growth, yield attributes and profitability in fenugreek under heavy clay soil of Southern Rajasthan

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Abstract
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. Therefore, the study was undertaken to evaluate the effect of vermicompost and different bio-fertilizers on growth and productivity of fenugreek. A field experiment was conducted at College of Horticulture and Forestry, Jhalawar during *Rabi* season 2018-2019 which consisted of 15 treatments in combinations of different organic fertilizers, *viz.* vermicompost, *Rhizobium, Azospirrilium* and PSB. The results revealed that among the different combinations of vermicompost and biofertilizers, application of Vermicompost + *Rhizobium* + *Azospirrilium* + PSB (T_{15}) significantly increased plant height (22.66 cm) at 45 DAS and (89.54 cm) at 90 DAS, number of leaves per plant at 45 DAS and 90 DAS (21 and 89.17, respectively), number of branches per plant (8.03) and yield parameters i.e. seed yield per plant (9.80 gm), seed yield per plot (0.98 kg.) and estimated yield (32.67 q/ha) as compared to control. Thus, it can be inferred that application of vermicompost with biofertlizers is better for realizing maximum growth and yield levels than use in single form.

Keywords: vermicompost, *Rhizobium*, azospirrilium, PSB, fenugreek

Introduction
India is known worldwide for its spices and condiments most common of which include fenugreek, garlic, mustard, cumin, turmeric and curry leaves, which add characteristic flavor and aroma to the various dishes in which they are used. India is the largest producer, consumer and exporter of seed spices in the world. Spices are good appetizers and are also considered essential in the culinary art all over the world. Fenugreek (*Trigonella foenum-graecum* L.) is an annual diploid species with chromosome number 2n=16. It is popularly known as "Methi", belongs to the sub-family "Papilionaceae" of the family "Fabaceae". In Rajasthan, fenugreek is commercially cultivated as spice in Nagour, Chittorgarh, Bundi, Churu, Jhalawar, Jhunjhunu, Jodhpur, Sikar, Jaipur etc. Fenugreek is extensively used as fresh leaves (green leafy vegetable), chopped leaves (flavouring agent), seeds (spice, condiment or medicines), extracts and powders (medicines). They are rich in vitamins such as thiamin, riboflavin, niacin, vitamin A, B_6 and C (Aykroyd, 1963) [1]. Saponins like yamogenin, tigogenin, diosgenin etc. are found in fenugreek but diosgenin is most important bio-active compound and recently the importance of fenugreek seed has enhanced due to the presence of alkaloids ´diosgenin` having pharmaceutical uses.

The productivity of the crop is low due to many limiting factors such as lack of proper management of fertilizers and nutrients. 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.

Organic manures like vermicompost is a potential source of macro and micronutrients and it improves soil structure by providing binding effect to soil aggregates, increases water holding capacity, improves buffering capacity of soils, soil productivity and enzymatic activity of soils. It is well known fact that organic materials such as vermicompost accelerate the process of decomposition as well as ready energy source for microbial proliferation. The application of vermicompost not only add plant nutrients and growth regulators to the soil but also increases water retention capacity, microbial population, humic substances of the soil, mineralization and release of nutrients, soil aeration and stimulates the microbial activity.

Biofertilizers also play an important role in the increasing availability of mineral nutrients. They increase the biological fixation of atmospheric nitrogen and also enhance phosphorus availability to the crop by solubilizing fixed phosphorus of soil. Therefore, introduction of efficient strain *of Rhizobium*, *Azosprillium* and PSB in the soil may be helpful in more nitrogen, phosphorus fixation and consequently boosting up productivity of crop and soil fertility.

Integrated use of vermicompost and biofertilizers in fenugreek can be a more efficient, economical and judicious approach than chemical fertilizers alone (Chaichi *et al*., 2015; Meena *et al*., 2015) [5, 16]. 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. Therefore, the study was undertaken to evaluate the effect of vermicompost and different bio-fertilizers on growth and productivity of fenugreek.

Materials and Methods

A field experiment was carried out during Rabi 2018-19 at the Vegetable Farm of Department of Vegetable Science, College of Horticulture and Forestry, Jhalawar (Rajasthan). The fenugreek cv. Ajmer Fenugreek- 3 (AFg-3) was used as an experimental material for this study. Three bio fertilizers *viz*. *Rhizobium*, *Azospirrilium* & PSB and Vermicompost were used in different combinations in the experiment. Field was ploughed by disc harrow and then by pulverized discing and harrowing. Then field was levelled properly with heavy wooden planker by tractor to bring the field to a good tilth. The recommended dose of NPK fertilizers (30:20:20 kg/ha) were applied as basal dose through Urea, DAP and MOP. Nitrogen was given into two split doses, first as basal dose and another was given after one month of sowing to each treatment plot. Vermicompost was applied as per the treatment. Seeds were treated with bio-fertilizers (*Rhizobium*, *Azospirrilium* and PSB) before sowing as per the treatment. The culture suspension was prepared by the standard method in which 10 per cent solution of jaggery was prepared. After cooling of jeggary solution the bio-fertilizers were added in according to the different treatments and treated seeds were dried in the shade for half an hour so that the culture was coated all around the seeds. Seed sowing was done according to treatment at the spacing of 30 x 10 cm. All the recommended package of practices was uniformly followed in all treatments. The necessary plant protection measures were adopted to raise healthy crop by using one spray of Imidachloroprid @ 2ml/lit water to control aphids at 60 days after sowing.

The observations on growth attributes *viz.* plant height (cm), number of leaves per plant, number of primary branches/plant, Days taken to 50 percent flowering, Days to Maturity and yield contributing characters *i.e.* Number of pods/plant, Length of pod (cm), Number of seeds/pod, seed yield/plant (g), seed yield/plot (kg) and estimated yield (q/ha) were recorded from randomly selected 10 plants from each treatment plots. B: C ratio was also computed by dividing gross returns with cost of cultivation for each treatment. The data on quantity observations recorded were subjected to statistical analysis by adopting randomized block design (RBD) with three replications. Significance of difference in the treatment effect was tested through 'F' test at 5 percent level of significance.

Results and Discussion

Performance of growth attributes: Application of vermicompost and biofertilizers significantly influenced growth attributes in fenugreek (Table 1). Growth characters *i.e.* plant height and number of leaves per plant was significantly increased with vermicompost and biofertilizers application at 45 and 90 DAS. Among the different treatment combinations treatments T_{15} (V+R+A+PSB) registered maximum values at 45 & 90 DAS for plant height (22.66 cm and 89.54 cm, respectively) and number of leaves per plant (21 and 89.17, respectively) in comparison to control. Significantly higher number of branches per plant (8.03) was observed in treatment T_{15} than control (3.91). Whereas number of days taken to 50 per cent flowering and number of days to maturity were found at par among different treatment combinations. Significantly increased in growth attributes might be due to the increased level of vermicompost and biofertilizers in combination. Since the vermicompost being a store house of almost all the plant nutrient required for proper growth and development of plants, its addition in the soil enhanced availability of nutrients. Thus the improvement in soil environment of encouraged proliferation of plant roots, which helped to draw more water and nutrients from larger area and deeper layers and thus owing to higher availability of nutrients, synthesis of more carbohydrates and their translocation to different plant parts resulted increased vegetative growth including the reproductive structures (Lunagariyain *et al*., 2018) [13]. These findings are in agreement with the reports of Biswas and Anusuya (2014) [4] in fenugreek, Das *et al*. (2013) [6] in chickpea, Jadhav *et al*. (2014) [9] in fenugreek, Sunanda *et al*. (2014) [22] in kasurimethi, Singh *et al*. (2015) [19], Chaichi *et al*. (2015) [5], Meena *et al*. (2015) [16], Badar *et al*. (2016) [2], Raghuwanshi *et al*. (2016) [18] and Vedpathak *et al*. (2016) [23] in fenugreek and Khan *et al*. (2017) [10] in cowpea.

Table 1: Effect of vermicompost and biofertilizers on growth attributes of fenugreek

Treatment	Treatment combination	Plant height (cm)		Number of leaves		Number of branches per plant	Days to 50% flowering	Days to Maturity
		45 DAS	90 DAS	45 DAS	90 DAS			
T_0	Control	17.49	69.34	17.20	75.06	3.91	48.50	129.00
T_1	Vermicompost	18.62	75.26	19.50	79.26	5.15	50.60	130.60
T_2	*Rhizobium*	18.02	73.82	18.00	77.69	4.86	49.60	130.30
T_3	*Azospirillum*	17.59	69.86	17.30	76.27	4.10	49.30	131.52
T_4	PSB	17.75	72.76	17.50	76.69	4.50	49.60	129.30
T_5	V+R	18.93	79.12	20.40	81.71	6.56	51.33	132.00
T_6	V+A	18.70	75.38	19.50	79.45	5.33	51.00	131.00
T_7	V+PSB	18.73	78.17	19.60	80.21	5.88	50.45	131.30
T_8	R+A	18.18	74.25	18.50	77.95	4.96	50.00	130.30
T_9	R+PSB	18.28	74.32	18.90	77.95	5.05	50.30	130.60
T_{10}	A+PSB	17.78	72.85	17.80	76.69	4.73	49.60	129.60

T_{11}	V+R+A	19.42	79.28	20.50	82.20	6.76	51.00	135.00
T_{12}	V+R+PSB	20.19	80.06	20.80	84.37	7.38	51.00	135.30
T_{13}	V+A+PSB	18.73	78.54	20.00	81.47	6.36	51.00	131.30
T_{14}	R+A+PSB	18.59	75.04	19.20	78.13	5.08	53.00	130.60
T_{15}	V+R+A+PSB	22.66	89.54	21.00	89.17	8.03	53.20	135.56
S.Em±		0.63	6.25	0.62	1.60	0.12	NS	NS
CD at 5%		1.83	2.17	1.80	4.61	0.36	NS	NS

PSB=Phosphorus Solublizing Bacteria, V=Vermicompost @3 tonnes/ha., A=*Azosprillium*, R=*Rhizobium*, Control = RDF.

Yield contributing characters: The data presented in Table 2 showed that application of vermicompost and biofertilizers significantly increased yield contributing characters. Yield contributing attributes *i.e.* number of pods per plant (73.21), length of pod (14.67 cm), number of seeds per pod (16.88), seed yield per plant (9.80 g), seed yield per plot (0.98 kg.) and estimated yield (32.67 q/ha) were recorded significantly high under treatment T_{15} (V+R+A+PSB) and the minimum value for yield parameters *i.e.* number of pods per plant (52.81), length of pod (10.44 cm), number of seeds per pod (12.33), seed yield per plant (5.93gm), seed yield per plot (0.59 kg.) and estimated yield (19.78 q/ha) were recorded under treatment T_0. This might be due to better growth of the plant, such as increased plant height, number of leaf and branches per plant. Besides, the above production of more food and their translocation might favour the development of yield components. Beneficial response of vermicompost to yield attributes and yield might be increased due to the availability of sufficient amount of plant nutrients throughout the growth period and especially at critical growth periods of crops resulting in better uptake, plant vigour and superior yield attributes (Kumar *et al*. 2004) [12]. Steady and higher availability of major, secondary and micronutrients due to effect of vermicompost and biofertilizers, during the crop growth period which have enhanced the growth and yield attributes and finally augmented to better seed yield (Stamford *et al*., 2013) [20]. The use of vermicompost with biofertilizers enhances root and shoot length, plant biomass and vigour, all leading to a better growth of the plant owing to the production of metabolites such as phytohormone and antibiotics which finally promotes the plant growth and grain yield (Balachandran and Nagarajan, 2002) [3]. *Azospirillum* inoculation with vermicompost and other biofertilizers i.e. *rhizobium* and PSB much greater access to water and nutrients and thus increase the shoot dry weight and this increase is probably due to the increased uptake of food, improving plant water potential, improving plant growth resulting in better nutrition and may the increase in activity is due to photosynthesis (Subramanian and Vijayakumar, 2001) [21]. These results are in conformity with the study of Mathur *et al*. (2006) [15], Mehta *et al.* (2010) [17], Godara *et al*. (2012) [7], Biswas and Anusuya (2014) [4], Jadhav *et al.* (2014) [9], Chaichi *et al*. (2015) [5], Raghuwanshi *et al*. (2016) [18], Godara *et al*. (2017) [8], Verma *et al*. (2017) [24], Khan *et al*. (2017) [10] and Malav *et al.* (2018) [14] in fenugreek and Kumar *et al*. (2018) [11] in radish.

Table 2: Effect of vermicompost and biofertilizers on yield attributes of fenugreek

Treatment notation	Treatment combination	Number of pods per plant	Length of pod (cm)	Number of seed per pod	Seed yield per plant (g)	Seed yield per plot (kg)	Estimated yield (q/ha)
T_0	Control	52.81	10.44	12.33	5.93	0.59	19.78
T_1	Vermicompost	61.36	12.30	15.35	7.47	0.75	24.89
T_2	*Rhizobium*	59.09	11.86	14.50	6.33	0.63	21.11
T_3	*Azospirillum*	55.23	11.06	13.50	6.03	0.60	20.11
T_4	PSB	58.14	11.42	14.20	6.23	0.62	20.78
T_5	V+R	64.45	13.64	16.01	8.03	0.80	26.78
T_6	V+A	61.71	12.39	15.36	7.57	0.76	25.22
T_7	V+PSB	62.16	13.03	15.48	7.60	0.76	25.33
T_8	R+A	59.16	12.01	14.80	6.50	0.65	21.67
T_9	R+PSB	60.53	12.14	15.02	7.27	0.73	24.22
T_{10}	A+PSB	58.47	11.76	14.35	6.30	0.63	21.00
T_{11}	V+R+A	66.74	14.13	16.39	8.50	0.85	28.33
T_{12}	V+R+PSB	70.00	14.34	16.40	9.43	0.94	31.44
T_{13}	V+A+PSB	62.94	13.41	15.68	7.67	0.77	25.56
T_{14}	R+A+PSB	61.27	12.18	15.20	7.30	0.73	24.33
T_{15}	V+R+A+PSB	73.21	14.67	16.88	9.80	0.98	32.67
S.Em±		2.01	0.25	0.48	0.35	0.04	1.18
CD at 5%		5.81	0.72	1.39	1.02	0.10	3.41

Cost of Economics: The data regarding to net return and B: C ratio is presented in Table 3 & figure 1 and showed that increase in net return and B: C ratio was obtained with application of vermicompost and biofertilizers. Treatment T_{15} (V+R+A+PSB) resulted maximum net profit of Rs. 100113.00 with B: C ratio (1.58), followed by Rs. 94212 net return and 1.13 B: C ratio under treatment T_{14} (V+R+PSB) than control (Rs. 41939.00 & 0.74, respectively).

Table 3: Economics of different treatments of fenugreek cultivation with the application of vermicompost and biofertilizers

Treatment notation	Treatment combination	Seed yield ha^{-1} (q)	Cost of cultivation including the cost of treatment	Gross return ha^{-1} @ Rs. 5000 q^{-1}	Net returns (Rs ha^{-1})	B:C ratio
T_0	Control	19.78	56950	98889	41939	0.74
T_1	Vermicompost	24.89	62950	124444	61494	0.98
T_2	*Rhizobium*	21.11	57010	105555	48545	0.85
T_3	*Azospirillum*	20.11	57100	100555	43455	0.76
T_4	PSB	20.78	57010	103889	46879	0.82
T_5	V+R	26.78	63010	133889	70879	1.12
T_6	V+A	25.22	63100	126111	63011	1.00
T_7	V+PSB	25.33	63010	126667	63657	1.01
T_8	R+A	21.67	57700	108333	50633	0.88
T_9	R+PSB	24.22	57070	121111	64041	1.12
T_{10}	A+PSB	21.00	57160	105000	47840	0.84
T_{11}	V+R+A	28.33	63160	141667	78507	1.24
T_{12}	V+R+PSB	31.44	63010	157222	94212	1.50
T_{13}	V+A+PSB	25.56	63160	127778	64618	1.02
T_{14}	R+A+PSB	24.33	57220	121667	64447	1.13
T_{15}	V+R+A+PSB	32.67	63220	163333	100113	1.58

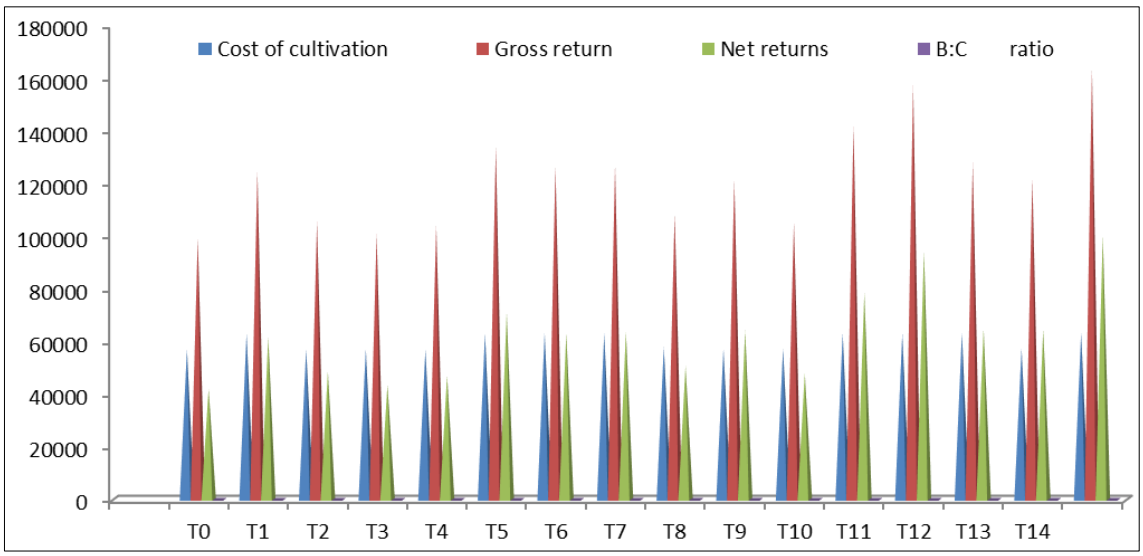

Fig 1: Profitability of fenugreek cultivation with the application of vermicompost and biofertilizers

Conclusion

From the study it was concluded that application of vermicompost and biofertilizers in combination significantly increased growth and yield contributing characters in fenugreek.

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