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Consequence of inorganic and organic sources of fertilization on nutrient content, uptake and quality of fenugreek (*Trigonella foenum-graecum* L.) under agro-climatic conditions of Southern Rajasthan

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Abstract
An experiment was laid out during *rabi* 2017-18 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Raj.) for studying the effect of inorganic and organic sources of fertilization on nutrient content, uptake and quality of fenugreek. Results revealed that the application of 100% RDF significantly enhanced growth kinetics *i.e.* CGR and RGR; nitrogen uptake by seed (73.2 kg ha^{-1}) and haulm (107.7 kg ha^{-1}); phosphorus uptake by seed (10.3 kg ha^{-1}) and haulm (19.8 kg ha^{-1}); chlorophyll content (3.42 mg g^{-1}) at 50 per cent flowering and crude protein (21.1%) in seed as compared to lower doses of inorganic sources of fertilization. The escalating levels of inorganic sources significantly improved nitrogen (289.41 kg ha^{-1}) and phosphorus (25.36 kg ha^{-1}) status of soil after harvesting of crop. The application of FYM 5 t ha^{-1} + *Rhizobium* + PSB notably increased nitrogen uptake by seed (68.8 kg ha^{-1}) and haulm (91.8 kg ha^{-1}). Phosphorus uptake was significantly higher with application of vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB. After harvesting of crop, significantly more N (302.32 kg ha^{-1}) and P (23.82 kg ha^{-1}) content in soil was observed under the application of FYM 5 t ha^{-1} + *Rhizobium* + PSB. Likewise, quality parameters *viz*. chlorophyll content (3.28 mg g^{-1}) at 50 per cent flowering stage and crude protein content (20.3%) in seed was significantly higher with the application of FYM 5 t ha^{-1} + *Rhizobium* + PSB.

Keywords: Organic, inorganic, nutrient, quality, fenugreek

Introduction
India has been the "Home of Spices" since ancient time. The crop fenugreek (*Trigonella foenum-graecum* L.) is related to Fabaceae family and crop is used for multi purposes. Fenugreek is an important and versatile *rabi* season crop and comes under seed spice which is mainly grown in states of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Haryana. Every plant part of this crop is utilized for many purposes like used as leafy vegetables, fodder and condiments. Seeds of fenugreek are a good source of protein, vitamins, alkaloid "*trigonellin"* and essential oil and have an immense medicinal value particularly against digestive disorders. This crop plays pivotal role in pharmaceutical industries and medicines for anticarcinogenic, antidiabetic, hypocholesterolemic, antioxidant and immunological activities. Apart this, it is also used for various food product developments like food stabilizer, adhesive and emulsifying agent.

In India fenugreek crop production is 248 thousand tonnes from an area of 0.23 million hectares with productivity 1089 kg ha^{-1}. The Rajasthan states ranks first and it covers more than 77 per cent of India's output and producing 0.19 million tonnes seed from an area of 0.15 million hectares with the productivity of 1212 kg ha^{-1} (Spice Board of India, 2016).

Germination of seeds and after that for their succeeding growth, nutrients are essential, which are uptake by plants in ionic form by root hairs. The essential nutrient plays significant role in completion of plant life cycle. The nitrogen is a primary essential nutrient and very important for vegetative growth and their after development of plant. It is a major component of chlorophyll, amino acids and energy currency. Soil nitrogen exists in three general forms *i.e.* organic nitrogen compounds, ammonium (NH_4^+) ions and nitrate (NO_3^-) ions but plants absorb it only in NH_4^+ and NO_3^- forms.

Plants require phosphorous mainly for root initiation and development, normal growth and maturity of the crop. It plays a pivotal role in many physiological and metabolic processes like photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement in plants.

At present prospective farmers supply essential nutrients to plants or crop through inorganic fertilizers. The major constraints with inorganic fertilizers are their higher cost and regular hike in price, non availability in time and also increment in the cost of cultivation which results in less monetary return to farmers. Regular use of inorganic fertilizers deteriorates physico-chemical and biological properties of soil, resulted soil becomes sick and low productive. Organic sources of fertilization like farmyard manure (FYM), vermicompost and biofertilizers can replace extreme use of inorganic fertilizers. Organic fertilizers improve soil organic carbon for sustaining the soil physical health and also make available nutrients to plants. Organic manures are of paramount importance for application in food crops. Addition of organic material to the soil such as farmyard manure (FYM) helps in maintaining soil fertility and productivity. It increases soil microbiological activities, plays a key role in transformation and recycling of nutrients. Vermicompost has been encouraged for use in field crops as good organic manure. Vermicompost is often earthworm-processed organic waste is finally divided peat like materials, which have optimum porosity, aeration, drain ability and water holding capacity and it exerts array of physical and biochemical changes in soil and maintains the soil in a proper homeostatic state which promotes plant growth.

Biofertilizers are products containing living or dormant microorganisms like bacteria, fungi, algae, actinomycetes alone or in combination, which an application help in fixing atmospheric nitrogen, solublize or mobilize nutrients in addition to secretion of growth promoting substances for enhancing crop vigour and growth. Nowadays, biofertilizers are popularising amongst farmers because they are eco-friendly and cannot be replaced by chemical fertilizers at any cost which are crucial for getting maximisation of crop yield.

Material and Methods

The experiment was carried out during *rabi* 2017-18 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan). Experimental site's soil texture was clay- loam, slightly alkaline in reaction (pH 8.1 and EC 0.81 dS m^{-1}), low in available nitrogen (263 kg ha^{-1}) and medium in available phosphorus (15.8 kg ha^{-1}). The experiment comprising three levels of inorganic sources (50% RDF, 75% RDF and 100% RDF) and five levels of organic sources (FYM 10 t ha^{-1}, Vermicompost 5 t ha^{-1}, *Rhizobium* + Phosphate solubilising bacteria (PSB), Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB and FYM 5 t ha^{-1} + *Rhizobium* + PSB) of nutrients was laid out in factorial randomized block design and replicated thrice. The fenugreek variety Pratap Raj Methi-45 (PRM-45) was grown and maintained plant geometry 30 x 10 cm, using 25 kg ha^{-1} seed rate. Before the sowing of seed in field, seeds were treated with biofertilizers *viz. Rhizobium meliloti* and PSB as per treatment recommendations. To ascertain physico-chemical characteristics of soil, samples were collected randomly from experimental site up to a depth of 15 cm and then prepared a composite sample. This representative soil sample has been analysed for various physical and chemical properties of soil. Growth kinetics, CGR and RGR were calculated as suggested by Watson (1956) [14] and Williams (1946) [15], respectively by following formulas.

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{p(t_2 - t_1)} \text{ ; RGR (g g}^{-1}\text{ day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Chlorophyll content in fresh leaves was determined calorimetrically by Arnon (1949) [1] method. Plant samples were subjected to chemical analysis for determination of N and P content as per the following standard methods *viz.*, nitrogen by Nessler's reagent colorimetric method (Snell and Snell, 1949) [9] and phosphorus by Ammonium vanadomolybdate yellow colour method (Richard, 1968). The uptake of N and P by seed and haulm were estimated by following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{) by seed or straw} = \frac{\text{Nutrient content (\%) in seed or haulm} \times \text{seed or haulm yield (kg ha}^{-1}\text{)}}{100}$$

Available nitrogen and phosphorus in soil was determined by alkaline permanganate method (Subbiah and Asija, 1956) [11] and Olsen method (Olsen *et al*., 1954) [6] respectively.

Results and Discussion

Effect of inorganic sources of fertilization

Results revealed that the maximum CGR 5.38 and 10.28 g m^{-2} day^{-1} between 30-60 and 60-90 DAS was recorded with 100% RDF. The maximum RGR (0.029 g g^{-1} day^{-1}) was recorded with 100% RDF between 60-90 DAS. All inorganic and organic sources of nutrients hadn't showed any significant effect on days to 50 per cent flowering and maturity. The maximum chlorophyll content (3.42 mg g^{-1} of fresh weight) was recorded under 100% RDF, whereas minimum (2.86 mg g^{-1} of fresh weight) was obtained under 50% RDF. Further the maximum crude protein content (21.1%) was recorded under 100% RDF, whereas minimum (18.5%) was recorded under 50% RDF. The maximum net return (₹ 55,804.3 ha^{-1}) was recorded under 100% RDF. The maximum seed yield (2218.7 kg ha^{-1}) was recorded with 100% RDF, whereas minimum (1623.6 kg ha^{-1}) was obtained under 50% RDF. Data further indicate that 100% RDF registered 222.6 kg ha^{-1} and 595.1 kg ha^{-1} higher seed yield comparison to 75% and 50% RDF, which were 11.15% and 36.65% higher respectively. All inorganic sources failed to show any significant effect on nitrogen and phosphorus content in seed and haulm of fenugreek. The maximum nitrogen and phosphorus uptake by seed (73.2 and 10.3 kg ha^{-1}) and haulm (107.7 and 19.8 kg ha^{-1}) was recorded with application of 100% RDF respectively. All fertility levels have improved soil nutrient status. Application of 100% RDF has significantly improved available soil nitrogen (289.41 kg ha^{-1}), which was statistically at par with 75% RDF (288.73 kg ha^{-1}). Similarly, application of 100% RDF also increased available soil phosphorus (25.36 kg ha^{-1}).

Among plant nutrients N and P are treated as the most important for exploiting genetic potential of crop through growth and development. Phosphorus plays an important role in root development and proliferation as well as it also improves root nodule formation and biological N fixation by supplying assimilates to the roots. A positive response to nitrogen application was also reported by Mehta *et al*. (2012) [5]. This could be due to early and abundant nitrogen availability resulting in a better nutritional environment in the root zone for growth and development of plant. In addition to its role in formation of protein nitrogen is an elemental part of chlorophyll, which is dominant absorber of light energy needed for photosynthesis. Under the present investigation, profound influence of increased N fertilization on fenugreek growth imply to be due to maintaining congenial nutritional environment of plant system on account of their higher availability from soil media. The results of significant improvement in overall growth of fenugreek crop under the influence of 100% RDF (40 kg N + 40 kg P_2O_5) are in close conformity with findings of Singh *et al*. (2010) [8].

Improvement in yield attributes with increasing RDF could be due to more transfer of photosynthates toward sink. Increased number of pods plant^{-1}, pod length and seed yield could be due to significant increase in the number of branches, plant height, pods plant^{-1} and pod length and also integrated nutrient management provided basic source for yield attributes and seed yield which is an output of sequential metamorphosis from the chain of source to sink relationship. It was also related to integrated nutrient management practice which improved soil physical, chemical and biological properties, resulting in higher fertilizer use efficiency. The results of present investigation indicated higher production of fenugreek grain and haulm yield under influence of inorganic sources are in close conformity with findings of Godara *et al.* (2017) [2]. Significant variation in nutrient uptake by seed and haulm can be ascribed to more nutrient availability at 100% RDF. Higher uptake of nutrients by seed and haulm having cumulative effect of higher grain and haulm yield as well as higher nutrient content in these. The results corroborate with the findings of Mehta *et al*. (2011) [4].

Effect of organic sources of fertilization

All the organic sources of fertilizers have not shown any significant effect on CGR and RGR. The maximum chlorophyll content (3.28 mg g^{-1} of fresh leaf weight) was recorded under FYM 5 t ha^{-1} + *Rhizobium* + PSB, which was at par with vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (3.24 mg g^{-1} of fresh leaf weight) and *Rhizobium* + PSB (3.19 mg g^{-1} of fresh leaf weight), whereas superior over all other treatments. Among organic sources of fertilization maximum crude protein content (20.3%) was recorded under FYM 5 t ha^{-1} + *Rhizobium* + PSB, which was at par with vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB but differing significantly over all other treatments. Treatment *Rhizobium* + PSB found superior over FYM 10 t ha^{-1} but was at par with vermicompost 5 t ha^{-1}. The maximum net return (₹ 58,771 ha^{-1}) was recorded under *Rhizobium* + PSB. Minimum net return was obtained under vermicompost 5 t ha^{-1}, which was at par with FYM 10 t ha^{-1}. Seed yield (2141.9 kg ha^{-1}) registered under vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB was significantly higher over treatments FYM 10 t ha^{-1}, Vermicompost 5 t ha^{-1} and *Rhizobium* + PSB. However, FYM 5 t ha^{-1} + *Rhizobium* + PSB (2065.3 kg ha^{-1}) was at par with this treatment. All organic sources failed to show any significant effect on nitrogen and phosphorus content in seed and haulm of fenugreek. The maximum nitrogen uptake by seeds (68.8 kg ha^{-1}) was recorded under FYM 5 t ha^{-1} + *Rhizobium* + PSB, which was at par with Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (67.8 kg ha^{-1}) and differing significantly over all rest of treatment. The maximum nitrogen uptake by haulm (91.8 kg ha^{-1}) was recorded under FYM 5 t ha^{-1} + *Rhizobium* + PSB, which was at par with vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (90.4 kg ha^{-1}), *Rhizobium* + PSB (86.7 kg ha^{-1}) and vermicompost 5 t ha^{-1} (83.6 kg ha^{-1}). Whereas, differing significantly with FYM 10 t ha^{-1} (73.9 kg ha^{-1}) with which minimum N uptake by haulm was recorded. The maximum P uptake by seeds (9.8 kg ha^{-1}) was recorded under Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB, which was at par with FYM 5 t ha^{-1} + *Rhizobium* + PSB (9.4 kg ha^{-1}), and differing significantly over all rest of treatments. Minimum P uptake by seeds was recorded under FYM 10 t ha^{-1} (7.6 kg ha^{-1}), which was at par with vermicompost 5 t ha^{-1} and differing significantly with *Rhizobium* + PSB. However, organic sources of fertilization failed to show any significant effect on P uptake by haulm. The maximum nitrogen content in soil (302.32 kg ha^{-1}) at harvest was recorded under FYM 5 t ha^{-1} + *Rhizobium* + PSB, which statistically higher over all other treatments. Phosphorus content in soil (23.82 kg ha^{-1}) at harvest was recorded greater under FYM 5 t ha^{-1} + *Rhizobium* + PSB followed by vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB (23.64 kg ha^{-1}) and *Rhizobium* + PSB (23.47 kg ha^{-1}).

The increase in growth parameters due to application of vermicompost and FYM may be due to the presence of growth substances, nitrogen fixers, and other essential nutrients and also due to higher phosphorus by a symbiotic mycorrhizal association. Application of vermicompost promotes the lush growth of plants which may be due to the presence of plant growth promoters like auxins and cytokinin in vermicompost, which are responsible for cell division and cell elongation. The results of present investigation indicated higher growth characters under influence of organic sources are in close conformity with findings of Vedpathak and Chavan (2016) [12]. FYM and vermicompost contains major and micro nutrients in plant available form along with enzymes, antibiotic, vitamins, growth hormones and beneficial microorganisms and have definite advantage over the other organic manure with respect to yield and quality. Farm yard manure acts as nutrient pool and upon disintegration produces organic acids, thereby absorbed ions are released slowly during entire growth period leading to higher seed yield and yield components. *Rhizobium* and PSB enhance the availability of N and P in soil as major plant nutrients as well as inoculation of both nitrogen fixer and PSB benefit plants than any group of organisms alone and may have additional benefits. Furthermore, some of the bacteria involved might be intermingling on more metabolic levels, *i.e.* P solublizer may also be auxin, IAA and gibberellins producer and N_2 fixer may also phosphorus solubilize. Thus, the increased availability of not only nitrogen and phosphorus, but growth hormones also encourage plant metabolism, resulting in enhanced yield attributes. The results of present investigation indicated higher production of fenugreek seed and haulm yield under influence of organic sources are in close conformity with findings of Mehta *et al.* (2012) [5] and Godara *et al.* (2017) [2]. The maximum nitrogen and phosphorus content may be due to maximum fixation of nitrogen and solubilized phosphorus by microbial inoculation of rhizobium and PSB and supply of adequate nitrogen and phosphorus through vermicompost and FYM. FYM and vermicompost improve the soil physical condition and promotes organic matter which in turn, produce organic acids, which inhibits particularly IAA oxidase enzyme, resulting in enhancing the promotive effect of auxin-IAA, which has direct effect on plant growth, herbage yield. The results of present investigation indicated higher nutrient content, uptake and quality of fenugreek under influence of organic sources are in close conformity with findings of Singh *et al*. (2010) [8] and Verma *et al*. (2012) [13].

Interaction effect of inorganic and organic sources of fertilization

Data presented in Table 1 and 4 indicated that seed yield (2540.7 kg ha^{-1}) registered under 100% RDF + Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB which was significantly superior over all other treatment combinations but was at par with 100% RDF + FYM 5 t ha^{-1} + *Rhizobium* + PSB (2285.3 kg ha^{-1}). The highest net return (Rs 70,781.15 ha^{-1}) was recorded under treatment combination 100% RDF + vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB, which superior over all rest of treatment combinations. Increased seed yield could be due to significant increase in the number of branches, plant height, pods plant^{-1} and pod length and also integrated nutrient management provided basic source for yield attributes and seed yield is an output of sequential metamorphosis from the chain of source to sink relationship. It was also related to INM practice which improved soil physical, chemical and biological properties, resulting in higher fertilizer use efficiency. These results are closely in line with findings of Godara *et al.* (2017) [2] and Malav *et al.* (2018) [3].

Table 1: Effect of inorganic and organic sources of fertilization on growth kinetics, quality yield and economics of fenugreek crop

Treatments	CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})		Days to 50% flowering	Days to maturity	Chlorophyll at 50% flowering (mg g^{-1})	Crude protein (%)	Seed yield (kg ha^{-1})	Net return (Rs ha^{-1})
	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS						
Inorganic sources										
50% RDF	4.43	6.35	0.045	0.024	57.2	107.6	2.86	18.5	1623.6	34553.1
75% RDF	5.08	7.63	0.047	0.025	58.0	109.0	3.18	19.9	1996.1	49378.7
100% RDF	5.38	10.28	0.046	0.029	60.9	111.4	3.42	21.1	2218.7	55804.3
SEm ±	0.15	0.32	0.001	0.001	1.1	1.4	0.04	0.1	40.5	1417.7
CD (P=0.05)	0.42	0.92	NS	0.002	NS	NS	0.11	0.2	117.4	4107.0
Organic sources										
FYM 10 t ha^{-1}	4.77	7.53	0.046	0.026	57.8	108.4	2.93	19.4	1783.9	31991.3
Vermicompost 5 t ha^{-1}	4.87	7.55	0.046	0.025	58.3	108.9	3.14	19.6	1837.3	30970.3
Rhizobium + PSB	4.88	7.92	0.045	0.026	59.2	109.3	3.19	19.8	1902.2	58771.4
Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB	5.12	8.50	0.046	0.027	58.2	109.8	3.24	20.1	2141.9	55639.0
FYM 5 t ha^{-1} + *Rhizobium* + PSB	5.19	8.95	0.046	0.027	60.0	110.2	3.28	20.3	2065.3	55521.6
SEm ±	0.19	0.41	0.001	0.001	1.4	1.9	0.05	0.1	52.3	1830.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.14	0.3	151.6	5302.1

Table 2: Interaction effect of inorganic and organic sources on seed yield (kg ha^{-1}) of fenugreek

Organic sources	Inorganic sources		
	50% RDF	**75% RDF**	**100% RDF**
FYM 10 t ha^{-1}	1350.00	1987.00	2014.67
Vermicompost 5 t ha^{-1}	1491.00	1987.67	2033.33
Rhizobium + PSB	1499.33	1988.00	2219.33
Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB	1879.67	2005.33	2540.67
FYM 5 t ha^{-1} + *Rhizobium* + PSB	1898.00	2012.67	2285.33
SEm ±	90.63		
CD (P=0.05)	262.54		

Table 3: Interaction effect of inorganic and organic sources on net return (₹ ha^{-1}) of fenugreek

Organic sources	Inorganic sources		
	50% RDF	**75% RDF**	**100% RDF**
FYM 10 t ha^{-1}	16530.98	40378.77	39064.03
Vermicompost 5 t ha^{-1}	18824.51	36962.60	37123.73
Rhizobium + PSB	44795.99	62873.28	68644.91
Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB	44739.95	51395.92	70781.15
FYM 5 t ha^{-1} + *Rhizobium* + PSB	47873.96	55282.91	63407.84
SEm ±	3170.13		
CD (P=0.05)	9183.51		

Table 4: Effect of inorganic and organic sources of fertilization on nutrient status of soil and plant and uptake by seed and haulm

Treatments	Content (%)				Uptake (kg ha^{-1})				Nutrient content in soil (kg ha^{-1})	
	N		P		N		P		N	P
	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm		
Inorganic sources										
50% RDF	3.07	1.14	0.421	0.212	49.9	67.0	6.9	12.4	279.83	21.02
75% RDF	3.13	1.15	0.452	0.217	62.6	81.9	9.0	15.4	288.73	23.77
100% RDF	3.30	1.21	0.462	0.221	73.2	107.7	10.3	19.8	289.41	25.36
SEm ±	0.07	0.02	0.135	0.003	2.0	3.3	0.3	0.6	2.79	0.10
CD (P=0.05)	NS	NS	NS	NS	5.7	9.7	0.8	1.8	8.07	0.29
Organic sources										
FYM 10 tonnes ha^{-1}	3.10	1.14	0.414	0.215	55.3	73.9	7.6	14.0	279.80	22.91
Vermicompost 5 t ha^{-1}	3.12	1.16	0.449	0.216	57.5	83.6	8.3	15.5	277.80	23.11

Rhizobium + PSB	3.15	1.18	0.451	0.217	60.0	86.7	8.6	16.0	281.90	23.47
Vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB	3.15	1.18	0.455	0.217	67.8	91.4	9.8	16.8	288.14	23.64
FYM 5 t ha^{-1} + *Rhizobium* + PSB	3.31	1.18	0.457	0.219	68.8	91.8	9.4	16.9	302.32	23.82
SEm ±	0.08	0.03	0.018	0.004	2.5	4.3	0.4	0.8	3.60	0.13
CD (P=0.05)	NS	NS	NS	NS	7.4	12.5	1.0	NS	10.42	0.37

Conclusion

On the basis of results emanated from the present investigation conducted on fenugreek during *rabi* 2017-18, it can be concluded that under prevailing agro-climatic conditions, fenugreek crop was fertilized with 100% RDF (40 kg N + 40 kg P ha^{-1}) and vermicompost 2.5 t ha^{-1} + *Rhizobium* + PSB proved as most efficient in enhancing quality, nutrient content, uptake, yield and monetary return of fenugreek.

References

1. Arnon DI. Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris*. Plant Physiology. 1949; 24(1):1-15.
2. Godara AS, Singh R, Chouhan GS, Nepalia V. Yield and economics of fenugreek (*Trigonella foenum-graecum* L.) as influenced by fertility levels, biofertilizers and brassinosteroid. Legume Research. 2017; 40(1):165-169.
3. Malav JK, Patel JK, Pavaya RP, Patel BB, Patel VR. Effect of different organic sources on fenugreek (*Trigonella foenum-graecum* L.) under organic farming module. International Journal of Current Microbiology and Applied Sciences. 2018; 7(2):17-25.
4. Mehta RS, Patel BS, Jat RA. Effect of nitrogen, phosphorus and bio-fertilizer inoculation on growth, productivity, nutrient uptake and economic returns in fenugreek (*Trigonella foenum-graecum* L). Indian Journal of Dryland Agricultural Research and Development. 2011; 26(1):102-108.
5. Mehta RS, Anwer MM, Aishwath OP, Meena RS. Growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.) as influenced by nitrogen, phosphorus and bio-fertilizers. Indian Journal of Horticulture. 2012; 69(1):94-97.
6. Olsen SR, Col SW, Watenable PS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Colorado Agricultural Experiment Station Scientific Journal. 1954; 418:18-19.
7. Richard LA. Diagnosis and improvement of saline and alkaline soils. Hand Book No. 60, Oxford and IBH Publishing Co., New Delhi, 1968.
8. Singh D, Nepalia V, Singh AK. Performance of fenugreek (*Trigonella foenum-graecum* L.) varieties at various fertilizer levels and biofertilizers inoculation. Indian Journal of Agronomy. 2010; 55(1):75-78.
9. Snell FD, Snell CT. Colorimetric methods of analysis. The Journal of Physical Chemistry. 1949; 52(7):1265-1266.
10. Spice Board of India. Major spice/state wise area and production of spices. Available online at, 2016. www.indianspices.com/statistics. Retrieved on dated January 12th, 2018.
11. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soil. Current Science. 1956; 27:259-260.
12. Ved, Pathak MM, Chavan BL. Fertilizers effects on growth and yield components of fenugreek vegetable (*Trigonella foenum-graecum* L.) in a field trial. International Journal for Innovative Research in Science & Technology. 2016; 3(7):180-183.
13. Verma SR, Shivran AC, Bhanwaria R, Singh M. Effect of vermicompost and sulphur on growth, yield and nutrient uptake of fenugreek (*Trigonella foenum-graecum* L.). The Bioscan. 2012; 9(2):667-670.
14. Watson DJ. Leaf growth in relation to crop yield. Ed. F.L. Milthrope, Butterworths Scientific publications London, 1956, 178-191.
15. Williams RF. The physiology of plant growth with special reference to the concept of net assimilation rate. Annals of Botany. 1946; 10:41-74.