Website : www.asthafoundation.in
Progressive Research : An International Journal
Vol 19 (2) : 90-95 (July-2024), Print ISSN : 0973-6417, Online ISSN : 2454-6003
Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) India

Evaluating Nitrogen Doses Effects on Fenugreek Growth Parameters

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Abstract

Fenugreek (*Trigonella foenum-graecum*) is an important vegetable spice plant, known for its medicinal properties, and is especially grown for its leaves and seeds throughout the country. Several factors contribute to the reduction of fenugreek growth, including poor crop management, nutrient availability, biotic stress, and others. Therefore, there is an urgent need to find sustainable ways to increase fenugreek production. In this regard, several studies have reported the interactive effects of different nitrogen doses on fenugreek, providing valuable insights into the optimal conditions for growing this important herb. To explore the effect of various nitrogen doses on fenugreek under field conditions, a field experiment was conducted at the Research Farm of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar (India) during the *Rabi* season of 2019-20. Among all the treatments, fastest emergence (4.33 days) occurred with treatments vermicompost and *Rhizobium*, while the slowest (5.70 days) was with FYM treatments. The longest time to 50% flowering and maturity was with 100% inorganic RDN + *Rhizobium*, while the control group had the shortest times. The highest number of pods per plant was observed in the 100% inorganic RDN + *Rhizobium* treatment, while control having the least. Based on this study, these treatments can be exploited for sustainable fenugreek production. Thus, this study provides valuable insights for fenugreek growers and researchers.

Key words : *Fenugreek, nitrogen, rabi, field.*

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) (2n=18) belongs to the Fabaceae family. The genus name "*Trigonella*" is derived from Latin, meaning "little triangle," which refers to the shape of its small triangular seeds. It is a versatile annual herb that originates from South-East Europe and West Asia and used as a principal odour constituent in curry powder (1, 2). In India, fenugreek has been recognized for its medicinal value since ancient times. Fenugreek boasts an array of pharmacological properties, *i.e.,* febrifuge, carminative, emollient, laxative, restorative, uterine tonic, expectorant, galactagogue, encompassing antimicrobial, anti-carcinogenic, anti-inflammatory, antiviral, antioxidant, demulcent, hypotensive *etc.* (2, 3). India is the largest producer of fenugreek in world. It is prominently cultivated in Rajasthan (80%), Gujarat, Madhya Pradesh, Chhattisgarh, and Uttar Pradesh. In India, the crop was grown over an area of 126.29 thousand ha with a production of 182.17 thousand MT. In Haryana, it was cultivated in an area of 905 ha with 3375 MT. Among the districts, Nuh is the leading producer with production of 2368 MT followed by Yamuna Nagar (1275 MT), Sirsa (830 MT) and Mahendragarh (645 MT) (4).

It is reported that deficiencies of nutrients cause crop quality and quantitative reduction. Especially, nitrogen deficiency cause yellowing of lower leaves, stunted plant growth, and shading of leaves, as well as fruits, which might be responsible for crop poor yield. Whereas the excess application of nitrogen is responsible for luxurious shoot growth which makes plant more susceptible to pest and diseases, poor root growth cause lodging and delays the crop maturity thus, it reduces the crop yield and quality of produce (5). The incorporation of essential plant nutrients in the right proportion and adequate quantity concerning soil and climatic conditions is very essential (6, 7). There are several options to provide nutrients to crops, but the indiscriminate use of chemical fertilizers has adverse impacts on soil and microbiome properties. To combat this major problem, nitrogen-fixing bacteria, composts, and manures could be potential substitutes. In view of the above concern, this study was undertaken to evaluate the effects of various nitrogen sources on fenugreek growth under field conditions.

Materials and Methods

Trial Location : The field trial was conducted at Research Farm of Vegetable Science Chaudhary Charan Singh Haryana Agricultural University, Hisar (India) (29^0 10' N, 75^0 46' E, Elevation 215.2 m) in the *Rabi* season of 2019-20. To find out the most suitable effect of different

Received : June-2024; Revised : June-2024; Accepted : June-2024

treatment combination of organic and inorganic sources inoculation with biofertilizer of crop.

Properties of the soil prior the experiment conducted : The soil of the experimental field was analyzed for mechanical and chemical properties, and cropping history details are given below in table-1.

Treatment details : The fenugreek seeds of variety Hisar Sonali (HM-57) were shown in the field in RBD design with three replications and the plot size was 3.0 m x 2.4 m. A total of eighteen treatments were applied with three replications (Table-2). The crop was raised with the standard agronomic practices followed by the details given below in table-3. In the study, half of the nitrogen was applied at the sowing time and the rest of the dose was applied after 4 weeks of the first dose. The ten plants were randomly selected for data collection and data was recorded as follows: Days to emergence, days to 50% flowering, days to maturity and number of primary branches.

Days to emergence : This developmental phase lies between germination and seedling stage. The rupture of soil upper layer and cotyledonary leaf appears after germination. The days to first leaf appearance was worked out.

Days to 50% flowering : Days taken to 50 percent flowering in each plot were recorded after first flowering on the basis of visual observation. The day after 50 per cent of the plants showed flowers in the plot was considered as 50 per cent flowering. The number of days taken from the date of sowing to 50 percent flowering was calculated and expressed as days taken for 50 percent flowering.

Days to maturity : When the lower leaves of the plants were almost shed and seed colour changed green to brownish and seed hardened, days were counted from sowing to maturity.

Number of primary branches : The branches that emerged from the main shoot of ten plants from each plot were counted at harvest and averaged.

Statistical Analysis : The experiment was conducted in a randomized block design (RBD) for the field. The data obtained from an experiment conducted in RBD was analyzed as per the standard method suggested by (8). The critical difference (CD) values were calculated at a 5 percent probability level whenever the 'F' test was significant.

Results and Discussion

Days to Emergence : In the study, days to emergence was lowest (4.33 days) was observed with T_5 (100% RDN through Vermicompost + *Rhizobium*) and T_{13} (75% RDN through Vermicompost + 25% RDN through FYM + *Rhizobium*), while the highest (5.70 days) was recorded with T_3 (100% RDN through FYM + *Rhizobium*), T_{15} (100% RDN through FYM), and T17 (*Rhizobium*) in both the years. This outcome could be attributed to the sufficient nitrogen and phosphorus supply facilitated by inorganic fertilizers that allows rapid release and increased availability of nitrogen and phosphorus during the initial stages of crop growth. Additionally, the application of bio-fertilizers (*Rhizobium* + PSB) was noted to enhance various physiological processes such as cell division, cell enlargement, and inter-nodal length. This enhancement was attributed to the production of growth-regulating hormones such as auxins, gibberellins and vitamins. Consequently, this led to heightened photosynthesis, resulting in increased nodulation, biological nitrogen fixation (BNF), chlorophyll content, photosynthates, and protein metabolism. These results are in accordance with the findings of (9) in feugreek.

Days to 50 percent flowering : The longest time to 50% flowering (55.3 and 56.3 days) was observed with T_1 (100% RDN (Inorganic) + *Rhizobium*), while the shortest time (51.7 and 52.7 days) was recorded with T_{18} (control) in 2021-22 and 2022-23, respectively. This might be due the balanced vegetative growth and the availability of certain micronutrients provided by higher doses of organic manures, in combination with inorganic fertilizers, which facilitated the transition of plants into the reproductive phase. These results are in conformity with the findings of (2) in fenugreek.

Days to maturity : The longest time to days to maturity (131.3 and 132.3 days) was observed with T_1 (100% RDN (Inorganic) + *Rhizobium*), while the shortest time (124 and 126 days) was recorded with T_{18} (control). This could be attributed by the combined use of inorganic fertilizers and bio-inoculants, which enhanced nutrient availability, photosynthetic activity, chlorophyll production and nitrogen metabolism in plants. These findings are suggested by (10).

Similarly, (2) found that sufficient and balanced vegetative growth, along with the availability of specific micronutrients from higher doses of organic manures combined with inorganic fertilizers, prompted plants to enter the reproductive phase earlier. Conversely, plants receiving lower doses of organic manures, and consequently fewer nutrients, exhibited stunted growth and delayed flowering

Number of primary branches per plant : In this study, according to the first year (2021-22), significantly highest number of pods per plant (73.70) were obtained in the treatment T_1 (100 % RDN (Inorganic) + *Rhizobium*) which was closely followed by T9 (75 % RDN (Inorganic) + 25 %

Table-1 : Detailed description of Mechanical, and chemical analysis of soil and cropping history.

Sr. No.	Soil parameters	Proportion in percentage	Methods and reference
Mechanical analysis of the soil			
1.	Sand	56	International pipette method (Piper, 1950)
2.	Silt	32	
3.	Clay	12	
4.	Soil texture	Sandy - loam	
Chemical analysis of the soil at the start of the experiment			
S. No.	Soil Parameters	Value	Methods and reference
1.	pH (1:2 soil: water suspension)	8.1	Potentiometric method (Jackson, 1973)
2.	EC (ds/m) at 25^{0}C (1:2 soil: water suspension)	0.36	Conductometric method (Jackson, 1973)
3.	Organic Carbon (%)	0.35	Wet oxidation method (Walkley and Black, 1934)
4.	Available nitrogen (kg/ha)	138	Kjeldhal- distillation method (Subbiah and Asija, 1956)
5.	Available phosphorus (kg/ha)	22.5	$NaHCO_3$ extraction and colorimetry method (Olsen *et al.*, 1954)
6.	Available potassium (kg/ha)	227	N NH_4OAC extraction and Flame photometry method, (Jackson 1973)
Cropping history of the experimental field			
Crop seasons			
Year	*Kharif*		*Rabi*
2017-18	*Okra*		*Potato*
2018-19	*Okra*		*Fennel*
2019-20	Bottle gourd		Coriander

Table-2 : Detailed treatment of different combination of organic and inorganic sources of nitrogen inoculation with biofertilizer.

Treatment	A detailed description of treatments
T_1	100 % RDN (Inorganic) + *Rhizobium*
T_2	75 % RDN (Inorganic) + *Rhizobium*
T_3	100 % RDN through FYM + *Rhizobium*
T_4	75 % RDN through FYM + *Rhizobium*
T_5	100 % RDN through Vermicompost + *Rhizobium*
T_6	75 % RDN through Vermicompost + *Rhizobium*
T_7	75 % RDN (Inorganic) + 25 % RDN through FYM + *Rhizobium*
T_8	50 % RDN (Inorganic) + 50 % RDN through FYM + *Rhizobium*
T_9	75 % RDN (Inorganic) + 25 % RDN through Vermicompost + *Rhizobium*
T_{10}	50 % RDN (Inorganic) + 50 % RDN through Vermicompost + *Rhizobium*
T_{11}	75 % RDN through FYM + 25 % RDN through Vermicompost + *Rhizobium*
T_{12}	50 % RDN through FYM + 50 % RDN through Vermicompost + *Rhizobium*
T_{13}	75 % RDN through Vermicompost + 25 % RDN through FYM + *Rhizobium*
T_{14}	100 % RDN (Inorganic)
T_{15}	100 % RDN through FYM
T_{16}	100 % RDN through Vermicompost
T_{17}	*Rhizobium*
T_{18}	Control

RDN through Vermicompost + *Rhizobium*) and T_{14} (100 % RDN (Inorganic) was 66.73 and 69.70. Significantly least number of pods per plant (49.71) was observed in Treatment T_{18} (control). During the second year (2022-23) of experimentation, the treatments almost followed the same order and were in line with the findings of first year 2021-22. This enhancement might be attributed to the augmented biological nitrogen fixation and nitrogen transformation within plants. This improvement was observed with the application of the liquid formulation containing *Rhizobium* and PSB, indicating its potential for fostering better crop development which results in a better nutritional environment in the root zone for plant growth and development. The similar findings were observed by (9, 11).

While (2, 12) that the inorganic sources ensured ready availability of nutrients for initial requirements through inorganic sources and slow-release long-term availability through organic sources throughout the crop growth period. Additionally, biofertilizers improved root

Table-3 : Details of agronomic practices followed in the experimental field.

Sr. No.	Field operations	2021-22	2022-23
1.	Pre- sowing irrigation	10 November, 2021	7 November, 2022
2.	Field preparation	17 November, 2021	13 November, 2022
3.	Layout and sowing	18 November, 2021	14 November, 2022
4.	1st Irrigation	22 December, 2021	20 December, 2022
5.	2nd Irrigation	22 January, 2022	20 January, 2023
6.	Harvesting for grain purpose	11 April, 2022	5 April, 2023
7.	Threshing	15 April, 2022	10 April, 2023

Table-4 : Effect of different nitrogen sources on days to emergence in fenugreek (*Trigonella foenum-graecum* L.).

T. No.	Treatment details	2021-22	2022-23	Pooled
T_1	100 % RDN (Inorganic) + *Rhizobium*	4.7	5.3	5.00
T_2	75 % RDN (Inorganic) + *Rhizobium*	5.3	5.3	5.33
T_3	100 % RDN through FYM + *Rhizobium*	5.7	5.7	5.70
T_4	75 % RDN through FYM + *Rhizobium*	5.7	5.3	5.50
T_5	100 % RDN through Vermicompost + *Rhizobium*	4.0	4.7	4.33
T_6	75 % RDN through Vermicompost + *Rhizobium*	5.3	5.7	5.50
T_7	75 % RDN (Inorganic) + 25 % RDN through FYM + *Rhizobium*	5.3	5.7	5.50
T_8	50 % RDN (Inorganic) + 50 % RDN through FYM + *Rhizobium*	5.3	5.3	5.33
T_9	75 % RDN (Inorganic) + 25 % RDN through Vermicompost + *Rhizobium*	4.3	5.3	4.83
T_{10}	50 % RDN (Inorganic) + 50 % RDN through Vermicompost + *Rhizobium*	5.3	4.3	4.83
T_{11}	75 % RDN through FYM + 25 % RDN through Vermicompost + *Rhizobium*	5.3	5.3	5.33
T_{12}	50 % RDN through FYM + 50 % RDN through Vermicompost + *Rhizobium*	5.3	5.3	5.33
T_{13}	75 % RDN through Vermicompost + 25 % RDN through FYM + *Rhizobium*	4.3	4.3	4.33
T_{14}	100 % RDN (Inorganic)	5.3	4.0	4.67
T_{15}	100 % RDN through FYM	5.7	5.7	5.70
T_{16}	100 % RDN through Vermicompost	5.3	5.3	5.33
T_{17}	*Rhizobium*	5.7	5.7	5.70
T_{18}	Control	5.7	5.3	5.50
	C.D. at 5%	NS	NS	NS

Table-5 : Effect of different nitrogen sources on days to 50 % flowering in fenugreek (*Trigonella foenum-graecum* L.).

T. No.	Treatment details	2021-22	2022-23	Pooled
T_1	100 % RDN (Inorganic) + *Rhizobium*	55.3	56.3	55.82
T_2	75 % RDN (Inorganic) + *Rhizobium*	54.0	55.0	54.50
T_3	100 % RDN through FYM + *Rhizobium*	53.7	54.3	54.00
T_4	75 % RDN through FYM + *Rhizobium*	53.7	54.0	53.85
T_5	100 % RDN through Vermicompost + *Rhizobium*	54.3	55.0	54.65
T_6	75 % RDN through Vermicompost + *Rhizobium*	54.0	54.3	54.15
T_7	75 % RDN (Inorganic) + 25 % RDN through FYM + *Rhizobium*	55.0	55.0	55.00
T_8	50 % RDN (Inorganic) + 50 % RDN through FYM + *Rhizobium*	54.0	54.7	54.35
T_9	75 % RDN (Inorganic) + 25 % RDN through Vermicompost + *Rhizobium*	55.0	55.3	55.15
T_{10}	50 % RDN (Inorganic) + 50 % RDN through Vermicompost + *Rhizobium*	54.7	54.7	54.70
T_{11}	75 % RDN through FYM + 25 % RDN through Vermicompost + *Rhizobium*	54.3	54.3	54.30
T_{12}	50 % RDN through FYM + 50 % RDN through Vermicompost + *Rhizobium*	54.3	54.3	54.30
T_{13}	75 % RDN through Vermicompost + 25 % RDN through FYM + *Rhizobium*	54.7	54.7	54.70
T_{14}	100 % RDN (Inorganic)	54.3	55.3	54.80
T_{15}	100 % RDN through FYM	53.0	54.0	53.50
T_{16}	100 % RDN through Vermicompost	54.0	54.7	54.35
T_{17}	*Rhizobium*	52.3	53.3	52.80
T_{18}	Control	51.7	52.7	52.20
	C.D. at 5%	NS	NS	NS

Table-6 : Effect of different nitrogen sources on days to maturity in fenugreek (*Trigonella foenum-graecum* L.).

T. No.	Treatment details	2021-22	2022-23	Pooled
T_1	100 % RDN (Inorganic) + *Rhizobium*	131.3	132.3	131.80
T_2	75 % RDN (Inorganic) + *Rhizobium*	129.3	131.3	130.30
T_3	100 % RDN through FYM + *Rhizobium*	126.3	128.3	127.30
T_4	75 % RDN through FYM + *Rhizobium*	126.3	128.3	127.30
T_5	100 % RDN through Vermicompost + *Rhizobium*	129.0	131.0	130.00
T_6	75 % RDN through Vermicompost + *Rhizobium*	127.0	129.0	128.00
T_7	75 % RDN (Inorganic) + 25 % RDN through FYM + *Rhizobium*	129.3	131.3	130.30
T_8	50 % RDN (Inorganic) + 50 % RDN through FYM + *Rhizobium*	128.0	130.0	129.00
T_9	75 % RDN (Inorganic) + 25 % RDN through Vermicompost + *Rhizobium*	129.7	131.7	130.70
T_{10}	50 % RDN (Inorganic) + 50 % RDN through Vermicompost + *Rhizobium*	128.3	130.3	129.30
T_{11}	75 % RDN through FYM + 25 % RDN through Vermicompost + *Rhizobium*	127.7	129.7	128.70
T_{12}	50 % RDN through FYM + 50 % RDN through Vermicompost + *Rhizobium*	126.7	128.7	127.70
T_{13}	75 % RDN through Vermicompost + 25 % RDN through FYM + *Rhizobium*	128.0	130.0	129.00
T_{14}	100 % RDN (Inorganic)	129.7	131.7	130.70
T_{15}	100 % RDN through FYM	125.7	127.7	126.70
T_{16}	100 % RDN through Vermicompost	128.0	130.0	129.00
T_{17}	*Rhizobium*	125.0	127.0	126.00
T_{18}	Control	124.0	126.0	125.00
	C.D. at 5%	NS	NS	NS

Table-7 : Effect of different nitrogen sources on number of primary branches per plant at harvest in fenugreek (*Trigonella foenum-graecum* L.).

T. No.	Treatment details	2021-22	2022-23	Pooled
T_1	100 % RDN (Inorganic) + *Rhizobium*	6.27	6.30	6.28
T_2	75 % RDN (Inorganic) + *Rhizobium*	5.47	6.03	5.75
T_3	100 % RDN through FYM + *Rhizobium*	5.20	5.40	5.30
T_4	75 % RDN through FYM + *Rhizobium*	5.17	5.40	5.28
T_5	100 % RDN through Vermicompost + *Rhizobium*	5.43	6.00	5.72
T_6	75 % RDN through Vermicompost + *Rhizobium*	5.23	5.60	5.42
T_7	75 % RDN (Inorganic) + 25 % RDN through FYM + *Rhizobium*	5.47	6.10	5.78
T_8	50 % RDN (Inorganic) + 50 % RDN through FYM + *Rhizobium*	5.43	5.77	5.60
T_9	75 % RDN (Inorganic) + 25 % RDN through Vermicompost + *Rhizobium*	5.90	6.20	6.05
T_{10}	50 % RDN (Inorganic) + 50 % RDN through Vermicompost + *Rhizobium*	5.43	5.97	5.70
T_{11}	75 % RDN through FYM + 25 % RDN through Vermicompost + *Rhizobium*	5.27	5.60	5.43
T_{12}	50 % RDN through FYM + 50 % RDN through Vermicompost + *Rhizobium*	5.20	5.47	5.33
T_{13}	75 % RDN through Vermicompost + 25 % RDN through FYM + *Rhizobium*	5.33	5.70	5.52
T_{14}	100 % RDN (Inorganic)	5.93	6.20	6.07
T_{15}	100 % RDN through FYM	5.13	5.37	5.25
T_{16}	100 % RDN through Vermicompost	5.37	5.70	5.53
T_{17}	*Rhizobium*	5.10	5.23	5.17
T_{18}	Control	5.10	5.17	5.13
	C.D. at 5%	0.36	0.26	0.26

nodulation, created a congenial soil environment in the plant rhizosphere, increased nitrogen fixation, phosphorus solubilization, and subsequently increased growth. This might have improved adequate biomass production and growth parameters. Moreover, organics, besides supplying macro and micronutrients, had a solubilizing effect on native soil nutrients due to the action of organic acids produced during decomposition, resulting in an increased number of primary branches per plant.

Conclusion

This study demonstrates that the combination of vermicompost and *Rhizobium* promotes the fastest emergence of fenugreek, while the use of FYM results in slower emergence. The longest times to 50% flowering and maturity were observed with 100% inorganic RDN + Rhizobium treatments, while the control group exhibited the shortest times. The highest number of pods per plant was also achieved with 100% inorganic RDN + Rhizobium, indicating its potential for enhancing fenugreek production. These findings suggest that integrating organic and inorganic nitrogen sources, along with *Rhizobium* inoculation, can significantly improve fenugreek growth and yield, offering a sustainable approach for fenugreek cultivation. This study provides practical recommendations for fenugreek growers and valuable insights for further research in optimizing fenugreek production.

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