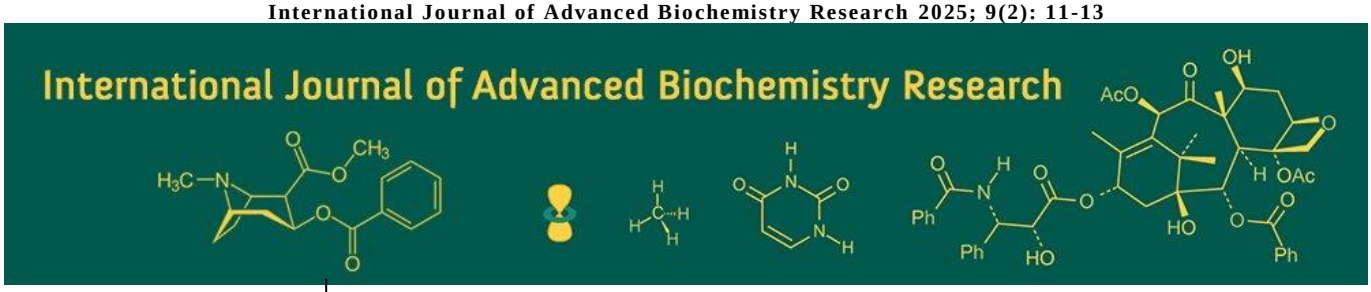

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Effect of organic manures and bio-fertilizers on growth and herb yield of fenugreek (*Trigonella foenum-graecum* L.)

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Abstract
Field experiment was carried out at carried out during early summer 2024 in the department of horticulture, Horticulture Research Farm, R.A.K., College of Agriculture, Sehore (M.P.). This experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments. The experimental crop fenugreek was line sown with the spacing of 15cm*10cm. This study evaluated the effects of various treatments on plant growth and development at different growth intervals. The treatments included NC (1 t ha^{-1}) with Rhizobium (1.5 kg ha^{-1}), FYM (10 t ha^{-1}) with Rhizobium (1.5 kg ha^{-1}), and NC (1 t ha^{-1}) with PSB (5 kg ha^{-1}). Among the treatments, NC + Rhizobium (T_8) consistently exhibited the highest growth parameters. The highest number of leaves (25.48) and fresh weight (27.06 g) were also found in T_8. The control treatment, T_1, consistently showed the lowest growth parameters, with the lowest leaf area (3.24 cm^2) and fresh weight (16.12 g) at harvest. These results demonstrate the positive effects of combining NC with Rhizobium on plant growth and yield parameters.

Keywords: Fenugreek, organic manures, bio-fertilizers, growth, herb yield

Introduction
Fenugreek (*Trigonella foenum-graecum* L.) is an important leguminous herb, widely cultivated for its culinary and medicinal properties. It is primarily grown for its leaves, seeds, and as a source of bioactive compounds that have potential therapeutic applications (Verma *et al.*, 2014) [13]. The productivity and quality of fenugreek can be significantly influenced by soil fertility management practices, including the application of organic manures and bio-fertilizers. Organic manures, such as farmyard manure (FYM), compost, and green manure, have been shown to improve soil structure, enhance nutrient availability, and promote beneficial soil microbial activity, thus contributing to better crop performance (Bhardwaj *et al.*, 2013) [2]. Similarly, bio-fertilizers, including nitrogen-fixing bacteria such as *Rhizobium* and phosphorus-solubilizing bacteria (PSB), can improve nutrient uptake by plants, thereby enhancing growth and yield.

Several studies have highlighted the positive impact of organic amendments and bio-fertilizers on the growth parameters and yield of fenugreek. For instance, studies by Singh *et al.* (2017) [11] and Sharma *et al.* (2018) [9] have demonstrated that the combined use of organic manures and bio-fertilizers can result in increased plant height, leaf number, chlorophyll content, and seed yield. In particular, *Rhizobium* inoculation has been reported to enhance nitrogen fixation in fenugreek, while PSB helps in phosphorus availability, leading to improved growth and herb yield (Saha *et al.*, 2015) [7].

The use of integrated nutrient management (INM), combining organic manures and bio-fertilizers, is gaining popularity as a sustainable agricultural practice. By reducing the reliance on synthetic fertilizers, INM not only promotes healthier crop growth but also ensures long-term soil fertility and sustainability (Bhat *et al.*, 2019) [3]. This research aims to evaluate the effect of different organic manures and bio-fertilizers on the growth and herb yield of fenugreek, contributing to a better understanding of their potential in enhancing crop productivity.

Materials and Methods

Field experiment was carried out at carried out during March 2024 in a farmer's field at Horticulture Research Farm, R.A.K., College of Agriculture, Sehore (M.P.). Sehore (experimental site) is situated in the Vindhya plateau in western part of M.P at 23°.10" N latitude and 76^0.64" E longitude with an altitude of 501.5 m above mean sea level. Sehore region comes under sub-tropical region, having a temperature ranging from 28 – 41 °C maximum and 8 – 24 °C minimum in summer and winter season, respectively. It is hotter during April to May while coolest in December to mid-January. Relative humidity generally fluctuates between 24.8 and 90%. In this area, most of the rainfall is received during June to late September, while winter rains are occasional. The annual rainfall is recorded 1000-1225 mm. The soil of the experimental field was medium black soil with good drainage and uniform texture.

This experiment was laid out in a Randomized Block Design (RBD) with three replications with the plot size 3 m x 2.5 m. Before sowing fertilizers are applied at the rate of 20:25:25 kg/ha (NPK kg ha^{-1}). Seeds are line sowed at the rate of 25-30 kg/ha [1]. Treatment details are T_1– Control, T_2– RDF 100%, T_3 - FYM (10 t ha^{-1}) + PSB (5 kg ha^{-1}), T_4 – FYM (10 t ha^{-1}) + KMB (5 kg ha^{-1}), T_5 – FYM (10 t ha^{-1}) + Rhizobium (1.5 kgha^{-1}), T_6 – NC (1 t ha^{-1}) + PSB (5 kg ha^{-1}), T_7 – NC (1 t ha^{-1}) + KMB (5 kg ha^{-1}), and T_8 - NC (1 t ha^{-1}) + Rhizobium (1.5 kg ha-1). Foliar spray of these bio-fertilizers was given at 20 DAS and the observations on growth and yield parameters were recorded at the time of harvest i.e., 30 DAS.

Results

The results presented in Table 1 indicate a significant effect of organic manures and bio-fertilizers on the growth and fresh weight of fenugreek plants at different growth stages. At 20 DAS, the plant height ranged from 4.20 cm in T_1 to 8.50 cm in T_8, with T_8 showing the highest values across all growth stages. The number of leaves, branches, leaf area, chlorophyll content (SPAD), and fresh weight also followed a similar trend, with T_8 consistently outperforming all other treatments. At 30 DAS, T_8 exhibited the highest values for plant height (10.18 cm), number of leaves (20.75), leaf area (4.09 cm^2), chlorophyll content (4.59), and fresh weight (21.91 g). At harvest, T_8 continued to show superior growth, with the highest values for plant height (21.29 cm), number of leaves (25.48), leaf area (6.32 cm^2), chlorophyll content (5.06), and fresh weight (27.06 g). In contrast, T_1, the control treatment, showed the lowest values for all parameters at all stages, with fresh weight reaching only 16.12 g at harvest.

Yield parameters

The table presents the effect of various organic manures and bio-fertilizers on fenugreek yield. Among all treatments, the combination of neem cake (NC) with Rhizobium (T_8) resulted in the highest fresh weight (27.06 g/plant), dry weight (4.16 g/plant), herb yield (100.00 kg/plot or 3.59 q/ha), and B:C ratio (3.59). Other treatments, such as FYM + Rhizobium (T_5) and NC + PSB (T_6), also showed significant improvements in yield, with T_5 achieving 95.00 kg/plot (3.29 q/ha) and T_6 reaching 90.35 kg/plot (3.28 q/ha). The control (T_1) had the lowest yields, while RDF 100% (T_2) showed a notable increase over the control, reaching 81.57 kg/plot (2.86 q/ha). Treatments with combinations of organic manures and bio-fertilizers consistently outperformed individual organic treatments, highlighting their positive impact on fenugreek productivity and economic efficiency. Statistical analysis confirmed that the differences between treatments were significant, reinforcing the advantages of using organic and bio-fertilizer combinations for enhanced yield and profitability.

Table 1: Effect of organic manures and bio-fertilizers on growth of fenugreek

S. No.	Plant height (cm)			Number of leaves			Number of branches			Leaf area (cm)			Chlorophyll content (SPAD)		
	20 DAS	30 DAS	At harvest	20 DAS	30 DAS	At harvest	20 DAS	30 DAS	At harvest	20 DAS	30 DAS	At harvest	20 DAS	30 DAS	At harvest
T_1	4.20	6.23	11.10	4.72	10.59	13.02	0.00	1.91	2.93	1.92	2.20	3.24	1.70	2.36	2.74
T_2	6.73	7.40	17.54	7.06	18.63	22.41	0.00	2.78	3.86	2.77	2.90	5.33	2.31	3.61	4.64
T_3	7.14	7.94	18.85	7.72	19.08	23.03	0.00	3.06	4.01	2.98	3.00	5.63	2.40	3.81	4.70
T_4	5.94	6.55	16.61	6.90	17.51	20.85	0.00	2.12	3.45	2.39	2.34	5.15	2.08	3.27	4.22
T_5	8.17	9.76	20.69	8.87	20.24	24.07	0.00	3.68	4.89	3.47	3.73	6.03	2.88	4.25	4.90
T_6	7.83	8.67	19.59	8.09	19.81	23.48	0.00	3.18	4.48	3.04	3.29	5.78	2.55	4.12	4.72
T_7	6.59	6.93	17.07	6.36	17.83	21.41	0.00	2.36	3.64	2.54	2.59	5.18	2.24	3.35	4.39
T_8	8.50	10.18	21.29	9.46	20.75	25.48	0.00	4.05	5.07	3.80	4.09	6.32	3.00	4.59	5.06
SE (m)	0.25	0.30	0.55	0.42	0.49	0.84	-	0.21	0.28	0.23	0.20	0.14	0.09	0.11	0.10
C.D. @ 5%	0.73	0.88	1.61	1.24	1.42	2.44	-	0.61	0.83	0.67	0.58	0.41	0.25	0.31	0.28

Table 2: Effect of organic manures and bio-fertilizers on yield of fenugreek

S. No.	Fresh weight (g) of plant			Dry weight of plant			Herb yield (kg/plot)	Herb yield (q/ha)	B:C
	20 DAS	30 DAS	at harvest	20 DAS	30 DAS	At harvest			
T_1	8.61	14.77	16.12	0.90	1.98	2.26	1.90	50.00	1.77
T_2	12.95	17.87	24.10	1.72	2.83	3.61	3.10	81.57	2.86
T_3	13.95	19.59	25.05	1.83	2.92	3.81	3.23	85.08	2.93
T_4	11.07	16.61	23.49	1.50	2.55	3.50	2.73	71.93	2.60
T_5	14.83	21.02	26.84	1.96	3.22	3.92	3.61	95.00	3.29
T_6	14.34	20.25	26.40	1.91	3.15	3.90	3.43	90.35	3.28
T_7	11.78	17.41	23.89	1.64	2.59	3.51	2.93	77.19	2.75
T_8	15.13	21.91	27.06	2.04	3.52	4.16	3.80	100.00	3.59
SE(m)	0.33	0.68	0.52	0.04	0.09	0.17	0.13	3.35	-
C.D. @ 5%	0.96	1.99	1.51	0.12	0.26	0.50	0.37	9.81	-

Discussion

The application of organic manures and bio-fertilizers had a positive effect on the fresh weight of fenugreek plants, as observed in this study. Organic amendments, such as compost, and the use of bio-fertilizers, are known to improve soil fertility, enhance nutrient uptake, and stimulate plant growth, which likely contributed to the observed increase in fresh weight. Several studies have reported similar findings where organic amendments and bio-fertilizers improved the growth parameters of crops like fenugreek. For instance, Sattar *et al*. (2014) [8] found that organic fertilization coupled with bio-fertilizers significantly enhanced the growth and yield of fenugreek, including fresh weight, by improving soil microbial activity and nutrient availability.

Additionally, the combination of organic and bio-fertilizers (such as in T_8) seems to provide an optimal growth environment for fenugreek. Similar synergistic effects have been reported by Ahmed *et al.* (2018) [1], who demonstrated that integrated nutrient management practices, including organic manures and bio-fertilizers, led to improved plant biomass accumulation in various crops, including fenugreek. The lower fresh weight observed in the control treatment (T_1) can be attributed to the lack of external nutrient supplementation, which limits the plants' growth potential. This aligns with the findings of Bhattacharyya *et al*. (2016) [4], who reported that plants receiving no fertilization had significantly lower growth parameters compared to those receiving organic or bio-fertilizer treatments.

Yield parameters

The results from the table highlight the significant positive impact of organic manures and bio-fertilizers on fenugreek yield. The combination of neem cake (NC) and Rhizobium (T_8) resulted in the highest fresh and dry weights, herb yield, and B:C ratio, consistent with studies showing that Rhizobium enhances nitrogen fixation, leading to better plant growth (Thies *et al*., 2005) [12]. Similarly, the combination of farmyard manure (FYM) and Rhizobium (T_5) also improved yield, which supports findings that FYM enhances soil fertility and microbial activity, further boosted by Rhizobium (Goyal *et al.*, 2005) [5]. The use of Phosphate Solubilizing Bacteria (PSB) in combination with FYM (T_3) also resulted in higher yields, indicating the importance of PSB in making phosphorus more available to plants (Khan *et al.*, 2007) [6]. Treatments with bio-fertilizers consistently outperformed those with organic manures alone, highlighting the synergistic effects of combining organic inputs with bio-fertilizers. The RDF 100% treatment also showed good results but had a lower B:C ratio, suggesting that organic-based treatments are more cost-effective. Overall, integrated nutrient management with organic manures and bio-fertilizers proves to be both economically and environmentally beneficial for fenugreek production Banik *et al*., (2024) [10].

Conclusions

The application of organic manures and bio-fertilizers significantly enhances the growth and yield of fenugreek (*Trigonella foenum-graecum* L.). Treatments involving bio-fertilizers like *Rhizobium* and *PSB* have consistently improved key growth parameters, such as plant height, leaf number, chlorophyll content, and fresh weight. Similar results have been observed in other studies, with Sharma *et al.* (2013) [2] highlighting the role of bio-fertilizers in improving nutrient uptake and plant growth. The combination of organic amendments and bio-fertilizers, such as those involving farmyard manure (FYM) and *Rhizobium*, has been shown to boost plant productivity (Singh *et al.*, 2017) [11]. Furthermore, Bhat *et al.* (2019) [3] confirmed the positive effects of integrated nutrient management on crop yield, emphasizing its importance in sustainable agriculture. This study corroborates these findings, suggesting that using organic and bio-fertilizer-based approaches can be an effective strategy for enhancing fenugreek growth and yield.

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