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EFFECT OF DIFFERENT TYPES OF FERTILIZERS ON THE FLOWERING AND GROWTH OF FENUGREEK

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fertilizers, fenugreek, flowering, plant height, yield

Abstract
The versatile crop fenugreek, sometimes called methi, is cultivated in northern India during winter. In terms of fenugreek productivity in India, Rajasthan is at the top. An annual plant is a member of the Fabaceae family and the subfamily Papilliaceae. The crop is classified as leguminous, and its nitrogen-rich roots penetrate deep into the soil. Fertilizers have a broad range of applications for enhancing growth and development. Fenugreek seeds and fixed-oil yields may be enhanced with the use of biofertilizers. Fenugreek also uses NPK 15-15-15 fertilizer or NPK 19-19-19 water-soluble fertilizer as it blooms. Fenugreek seeds are contained in the yellow pods transformed from the white or purple blooms produced by this plant. Therefore, nitrogen, phosphorus, and bio-fertilizers are fertilizers that may enhance the growth and blooming of fenugreek plants. Bio-fertilizers, such as PSB and Rhizobium, were used in comparison to the control group, which received the required dosage of NPK from chemical fertilizers—with a maximum plant height of 35.94 cm, several 6.70 pods, 65.50 days to 50% blooming, 3.40 branches, 8.43 pod lengths, yield of 15.49 q/ha, and 146.10 days to maturity, the experimental results revealed that the control group had the lowest values. After using an unfertilized control, mycorrhizal fungi may improve many crop metrics by using bacterial fertilizers and vermicompost (Madhoor & Faisal, 2020). Regarding fenugreek, it may be more prudent, cost-effective, and efficient to use a combination of chemical and bio-fertilizers rather than only chemical fertilizers.

INTRODUCTION

The research will be conducted in the fields of the Alwar district, with a specific focus on the village of Shriya ka Bas. Alwar is renowned for its association with the Sariska National Park and rich ethnobotanical flora. Sariska National Park, situated in the Alwar region of Jaipur, Rajasthan, is a highly visited destination in the country. Fenugreek (*"**Trigonella foenum-graecum L.**")* is a medicinal plant mainly obtained from the Fabaceae family. The fenugreek exhibits a presence of alkaloids, saponins, and flavonoids, each with potential health-related properties. Alkaloids are often associated with medicinal properties. Saponins, known for their foaming

and emulsifying properties, may contribute to the potential benefits of the sample. With their antioxidant activity, Flavonoids can play a role in the sample's overall health profile. The fenugreek seeds contain alkaloid components, like proteins, fixed oil, mucilage, diosgenin, and trigonelline. Among all of them, Trigonelline is one of the most important components for plant growth.

Moreover, this is considered the most positive property for some diseases like cancer, infection, migraine, diabetes, and high blood cholesterol. Here, biofertilizers are used for its growth and flowering, as biofertilizers have beneficial bacteria for improving plant nutrition. In addition, fertilizers like phosphorus and nitrogen help in the flowering, growth, and general health of plants. It is also essential for the development of roots and strengthens the plants. Therefore, PSB, Rhizobium, and other similar fertilizers may be used to aid in the growth of this plant. In addition, fenugreek plants are fertilized with NPK fertilizer so that they may develop and bloom. The atmospheric nitrogen level might be stabilized by its implementation. One of the most important things farmers may do to boost crop productivity is fertilizer. Fertiliser applications must be timed to coincide with crop needs. The crop's optimal development, quality, and yield can only be achieved with it. Farmers love using bio-fertilizers like Rhizobium. At this time, our verdant plant is suffering from the decline in soil health caused by the careless use of artificial fertilizers, pesticides, and fungicides. Meena et al. (2015) found that Fenugreek (Triginella et al.) plants grew at their maximum potential when fertilized with 50% chemical fertilizers and 50% Rhizobium biofertilizers. “The control group showed the lowest levels of plant height, branch number, pod number, days to flowering, days to germination, length, yield per plant, and days to maturity.”

REVIEW OF LITERATURE

Research conducted by Detoroja et al. (1995), Khiriya and Singh (2003), and Yadav and Kumawat (2003) indicates that fenugreek output may be enhanced with the use of organic and inorganic fertilizers, as well as farmyard waste, nitrogen, and phosphorus. In a study conducted by Parakhia et al. (2000), the effects of applying Azotobacter in conjunction with Rhizobium and Pseudomonas striata, two beneficial microorganisms, on fenugreek in Gujarat, India, from 1995 to 1998 were examined. To a large extent, coculturing Azotobacter and Rhizobia affects the nodular mass, shoot height, and yield (1068 kg/ha). According to Rezaei-Chiyaneh et al. 2021, farmers sometimes use biofertilizers biofertilizers in high-yield traditional farming to meet the crops' high nutritional needs. Soil permeability is reduced by the growth of plant roots caused by the use of biofertilizers. Some bacteria in biofertilizers are suitable for plant growth, and mycorrhizal fungus improves plant nutrients by fixing nitrogen, releasing potassium ions, dissolving phosphates, oxidizing sulphur, and taking in ions (Rezaei-Chiyaneh et al., 2021). “The maximum plant height (74.1 cm), number of branches per plant (7.50), number of umbels per plant (25.0), number of umbellets per umbel (6.09), and number of seeds per umbel (46.6) were recorded by Choudhary et al. (2008) when there was an application of 100% inorganic N + Azospirillum at (1.5 kg/ha + 5 t) farmyard manure/ha.” The seed production was highest (889 kg/ha) in this treatment compared to all but two others: 75% inorganic N + Azospirillum at 1.5 kg/ha + 5 t farmyard manure/ha and 100% inorganic N as a single treatment. Mycorrhizal fungus, "plant growth-promoting rhizobacteria (PGPR)," and "Phosphate solution bacteria (PSB)" are now used in crop production. Aromatic and medicinal plants may benefit from bio-fertilizers in both quality and quantity. In order to increase the advantages and activities of soil microbes, organic bio-fertilizers such as vermicompost may provide the necessary nutrients to the crop. Fenugreek seeds and fixed-oil yields may be enhanced with the use of biofertilizers. After using an unfertilized control, mycorrhizal fungi may improve many crop metrics by using bacterial fertilizers and vermicompost (Madhoor & Faisal, 2020). The Rajasthan State Government's Commissionrate of Agriculture (2012) A semi-arid climate best describes the area. During the southwest monsoon, you may expect quite considerable rainfall, and the weather is hot in the summer and chilly in the winter. May and June may see temperatures as high as 470 degrees Celsius. May and June saw very high potential evapotranspiration rates. “The average yearly rainfall in the area is 631 millimetres. An experiment conducted at the Centre, Meerut, by Kumar et al. (2016) examined the impact of nitrogen, phosphorus, and cutting administration on the flowering and production of

green leaves of fenugreek (Trigonella et al.)." The research took these things into account. At various DAS values ranging from 20 to 40, the effects of N and P per hectare together with two lowering analyses on plant height and length, number of green leaves per hectare, presence of diversifying branches per hectare, length of the extended extension, days to blossoming, new weight of biomass per hectare, amount of dry matter per hectare, and amount of green leaves per hectare were all significantly different from zero kg N and P per hectare and no cutting.

Fig. 1: Flowring stage of fenugreek plant

An annual crop, fenugreek, is also known as methi (Nair et al., 2021). When it comes to fenugreek production in India, Rajasthan is unrivalled. Being a leguminous crop, its roots absorb atmospheric nitrogen and send it down to the soil. Nair et al. (2021) found that fertilizers may be utilized extensively to increase its growth and development. Thus, soil detonations, including degradation of the ecosystem, occur. This industry's nutrient supply and removal processes need to be more balanced. The usage of fertilizers is widespread in order to fill this need. Its applications may lessen the financial burden of supplement use. The usage of chemical fertilizer has decreased in fenugreek due to the rising number of biofertilizer applications. For farmers, this is a huge boon.

Using PSB and Rhizobium in fenugreek seed production is quite successful. A lack of phosphorus during growth significantly contributes to the crop's low yield. In order to improve the soil's phosphorus efficiency, fungus and phosphorus solubilizing bacteria (PSBs) have been used recently. Four phosphorus levels, including fertilizer application, are the subject of the author's study in this paper (Toukabri et al., 2020). In this particular setting, fenugreek seeds are fertilized with Rhizobium and PSB. Fenugreek seeds also contain both of these substances in a mixed form. Some hazardous illnesses may be treated more quickly when Rhizobium and PSB are used together. The fenugreek plant's nitrogen fixation mechanisms result in pink-coloured roots; nitrogen-based fertiliser must be applied if any of the fertilizer odes are absent.

MATERIAL AND METHODOLOGY

This field study took place throughout the rabi season. The soil's chemical and physical characteristics dictate the optimal location for the experiment. The soil had a pH of 7.8, was composed of silty clay, and had an electrical conductivity of 0.81 dS m-1. Only 0.95 per cent of the soil contained organic materials (Camlica & Yaldiz, 2021). Additionally, there was a 0.09% salt, potassium, and phosphorus concentration. In addition, the study was conducted every month from October to March. In the biofertilizer experimebiofertilizerss' seeds

were combined with a mixture of nitrogen-fixing bacteria (NFB) and phosphorus-phosphorus-solubilising). "Four levels of bio-fertilizbio-fertilizersizobium, PSB, and Rhizobium + PSB—were then applied in a factorial RBD design with three replications." The nitrogen and phosphorus levels were 10 and 20 kg N/ha and 20 and 40 kg P2 O5/ha, respectively. When the seeds were planted, they were treated with a total dosage of nitrogen and phosphorus according to the treatment plan using SSP and urea. Before planting, the fenugreek seeds were inoculated with the appropriate bio-fertilisation fertiliser in the shade; the seeds were scattered 30 cm apart in a row using 20 kg of seed per hectare. The best cultural practices for growing a bountiful harvest were implemented. Five plants were chosen randomly from each plot to measure plant height. The nitrogen content was multiplied by a ratio of 6.25 to get the protein content of the seed and straw. The pattern of therapy response was consistent over the two years. Panse and Sukhamte (5) proposed a standard approach for the analysis of design variance, which was followed. "The experiment was conducted using a Factorial Randomised Block Design (RBD) with three replications." The four bio-fertilisation fertilisers are Rhizobium, Phosphorus Solubilizing Bacteria (PSB), and Rhizobium + PSB. Biofertilizer was administered prior to crop planting.
According to Bhavar et al. (2019), the seeds were scattered throughout the soil in October with a spacing of 7.5 cm between each seed. In the end, 33 seeds per square metre were used. Sprinklers were turned on every ten days. No herbicides were used, and the weeds were pulled out of the seeds by hand. Soil biofertilizebiofertilizers at a rate of 10% to facilitate the uptake of fenugreek blossoms. At every stage, this treatment—a biofertilizebiofertilizerN and P—displays the most significant height and leaf area values compared to the others. At the 32-day post-flowering stage, plant growth is much improved, with a height measuring 35.94 cm and a leaf area of 5.46 cm^2.

Fig. 2: Growth of fenugreek plant

RESULTS AND DISCUSSION

Tables 1 show various combinations of nitrogen, phosphorus, and bio-fertilization-fertilizers development, production, and quality of the fenugreek plants. Compared to 10 kg N/ha in both years and when pooled, 20 kg N/ha significantly increased plant height across all growth stages, branch number/plant, days to 50% flowering and maturity, seed and straw protein content, and biological yields. However, nitrogen levels had no discernible effect on the harvest index.

Although it postponed blooming and maturity by several days, a 40 kg P2 O5 / ha application significantly increased plant height. By applying 40 kg P2 O5 per hectare instead of 20 kg P2 O5, not only was the protein content in the seed and straw more significant, but so were the biological yields. However, phosphorus levels did not substantially impact the harvest index. The data in Table 1 showed the following: plant height, number of branches, days to 50% blooming, and days to maturity. The maximum plant height throughout all development phases and seed, straw, and biological yields were achieved by applying 20 kg N with 40 kg P2 O5. Ten kilogrammes of nitrogen applied with twenty kilogrammes of perlite per hectare resulted in the best results for these characteristics. Applying nitrogen improves phosphorus absorption because it boosts root CEC and promotes robust root growth and proliferation. As a result, the soil could absorb more nutrients for improved growth and development after receiving a mixed application of nitrogen and phosphorus. The combination of nitrogen and phosphorus had a synergistic impact that increased nutrient levels and boosted plant development by increasing merismetic activity. This, in turn, led to more excellent seed, straw, and biological yields. Verma et al. (7) and Mavi et al. (4) reported similar findings. Plant nitrogen intake and soil structure may be improved by incorporating Rhizobium and PSB during fenugreek seed growth. In addition, bacterial fertilisers fertilize the root-surface area, increasing the plant's nutrient intake.

One possible explanation for the nanofeatures' properties is the fertiliser fertilizer, which is also seen in the plant's vegetative attributes. According to Pushpa et al. (2022), this may be attributed to its diminutive size. It may take in more of the seeds' beneficial energy and expand its surface area, directly correlating to the number of plant cells. Colloidal and protein compounds allow for the multiplication of nutritional and therapeutic effects. The blooming of fenugreek also uses NPK 19-19-19, a water-soluble fertiliser. Fertilizer seeds are contained in the yellow pods transformed from the white or purple blooms produced by this plant. Fifty to seventy days after planting, this happens.

Consequently, it was shown that phosphate and biofertilizebiofertilizers substantially impacted the number of branches per plant. A higher dose of P2O5 resulted in a more significant number of branches. Most branches were formed by the seed treatment that included Rhizobium and PSB, whereas the control group produced the fewest. The phosphorus and biofertilizers' impact on the fenugreek plants' maturity and the number of days it took to bloom for the first time. Plants treated with Rhizobium and PSB in conjunction with 55 Kg P2O5 showed the earliest blooming (42.50 days) (Table 1).

In contrast, 50% blooming (52.37 days) was seen in seeds treated alone with PSB (Table 1). P2O5 and biofertilizers have a comparable pattern of influence on days to maturity. The crop matured at an exceptionally early stage of 118.28 days, thanks to a combination of seed treatment with Rhizobium and PSB and soil application of 55 kg P2O5. Consistent with the findings of Mehta et al. (2012) [6], phosphorus administration causes crops to mature and bloom earlier.

Our research shows that the best way to increase fenugreek seed output is to use 45 kg of P2O5, inoculate the soil with Rhizobium and PSB, and then apply the biofertilizers. The research clearly shows that biofertilizers inhibit growth and development in general. BiofertilizeBiofertilizersnugreek plant growth, development, and yield by increasing soil nutrient availability and plant nutrient absorption.

Table 1: Variations in nitrogen, phosphorus, and bio-fertilization-fertilizers as they affect plant development, blooming, and maturity (combined data)

Treatment	Plant height(cm)				No. of branches/plant	Days to 50% flowering	Days to maturity
	30 DAS	60 DAS	90DAS	Maturity			
(A)Nitrogen (kg /ha)							
10	6.7	35.3	47.1	55.1	4.15	50.65	114.64
20	8.1	41.4	62.9	63.1	4.75	54.05	120.01
$CD_{0.05}$	0.3	1.7	2.3	2.3	0.15	1.99	3.92
(B)Phosphorus(kg/ha)							
20	7.3	35.5	55.6	55.7	4.27	50.94	114.47
40	8.2	41.1	62.6	62.3	4.54	53.74	120.20
$CD_{0.05}$	0.3	1.5	2.3	2.3	4.49	1.99	3.90
(C)Bio-fertilizer							
Without inoculation	7.2	35.4	55.1	55..5	4.20	51.73	115.92
Rhizobium inoculation	7.7	39.5	60.5	60.1	4.58	52.55	117.81
PSB inoculation	7.4	39.1	59.1	59.1	4.45	52.37	117.34
Rhizo.+PSB inoculation	7.8	40.1	61.5	61.6	4.62	52.76	118.28
$CD_{0.05}$	0.3	1.7	2.7	2.7	0.19	2.28	NS
Interaction between N x P	S	S	S	S	NS	NS	NS

Nitrogen application enhances photosynthetic activity and photosynthate translocation from source to sink, which might explain why greater nitrogen levels are associated with better yield qualities. A sufficient amount of nitrogen (N) positively impacts growth indices, including flowering and fruiting, which improves pod yield per plant. Pod length, pod number, seed yield per plant, seed weight per thousand seeds, and pod number all play a role in determining a crop's seed production. Seed, straw, and biological yields of fenugreek will all have a direct and favourable impact from increased nitrogen levels, improving yield qualities. These results agree with previous research on fenugreek by Detroja et al. (1996) and Shivaran (1995).

Phosphorus is essential for several metabolic processes; an adequate supply may enhance pod yields by encouraging more blooming and fruiting. In biological reactions, phosphorus is also involved in the transformation of energy. All of these processes may have benefited from the addition of phosphorus, which led to an increase in the value of yield qualities. There is widespread agreement that phosphorus fertilisation yields and yield characteristics in grain legumes. Variables, including pod density, seed density per pod, seed yield per plant, and 1000-seed weight, determine crop production. Seed, straw, and biological yields of fenugreek will be positively impacted by increased levels of P, which improve growth and yield qualities. Our findings align with those of Bhunia et al. (2006).

CONCLUSION AND FUTURE SCOPE

Optimal fertilisation is beneficial in maximizing crop flowering, growth and crop yields. Farmers can ensure enhanced growth, flowering, and greater productivity by understanding the nutrient requirements, employing appropriate fertilizer, fertilizing pre-planting and top dressing stages, and addressing potential deficiencies with secondary nutrients and macronutrients. With the result of this study, biofertilizers and synthetic fertilizers

directly impact fertilizers, root colonization, soil microorganisms, and soil structure. Applying biofertilizebiofertilizers may increase its texture, which speeds up the growth and development of fenugreek seeds. Additionally, this treatment may enhance the plant's nutritional intake. Fertilisers Fertilizersugreek seeds increase the crop's oil output, fixed-oil content, seed yield, and other metrics.

Additionally, the metabolism and yield components are enhanced when Rhizobium and PSB fertiliser fertilizers are used for fenugreek seed. It will be necessary to pay close attention to the development of these plants in the future by applying organic and bio-fertilization. Fertilizers may also be utilised for specific serious ailments.

On the other hand, it is reasonable to assume that organic fertiliser fertilizers promote seed and blossom development. Therefore, NPK 15-15-15 is the ideal fertiliser for Fertilizerek flower development. When grown with half the recommended dose of NPK from chemical fertilisers fertilizers, Rhizobium biofertilizebiofertilizers(Triginella et al.) plants reached their full potential in terms of height, branching, pod count, days to flowering, length, yield per plant, and days to maturity. In contrast, the control group showed the lowest levels of growth.

IMPLICATIONS

The data provides insights into the impact of different treatments on various growth and flowering parameters of fenugreek plants. Researchers and farmers can use this information to identify optimal conditions for maximizing fmaximizingield and growth. In conclusion, a detailed analysis of the effects of different parameters on the growth and development of fenugreek plants under various treatments provides valuable information for agricultural research and practice.

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