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Riddhi Patel
Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

JC Shroff
Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

PM Parmar
Ph.D., Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

SN Shah
Associate Director of Research Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
Riddhi Patel
Department of Agronomy, Anand Agricultural University, Anand, Gujarat, India

Enhancement of yield and quality of fenugreek (*Trigonella foenum-graecum* L.) through fertilizer level and bio NP

Riddhi Patel, JC Shroff, PM Parmar and SN Shah

Abstract
A field experiment was conducted at the College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat to assess the effect of Varying fertilizer levels and biofertilizer on yield and quality of fenugreek during *rabi* season of year 2020-2021. The experiment was laid out in factorial randomized block design with three replications. Treatment combinations includes three fertilizer levels *viz.*, 50% RDF, 75% RDF and 100% RDF (20 kg N/ha & 40 kg P_2O_5/ha) and four levels of biofertilizer *viz.*, Control, Seed treatment with Bio NP, Drenching of Bio NP, Seed treatment with Bio NP + Drenching of Bio NP at 30 DAS. The results revealed that application of 100% RDF recorded significantly highest green biomass yield at 30 DAS (1057 kg/ha), number of pods/plant (30.04), pod length (12.16 cm), number of seeds/pod (16.79), seed yield (2259 kg/ha), straw yield (3198 kg/ha) test weight(14.42 g), crude protein content of seed (22.36%), nitrogen content (3.58% and 1.21%) and uptake (80.86 kg/ha and 38.96 kg/ha) in seed and straw, phosphorus content (0.395 and 0.134%) and uptake (8.94 and 4.31 kg/ha) in seed and straw. Among different biofertilizer levels application of Bio NP as seed treatment at the time of sowing followed by drenching of Bio NP at 30 DAS registered significantly higher green biomass yield (925 kg/ha), number of pods/plant (28.31), seed yield (2071 kg/ha), straw yield (2923 kg/ha), pod length (12.16 cm), number of seeds/pod (16.79) test weight(14.10 g), crude protein content of seed (21.93%), nitrogen content (3.51% and 1.19%) and uptake (73.30 and 35.21 kg/ha) by seed and straw and phosphorus content (0.388 and 0.132%) and uptake (8.10 and 3.89 kg/ha) by seed and straw.

Keywords: Fenugreek, biofertilizers, bio NP, seed treatment, drenching

Introduction
Fenugreek commonly known as *methi* (*Trigonella foenum-graecum* L.) belonging to the family *fabaceae* is multipurpose crop being utilized as leafy vegetable, spices, condiments, green fodder and also used sometimes as green manure crop (Khiriya and Singh, 2003) [15]. Methi seeds and leaves are important particularly against the digestive disorders (Sheoran *et al.* 1999) [22]. It is a good source of protein (27.7 to 38.6%), vitamins (A and C), minerals (3.4 to 6.8%), alkaloid trigonellin (0.12 to 0.38%), essential oil (0.02%) and fatty acids. India is the largest producer of fenugreek, where it is the third largest spice after coriander and cumin. In India major fenugreek growing states are Rajasthan, Gujarat, Tamil Nadu, Utter Pradesh, Himachal Pradesh, Madhya Pradesh and Andhra Pradesh. Gujarat is third largest producer of fenugreek in India followed by Madhya Pradesh and Rajasthan. For higher yield and also for quality of seed, optimum supply of nutrient is very important. Altering the soil nutrients and fertilility status by providing balanced and adequate dose of major nutrients like nitrogen phosphorus as per the crop requirement is one of the easiest way to boost up the productivity of fenugreek. Nitrogen is a common plant nutrition which promotes vegetative developments in plant. It plays a key role in the synthesis of chlorophyll and also important for producing herb, folium and seed yield in medicinal and spice plants. It is an essential constituent of compounds like amino acids, protein, nucleic acid, porphyrin, flavin, pyridine, nucleotides, enzyme, coenzymes and alkaloids which contributes to the growth of the plant. The general role of phosphorus in plant metabolism is known to enhance the symbiotic nitrogen fixation, improves grain quality, imparts hardiness to shoot, regulates the photosynthesis, helps root enlargement and governs physic-bio-chemical processes. It participates in metabolic activities as a constituent of nucleoprotein and nucleotides and also plays a key role in the formation of energy rich bond phosphate like Adenosine diphosphate and Adenosine triphosphate (Tisdale *et al.*, 1985) [26].

Using of biofertilizers, healthy plants can be grown, while enhancing the sustainability and health of the soil. Therefore, they are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through microorganism and their byproducts. The seed inoculation with *Rhizobium* has been reported to boost the growth, yield and quality attributes in fenugreek and green gram (Jat and Shaktawat, 2001) [12]. PSB are capable of transforming insoluble phosphorus to soluble form. Inoculation of fenugreek seed with *Rhizobium* and PSB improves growth and yield of fenugreek (Godara *et al.*, 2018) [10]. Keeping all facts in view the present field experiment was planned to test the 'Yield and quality enhancement in fenugreek through fertilizer levels and bio NP'.

Materials and Methods

The field experiment conducted at the College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during *rabi* season of year 2020-2021. The soil of the experimental site was loamy sand with pH 7.97 having 0.38 per cent organic carbon and 189.41, 37.57, and 288.1 kg/ha available N, P_2O_5 and K_2O respectively. The experiment laid out in factorial randomized block design comprising three fertilizer levels *viz.*, 50% RDF, 75% RDF and 100% RDF (20 kg N/ha & 40 kg P_2O_5/ha) and four levels of biofertilizer *viz.*, Control, Seed treatment with Bio NP, Drenching of Bio NP, Seed treatment with Bio NP + Drenching of Bio NP at 30 DAS. The seed of variety Gujarat Methi-2 was sown keeping seed rate of 20 kg/ha. Seeds of fenugreek were sown at row to row spacing of 30 cm. The half dose of nitrogen in the form of urea and entire dose of phosphorus in the form of SSP was applied as basal application as per treatment. Remaining half dose of nitrogen was applied as top dressing at 30 DAS. Bio NP was applied as seed treatment and soil drenching at the time of sowing and at 30 DAS according to treatments. Weeds are controlled by manual hand weeding and interculturing as per need of the crop. Modified AOAC method (Ahuja and Bajaj, 1999) [2] was used for estimation of crude fibre content in fenugreek. Crude protein content of seed was determined by multiplying N content with factor 6.25. The content of N and P in seed and straw was determined by Micro kjeldhal's method and Vanadomolybdate yellow colour (spectrophotometric) method, respectively, which were suggested by Jackson (1973) [11]. The uptake of N and P by seed and straw at harvest in each treatment was computed by multiplying N and P content in seed and straw with the respective seed and straw yield and expressed as kg/ha. Statistical analysis of data was done by procedure prescribed by Cochran and Cox (1967) [6].

Results and Discussion

A. Effect of fertilizer levels

I. Yield and yield attributes

The yield and yield attributes as influenced by different fertilizer levels presented in Table 1. Among the different yield attributes significantly the highest green biomass yield at 30 DAS, number of pods/plant, pod length, number of seeds/pod and test weight recorded with application 100% RDF (20 kg N and 40 kg P2O5 kg/ha). Significant improvement in yield attributes might be due to the fact that the balanced proportion of availability of nitrogen and phosphorus helped to promote the flowering and fruiting by enhanced CO_2 fixation and effective partitioning of assimilates to the reproductive parts which plays vital role in the pod and seed development and hence it had positively reflacted into the seed weight. These results are in close accordance with the findings of Shivran *et al.* (2016) [23], Chaudhary and Chaudhari (2017) [7], Deshmukh *et al.* (2020) [9], Swain *et al.* (2020) [24] and Nair *et al.* (2021) [21]. Significantly the highest seed yield and straw yield recorded with 100% RDF compared to other fertilizer levels might be due to optimum supply of nitrogen and phosphorus which plays crucial role in physiological processes in plant which resulted in increased growth and ultimately resulted in increased yield. These are in conformity with Bhunia *et al.* (2006) [4], Kumar *et al.* (2009) [13], Mehta *et al.* (2012) [16] and Godara *et al.* (2018) [10].

II. Quality parameters

Application 20 kg N/ha and 40 kg P_2O_5/ha of phosphorus (F_3) acquired significantly the highest crude protein content of seed whereas application of 10 kg/ha of nitrogen and 20 kg/ha phosphorus (F_1) registered the lowest crude protein content of seed. Increase in protein percentage in seed might be due to optimum availability of nutrients (N) which are main constituents of protein. These results are supported by Deshmukh *et al.* (2020) [9] in fenugreek and Karnavat *et al.* (2018) [14] in greengram. Crude fiber content in seed of fenugreek was found non-significant under different fertilizer levels.

A perusal of data presented in Table 2 revealed that nitrogen and phosphorus content in seed and straw as well as nitrogen and phosphorus uptake by seed and straw of fenugreek noted at harvest were found significantly the highest in 100% RDF (20 kg N and 40 kg P2O5 kg/ha). Higher dose of application of fertilizers proved worthy in increasing nitrogen and phosphorous content in seed and straw might be due to balanced proportion of nitrogen and phosphorus facilitated more availability of N and P to plant which increased the N and P content in seed and straw. This is in harmony with the findings of Ali *et al.* (2009) [3], Mehta *et al.* (2012) [16], Mahala *et al.* (2015) [20], Ahirwar *et al.* (2016) [1] and Singh *et al.* (2017) [25].

B. Effect of biofertilizer

I. Yield and yield attributes

Among different biofertilizer application method Bio NP as seed treatment at the time of sowing followed by drenching of Bio NP at 30 DAS registered significantly higher green biomass yield, number of pods/plant, pod length, number of seeds/pod, test weight, seed yield and straw yield. They were found at par with treatment B_1 (seed treatment with Bio NP) and B_2 (Drenching of Bio NP). Application of biofertilizer produced higher yield over control might be due biofertilizer which consist *Rhizobium* and PSB are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through symbiotic nitrogen fixing and transforming insoluble phosphorus to soluble form, as a result nitrogen and phosohorus increased all growth and development of plant which eventually helps in increase the growth, yield attributes and yield. These results are in compliance with Ali *et al.* (2009) [3], Mehta *et al.* (2012) [17], Meena *et al.* (2014) [19], Chaudhary and Chaudhari (2017) [7], Godara *et al.* (2018) [10] and Nair *et al.* (2021) [21].

II. Quality parameters

Data displayed in Table 2 on crude protein content of seed affected by different treatments of biofertilizer revealed that treatment B_3 (Seed treatment with Bio NP + Drenching of Bio NP at 30 DAS) registered significantly higher crude protein content of 21.93% which was remained at par with treatment B_1 (Seed treatment with Bio NP) and B_2 (Drenching of Bio NP). Result manifested that application of Bio NP which contains *Rhizobium* and PSB procured higher protein content in seed as compare to control might be due to *Rhizobium* fix atmospheric nitrogen and PSB solubilize the fixed phosphorus, ultimately increased the availability of nitrogen and phosphorus to plant which accelerated the synthesis of protein. These results are in concurrence with the findings of Banker *et al.* (2018) in garden pea and Mir *et al.* (2013) [18] in black gram. Crude fiber content in seed of fenugreek was found non-significant under different treatment of biofertilizer.

Significantly higher nitrogen and phosphorus content in seed and straw as well as nitrogen and phosphorus uptake by seed and straw were noted in treatment B_3 (Seed treatment of Bio NP + Drenching of Bio NP at 30 DAS) but it was failed to create any significant superiority over treatment B_1 (Seed treatment with Bio NP) and B_2 (Drenching of Bio NP). The observed differences between the control (no application of biofertilizer) and treatments of biofertilizer application on content and uptake of nitrogen and phosphorus by plant could be attributed to the availability of nitrogen improved by *Rhizobium* and phosphorus availability improved by PSB. These results are in concurrence with the findings of Mehta *et al.* (2012) [17] Mir *et al.* (2013) [18], Mahala *et al.* (2015) [20] and Singh *et al.* (2017) [25].

Table 1: Seed yield, straw yield and quality of fenugreek as influenced by fertilizer levels and biofertilizer

Treatments	Green biomass yield at 30 DAS (kg/ha)	Number of pods/plant	Pod length (cm)	Number of seeds/pod	Seed yield (kg/ha)	Straw yield (kg/ha)	Test weight (g)
Fertilizer levels							
F_1: 50% RDF (10:20:00 NPK kg/ha)	658	22.42	9.86	12.03	1602	2249	12.85
F_2: 75% RDF (15:30:00 NPK kg/ha)	922	26.06	10.99	14.05	1956	2826	13.70
F_3: 100% RDF (20:40:00 NPK kg/ha)	1057	30.04	12.16	16.79	2259	3198	14.42
S.Em±	19	0.67	0.20	0.33	46	65	0.21
CD (P=0.05)	56	1.96	0.58	0.98	135	190	0.62
Biofertilizer							
B_0: Control	791	23.34	9.95	12.82	1737	2511	12.96
B_1:Seed treatment with Bio NP (5ml/kg seed)	916	26.78	11.39	14.68	1981	2809	13.80
B_2: Drenching of Bio NP (1 lit/ha)	884	26.26	10.86	14.03	1968	2788	13.78
B_3: B_1+ Drenching of Bio NP at 30 DAS	925	28.31	11.82	15.63	2071	2923	14.10
S.Em±	22	0.77	0.23	0.38	53	75	0.25
CD (P=0.05)	64	2.27	0.67	1.13	156	220	0.72
F×B	NS	NS	NS	NS	NS	NS	NS
CV(%)	7.52	8.87	6.30	8.15	8.23	8.16	5.56

Table 2: Nitrogen and phosphorus content and uptake by seed and straw as influenced by fertilizer levels and biofertilizer

Treatments	Crude protein content (%)	Crude fiber content (%)	N content (%)		P content (%)		N uptake (kg/ha)		P uptake (kg/ha)	
			Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
Fertilizer levels										
F_1: 50% RDF (10:20:00 NPK kg/ha)	20.05	16.04	3.21	1.09	0.354	0.120	51.46	24.59	5.59	2.72
F_2: 75% RDF (15:30:00 NPK kg/ha)	21.13	16.16	3.38	1.15	0.374	0.127	66.61	32.68	7.36	3.61
F_3: 100% RDF (20:40:00 NPK kg/ha)	22.36	16.12	3.58	1.21	0.395	0.134	80.86	38.96	8.94	4.31
S.Em±	0.34	0.27	0.05	0.02	0.005	0.002	2.02	0.99	0.22	0.11
CD (P=0.05)	1.00	NS	0.16	0.05	0.017	0.006	5.93	2.92	0.65	0.32
Biofertilizer										
B_0: Control	20.11	15.67	3.20	1.09	0.355	0.121	56.45	27.75	6.24	3.07
B_1:Seed treatment with Bio NP (5ml/kg seed)	21.47	16.24	3.44	1.16	0.380	0.129	68.44	33.01	7.57	3.65
B_2: Drenching of Bio NP (1 lit/ha)	21.29	16.01	3.39	1.16	0.375	0.128	67.04	32.33	7.41	3.57
B_3: B_1+ Drenching of Bio NP at 30 DAS	21.93	16.51	3.51	1.19	0.388	0.132	73.30	35.21	8.10	3.89
S.Em±	0.39	0.32	0.06	0.02	0.006	0.002	2.33	1.15	0.25	0.12
CD (P=0.05)	1.16	NS	0.18	0.06	0.019	0.006	5.84	3.37	0.75	0.37
F×B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	5.58	6.01	5.58	5.6	5.45	5.58	10.55	10.76	10.55	10.76

Conclusion

On the basis of results obtained from present experiment, it can be stated that for accruing higher seed yield from fenugreek crop (*cv.* GM 2) and for higher quality seed and straw, crop should be fertilized with 20 kg nitrogen and 40 kg phosphorus per hectare and application of biofertilizer either as a seed treatment with Bio NP (5 ml/kg seed) or drenching of Bio NP (1 lit/ha) at the time of sowing or both seed treatment with Bio NP (5 ml/kg seed) and drenching of Bio NP (1 lit/ha) at 30 DAS will provide better yield in middle Gujarat condition.

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