Biological Forum – An International Journal **14(2): 166-170(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Phosphorus and Sulphur Fertilization on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.)

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(Received 19 January 2022, Accepted 27 March, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Fenugreek is an annual spices herb of the sub-family Papilionaceae of Leguminaceae family. Fenugreek is herbaceous annual whose seeds contain proteins and a range of vitamins. Its seeds also contain different amounts of nutrients, most important like iron, calcium, phosphorus, potassium and other mineral elements. The research on phosphorus and sulphur in fenugreek was need of the hour in Saurashtra region of Gujarat. To decide as well as to evaluate the potential productivity of fenugreek in Gujarat state through phosphorus and sulphur fertilization. Keeping all these points in view, a field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* 2016-17 to study the effect of phosphorus and sulphur fertilization on growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.). The experiment was laid out in a factorial randomized block design with three replications. Treament combinations includethree levels of phosphorus (0, 20 and 40 kg P_2O_5 ha^{-1}) and three levels of sulphur (0, 20 and 40 kg S ha^{-1}). Among the different levels of phosphorus, application of 40 kg P_2O_5 ha^{-1} (P_2) registered significantly higher growth parameters, yield attributes and yield. In case of different levels of sulphur, Application of 40 kg S ha^{-1} (S_2) resulted in significantly higher growth parameters, yield attributes and yield but yield attributes were statistically at par with treatment S_1 (20 kg S ha^{-1}). The interaction effect of levels of phosphorus and sulphur was found non-significant in all the parameters recorded during an investigation.

Keywords: Fenugreek, Phosphorus, Sulphur, Growth, Yield.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is an annual spices herb of the subfamily Papilionaceae of Leguminaceae family. Fenugreek is commonly known as *methi*. It is a multipurpose crop being utilized as leafy vegetable, spices, condiments, green fodder and also used sometimes as green manure crop (Khiriya and Singh, 2003). The genus ‘Trigonella’ comes from Latin, meaning ‘little tringle’ in reference to the triangle shape of the flower (Rosenngarten, 1969). Since antioxidant properties have been linked to health benefits of natural products, such properties were studied in germinated fenugreek seeds which are considered to be more beneficial than dried seeds (Dixit *et al.*, 2005). Methi seeds and leaves are important particularly against the digestive disorders (Sheoran *et al.* 1999). Fenugreek (*Trigonella foenum - graecum* L.) is herbaceous annual whose seeds contain proteins (25-36% of the dry weight of the plant) and a range of vitamins (Mehrafarin *et al.*, 2011). Its seeds also contain different amounts of nutrients, most important like iron, calcium, phosphorus, potassium and other mineral elements (Ali *et al.*, 2012). The spices name “*foenum-graecum*” means “Greek hay” indicating its use as a forage crop in the past. Fenugreek is widely cultivated in warm temperate and tropical regions of the Mediterranean, Europe and Asia. Fenugreek is cultivated worldwide under semi-arid agro-climatic conditions having potential to fix atmospheric nitrogen and tolerant to mild salinity (Habib *et al*., 1971). 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 nutrients is very important. Altering the soil nutrients and fertility status by providing balanced and adequate dose of major nutrients like nitrogen phosphorus as per the crop requirement is one of the easiest ways to boost the productivity of fenugreek. The general role of phosphorus in plant metabolism is known to enhance the symbiotic nitrogen fixation, improve grain quality, imparts hardiness to shoot, regulate 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 phosphates like Adenosine diphosphate and Adenosine triphosphate (Tisdale *et al.*, 1995). Sulphur plays an important role in enhancing the productivity and quality of legumes by providing a proper nutritional environment in the soil (Lal *et al.*, 2015). Sulphur being the constituent of some amino acids promotes the biosynthesis of protein. The application of sulphur is a key component of modern pulse production technology. The importance of sulphur in balance plant nutrition is realized with increasing sulphur deficiency in several areas due to intensive agriculture, less addition of organic manures and extensive use of sulphur free fertilizers. The judicious use of phosphorus and sulphur fertilizer in cropland results in increased growth, yield, nutritive quality and soil fertility. Especially its nutritive requirements for fenugreek in medium black calcareous soil of Saurashtra region in *rabi* season is low to medium. At present area of fenugreek increase in the Saurashtra region.

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during rabi 2016-17 to study the effect of phosphorus and sulphur fertilization on growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.). The experiment was laid out in factorial randomized block design with three replications. Treatment combinations include three levels of phosphorus (0, 20 and 40 kg P_2O_5 ha^{-1}) and three levels of sulphur (0, 20 and 40 kg S ha^{-1}). The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH 7.9 and EC 0.38 dS m^{-1} and organic carbon 0.62 %. The soil was low in available nitrogen (241 kg ha^{-1}) and available phosphorus (31.60 kg $^{-1}$ ha), while medium in available potash (245.36 kg ha^{-1}) and low in available sulphur (11 ppm). The seed of variety Gujarat Methi-2 was sown keeping seed rate of 25 kg/ha. Seeds of fenugreek were sown at row to row spacing of 30 cm. The crop was uniformly fertilized with 20 kg N ha^{-1} nitrogen in the form of urea and full dose of phosphorus in the form of di-ammonium phosphate applied as a basal application as per treatment and sulphur in the form of cosavet (90% S) as per treatment just before sowing. Weeds are controlled by manual hand weeding and interculturing as per need of the crop. The observation recorded for growth parameter, yield and other characters were put to statistical analysis in accordance with the analysis of variance techniques as suggested by Fisher (1950) for randomized block design (Factorial).

RESULTS AND DISCUSSION

A. Effect of Phosphorus Levels

Growth Parameters. Growth of plant can be measured vertically in terms of plant height and horizontally in terms of number of branches (primary and secondary). The data pertaining to plant height as affected by different levels of phosphorus on different dates of observation are depicted in Table 1. Among the different levels of phosphorus, application of 40 kg P_2O_5 ha^{-1} (P_2) registered significantly higher plant height 14.78cm, 42.07 cm and 62.67 cm at 30 DAS, 60 DAS and at harvest, respectively. While significantly the lowest plant height was recorded under control (0 kg P_2O_5 ha^{-1}). Application of phosphorus @ 40 kg ha^{-1} (P_2) was recorded significantly higher primary (7.52) and secondary branches (11.60) per plant at harvest and it was statistically at par with 20 kg P_2O_5 ha^{-1} (P_1) with the value of 6.86 and 10.90, respectively. The data pertaining today to 50% floweringshowed that the different levels of phosphorus did not exerted their significant effect.Increased endogenous level of P in plant by virtue of its increased availability in the soil medium and there after efficient absorption and translocation in various growth by way of active cell division and elongation resulting in greater plant height, number of primary and secondary branches.

The improvement in morphological parameters under the influence of phosphorus application might have resulted in larger canopy development and presumably higher chlorophyll content of leaves as nutrient actively participate in its formation. Similar trend in results was also found by Jat (2004); Meena *et al*. **(**2012**)**; Mehta *et al*. (2012); Kumar *et al*. (2015) in coriander, Ali *et al*. (2016); Godara *et al.* (2018); Nair *et al.* (2021).

Yield and yield attributes. The effect of different levels of phosphorus on the yield attributes and yield is mentioned in Table 2. Various yield attributing characters like as number of pods per plant, number of seeds per pod, length of pod (cm) and test weight (g) were influenced by the application of the different levels of phosphorus. Significantly higher number of pods per plant, number of seeds per pod, length of pods and test weight were recorded under application of 40 kg P_2O_5 $ha^{-1}$and found statistically at par with application of 20 kg P_2O_5 ha^{-1}in case of test weight.

Seed and stover yield were significantly influenced by different levels of phosphorus. Application of 40 kg P_2O_5 ha^{-1} recorded significantly higher seed and stover yields. Because of the outside supply of phosphorus to the soil deficient in phosphorus might have accelerated various physiological processes in plants favoring increased seed and stover yields of crop. The increase in seed yield due to phosphorus application might be attributed to a better source and sink relationship in terms of greater translocation of food material to yield attributing parts. It appears that greater translocation of photosynthates from source to sink (seed) might have increased the seed yield.

Table 1: Growth parameters as influenced by different levels of phosphorus and sulphur.

Treatments	Plant Height (cm)			Number of branches per plant		Days to 50 % Flowering
	30 DAS	60 DAS	At harvest	Primary	Secondary	
Phosphorus Levels (P)						
P_0= 0 kg ha^{-1}	11.40	32.07	52.73	5.79	10.17	42.78
P_1= 20 kg ha^{-1}	13.20	36.53	57.22	6.86	10.90	41.78
P_2= 40 kg ha^{-1}	14.78	42.07	62.67	7.57	11.60	42.22
S.Em±	0.32	0.89	1.05	0.22	0.27	0.96
CD (P=0.05)	0.96	2.68	3.16	0.65	0.80	NS
Sulphur Levels (S)						
S_0= 0 kg ha^{-1}	12.52	35.30	55.29	6.36	10.32	41.89
S_1= 20 kg ha^{-1}	13.10	36.69	58.17	6.67	11.07	42.67
S_2= 40 kg ha^{-1}	13.75	38.69	59.17	7.18	11.29	42.22
S.Em±	0.32	0.89	1.05	0.22	0.27	0.96
CD (P=0.05)	0.96	2.68	3.16	0.65	0.80	NS
Interaction						
P×S	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV(%)	7.32	7.26	9.59	7.34	8.23	6.83

So, ultimately increase the seed and stover yield of fenugreek. Similar results were found by Bairagi (2014); Koyani *et al*. (2014) in fennel, Sharma *et al.* (2014); Srivastava *et al*. (2014); Abha and Sharma (2016) in fennel and Mishra *et al*. (2016) in coriander Godara *et al.* (2018); Nair *et al.* (2021).

B. Effect of Sulphur

Growth Parameters. In case of different level of sulphur, Application of 40 kg S ha^{-1} (S_2) resulted in significantly higher plant height at 30, 60 DAS and harvest 13.75, 38.69, 59.17 cm, respectively but it was statistically at par with S_1 (20 kg S ha^{-1}). Application of 40 kg S ha^{-1} (S_2) produced significantly higher number of primary (7.18) and secondary branches (11.29) per plant. Sulphur levels proved significant in improving growth parameters. Sulphur application promoted chlorophyll synthesis which, in turn, increases dry matter production. Sulphur increased meristematic tissue activity resulting in the taller plant at higher sulphur levels. Leaf formation depends on tissue differentiation and expansion. Sulphur is a constituent of three essential amino acids *viz.*, cystine, cysteine and methionine. It resembles N in its capacity to enhance cell division, cell elongation and tissue differentiation. Thus, sulphur fertilization has improved all the growth parameters. Similar results were also reported by Tuncturk *et al.* (2011); Lal *et al.* (2014); Verma *et al.* (2014); Meena *et al.* (2015); Boori *et al.* (2017); Solanki *et al.* (2017); Suthar and Kukreja (2021).

Yield and yield attributes. The number of pods per plant, number of seeds per pod, length of pod, seed yield, stover yield and test weight are shown in Table 2. Most of the yield attributing characters were found significant under application of 40 kg S ha^{-1} (S_2) and it is statistically at par with 20 kg S ha^{-1} (S_1). Because sulphur has increased availability of the other nutrients like nitrogen, phosphorus etc. higher sulphur dose was responsible for increased leaf area and chlorophyll content of leaves causing higher photosynthesis and assimilation, metabolic activities which were responsible for overall improvement in yield attributes and finally seed yield of fenugreek. The increase in seed yield might be attributed to increase in number of pods per plant, number of seeds per pod, length of pod and test weight of seeds. Sulphur is mainly responsible for enhancing the reproductive growth and the proportion of reproductive tissues. The total dry matter (seed + stover) yield followed similar trends as in case of seed and stover yields. The increase in yield due to application of sulphur might be due to better metabolism and increased efficiency of the other nutrients. Manohar *et al.* (2014) reported that significant response of 40 kg S ha^{-1} in seed and stover yields of fenugreek. This may be attributed to the increasing levels of S which resulted in greater accumulation of carbohydrates, protein and their translocation to the productive organs, which in turn improved all the growth and yield attributing characters resulted in more seed yield. The results are in conformity with the finding of Bochalia *et al.* (2011); Ruveyde and Murat (2011); Patel *et al.* (2013); Ramkishor *et al.* (2015; Meena *et al*. (2017); Suthar and Kukreja (2021).

C. Interaction Effect

Data from present investigation revealed that the interaction effect of levels of phosphorus and sulphur was found non-significant with respect to all the parameters under the study.

Table 2: Yield attributes and yield as influenced by different levels of phosphorus and sulphur.

Treatments	Length of pod (cm)	No. of pods per plant	No. of seeds per pod	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Phosphorus Levels (P)								
P_0= 0 kg ha^{-1}	10.05	19.00	10.21	15.87	1096	2626	3750	29.34
P_1= 20 kg ha^{-1}	10.88	19.73	11.15	16.31	1302	2967	4276	30.43
P_2= 40 kg ha^{-1}	12.40	20.01	13.14	17.76	1565	3273	4875	32.02
S.Em±	0.31	0.36	0.30	0.50	41.1	60.5	78.36	0.77
CD (P=0.05)	0.94	1.09	0.88	1.49	123	181	235	NS
Sulphur Levels (S)								
S_0= 0 kg ha^{-1}	10.46	19.02	10.93	15.02	1162	2838	4000	29.12
S_1= 20 kg ha^{-1}	11.03	20.00	11.49	16.03	1336	2946	4317	30.78
S_2= 40 kg ha^{-1}	11.84	21.00	12.08	16.92	1492	3082	4575	32.63
S.Em±	0.31	0.36	0.30	0.50	41.10	60.52	78.36	0.77
CD (P=0.05)	0.94	1.09	0.88	1.49	123	181	235	NS
Interaction								
P×S	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	8.46	7.92	7.70	9.34	9.33	6.14	5.47	7.50

CONCLUSION

Based on the one year field experiment results obtained from present experiment, it can be stated that good growth and higher seed yield from fenugreek crop (cv. Gujarat Methi-2) can be obtained by the application of 40 kg P_2O_5 ha^{-1} with RDN (20 kg N ha^{-1}) and also 40 kg S ha^{-1} with RDN (20 kg N ha^{-1}) in the medium black calcareous soil of South Saurashtra Agro-climatic Zone of Gujarat.

Acknowledgment. Financial support for the research study was provided by Junagadh Agricultural University, Junagadh, Gujarat under the master research project during the research carried out in the university as a part of academic. Authors are thankful to the principal and dean of the Junagadh Agricultural University for their kind support and to department of soil science and agricultural chemistry for chemical analysis and to department of statistics for statistical analysis.
Conflict of Interest. None.

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How to cite this article: Nitesh Baldaneeya, J.M. Modhvadia, P.M. Parmar and V.N. Raiyani (2022). Effect of Phosphorus and Sulphur Fertilization on Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.). *Biological Forum – An International Journal*, *14*(2): 166-170.