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Influence of phosphorus and sulphur levels on nutrient content uptake and quality of fenugreek

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Abstract
Background: 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.).
Method: The experiment was laid out in factorial randomized block design with three replications. Treatment combinations includes 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}).
Result: Among the different levels of phosphorus, application of 40 kg P_2O_5 ha^{-1} recorded significantly higher seed, stover and biological yield. Application of 40 kg P_2O_5 ha^{-1} recorded significantly higher protein yield. N, K and S content in seed and stover was found non-significant, while phosphorus content in seed (0.54%) and stover (0.29%) was significant under the application of 40 kg P_2O_5 ha^{-1}, it also recorded significantly higher uptake of NPK and S by seed and stover. Significantly higher seed, stover and biological yield were recorded under application of 40 kg S ha^{-1}. Application of 40 kg S ha^{-1} recorded significantly higher protein yield, S content in seed and stover and maximum uptake of P and S by stover.

Keywords: Fenugreek, phosphorus, sulphur, quality, yield

Introduction
Fenugreek commonly known as *methi.* It is multipurpose crop being utilized as leafy vegetable, spices, condiments, green fodder and also used sometimes as green manure crop (Khiriya and Singh, 2003) [3]. 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) [6]. Methi seeds and leaves are important particularly against the digestive disorders. 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) [17]. Its seeds also contain different amounts of nutrients, most important like iron, calcium, phosphorus, potassium and other mineral elements (Ali *et al.*, 2012) [2]. 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 region 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) [8]. 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 fertility 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. 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. Sulphur plays an important role in enhancing the productivity and quality of legumes by providing proper nutritional environment in the soil (Lal *et al.*, 2015) [13].

Sulphur being the constituent of some amino acids, promotes the biosynthesis of protein. 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 crop land result 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 Saurashtra region. Keeping all these points in view, the present research on "Response of fenugreek (*Trigonella foenum- graecum* L.) to phosphorus and suphur fertilization " was undertaken.

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. Treament combinations includes 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. 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) [9]. 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. Potash was extracted by diacid digestion and then determined by Flame photometer method (Jackson, 1973) [9]. Sulphur content in plant was determined on per cent dry weight basis as per method of turbidimetry method as described by Willians and Steinberg (1959) [31].

Results and Discussion

A. Effect of phosphorus levels

1. Yield of Fenugreek

Effect of different levels of phosphorus on the yield is mentioned in the Table 1. 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 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. So, ultimately increase the seed and stover yield of fenugreek. Similar result found by Bairagi (2014) [3], Sharma *et al.* (2014) [24], Srivastava *et al*. (2014) [26], Abha and Sharma (2016) [1] in fennel and Mishra *et al*. (2016) [18] in coriander Godara *et al.* (2018) [7] and Nair *et al*. (2021) [20].

Table 1: Yield and protein content as influenced by different levels of phosphorus and sulphur

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein Content in seed (%)	Protein Yield (Kg ha^{-1})
Phosphorus Levels (P)					
P_0= 0 kg ha^{-1}	1096	2626	3750	21.25	232.5
P_1= 20 kg ha^{-1}	1302	2967	4276	22.30	290.9
P_2= 40 kg ha^{-1}	1565	3273	4875	23.71	378.5
S.Em±	41.1	60.5	78.36	0.65	15.8
CD (P=0.05)	123	181	235	**NS**	47.4
Sulphur Levels (S)					
S_0= 0 kg ha^{-1}	1162	2838	4000	22.14	257.5
S_1= 20 kg ha^{-1}	1336	2946	4317	22.43	302.1
S_2= 40 kg ha^{-1}	1492	3082	4575	22.68	342.3
S.Em±	41.10	60.52	78.36	0.65	15.8
CD (P=0.05)	123	181	235	**NS**	47.4
Intercation					
P×S	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	9.33	6.14	5.47	8.74	15.77

2. Quality parameters

Application of 40 kg P_2O_5 ha^{-1} recorded the highest protein content (23.72%) and protein yield (378.51 kg ha^{-1}). Whereas, the lowest protein content (22.30%) and protein yield (232.48 kg ha^{-1}) were recorded under no application phosphorus (Control). Similar results was found by Dar *et al.* (2015) [4], Muvel *et al*. (2015) [19] and Shiurkar *et al*. (2016) [25]. N, P, K and S content in seed and stover were presented in the Table 2. It can be seen from Table that there is no any significant effect of different levels of phosphorus on the N, K and S content in seed and stover. Phosphorus content in seed significantly influenced by application of 40 kg P_2O_5 ha^{-1}. Similar result was found by Kumar (2015) [12], Abha and Sharma (2016) [1] and Patil *et al.* (2008) in fenugreek. Significantly the higher P uptake by seed as well as stover was recorded under the application of 40 kg P_2O_5 ha^{-1}. It may

be due application of phosphors marked improvement in nitrogen and phosphorus content and their uptake. The release of nutrient in soil solution depends upon intensity and capacity of soil to supply these nutrients. Adequate supply of nutrient increased nitrogen and phosphorus content for their effective uptake. This result is similar with a finding of, Deora and Singh (2008) [5], Tarun and Sachan (2009) [27] and Meena *et al*. (2012) [16] in fenugreek.

Table 2: NPK and S content and uptake in seed and stover as influenced by different levels of phosphorus and sulphur

Treatments	Nitrogen Content (%)		Phosphorus Content (%)		Potassium Content (%)		Sulphur content (%)		Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})		Sulphur uptake (kg ha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
Phosphorus Levels (P)																
P_0= 0 kg ha^{-1}	3.40	2.15	0.39	0.24	0.60	0.54	0.31	0.19	37.20	63.21	4.23	7.11	6.60	15.13	3.35	5.89
P_1= 20 kg ha^{-1}	3.57	2.35	0.49	0.27	0.64	0.56	0.32	0.20	46.55	69.89	6.45	7.96	8.28	16.66	4.10	6.07
P_2= 40 kg ha^{-1}	3.79	2.46	0.54	0.29	0.68	0.59	0.32	0.21	59.46	80.46	8.43	9.37	10.66	19.28	4.96	6.87
S.Em±	0.10	0.08	0.02	0.01	0.02	0.02	0.01	0.00	2.12	2.99	0.26	0.24	0.35	0.61	0.15	0.19
CD (P=0.05)	NS	NS	0.05	0.03	NS	NS	NS	NS	6.35	8.96	0.78	0.73	1.04	1.82	0.46	0.57
Sulphur Levels (S)																
S_0= 0 kg ha^{-1}	3.54	2.25	0.45	0.25	0.63	0.55	0.30	0.20	41.15	64.26	5.23	7.21	7.32	15.68	3.48	5.64
S_1= 20 kg ha^{-1}	3.59	2.34	0.48	0.26	0.64	0.56	0.31	0.20	48.34	69.10	6.52	7.83	8.60	16.60	4.08	5.92
S_2= 40 kg ha^{-1}	3.63	2.38	0.49	0.28	0.65	0.57	0.33	0.21	54.19	73.58	7.31	8.55	9.70	17.75	4.93	6.62
S.Em±	0.10	0.08	0.02	0.01	0.02	0.02	0.01	0.00	2.12	2.99	0.26	0.24	0.35	0.61	0.15	0.19
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.02	0.01	6.35	**NS**	0.78	0.73	1.04	NS	0.46	0.57
Interaction																
P×S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	8.74	10.71	9.88	10.82	9.85	8.14	6.72	6.30	13.31	12.99	12.32	9.33	12.24	10.93	11.13	9.34

B. Effect of sulphur

1. Yields of Fenugreek

Significantly higher seed, stover and biological yield were recorded under application of 40 kg S ha^{-1}. Sulphur is mainly responsible for enhancing the reproductive growth and the proportion of the reproductive tissues. The total dry matter (seed + stover) yield followed the 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. Beneficial effect of sulphur on yield attributes might be due to better availability of N, P and S and their translocation which reflects in terms of increased yield attributes of the crop. 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 more seed yield. The results are in conformity with the finding of Pate *et al.* (2013) [21], Manohar *et al*. (2014) [14], Meena *et al*. (2017) [17] and Ramkishor *et al.* (2015) [22].

2. Quality parameters

The data on protein content present in Table 1. showed that the different levels of sulphur did not showed any significant effect on protein content. Amongst the different levels of sulphur, 40 kg S ha^{-1} was recorded significantly higher protein yield. Non-significant protein content in seed is mainly due to lower content of nitrogen found in seed. Because protein content is mainly depend upon the nitrogen content. The results are in close conformity with the findings of Tuncturk *et al.* (2011) [29] and Patel *et al.* (2013) [21]. N, P, K, S content in seed and stover were represented in the Table 2. Different levels of sulphur did not cause any significant effect on the N, P and K content in seed. While S content in seed and stover was found significant. Different levels of sulphur produced the significant effect on the N, P, K and S uptake by seed and stover, except N and K uptake by stover. Application of 40 kg S ha^{-1} recorded significantly higher uptake of N, P, K and S by seed. Balanced nutrition had led to the higher seed and stover yield, so uptake of this nutrient is increased. This result is in conformity with the finding of Tripathi (2006) [28] and Vidyathi *et al*. (2011) [30].

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.

Conclusion

Based on the one year field experiment results obtained from present experiment, it can be stated that for obtaining higher seed yield from fenugreek crop (*cv.* GM 2) and for higher quality seed and straw, crop should be fertilized with 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 calcarious soil of South Saurashtra Agro-climatic Zone of Gujarat.

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