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Research Article

EFFECT OF PHOSPHORUS AND SULPHUR ON SOIL FERTILITY, NUTRIENT BALANCE AND PRODUCTIVITY OF FENUGREEK

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Abstract- Field experiment on fenugreek (*Trigonella foenum*-graecum L.) was carried out in the clay loam soil under agro ecological zone "Northern Plain and Central Highlands including Aravallis" at Research Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during the *rabi* season of 2010-11. The objective of the study was to determine the effect of phosphorus and sulphur on soil fertility, nutrient balance and productivity of fenugreek in Southern Rajasthan. The experiment was laid out in Factorial Randomized Block Design (FRBD) with four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) with three replications. The results revealed that application of 60 kg P_2O_5 ha^{-1} significantly affected total chlorophyll content, grain, haulm and protein yield of fenugreek over its lower levels but did not significantly differ with 40 kg P_2O_5 ha^{-1} with respect to chlorophyll content and haulm yield. It was also recorded significant improvement in phosphorus content in soil and enhanced nutrient balance after harvest of crop over rest of the treatments. Application of sulphur at 45 kg ha^{-1} significantly improved total chlorophyll content as well as grain, haulm and protein yield as compared to other remaining levels of sulphur. Furthermore, it was significantly influenced the sulphur content in soil after harvest of crop and also improved the nutrient balance in soil. However, it was statistically identical with 30 kg S ha^{-1} in respect to sulphur content in soil. Hence, application 60 kg P_2O_5 ha^{-1} as well as 45 S kg ha^{-1}, was found to be the best treatment as sustaining the higher productivity of fenugreek with improvement in soil fertility and nutrient balance in Southern Rajasthan.

Keywords- *Phosphorus, Sulphur, Fenugreek, Nutrient balance, Productivity and Soil fertility*

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Introduction

Fenugreek (*Trigonella foenum*-graecum L.) vernacularly known as methi is an annual spice multipurpose crop grown during winter season in northern India. It is herbaceous annual self pollinated crop which belong to sub family papilionaceae of the family leguminoceae. Both leaves and seeds of fenugreek are extensively used for medicinal purpose as traditional medicine for diabetes, indigestion, lipids elevation and edema (fluid retention) of the legs. Fresh tender pods and leaves of fenugreek are rich in iron, calcium, vitamins A and C. Fenugreek is also used as a leafy vegetable. It has high proportion of protein (20-30%) as well as amino acids. Among amino acids, 4-hydroxyisoleucine has high potential as insulin stimulating agent [21]. Fenugreek is a good soil renovator having property of nitrogen fixation and is widely used as green manure crop [2]. Fenugreek occupies prime place amongst the seed spices grown in northern India particularly in Rajasthan. In Rajasthan the area under fenugreek is 157004 ha with production of 190362 tonnes and the productivity is 1212 kg ha^{-1} [11]. The fenugreek productivity is much lower to potential yield thus revealing greater chances of productivity enhancement in the country. Among various agronomical, physiological and genetic constraints behind the lower productivity, inadequate and imbalanced fertilization occupy important place. One of the important factors responsible for its low yield is no or inadequate use of plant nutrients particularly phosphorus and sulphur. Fenugreek, being a pulse crop requires high amount of phosphorus (P). Phosphorus plays a key role in photosynthesis, metabolism of sugars, energy storage and transfer, cell division, cell enlargement, transfer of genetic information, root growth, nodulation and nitrogen fixation in plants. It serves as "energy currency" within plants and helps in root development and grain formation. Sulphur is the second most important plant nutrient after phosphorus for grain legumes. Sulphur has a profound influence on protein synthesis because it is constituting the main element of amino acids such as cystein, cystine and methionine. Wide spread S deficiency have been observed on larger areas due to use of high analysis S free fertilizers like urea and di-ammonium phosphate in high yielding varieties and intensive cropping, and is more conspicuous in light textured soils which low in organic matter [23]. Keeping these views in consideration, the investigation on the performance of fenugreek under different levels of phosphorus and sulphur was carried out for maximization of yield and improve soil fertility status.

Materials and methods

Field experiment described here was conducted at Instruction Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India during *rabi* season of 2010-11. The experimental site is located at an altitude of 582.17 m above mean sea level with the geographical location of 24°35' N latitude and 72°42' E longitude in the step foot of Aravali hills. The soil of the experimental field was clay loam in texture having pH 8.2, medium in organic carbon (0.7%), available phosphorus (20.1 kg ha^{-1}), high in available potassium (326.0 kg ha^{-1}), low in available nitrogen (277.0 kg ha^{-1}) and available sulphur (8.7 kg ha^{-1}). Experiment was carried out in factorial randomized block design with three replications.

There were 16 treatment combinations consisting of four levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}) and four levels of sulphur (0, 15, 30 and 45 kg ha^{-1}). Phosphorus and sulphur fertilizers were applied as per treatments at the time of sowing. N, P_2O_5, and S were applied through urea, di-ammonium phosphate (DAP) and gypsum, respectively. The seed was inoculated with Rhizobium and PSB at the rate of 5 g kg^{-1} seed each by slurry method. The fenugreek seed of variety Rmt^{-1} was sown in lines at 30 cm apart on November 15, 2010 using a seed rate of 25 kg ha^{-1}. The yield parameters and yield were recorded at harvesting stage (133 DAS) of plant. The soil sample from surface depth (0-15cm) were taken from each experimental plot after harvest of crop and analysed for chemical properties as per standard procedures. The soil sample was analyzed for pH in 1:2 soil water suspension using glass electrode and organic carbon by Walkley and Black [26]. The soil samples were analyzed for available N [25], available P [17] and available K [15] and available S [5]. The Total chlorophyll content was extracted by 80 percent acetone and determined calorimetrically method [3] and expressed as mg g^{-1} of fresh leaf weight. The protein content of seed was estimated by multiplying nitrogen content of seed with conversion factor of 6.25 [1]. The Statistical analysis of the data was done as per the methodology described by Gomez and Gomez [10].

Result and Discussion

Chlorophyll content

Phosphorus and sulphur had significant impact on total chlorophyll content in leaf at 60 DAS [Table-1]. Increasing level of phosphorus up to 40 kg P_2O_5 ha^{-1} was recorded significantly higher chlorophyll content over lower levels (control and 20 kg P_2O_5 ha^{-1}). The increment was 11.90 and 6.21 percent over control and 20 kg P_2O_5 ha^{-1}, respectively. However, it was failed to record any significant improvement over 40 kg P_2O_5 ha^{-1}. The result is in conformity with those of Sharma *et al*. [22], Nyoki and Ndakidemi [16] and Pingoliya *et al*. [20]. Data also indicated that total chlorophyll content was improved by sulphur fertilization. Application of 45 kg S ha^{-1} recorded the maximum chlorophyll content (1.89 mg g^{-1} fresh weight) which was significantly higher by 12.50, 7.38 and 3.27 percent over control, 15 and 30 kg S ha^{-1}, respectively. Similar results have been reported by Yadav *et al*. [27] and Patra *et al*. [18].

Protein content

The percentage of seed protein content of fenugreek did not affect significantly by application of both phosphorus and sulphur levels are presented in [Table-1]. However, phosphorus 60 kg P_2O_5 ha^{-1} recorded the highest protein content (20.29%) and lowest was in control (19.31%). Among the sulphur levels, 45 kg S ha^{-1} recorded highest value of seed protein content (20.24%) and lowest was recorded in the control (19.27%).

Yield

Application of phosphorus and sulphur at different levels had significant effect on yield of fenugreek [Table-1]. As regards to phosphorus levels, use of phosphorus at 60 kg P_2O_5 ha^{-1} significantly recorded the maximum grain yield (1689 kg ha^{-1}) then those produced in lower levels and registered significant increase of 51.88, 17.29 and 4.77 percent over control, 20 and 40 kg P_2O_5 ha^{-1}, respectively. This confirms the findings of Jat *et al*. [13] and Datta *et al*. [8]. The grain yield of fenugreek increased significantly by the successive dose of added sulphur. Application 45 kg S ha-1 produced the significantly higher grain yield (1668 kg ha^{-1}) by 39.46, 19.05 and 5.03 percent over control, 15 and 30 kg S ha^{-1}, respectively. These results were in agreement with the findings of Jat *et al*. [13] and Boori *et al*. [7]. Similarly, the haulm yield (5315 kg ha-1) was also significantly higher with the treatment of 60 kg P_2O_5 ha^{-1} over control, 20 and 40 kg P_2O_5 ha^{-1}. It was higher by 19.84 and 9.67 percent, respectively over control and 20 kg P_2O_5 ha^{-1}. Whereas, 40 kg P_2O_5 ha^{-1} was statistically at par with 60 kg P_2O_5 ha^{-1}. Similar results were also reported by Bochalia *et al*. [6], Jat *et al*. [13] and Datta *et al*. [8]. Among the sulphur levels, 45 kg S ha^{-1} recorded the significantly higher haulm yield (5321 kg ha^{-1}) which was statistically at par with 30 kg S ha^{-1}. This level recorded 18.71 and 10.34 percent higher haulm yield as compared to control and 15 kg S ha^{-1}, respectively. These results were in agreement with the findings of Bochalia *et al*. [6], Jat *et al*. [12] and Boori *et al*. [7]. The seed protein yield of fenugreek as affected by application of phosphorus and sulphur is presented in [Table-1]. Application of 60 kg P_2O_5 ha^{-1} registered significantly higher seed protein yield (343 kg ha^{-1}) then those recorded in lower levels. It was 59.53, 20.77 and 6.19 percent higher over control, 20 and 40 kg P_2O_5 ha^{-1}, respectively. This confirms the findings of Awami *et al*. [4]. Among the sulphur levels, 45 kg S ha^{-1} recorded the significantly highest seed protein yield (338 kg ha^{-1}) which was 46.95, 22.02 and 5.95 percent higher over control, 15 and 30 kg S ha^{-1}, respectively. These results were in agreement with the findings of Ruveyde *et al*. [21].

Soil fertility

The estimates of available nitrogen, phosphorus, potassium and sulphur status of soil after harvest of fenugreek crop under the influence of phosphorus and sulphur are presented in [Table-2]. The data revealed that the application of phosphorus did not significantly improve the available nitrogen, potassium and sulphur content in soil after harvest of crop. However, the available phosphorus content was significantly influenced by the application of phosphorus levels. The application of 60 kg P_2O_5 ha^{-1} significantly increased available phosphorus in soil over control and 20 kg P_2O_5 ha^{-1} by 11.93 and 6.37 percent respectively. However, it was at par with 40 kg P_2O_5 ha^{-1}. Similar results have been reported by Islam *et al*. [12], Phogat [19] and Sipai *et al*. [24]. Among the sulphur levels, application of sulphur did not influenced the available nitrogen, phosphorus and potassium content in soil after harvest of fenugreek. However, increasing levels of sulphur application increased significantly the available sulphur content in soil after harvest up to 45 kg S ha^{-1}. Application of 45 kg S ha^{-1} recorded maximum available sulphur content (9.87 kg ha^{-1}) in soil, which was higher by 15.43 and 10.40 percent over control and 15 kg S ha^{-1} but remaining on par with 30 kg S ha^{-1}. These results are in conformity with the findings of Deshbhratar *et al*. [9], Sipai *et al*. [24] and Phogat [19].

Nutrient balance after harvest of crop

Nitrogen balance

The actual status of available N in soil after the harvest of fenugreek was considerably reduced in all levels of phosphorus ranged from -14.32 (60 kg P_2O_5 ha^{-1}) to -28.31 kg ha^{-1} (control) over initial N status of soil [Table-3]. The actual gain or loss was maximum loss (-28.31 kg ha^{-1}) of nitrogen in control treatment receiving no phosphorus which might be due to maximum withdrawal of N by the crop. The highest negative balance observed in control could be attributed to the fact that crop removed a large quantity of nutrient albeit less as compared to other treatments but entirely from the soil's own resources depleting it considerably. Similar results have been reported by Kumar and Thenua [14]. Further, in sulphur applications also the actual/loss of nitrogen was recorded higher in control (-25.96 kg ha^{-1}) as compare to other sulphur levels. The minimum loss of nitrogen (-12.46 kg ha^{-1}) was observed in highest level of sulphur (45 kg S ha^{-1}) and increasing with reducing the levels of sulphur.

Phosphorus balance

The data on phosphorus balance in soil after harvest of fenugreek is illustrated in [Table-3] which showed that both phosphorus and sulphur levels had positive and higher phosphorus balance in soil. Apparent gain/ loss of soil phosphorus indicates that all phosphorus levels recorded positive values for soil phosphorus ranging from 4.52 (control) to 28.55 kg ha^{-1} (60 kg P_2O_5 ha^{-1}). Application of 60 kg P_2O_5 ha^{-1} recorded higher values for actual gain in phosphorus over their preceding lower levels. However, control (no phosphorus) recorded minimum gain in phosphorus. An interpretation of data further indicates that actual gain/ loss in soil phosphorus under different sulphur levels recorded maximum gain (6.58 kg ha^{-1}) in phosphorus with 45 kg S ha^{-1} as compare to remaining lower levels. However, control (no phosphorus) recorded minimum gain in phosphorus.

Potassium balance

The data on potassium balance in soil after harvest of fenugreek [Table-3] showed that all levels of phosphorus and sulphur showed negative balance of K after the harvest of fenugreek.

Table-1 *Effect of phosphorus and sulphur on chlorophyll content, protein content and yield of fenugreek*

Treatments	Chlorophyll content (mg g^{-1})	Protein content in seed (%)	Yield (kg ha^{-1})		
			Grain	Haulm	Protein
Phosphorus (kg ha^{-1})					
0	1.68	19.31	1112	4435	215
20	1.77	19.70	1440	4846	284
40	1.83	20.06	1612	5137	323
60	1.88	20.29	1689	5315	343
SEm ±	0.02	0.26	25	82	6
LSD at 5%	0.05	NS	73	238	16
Sulphur (kg ha^{-1})					
0	1.68	19.27	1196	4482	230
15	1.76	19.79	1401	4822	277
30	1.83	20.07	1588	5108	319
45	1.89	20.24	1668	5321	338
SEm ±	0.02	0.26	25	82	6
LSD at 5%	0.05	NS	73	238	16

Table-2 *Effect of phosphorus and sulphur on soil nutrient status after harvest of fenugreek*

Treatments	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})	Available sulphur (kg ha^{-1})
Phosphorus (kg ha^{-1})				
0	248.69	23.84	298.37	8.71
20	256.11	25.08	305.80	9.01
40	261.46	25.90	311.61	9.48
60	262.68	26.68	314.35	9.50
SEm ±	4.04	0.57	5.49	0.23
LSD at 5%	NS	1.64	NS	NS
Sulphur (kg ha^{-1})				
0	251.04	24.27	297.82	8.55
15	252.95	24.95	304.19	8.94
30	260.40	25.83	310.81	9.33
45	264.54	26.45	317.30	9.87
SEm ±	4.04	0.57	5.49	0.23
LSD at 5%	NS	NS	NS	0.67

Table-3 *Effect of phosphorus and sulphur on nutrient balance*

Treatments	Nutrient gain/loss (kg ha^{-1})			
	N	P	K	S
Phosphorus (kg ha-1)				
0	-28.31	3.74	-27.63	0.01
20	-20.89	4.98	-20.2	0.31
40	-15.54	5.8	-14.39	0.78
60	-14.32	6.58	-11.65	0.8
Sulphur (kg ha-1)				
0	-25.96	4.17	-28.18	-0.15
15	-24.05	4.85	-21.81	0.24
30	-16.6	5.73	-15.19	0.63
45	-12.46	6.35	-8.7	1.17

The data in respect of actual gain or loss revealed that there was a maximum loss (10.08 kg ha^{-1}) of potassium in treatment receiving no phosphorus and minimum loss was observed in 60 kg P_2O_5 ha^{-1} which might be due to of N in soil. Among the sulphur levels, maximum actual loss of K (9.23 kg ha^{-1}) was recorded in control. On the other hand, the lowest potassium loss (8.7 kg ha^{-1}) was found with the application of 45 kg S ha^{-1}. This was mainly due to exhaustive nature of crops as more N, P and K were taken up by crop compared to amount of nutrient added in all the treatments.

Sulphur balance

The available sulphur status after harvest of fenugreek is presented [Table-3]. Both phosphorus and sulphur levels had positive impact on the actual gain of S in soil after harvest of the crop. The higher gain in sulphur (6 kg ha^{-1}) was observed with the application of 60 kg P_2O_5 ha^{-1} as compare to rest of the levels of phosphorus. On the other hand the lowest P build up was recorded in control treatment. As regard to sulphur levels, maximum actual gain of S (1.42 kg ha^{-1}) was observed under the application of 45 kg S ha^{-1} among all the levels of sulphur application. However, the loss of the sulphur was highest in the control (1.42 kg ha^{-1}).

Conclusion

On the basis of the results emanated from investigation it could be concluded that application of phosphorus @ 60 kg/ha and sulphur @ 45 kg/ha proved their superiority than the lower levels of both the nutrients with improvement in soil fertility and nutrient balance under fenugreek grown on medium fertility clay loam soils of agro-climatic zone IVa "Sub-humid Southern Plain and Aravalli Hills of Rajasthan"

Application of research: Study of soil fertility and nutrient balance in Southern Rajasthan

Research Category: Crop Production

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References

[1] A.O.A.C. (1965) *Official method of analysis. 10th Ed. Association of Official Agricultural Chemists, Washington.*

[2] Abdelgani M.E., Elsheik A.E. and Mukhtar N.O. (1999) *Food Chemistry*, 64, 289-293.

[3] Arnon D.I. (1949) *Plant Physiology* 242, 1-15.

[4] Awami T. A., Singh A. K., Kumar M. and Bordoloi L. J. (2012) *Indian Journal of Hill Farming* 25(2),22-26.

[5] Black C.A. (1965) *Method of Soil Analysis. American Society of Agronomy, Madison. Wisconsin, USA.*

[6] Bochalia G.S., Tiwari R.C., Ram B., Kantwa S.R. and Choudhary A.C. (2011) *Indian Journal of Agronomy* 56, 273-279.

[7] Boori P.K., Shivran A.C., Giana G.K., Jat M.L., Yadav Gopali and Meena Sangita (2017) *Journal of Pharmacognosy and Phytochemistry* 6(4), 1945-1949.

[8] Datta N., Hore J.K. and Sarkar T. (2017) *International Journal of Current Microbiology and Applied Sciences* 6(9), 2304-2312.

[9] Deshbhratar P.B., Singh P.K., Jambhulkar A.P. and Ramteke D.S. (2010) *J. Environ. Biol*. 31(6), 933-937.

[10] Gomez K.A. and Gomez A.A. (1984) *Statistical Procedures for Agricultural Research. (2nd Edition). Wiley Intersicence, New York*.

[11] Government of Rajasthan (2016) *Vital Agricultural Statistics. Directorate of Agriculture cooperation and farmers welfare, Rajasthan*

[12] Islam, M.N., Hoque, S. and Islam, A. (2006) *J. Indian Soc. Soil Sci*. 54(1), 86-91.

[13] Jat S.R., Patel B.J., Shivran A.C., Kuri B.R. and Jat G. (2013) *Annals of Plant and Soil Research* 15, 114-117.

[14] Kumar B. and Thenua O.V.S. (2012) *Ph.D. Thesis (Agronomy), CCS University, Meerut (UP).*

[15] Metson, A.J. (1956) *Method of chemical analysis for Soil Survey sample. Bull.No.2 Deptt. Serent. Mol. Res. Soil bue* 12.

[16] Nyoki Daniel and Ndakidemi P. A. (2014) *American Journal of Experimental Agriculture* 4(10): 1120-1136.

[17] Olsen S.R., Cole C. W., Wathade F. S. and Dean L. A. (1954) *Estimation of available phosphorus in soil by extraction with sodium bicarbonate, USDA Cir. No. 939, Washington*, p.13.

[18] Patra P, Pati BK, Ghosh GK, Mura SS and Saha A (2013) *Scientific Reports* 2 (1), 603.

[19] Phogat M. (2016) *M. Sc. (Ag) Thesis, Division of Soil Science and Agricultural Chemistry Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu 180009*.

[20] Pingoliya K.K., Mathur A.K., Dotaniya M.L. and Dotaniya C.K. (2015) *Legume Research*, 38 (4), 558-560.

[21] Ruveyde T., Esen C.A. and Murat T. (2011) *Turkish Journal of Field Crops* 16(1),69-75.

[22] Sharma S., Sharma Y. and Balai C.M. (2014) *Agricultural Update*, 9(3), 301-305.

[23] Sinha R. B., Sakal R. and Kumar S. (1995) *Journal of Indian Society of Soil Science*, 43, 413-418.

[24] Sipai A.H., Jat J.S., Rathore B.S., Sevak Kuldeep and Jodha Jitendra Singh (2015) *Asian J. Soil Sci*. 10(2), 228-236.

[25] Subbiah B.V. and Asija G.L. (1956) *Current Science* 27, 259-260.

[26] Walkley A.J. and Black I.A. (1947) *Soil Science* 37, 29-38.

[27] Yadav H.K., Thomas T., Khajuria V. (2010) *Journal of Agricultural Physics* 10, 61-65.