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Research Article

Yield attributes and yield of fenugreek (*Trigonella foenum graecum* L.) under different levels of phosphorus, molybdenum and inoculation of PSB

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SUMMARY : A field experiment was conducted at Agronomy farm, College of Agriculture, Bikaner during *Rabi* season, 2010-11 on loamy sand soil to investigate the effect of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}), molybdenum (0.0, 0.5 and 1.0 kg Mo ha^{-1}) and PSB (without inoculation and with inoculation) on yield attributes, yield and seed quality of fenugreek (*Trigonella foenum graecum* L.). The application of phosphorus upto 40 kg P_2O_5 ha^{-1} resulted in significantly higher number of branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield over their respective preceding levels (0 and 20 P_2O_5 ha^{-1}) but it was found at par with 60 kg P_2O_5 ha^{-1} in respect to branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield of fenugreek. Among different levels of molybdenum, 0.5 kg Mo ha^{-1} gave significantly higher branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield over respective lower level. PSB inoculation significantly enhanced the branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield of fenugreek. The test weight increased with the successive levels of applied phosphorus, molybdenum and PSB inoculation but difference could not reach the level of significance. The interaction effect of phosphorus × PSB was found significantly higher branches per plant, pod per plant and seed yield (1568 kg ha^{-1}) recorded with treatment combination 40 kg P_2O_5 ha^{-1} + with inoculation of PSB which was at par with other treatment combination 60 kg P_2O_5 ha^{-1} + with inoculation of PSB.

KEY WORDS :
Fenugreek, Interaction, Molybdenum, Nodules, Phosphorus, Protein, PSB, Yield

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BACKGROUND AND OBJECTIVES

Fenugreek (*Trigonella foenum-graecum* L.) is grown on wide range of soils but flourishes on well drained loams or sandy loam. Fenugreek is also adapted to dry land including slightly alkaline soils or marginal lands (Acharya *et al.*, 2006). 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). Fenugreek seeds contain proteins (27.7 to 28.6%) and are good source of vitamins. (Gad *et al.*, 1982). The seeds are used as spice on the worldwide, whereas the leaves are used as green leafy vegetables in diets. Fenugreek seeds are bitter to taste and have been known over 2500 years for their medicinal qualities (Srinivasan, 2006). Its seeds are bitter in taste due to presence of alkaloid "trigonellin" (0.12 to 0.38%). It contains essential oil (<0.02%), fatty oil (6.8%) and minerals (3.4 to 6.8%) with a foetid odour and bitter taste. India is the dominant producer and exporter of fenugreek seeds to the Saudi Arabia, Japan, Singapore, Nepal, U.K and U.S.A. accounting for more than 60 per cent of the world trade. In India, fenugreek is mainly cultivated in the state of Rajasthan, Gujarat, Madhya Pradesh and to limited extent in Andhra Pradesh, Tamil Nadu, Haryana, Maharastra and Punjab. Rajasthan is considered as “fenugreek bowl” of the country. In Rajasthan it is mainly grown, in the districts of Sikar, Bilara traits of Jodhpur, Nagaur, Sirohi, Chittorgarh and Kota covering an area of 80364 hectares and produces 94182 MT with 1172 kg ha^{-1} productivity (Anonymous, 2011). The productivity of fenugreek can be further enhanced by judicious package of fertilizers especially phosphorus, molybdenum and increasing the availability of phosphorus by seed inoculation with phosphate solubilizing bacteria. Phosphorus (P) is critical in plant metabolism which plays an important role in cellular energy transfer, respiration, photosynthesis and it is a key structural component of nucleic acids coenzymes, phosphorproteins and phospholipids. Phosphorus fertilization is a major input in crop production (Blackshaw *et al*., 2004). Adequate supply of phosphorus has been reported by various workers for vigorous growth, bumper yield, better quality and enormous nodule formation in legumes. Molybdenum either by soil application or through seed treatment significantly increased the grain yield of leguminous crop. Kumari *et al.* (2009) concluded that with inoculation of phosphate solublising bacteria increased number of branches per plant, number of flowers per plant, number of pods per plant and dry weight/plant of urdbean.

RESOURCES AND METHODS

A field experiment was conducted at Agronomy farm, College of Agriculture, Bikaner during *Rabi* season, 2010-11. The soil of experiment site was loamy sand in texture containing 90.75, 21.80 and 201.15 kg ha^{-1} available nitrogen, phosphorus and potassium, respectively in 0-15 cm soil depth with pH 8.41 and organic carbon 0.09 per cent. The experiment was laid out in factorial Randomized Block Design with three replications, assigning twenty four treatments consisting of four levels of phosphorus (control, 20, 40 and 60 kg P_2O_5 ha^{-1}), three levels of molybdenum (control, 0.5 and 1.0 kg Mo ha^{-1}) and two levels of PSB, without inoculation and with inoculation (I_0 and I_1). The uniform dose of N was maintained and phosphorus and molybdenum as per treatment were drilled manually supplied through diammonium phosphate and ammonium molybdate at the time of sowing. Inoculation of seeds with phosphate solubilizing bacteria was done as per treatment. Furrows were opened manually at 30cm apart and seeds were placed at a depth of 5cm, using variety RMt 1 with seed rate 25kg ha^{-1}. Weed control, irrigation and plant protection measures were followed as per zonal package. Numbers of nodules per plant were observed at 45 DAS by uprooting five plants from the two rows of each experimental plots and after washing with tap water. The root nodules were counted manually and average was worked out. Chlorophyll content was determined at 40 DAS as suggested by Hiscox and Isrelastem (1979) and Arnon’s equation (1949) was used to workout chlorophyll content as under:

$$\text{Chlorophyll"a" mgg}^{-1}\text{fresh weight of leaves)} = \frac{(12.7\text{xA663}) - (2.69\text{xA645})}{1000} \text{x} \frac{\text{Volume of DMSO}}{\text{Weight of leaf sample}}$$

$$\text{Chlorophyll"b" (mgg}^{-1}\text{fresh weight of leaves)} = \frac{(22.9\text{xA645}) - (4.65\text{xA663})}{1000} \text{x} \frac{\text{Volume of DMSO}}{\text{Weight of leaf sample}}$$

Total chlorophyll content was worked out by adding chlorophyll “a” and chlorophyll “b” as under:

$$\text{Total chlorophyll (mg g-1 fresh weight of leaves)} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

The observations were recorded for traits *viz.*, seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}). The data were subjected to statistical analysis of variance as described by Fisher (1950).

OBSERVATIONS AND ANALYSIS

The experimental findings obtained from the present study have been discussed in following heads:

Effect of phosphorus:

Data (Table 1) revealed that the application of 40 kg P_2O_5 ha^{-1} significantly increased number of branches per plant, number of nodules per plant, chlorophyll content in leaves and number of pods per plant over the other lower levels (0 and 20 kg P_2O_5 ha^{-1}). But it was found at par with 60 kg P_2O_5 ha^{-1} in respect to number of branches per plant, number of nodules per plant, chlorophyll content in leaves and number of pods per plant. Similarly, data embodied in Table 1 revealed that application of 40 kg P_2O_5 ha^{-1} significantly increased number of seeds pod (13.92), seed yield (1454 kg ha^{-1}) and straw yield (3614 kg ha^{-1}) over preceding levels (0 and 20 kg P_2O_5 ha^{-1}). The increase in number of seeds per pod, seed yield and straw yield were 14.85 and 6.01, 47.16 and 10.65, 15.80 and 5.73 per cent over control and 20 kg P_2O_5 ha^{-1}, respectively but it was at par with 60 kg P_2O_5 ha^{-1} in respect to seeds per pod, seed and straw yield of fenugreek. In many researches it was reported that highest seed yields in fenugreek were obtained from maximum P applications (Bhati, 1993; Chaudhary, 1999; Halesh *et al.*, 2000; Mavai *et al.*, 2000, Ram and Verma, 2001; Dayanand, 2004; Thapa and Maity, 2004 and Khan *et al.*, 2005). Some researchers reported that an increase in the seed yield of fenugreek was obtained with P doses of 40 and 60 kg ha^{-1} (Khiriya *et al*., 2001; Khiriya *et al*., 2003 and

Sheoran *et al.*, 1999).

The test weight increased with the successive levels of applied phosphorus but difference could not reach the level of significance. There was highly significant positive correlation between yield attributes and seed yield. Significantly higher values of yield attributes and seed yield of fenugreek were reported from different locations at 40 kg P_2O_5 ha^{-1} by Dutta *et al.* (2008) and Deo and Khandelwal (2009).

Effect of molybdenum:

It is also apparent from the data (Table 1) that application of molybdenum at 0.5 kg Mo ha^{-1} significantly increased the number of branches per plant, number of nodules per plant, chlorophyll content in leaves and number of pods per plant of fenugreek over control but it was found at par with 1.0 kg Mo ha^{-1} in respect to number of branches per plant, number of nodules per plant, chlorophyll content in leaves and number of pods per plant. Similarly, the data depicted in the Table 1 also showed that application of molybdenum up to 0.5 kg Mo ha^{-1} significantly increased the number of seeds per pod (13.44), seed yield (1376 kg ha^{-1}) and straw yield (3561 kg ha^{-1}) of fenugreek over control by 5.24, 20.06 and 10.52 per cent, respectively. But, it was at par with 1.0

Table 1 : Effect of phosphorus, molybdenum and PSB on number of branches per plant at harvest, number of nodules per plant, chlorophyll content, number of pods per plant, number of seeds per pod, test weight, seed yield and straw yield of fenugreek

Treatments	Number of branches per plant at harvest	Number of nodules per plant	Chlorophyll content in leaves at flowering stage (mg g^{-1})	Number of pods per plant	Number of seeds per pod	Test weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Phosphorus (kg P_2O_5 ha^{-1})								
0	7.81	4.87	1.63	29.81	12.12	11.34	988	3121
20	9.42	5.28	2.18	34.26	13.13	11.51	1314	3418
40	10.44	5.59	2.37	37.26	13.92	11.78	1454	3614
60	10.67	5.71	2.41	37.48	14.28	11.83	1486	3668
S.E.±	0.21	0.09	0.03	0.55	0.26	0.21	25	56
C.D. (P=0.05)	0.60	0.24	0.09	1.56	0.73	NS	71	159
Molybdenum levels (kg Mo ha^{-1})								
0.0	8.85	5.13	2.03	32.68	12.77	11.40	1146	3222
0.5	9.90	5.40	2.20	35.72	13.44	11.68	1376	3561
1.0	10.01	5.55	2.21	35.70	13.88	11.78	1410	3584
S.E.±	0.18	0.07	0.03	0.48	0.22	0.18	22	48
C.D. (P=0.05)	0.52	0.21	0.08	1.35	0.63	NS	61	138
PSB								
I_0	8.89	5.27	2.10	31.56	13.19	11.42	1219	3179
I_1	10.29	5.46	2.20	37.84	13.54	11.81	1402	3732
S.E.±	0.15	0.06	0.02	0.39	0.18	0.15	18	40
C.D. (P=0.05)	0.43	0.17	0.07	1.10	NS	NS	50	112

NS=Non-significanct

Table 2: Interaction effect between phosphorus levels and PSB on branches per plant, pods per plant and seed yield of fenugreek

Phosphorus levels (kg P_2O_5)	PSB			PSB			PSB		
	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean
	Branches per plant			Pods per plant			Seed yield (kgha^{-1})		
Control	6.52	9.09	7.81	25.24	34.37	29.81	961	1016	988
20	8.87	9.98	9.42	31.38	37.13	34.26	1193	1436	1314
40	9.93	10.96	10.44	34.72	39.80	37.26	1341	1568	1454
60	10.22	11.12	10.67	34.91	40.04	37.48	1382	1590	1486
Mean	8.89	10.29	9.59	31.56	37.84	34.70	1219	1402	1311
S.E.±		0.30			0.78			35	
C.D. (5%)		0.85			2.21			100	

kg Mo ha^{-1} in respect to seeds per pod, seed and straw yield. The test weight increased with the successive levels of applied molybdenum but difference could not reach the level of significance. The increase in these yield attributing characters with application of molybdenum fertilization might be due to its unique role in enhancement of nitrogen fixation, thereby, increasing availability to the plants for efficient growth and development. The increase in yield attributes was probably due to source and sink relationship. The improvement in photosynthesis and carbohydrate metabolism resulting into greater formation of photosynthates and metabolites in source and later on translocated in the newly formed sinks *i.e.* reproductive structures (flowering and seed setting) which ultimately increased pods per plant and test weight. Similar findings were also reported by Johansen *et al.* (2007) and Cvijanovic *et al.* (2011).

Effect of PSB:

The data (Table 1) revealed that seed inoculation with PSB significantly increased the number of branches per plant (10.29), number of nodules per plant (5.46), chlorophyll content in leaves at flowering stage (2.20mg g^{-1}) and number of pods per plant (37.84) as compared to their respective control representing per cent increase of 13.60, 3.60, 4.76 and 19.9. The data (Table 1) also showed that seed inoculation with PSB significantly increased the seed yield (1402 kg ha^{-1}) and straw yield (3732 kg ha^{-1}) as compared to their respective control representing per cent increase of 15.01 and 17.39. Number of seeds per pod and test weight increased with the seed inoculation with PSB but difference could not reach the level of significance. These results get support from the findings of Gaind and Gaur (1991) and Vikram and Hamzehzarghani (2008).

Interaction effect of phosphorus and PSB inoculation:

Data presented in Table 2 indicated that significantly higher number of branches per plant, pods per plant and seed yield were recorded with treatment combination 40 kg P_2O_5 ha^{-1} + with inoculation of PSB, However, which were found at par with other treatment combinations of 60 kg P_2O_5 ha^{-1} + with inoculation of PSB and 60 kg P_2O_5 ha^{-1} + without inoculation of PSB. It is obvious that phosphate solubilizing bacteria produced higher quantity of organic acids which dissolved mineral phosphate and made it available to plants. These acids associate with metals and increase the concentration of soluble phosphate. They also synthesize growth promoting substances and produce vitamins which augment the plant growth (Gaind and Gaur, 1991). These results are in close accordance with the findings of Sarawagi and Rajput (2005), Gupta and Sharma (2006).

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REFERENCES

Acharya, S.N., Thomus. J.E. and Basu, S.K. (2006). Fenugreek: an 'old world' crop for new world. *Biodiversity*, **7**(3&4): 27.30.

Anonymous (2011). *Agricultural statistics of Rajasthan*, Published by Directorate of Economics and statistics, Rajasthan, Jaipur. pp. 37-71.

Arnon, D.I. (1949). Copper enzyme in isolated chloroplast. *Plant Physiol.*, **24**(1): 15.

Bhati, D.S. (1993). Effect of irrigation and phosphorus on seed yield and its attributes of fenugreek (*Trigonella foenum graecum* L.). *Indian J. Agron.*, **38** (3): 449-452.

Blackshaw, R.E., Brandt, R. N., Janzen, H.H. and Entz, T. (2004). Weed species response to phosphorus fertilization. *Weed Sci.*, **52** (3) : 406-412.

Chaudhary, G. R. (1999). Response of fenugreek (*Trigonella foenum-graecum* L.) to seed rate and fertilizer application. *Indian J. Agron.*, **44** (2): 427-429.

Cvijanovic, G., Dozet, G.D., Dukic V., Subic, J., Cvijanovic, D. and Dukic, V. (2011). Effects of nitrogen fertilizing on the preceding crop and the application of Co and Mo on *Azotobacter* abundance in soya bean. *Romanian Biotechnol. Letters*, **16**: 1.

Dayanand, S.O.P. (2004). Total biomass production and net return of fenugreek (*Trigonella foenum-graecum* L.) as influenced by phosphorus and sulphur fertilization. *Haryana J. Agron.*, **20** (1&2): 129-130.

Deo, C. and Khandelwal, R.B. (2009). Effect of P and S nutrition on yield and quality of chickpea (*Cicer arietinum*). *J. Indian Soc. Soil Sci.*, **57** (3): 352 – 356.

Dutta, D., Bandyopadhyay, P. and Maiti, D. (2008). Effect of P fertilization and growth regulators on yield, nutrient uptake and economics of fenugreek (*Trigonella foeum graecum*). *Res. Crops*, **9** (3): 599 – 601.

Fisher, R.A. (1950). *Statistical methods for research workers.* Oliver and Boyd. Edinburg, London, UNITED KINGDOM.

Gad, S.S., Mohamed, M.S. and Zalaki, M.E. (1982). Effect of processing on phosphorus and phytic acid contents of some Egyptian variety of legumes. *Food Chem.*, **8** (1) : 11-19.

Gaind, S. and Gaur, A.C. (1991). Thermotolerant phosphate solubilising micro-organisms and their interaction with mungbean. *Plant & Soil.*, **133** (1) : 141-149.

Gupta, A. and Sharma, V.K. (2006). Study on the effect of biofertilizer and phosphorus levels on yield and economics of urdbean [*Vigna mungo* (L.) Hepper]. *Legume Res.*, **29** (4):278-281.

Habib, A.F., Swamy, R.J. and Mensinkai, S.W. (1971). Salt tolerance in *methi* at germination stage. *Curr. Sci.,* **40**(3): 67.

Halesh, D. P., Gowda, M.C., Forooqi, A. A.,Vasundhara, M. and Srinivasappa, K. N. (2000). Influence of nitrogen and phosphorus on growth, yield and nutrient content of fenugreek (*Trigonella foenum-graecum* L.). Spices and aromatic plants: Challenges and opportunities in the new century. Contributory papers. *Centennial conference on spices and aromatic plants,* 20-23 September, Calicut (KERALA) INDIA.

Hiscox, J.D. and Isrelastem, G.F. (1979). A method for the extraction of chlorophyll from leaf tissue without maccration. *Canadian J. Bot.,* **57** (12) : 1332-1334.

Johansen, C., Musa, A.M., Rao, J.V.D., Harris, D. and Ali, M.Y. (2007). Correcting molybdenum deficiency of chickpea in the High Barind Tract of Bangladesh. *J. Plant Nut. Soil Sci.,* **170** (6): 752–761.

Khan, M.B., Khan, M.A. and Sheikh, M. (2005). Effect of phosphorus levels on growth and yield of fenugreek (*Trigonella foenum-graecum* L.) grown under different spatial arrangements. *Internat. J.Agric. & Biol.,* **7** (3): 504-507.

Khiriya, K.D., Sheoran, R.S. and Singh, B.P. (2001). Growth analysis of fenugreek (*Trigonella foenum-graecum* L.) under various levels of farmyard manure and phosphorus. *J. Spices & Aromatic Crops,* **10** (2): 105-110.

Khiriya, K.D. and Singh, B.P. (2003). Effect of phosphorus and farmyard manure on yield, yield attributes and nitrogen, phosphorus and potassium uptake of fenugreek (*Trigonella foenum-graecum* L.). *Indian J. Agron.,* **48** (1): 62-65.

Khiriya, K.D., Singh, B.P. and Taneja, K.D. (2003). Effect of farm yard manure and phosphorus levels on yield, quality and nutrient uptake by fenugreek (*Trigonella foenum-graecum* L.). *Forage Res.,* **28** (4): 210-214.

Kumari, M., Vasu, D., Hasan, Z.U. and Dhurwe, U.K. (2009). Effects of PSB (Phosphate solubilizing bacteria) on morphological characters of lentil (*Lens culinaris). Medicinal Biological Forum. Internat. J.,* **1**(2): 5-7.

Mavai, D., Lal, S., Singh, K.S. B. A. and Singh, N. (2000). Response of fenugreek (*Trigonella foenum-graecum* L.) to seed rate, nitrogen and phosphorus fertilizer. *Haryana J. Hort. Sci.,* **29** (3&4): 244-246.

Ram, D. and Verma, J. P. (2001). Effect of level of phosphorus and potash on the performance of seed crop of fenugreek (*Trigonella foenum graecum* L.) cv. Pusa Early Bunching. *Haryana J. Hort. Sci.,* **30** (3&4): 249-250.

Sarawagi, S.K. and Rajput, R.S. (2005). Effect of phosphorus, zinc and PSB on growth and yield of soybean [*Glycine max* (L.) merril] in vertisol of Chhattisgarh plains. *Ann. Agric. Res.,* **26** (2): 302 – 305.

Sheoran, R.S., Sharma, H.C. and Pannu, R.K. (1999). Efficiency of phosphorus fertilizer applied to fenugreek (*Trigonella foenum-graecum* L.) genotypes under different dates of sowing. *Haryana Agric. Univ. J. Res.,* **29** (3&4): 101-107.

Srinivasan, K. (2006). Fenugreek (*Trigonella foenum-graecum*): A review of health beneficial physiological effects. *Food Rev. Internat.,* **22** (2) : 203–224.

Thapa, U. and Maity, T.K. (2004). Influence of nitrogen, phosphorus and number of cutting on seed yield of fenugreek (*Trigonella foenum-graecum* L.). *Seed Res.,* **32** (1): 33-35.

Vikram, A. and Hamzehzarghani, H. (2008). Effect of PSB on nodulation and growth parameters of green gram [*Vigna radiata* (L.) Wilczek]. *Res. J. Microbio.,* **3** (2): 62-72.

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