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Effect of Phosphorus Levels on Growth and Yield of Fenugreek (*Trigonella foenum graecum* L.) Grown Under Different Spatial Arrangements

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ABSTRACT

Effect of different phosphorus levels (0, 30, 45, 60 kg P_2O_5 ha^{-1}) and spatial arrangement of 1.8 × 6 m, 2.4 × 6 m and 3 × 6 m for row spacing 30, 40, and 50 cm, respectively on growth and yield of fenugreek was investigated at Research Area, University college of Agriculture, Bahauddin Zakariya University Multan, during 2003-2004. Spatial arrangement only affected fenugreek plant population per unit area. Interaction effect of phosphorus and spatial arrangement was non-significant on growth and yield of fenugreek. Phosphorus application improved the performance of fenugreek plants for number of seeds $plant^{-1}$, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek. Number of branches and pods per plant remained unaffected by phosphorus application. Significant increased seed yield of fenugreek (1358.29 kg ha^{-1}) was obtained for the crop raised with 60 kg P_2O_5 ha^{-1} but was statistically at par with 45 kg P_2O_5 ha^{-1} (1326.47 kg ha^{-1}). It is concluded that optimum dose of phosphorus for fenugreek crop is 45 kg P_2O_5 ha^{-1}. It is also suggested that further research should be done on planting geometry of fenugreek under different environmental conditions.

Key Words: Phosphorus; Yield; Fenugreek; Spatial

INTRODUCTION

Fenugreek is a self-pollinated small seeded annual legume, which is grown as vegetable, fodder and seed crop. Green leaves are good source of protein, mineral and vitamin C, and seeds contain high level of iron and phosphorus rich in lysine and lipids and whole seed and dried plants are used as insect and pest repellent in grain storage (Billaud & Adrian, 2001). Fenugreek seed has been found beneficial in many diseases. Disrupted free radical metabolism in diabetic animals may be normalized by fenugreek seed supplementation in the diet (Ravikumar & Anuradha, 1999).

Despite being multi-purpose crop, fenugreek has not obtained due importance in our cropping pattern and little research work has been done on agronomic aspect of fenugreek like row spacing and nutrient requirement. Spatial and fertilizer requirements of crops are dependent on the intended purpose and environment. Kumawat *et al*. (1998) reported that seed yield of fenugreek was higher with 30 cm spacing and application of 40 kg P_2O_5 ha^{-1}. Bothe *et al*. (2000) found non-significant effects of crop spacings and phosphorus application on the seed yield of fenugreek. Khiriya *et al.* (2003) stated that phosphorus uptake in seed and straw of fenugreek increased with increasing levels of phosphorus up to 40 kg ha^{-1}. Ramesh *et al*. (2002) assessed that increasing phosphorus rate up to 50 kg ha^{-1} increased pods per plant, seed and straw yield of fenugreek. Sharma (2000) achieved the highest fenugreek seed yield per plot, 1000 seed weight with 30x7.5 cm planting among different row spacings (30 × 7.5, 60 × 7.5 cm). These controversial results require further research on effect of phosphorus and planting geometry on growth and yield of fenugreek.

Keeping in view the importance of these two factors, the present study was designed to investigate the effect of different phosphorus levels in combination with varying spatial arrangements for different row spacings on growth and yield of fenugreek.

MATERIALS AND METHODS

The study was conducted at the Experimental Farm, University College of Agriculture, Bahauddin Zakariya University, Multan, during crop season 2003-2004. The experiment was laid out in Randomized Complete Block Design in split plot arrangement with three replications. The various treatments comprised of four phosphorus levels (0, 30, 45, 60 kg P_2O_5 ha^{-1}) and three row spacings (30, 40, 50 cm). The net plot sizes were 1.8 × 6 m, 2.4 × 6 m and 3 × 6 m for row spacings 30 cm, 40 cm, and 50 cm, respectively. Row spacings were randomized in the main plots and phosphorus levels in sub plots. The crop was sown on a well-prepared moist seedbed with a single row hand drill using a seed rate of 80 kg ha^{-1}. Recommended doses of nitrogen and potassium i.e. 60 kg N and 40 kg ha^{-1} K_2O were applied to the crop (Billaud & Adrian, 2001). Hoeing was done with Kasola and Kurpa after first and second irrigations. Four irrigations were applied in all to crop. The

crop was treated once with Imidacloprid against black aphids.

Number of plants m^{-1} was counted from each sample area randomly from all experimental units. To record data on plant height, number of branches $plant^{-1}$, number of pods $plant^{-1}$ and number of seeds pod^{-1}, ten plants from each experimental unit were randomly selected and then averages thereof were calculated. At maturity, the crop was harvested manually in each plot separately and tied into bundles. The bundles were left in the field for drying until constant weight. The sun-dried bundles were weighed to determine total biomass $plot^{-1}$ and converted into kg ha^{-1}. The bundles were manually threshed to record seed yield (kg ha^{-1}). Three samples of 1000 seeds were taken from each seed lot of the experimental units and then weighed. Their average recorded 1000 seed weight (g). Economic yield divided by biological yield multiplied with 100 gave harvest index in percent.

The data so collected were analyzed statistically by using Fisher's analysis of variance technique and differences among the treatment means were compared using least significant difference (LSD) test at 0.05 probability level (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

Number of plants m^{-1} was significantly affected by different spatial arrangements (Table I) whereas phosphorus and interaction between spatial arrangement and phosphorus showed non-significant effects (Table II & III). Statistically higher number of plants m^{-1} (36.25) was recorded in spatial arrangement of 1.8 × 6.0 m for row spacing 30 cm than spatial arrangements of 2.4 × 6.0 m for row spacing 40 cm (27.17) and 3.0 × 6.0 m for row spacing 50 cm (20.08). The reason in variation of plant population per unit area was due to variation in area available to individual fenugreek plants. Plant population per nit area depends upon germination percentage and seedling establishment after germination. The higher number of plants m^{-1} indicated that spatial arrangement of 1.6 × 6.0 m for row spacing 30 cm provided the most favorable environment for germination as well as for seedling establishment. The results are contradictory to those of Sharma (2000) who reported that germination rate of fenugreek was highest with 60 × 7.5 cm spacing. The differences in results might be due to differences in environmental conditions under which two experiments were conducted.

The results in Tables I, II and III indicated that plant height at maturity, number of branches per plant and number of pods per plant of fenugreek appeared as genetically controlled parameters and were not significantly affected by different spatial arrangements, phosphorus levels and interaction thereof. However, the interaction between 60kg P_2O_5 ha^{-1} and 50 cm row spacing produced maximum plant height (44.0 cm) and number of branches (4.27). The results did not confirm the findings of earlier workers. Khiriya *et al*. (2001) and Nehare *et al.* (2002) reported that increasing levels of phosphorus up to 40 kg ha^{-1} significantly increased the growth characters of fenugreek. Number of branches per plant (Kumar *et al*., 2000) and pods per plant of fenugreek has been increased significantly by increasing phosphorus rates (Kumar *et al*., 2000; Ramesh *et al*., 2002). However, they conducted their experiments under different conditions and did not combine the levels of phosphorus with different spatial arrangements.

Phosphorus application showing non-significant effect on number of branches and pods per plant influenced significantly number of seeds $plant^{-1}$, 1000 seed weight, biological yield, seed yield and harvest index (Table II). But, differences among spatial arrangements and interaction between spatial arrangements and phosphorus levels were non significant (Tables I & II). Bothe *et al.* (2000) reported that plant population (spacing 30 × 10, 20 × 10 and 30 × 5 cm) did not affect significantly yield of fenugreek crop. But Glamoclija *et al*. (2002) found contradictory results. They reported that seed yield and 1000 seed weight were highest with decreasing crop density up to 50 × 10 cm. Application of 60 kg ha^{-1} produced the maximum number of seeds per pod (17.77), which was statistically at par with 45 kg P_2O_5 ha^{-1} (17.18). Both 60 kg P_2O_5 ha^{-1} and 45 kg P_2O_5 ha^{-1} were statistically superior to other two phosphorus levels. It may be due to the reason that phosphorus aids in seed development in legumes. Application of 60 kg P_2O_5 ha^{-1} produced the maximum 1000- seed weight (22.89 g). The result of 60 kg P_2O_5 ha^{-1}, 45 kg P_2O_5 $ha^{-1}$and 30 kg P_2O_5 ha^{-1} were statistically at par with each other. The 1000-seed weight increased consistently up to 60 kg P_2O_5 ha^{-1}. In relation to biological yield, phosphorus applications of 30 kg P_2O_5 ha^{-1}, 45 kg P_2O_5 ha^{-1} and 60 kg P_2O_5 ha^{-1} were statistically at par with each other. Phosphorus application of 0 kg P_2O_5 ha^{-1} produced the lowest biological yield. Maximum seed yield (1358.29 kg ha^{-1}) was obtained from 60 kg P_2O_5 ha^{-1}, which was statistically at par with 45 kg P_2O_5 ha^{-1} (1326.47 kg ha^{-1}). Phosphorus application at the rate of 0 kg P_2O_5 ha^{-1}produced the lowest seed yield (1105.61 kg ha^{-1}) but statistically at par with 30 kg P_2O_5 ha^{-1} (1164.59). Improved water-use efficiency by phosphorus application increased significantly seeds per pod seed and stover yields (Kumar *et al*., 2000). It has been found that phosphorus application increases NPK contents and nitrogen and phosphorus uptake in seed and straw that significantly increases seed and straw yields over the lower doses (Khiriya *et al*., 2001). The higher uptake of nitrogen and phosphorus during seed formation might have increased number of seeds per plant and 1000 seed weight. Ramesh *et al.* (2001) also reported that increasing phosphorus rates up to 50 kg ha^{-1} increased seed and straw yields of fenugreek.

Table I. Effect of spatial arrangement on number of plants m^{-1}, plant height at maturity, branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek

Spatial arrangement for 6 plant rows	Plants m^{-1}	Plant height at maturity (cm)	Branches $plnat^{-1}$	Pods $plant^{-1}$	Seeds pod^{-1}	1000 seed weight (g)	Bio yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)
1.8 m × 6.0 m	36.25a	39.78	3.98	12.01	15.90	22.21	4631.94	1239.88	26.38
2.4 m × 6 m	27.17b	39.97	4.11	12.03	15.89	22.18	4713.95	1256.43	26.83
3 m × 6 m	20.08c	42.48	4.21	12.26	15.81	21.65	4640.72	1240.21	26.48
LSD (0.05)	6.54	NS	NS	NS	NS	NS	NS	NS	NS

Means not sharing a common letter in a column differ significantly at 0.05% level of probability
NS = Non-significant

Table II. Effect of phosphorus levels on number of plants m^{-1}, plant height at maturity, branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek

Kg P_2O_5 ha^{-1}	Plants m^{-1}	Plant height at maturity (cm)	Branches $plnat^{-1}$	Pods $plant^{-1}$	Seeds pod^{-1}	1000 seed weight (g)	Bio Yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)
0	27.56	39.80	4.00	11.43	13.49c	20.39c	4512.42b	1105.61b	25.50b
30	28.33	40.21	4.07	12.19	15.02b	21.94b	4584.32ab	1164.59b	25.79b
45	27.78	41.42	4.14	12.06	17.18a	22.54ab	4777.13a	1326.47a	27.66a
60	27.67	41.80	4.20	12.63	17.77a	22.89a	4779.76a	1358.29a	27.87a
LSD (0.05)	NS	NS	NS	NS	0.97	0.93	210.00	81.57	1.29

Means not sharing a common letter in a column differ significantly at 0.05% level of probability
NS = Non-significant

Table III. Interaction effect of spatial arrangement and phosphorus on number of plants m^{-1}, plant height at maturity, branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek

(Spatial arrangement for 6 plant rows) × phosphorus	Plants m^{-1}	Plant height at maturity (cm)	Branches $plnat^{-1}$	Pods $plant^{-1}$	Seeds pod^{-1}	1000 seed weight (g)	Bio yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)
(1.8 m × 6 m) × 0 kg P_2O_5 ha^{-1}	35.67	38.80	3.80	10.90	13.27	22.31	4589.06	1106.59	24.09
(1.8 m × 6 m) × 30 kg P_2O_5 ha^{-1}	37.33	39.53	3.90	12.53	16.27	21.92	4555.13	1189.13	26.02
(1.8 m × 6 m) × 45 P_2O_5 kg ha^{-1}	36.00	40.47	4.10	11.70	16.43	22.14	4741.20	1258.70	26.26
(1.8 m × 6 m) × 60 kg P_2O_5 ha^{-1}	36.00	40.87	4.13	12.90	17.63	23.65	4642.36	1409.45	27.87
(2.4 m × 6 m) × 0 kg P_2O_5 ha^{-1}	26.67	40.23	3.97	10.97	13.16	20.21	4355.13	1089.53	25.03
(2.4 m × 6 m) × 30 kg P_2O_5 ha^{-1}	27.33	39.30	4.13	11.43	15.13	22.41	4804.26	1192.62	25.90
(2.4 m × 6 m) × 45 P_2O_5 kg ha^{-1}	27.00	41.63	4.17	12.57	17.47	23.16	4803.30	1372.23	28.56
(2.4 m × 6 m) × 60 kg P_2O_5 ha^{-1}	27.67	40.53	4.20	12.30	17.79	22.93	4892.50	1291.33	27.82
(3 m × 6 m) × 0 kg P_2O_5 ha^{-1}	20.33	40.90	4.23	11.83	14.03	20.66	4593.06	1120.70	24.39
(3 m × 6 m) × 30 P_2O_5 kg ha^{-1}	20.33	42.53	4.17	12.60	13.67	21.51	4393.57	1117.50	25.47
(3 m × 6 m) × 45 kg P_2O_5 ha^{-1}	20.33	42.50	4.17	11.90	17.63	22.31	4786.84	1348.47	28.16
(3 m × 6 m) × 60 kg P_2O_5 ha^{-1}	19.33	44.00	4.27	12.70	17.89	22.10	4789.43	1374.10	27.91
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means not sharing a common letter in a column differ significantly at 0.05% level of probability
NS = Non-significant

As regards harvest index (Table II), phosphorus application at 60 kg P_2O_5 ha^{-1} resulted in highest harvest index (27.87%), which was statistically at par with 45 kg P_2O_5 ha^{-1} (27.66%) while minimum harvest index (24.50%) was obtained from 0 kg P_2O_5 ha^{-1} that was in turn at par with 30 kg P_2O_5 ha^{-1} (25.79%). This might be due to the increase in biological and seed yields up to 60 kg P_2O_5 ha^{-1}. Halesh *et al.* (1998) reported that good plant growth and

high seed yield were obtained with high phosphorus application i.e. of 60 and 90 kg P_2O_5 ha^{-1}. Chaudhary (1999) reported increased yield of fenugreek with phosphorus application along with nitrogen.

It is concluded that spatial arrangement only affected fenugreek plant population per unit area. No other parameter was found to be influences by changing planting geometry of fenugreek. Interaction effect of phosphorus and spatial arrangement was non-significant on growth and yield of fenugreek. Phosphorus application showed non-significant effect on number of branches and pods per plant but improved significantly number of seeds $plant^{-1}$, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek.

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