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Effect of Phosphorus and Planting Density on Seed Production in Okra (*Abelmoschus esculentus* L. Moench)

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ABSTRACT

The studies were carried out to observe the effect of various doses of phosphorus and different planting densities on seed yield and quality of okra cv. Sabz Pari. Phosphorus as a basal dose was applied @ 0, 33 or 66 kg P_2O_5 ha^{-1} at the time of seed bed preparation. Plants were grown at a density of 111000, 55500 or 37000 plants ha^{-1}. Phosphorus application had no significant effect on number of mature pods per plant and seed moisture content. Weight of mature pods per plant, number of seeds per pod, seed yields per plant and per hectare and 1000 seed weight were significantly affected by the phosphorus levels, being maximum at the highest level and minimum at the lowest one. Planting densities could not affect the number of seeds per pod, 1000 seed weight and seed moisture content. However, number and weight of mature pods and seed yields per plant and per hectare were significantly influenced by the planting densities. The lowest planting density resulted in maximum number of mature pods per plant, highest weight of mature pods per plant and also highest seed yield per plant, while seed yield per hectare was highest at the highest plating density.

Key Words: Fertilizer; Lady's finger; Planting distance; Seed yield; Seed quality

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is one of the most important summer vegetables of the tropical and subtropical world including Pakistan, grown for its immature pods. The crop is raised through seed, which looses its viability quickly. Seed may remain viable for two years under ordinary storage conditions (Thakur & Arora, 1993), which necessitates to produce good quality seed every year. The seed production is affected by climatic factors and various agronomic practices including fertilizer application and planting density. Among the macronutrients, phosphorus is the key element, which improves root growth, hastens seed maturity and increases fruit yield especially when applied in combination with nitrogen (Naik, 1994; Pandey & Dubey, 1996). Singh and Pandita (1981) studied the response of okra seed crop to various levels of nitrogen and phosphorus. The highest seed yield was obtained from the plants received 120 and 25 kg ha^{-1} nitrogen and phosphorus, respectively. However, Lenka *et al*. (1989) obtained satisfactory seed yield with 100 kg ha^{-1} N and 30 kg ha^{-1} P_2O_5. Naik and Srinivas (1992) applied N at 50, 100, 150 or 200 kg ha^{-1}, P at 30, 60 or 90 kg of P_2O_5 ha^{-1} and K at 40 kg of K_2O ha^{-1} to okra cv. Pusa Sawani, grown on a sandy loam soil with low available N and P. The highest seed yields were obtained from the highest rate of fertilizer application. Number of pods per plant, number of seeds per pod and 1000 seed weight were also highest at the highest dose. Dwievedi *et al*. (1993) applied 80, 120 or 160 kg N and 60, 80 or 100 kg P ha^{-1} to okra cv. Pusa Sawani and found that the seed yield were highest at 120 kg N and 100 kg P ha^{-1}.

Crop yield also depends on plant population per unit area. Generally, increase in planting density results in increased yield per unit area till a certain limit (Weiner, 1990). According to Mangual and Martin (1980), the optimal population density for high yielding okra cultivars is 6-8 plants m^{-2}. Baruah (1995) planted okra cvs. Parbhani Kranti, Pusa Sawani and Local at plant spacing of 45 x 10, 45 x 20 or 45 x 30 cm and found that seed yield per unit area was highest with closest spacing and lowest with widest spacing. Hence, among the several factors affecting seed yield of okra, nutrition especially phosphorus and planting density play an important role in okra seed production and need to be studied more precisely. Therefore, the present study was initiated to find out the optimum level of phosphorus and planting density for seed production in okra cv. Sabz Pari.

MATERIALS AND METHODS

The present studies were conducted at the Experimental Vegetable Area, Department of Horticulture, University of Agriculture, Faisalabad during the year 1999. The seed of okra cv. Sabz Pari was obtained from the Vegetable Section, Ayub Agricultural Research Institute, Faisalabad. The soil was prepared thoroughly and crop was sown on 10th of April 1999. The experiment was laid out according to split plot design with three replications. Three levels of phosphorus (i.e. 0, 33 and 66 kg P_2O_5 ha^{-1}) and three planting densities (i.e. 37000, 55500 and 111000 plants ha^{-1}) were tested in main plots and subplots, respectively. Distance between rows was kept constant as 60 cm and between plants was adjusted according to the planting densities (i.e. 15, 30 and 45 cm). Area under each subplot was 1.8 m x 6.1 m. Nitrogen and potassium (K_2O)

were applied @ 78 and 62 kg ha^{-1}, respectively. The sources of these nutrients were urea, DAP (Di-ammonium phosphate) and MOP (Murate of potash) fertilizers. The required amounts of these fertilizers were applied in each main plot in each replication. Entire dose of phosphorus and potash and half dose of nitrogen were applied at the time of seedbed preparation. Remaining half dose of nitrogen was applied at the time of flowering. Other cultural practices like irrigation, weeding etc. were uniform for all the plots. Ten plants were randomly selected from each subplot at maturity and observations on number and weight of mature pods per plant, number of seeds per pod and seed yield per plant were recorded. The data on seed yield per hectare was obtained on the basis of seed yield per plant and plant population per unit area. 1000 seed weight was recorded by taking 1000 seeds randomly from pods of the selected plants in each treatment. The moisture content of the seeds was estimated by taking 4 g samples of seed from each treatment and using oven dry method at 103±2ºC for 17 h (ISTA, 1985). The data collected were analyzed statistically by constructing analysis of variance tables. Differences among the treatment means were compared by using least significant difference (LSD) test at 5% level of probability (Petersen, 1994).

RESULTS AND DISCUSSION

Number of mature pods per plant. Data revealed that the effect of phosphorus levels on number of mature pods per plant was non-significant (Table I). However, the parameter was significantly affected by the planting densities and their interaction with phosphorus levels. The lowest planting density (37000 plants ha^{-1}) resulted in the maximum number of mature pods per plant and the highest planting density (111000 plants ha^{-1}) in the minimum number (Table II). This was probably because in lowest planting density, plants receive more nutrients and lateral growth takes place resulting in increased number of pods per plant. These findings are in close conformity with the results of Birbal *et al.* (1995), who reported that with the increase in plant spacing, number of pods per plant increased. Phosphorus levels with their interaction with planting densities had significantly affected the number of mature pods per plant and plants in lowest planting density regardless the effect of various levels of phosphorus resulted in maximum number of mature pods per plant (Table III). Abdul and Aarf (1986) observed similar results that fertilizer application slightly increased number of pods per plant at widest spacing.

Table I. Effect of various levels of phosphorus on seed yield and quality of okra cv. Sabz Pari

Parameters Studied	Phosphorus level (P_2O_5 kg ha^{-1})		
	0	33	66
Number of mature pods per plant	12.88 a*	13.24 a	13.80 a
Weight of mature pods per plant (g)	47.04 b	52.55 ab	57.41 a
Number of seeds per pod	41.26 b	44.90 a	46.99 a
Seed yield per plant (g)	27.70 c	32.88 b	38.39 a
Seed yield per hectare (kg)	1756.3 c	2131.2 b	2477.4 a
1000 seed weight (g)	51.89 b	55.29 ab	59.11 a
Seed moisture content (%)	8.76 a	9.19 a	9.10 a

*Means in each row sharing same letter (s) are non-significant at 5% probability

Table II. Effect of different planting densities on seed yield and quality of okra cv. Sabz Pari

Parameters studied	Plant densities (plants ha^{-1})		
	111000	55500	37000
Number of mature pods per plant	12.11 c*	12.95 b	14.85 a
Weight of mature pods per plant (g)	45.13 b	53.07 ab	58.81 a
	42.28 a	45.52 a	45.35 a
Number of seeds per pod	28.35 c	32.69 b	37.93 a
Seed yield per plant (g)	3146.8 a	1814.6 b	1403.5 c
Seed yield per hectare (kg)	55.00 a	55.11 a	56.18 a
1000 seed weight (g)	9.49 a	8.81 a	8.76 a
Seed moisture content (%)			

*Means in each row sharing same letter (s) are non-significant at 5% probability

Weight of mature pods per plant. Various phosphorus levels, different planting densities and their interaction had significant effect on the weight of mature pods per plant. The highest weight of mature pods was recorded in plants received 66 kg P_2O_5 ha^{-1}, followed by those received 33 kg P_2O_5 ha^{-1} and both these stood statistically at par. The minimum weight of mature pods was obtained from the plants received no phosphorus (0 kg P_2O_5 ha^{-1}). This indicates that phosphorus application play a significant role in pod weight of okra (Table I). Comparison of means of planting densities reveals that the highest mature pod weight per plant was recorded at the lowest planting density, followed by the intermediate one. Both of these planting densities stood at par. The lowest mature pod weight was recorded at the highest planting density and this also stood at par with the intermediate planting density (Table II). The highest weight of mature pods per plant at the lowest planting density might be attributed to more nutrient availability and vegetative growth in widest spacing giving more number of pods and increased individual pod weight, ultimately resulting in higher weight of pods per plant. Similar results have been reported by Albregts and Howard (1974), who found that pod size of okra cv. Clemson Spineless decreased with increasing plant density. The means of interaction between phosphorus levels and planting densities reveal that the maximum weight of pods per plant was at a combination of highest phosphorus level and the lowest planting density. This was followed by the second dose of phosphorus and the lowest planting density. The minimum weight of pods per plant was recorded from the plants in the highest density and either did not receive any phosphorus (0 kg P_2O_5 ha^{-1}) or received a lower dose of 33 kg P_2O_5 ha^{-1} (Table III). These results are in accordance with those obtained for individual effect of phosphorus levels and planting densities for the parameter under study.

Number of seeds per pod. Data revealed that number of seeds per pod was significantly affected by the phosphorus levels applied and their interaction with planting densities.

Table III. Effect of various phosphorus levels and different plant densities (interaction) on seed yield ad quality of okra cv. Sabz Pari

Parameters studied	Phosphorus level (P_2O_5 kg ha^{-1})								
	0			33			66		
	Plant density (plants ha^{-1})								
	111000	55500	37000	111000	55500	37000	111000	55500	37000
Number of mature pods per plant	11.13 c*	13.07 b	14.43 a	12.00 c	12.72 bc	14.99 a	13.20 b	13.07 b	15.12 a
Wt. of mature pods per plant (g)	44.00 d	47.60 cd	49.53 cd	43.63 d	54.30 bc	59.73 ab	47.77 cd	57.30 abc	67.17 a
Number of seeds per pod	38.95 d	41.43 cd	43.41 bcd	43.76 bcd	45.02 abc	45.92 abc	44.14 bc	50.12 a	46.72 ab
Seed yield per plant (g)	22.98 e	26.71 e	33.41 c	29.05 de	32.07 cd	37.53 b	33.02 c	39.30 ab	42.86 a
Seed yield per hectare (kg)	2550.4 b	1482.5 d	1236.0 d	3225.1 a	1779.8 cd	1388.8 d	3665.1 a	2181.4 bc	1585.7 cd
1000 seed weight (g)	53.00 bc	49.33 c	53.33 bc	55.33 abc	56.00 ab	54.53 abc	56.67 ab	60.00 a	60.67 a
Seed moisture content (%)	9.80 a	8.47 a	8.00 a	8.53 a	9.77 a	9.27 a	10.13 a	8.18 a	9.00 a

*Means in each row sharing same letter (s) are non-significant at 5% probability

However, the effect of different planting densities was found non-significant (Table II). Mean values of phosphorus levels indicate that the maximum number of seeds per pod was recorded in plants received 66 kg P_2O_5 ha^{-1}, followed by in the plants, which received 33 kg P_2O_5 ha^{-1}. Both these levels stood at par and significantly differed from the 0 kg P_2O_5 ha^{-1} (Table I). Majanbu *et al.* (1986) had already reported that phosphorus application increased the number of seeds per pod significantly in okra cultivars. Naik and Srinivas (1992) also recorded maximum number of seeds per pod in plants, which received the highest dose of phosphorus. Comparison of means of interaction (phosphorus levels x planting densities) indicate that the maximum number of seeds per pods was recorded in the combinations of highest phosphorus level with lower plant densities followed by the combinations of lower phosphorus level with lower plant densities. The minimum seed number per pod was recoded in combinations of no phosphorus application with the highest planting density (Table III) confirming the supremacy of the highest phosphorus level on seed number per plant.

Seed yield per plant. All the three sources of variation i.e. phosphorus levels, planting densities and their interaction significantly affected the seed yield per plant. The highest seed yield per plant was obtained from the plants received 66 kg P_2O_5 ha^{-1}. This was followed by those plants, which received 33 kg P_2O_5 ha^{-1} and both these levels differed significantly. The lowest seed yield per plant was recorded in the plants, which did not receive any phosphorus (0 kg P_2O_5 ha^{-1}) (Table I). This indicates that application of phosphorus to okra resulted in increased seed yield per plant. These results are in close conformity with the findings of Naik and Srinivas (1992). Comparison of planting densities indicates that all the densities differed significantly from each other and as number of plants per unit area increased, seed yield per plant decreased (Table II). Highest seed yield per plant at the lowest planting density might be due to increased number of pods per plant. Means of the interaction (phosphorus levels x planting densities) indicate that the highest seed yield per plant was obtained from plants received 66 kg P_2O_5 ha^{-1} and in the lowest planting density of 37000 plants ha^{-1}. The minimum seed yield per plant was harvested from those, which received no phosphorus and planted at the highest density of 111000 plants ha^{-1} (Table III). This clearly demonstrates that in the present study, the highest dose of phosphorus and the lowest planting density was better to obtain the higher seed yield.

Seed yield per hectare. The seed yield per hectare was significantly affected by phosphorus levels, plant densities and their interaction. Comparison of phosphorus levels indicates that the highest seed yield per hectare was obtained from plants received 66 kg P_2O_5 ha^{-1} and this significantly differed from other levels. The minimum seed yield per hectare was recorded in plants received no phosphorus (0 kg P_2O_5 ha^{-1}) (Table I). This indicates that application of phosphorus had increased the seed yield per unit area. These results are in accordance with the findings of Sarnaik *et al*. (1986), who obtained highest seed yield with nitrogen 120, phosphorus 60 kg ha^{-1}. Lenka *et al.* (1989) obtained satisfactory seed yield with 30 kg P_2O_5 ha^{-1}. Similar findings have also been reported by Zanin and Kimoto (1980) and Naik and Srinivas (1992), who in separate studies observed that fertilizer application increased seed yield per unit area of okra. Comparison of planting densities reveals that the highest density resulted in the highest seed yield per hectare and differed significantly from other planting densities. The lowest planting density resulted in the lowest seed yield per hectare (Table II). The possible reason for highest seed yield at the highest planting density could be more number of plants per unit area in this planting density. Comparison of the interaction means reveal that the combination of highest phosphorus dose (66 kg P_2O_5 ha^{-1}) with the highest plant density (111000 plants ha^{-1}) and the combination of 33 kg P_2O_5 ha^{-1} with the highest plant density resulted in the highest seed yield per hectare and both these combinations statistically stood at par. This was followed by the combination of 0 kg P_2O_5 ha^{-1} with the highest plant density but significantly differed from the former combinations (Table III). These results indicate the superiority of the highest planting density for seed yield per unit area possibly due to more number of plants.

1000 seed weight. Weight of 1000 seeds was significantly affected by the phosphorus levels and their interaction with planting densities. Comparison of phosphorus levels indicate that the highest seed weight was recorded in the plants received the highest dose of phosphorus (66 kg P_2O_5

ha^{-1}) and the lowest seed yield when phosphorus was not applied (0 kg P_2O_5 ha^{-1}) and both these behaved statistically alike. While the dose of 33 kg P_2O_5 ha^{-1} was intermediate in its effect (Table I). These results are in accordance with the findings of Naik and Srinivas (1992), who recorded maximum 1000 seed weight when nitrogen and phosphorus were applied at the highest rate. Comparison of means of planting densities reveals that these had no significant effect on the parameter (Table II). Rastogi *et al.* (1987) had already reported that spacing treatments did not affect 1000 seed weight in okra cv. Sel 6-2. Regarding the means of interaction, the results reveal that the highest phosphorus level irrespective of its combination with planting density resulted in the highest seed weight. This was followed by the combinations of other phosphorus level (33 kg P_2O_5 ha^{-1}) with all the three plant densities (Table III). This indicates that the phosphorus application increased the 1000 seed weight, being more at the highest phosphorus level in the present study.

Seed moisture content. Moisture content of the seed was not affected by the phosphorus application, planting densities and their interaction (Table I-III). Moisture content of seed is an important factor, which determines the life of seed and storagable duration. In fact, seed moisture content depends upon the physiological maturity of the seed (time of harvesting) and weather conditions at the time of harvesting. Therefore, the phosphorus levels and planting densities did not have any significant effect on moisture contents of the seeds.

REFERENCES

Abdul, K.S. and L.H. Aarf, 1986. Effects of plant spacing and fertilizer levels on the growth and yield of okra. *Iraqi J. Agric. Sci.,* 4: 77–89.

Albregts, E.E. and C.M. Howard, 1974. Response of okra cultivars to plant density and fertilization. *HortSci.,* 9: 400–2.

Baruah, G.K.S, 1995. Effect of varieties and plant spacing on seed yield of okra. *Hort. J*., 8: 119–24.

Birbal, R.K., N. Nehra and S.Y. Malik, 1995. Effect of spacing and N on fruit yield of okra cv. Varsha Uphar. *Haryana Agric. Univ. J. Res.,* 25: 47–51.

Dwievedi, Y.C., S.K. Sengupta, A.K. Naidu and P.C. Choubey, 1993. Effect of N and P on growth and seed yield of okra. *JNKVV Res. J.,* 27: 53–5.

ISTA, 1985. International rules for seed testing. *Seed Sci. Technol.,* 13: 338–41.

Lenka, P.C., D.K. Das and H.N. Mishra, 1989. Effect of nitrogen and phosphorus on seed yield of Bhindi. *J. Agric. Res.,* 2: 127–9.

Majanbu, I.S., V.B. Ogunlela and M.K. Ahmad, 1986. Response of two okra (*Abelmoschus esculentus* (L.) Moench) varieties to fertilizers. I. Growth and nutrients concentration as influenced by nitrogen and phosphorus application. *Fertilizer Res.,* 8: 297–306.

Mangual, G. and F.W. Martin, 1980. Effect of spacing on seed, protein and oil production of four okra varieties. *J. Agric. Univ. Puerto Rico,* 64: 450–9.

Naik, L.B., 1994. Influence of fertilization and dry matter distribution in okra. *Haryana J. Hort. Sci.,* 23: 61–5.

Naik, L.B. and K. Srinivas, 1992. Influence of nitrogen and phosphorus fertilization on seed crop of okra (*Hibiscus esculentus* L.). *Indian J. Agron.*, 37: 769–71.

Pandey, V.B. and R.P. Dueby, 1996. Effect of nitrogen, phosphorus and intra row spacings on quality chemical composition of okra. *Indian J. Hort.,* 53: 141–4.

Petersen, R.G., 1994. *Agricultural Field Experiments – Design and Analysis.* Marcel Dekker, Inc., New York.

Rastogi, K.B., P.P. Sharma, N.P. Singh and B.N. Korla, 1987. Effect of different levels of nitrogen and plant spacing on seed yield of okra. *Vegetable Sci.*, 14: 120–3.

Sarnaik, D.A., B.S. Bahgel and K. Singh, 1986. Response of okra seed crop to major nutrients. *Res. Dev. Reptr.,* 3: 10–2.

Singh, K.P and M.C. Pandita, 1981. Effect of various levels of nitrogen and phosphorus on seed crop of okra. *Haryana J. Hort. Sci.,* 10: 136–40.

Thakur M.R. and S.K. Arora, 1993. Okra. *In:* Bose, T.K., M.G. Som and J. Kabir (Eds.), *Vegetable Crops,* p.711. Naya Prokash, Calcutta.

Weiner, J., 1990. Plant population ecology in agriculture. *In:* C.R. Carrol, J.H. Vandermeer and P.M. Rosett (Eds.). *Agrocology.* McGraw Hill Book Company Inc., New York.

Zanin, A.C.W. and T. Kimoto, 1980. Effect of plant spacing and fertilizers on okra seed production. *Rev. Brasil. Sem.,* 2: 105–12 [*Hort. Abst.,* 54: 161; 1984].

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