INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2001/03–4–341–344
http://www.ijab.org

Impact of Phosphorus and Planting Geometry on Growth, Yield and Quality of Green Pods in Okra

MUHAMMAD AMJAD, MUHAMMAD AKBAR ANJUM† AND AHMED ALI
Department of Horticulture, University of Agriculture, Faisalabad–38040, Pakistan
†University College of Agriculture, Bahauddin Zakariya University, Multan–60800, Pakistan

ABSTRACT

Phosphorus was applied @ 0, 33 or 66 kg P_2O_5 ha^{-1} to okra cv. Sabz Pari at the time of sowing. Plants were grown at distance of 15, 30 or 45 cm, while distance between rows was maintained as 60 cm. Phosphorus did not have any significant effect on days taken to flowering and plant height at flowering, while the parameters were significantly affected by the planting geometry. Plants spaced at 30 and 45 cm took significantly lesser number of days to flower than those spaced at 15 cm but plant height was maximum at 15 cm. Green pod length was maximum with 33 kg P_2O_5 ha^{-1} and at plant spacing of 45 cm. Number of green pods per plant and average weight per green pod were significantly affected by planting geometry but not by the phosphorus application and both were highest at the widest plant spacing (45 cm). The yields of green pods per plant and per hectare increased significantly with the application of phosphorus but both the levels of phosphorus (33 and 66 kg P_2O_5 ha^{-1}) were statistically alike. Regarding the effect of planting geometry, the pod yield $plant^{-1}$ was highest at 45 cm, while pod yield ha^{-1} was the highest at 15 cm. There was no significant difference in pod protein content of plants receiving 33 and 66 kg P_2O_5 ha^{-1} but both the levels resulted in higher pod protein content than the control (0 kg P_2O_5 ha^{-1}). Planting geometry had no significant effect on pod protein content.

Key Words: *Abelmoschus esculentus*; Fertilizer; Green pod yield; Okra; Planting distance

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is widely grown in tropics and subtropics for its tender green pods. The crop is grown in Pakistan during summer season and its average yield is 8 to 10 tons ha^{-1} only. Further increase in yield and improvement in quality of the produce can be exploited by use of high yielding cultivars and manipulation of improved cultural practices. Among the cultural practices, application of fertilizer and proper crop geometry are the most important factors, which influence both yield and quality of green pods. Okra is highly responsive to fertilizer application. Phosphorus is considered an important element, which improves root growth, increases fruit yield and its quality especially when it is applied in combination with nitrogen (Naik, 1994; Pandey & Dubey, 1996). Anjum and Amjad (1999) applied N @ 50, 75, 100 or 125 kg, P_2O_5 @ 60, 80 or 100 kg and K_2O @ 60 or 80 kg ha^{-1} in different combinations to okra cv. Pusa Sawani. Number of pods per plant, pod length and green pod yield were affected significantly and were highest at the highest dose of fertilizers. Similarly, there is a positive relationship between plant population and crop yield (Weiner, 1990). It has been observed that green pod yield per unit area of okra could be increased at closer spacing but individual pod weight and length were higher at wider spacings (Singh, 1990). Birbal *et al.* (1995) observed that when okra cv. Varsha Uphar was sown at different spacings, tallest plants were in closest spacing and highest number of branches per plant in the widest spacing. Spacing did not affect the number of days to 50% flowering. However, number of pods per plant, pod weight and yield per plant were highest at wider spacing. Thus, to get high yield of good quality green pods of okra, proper nutrient application and optimum plant population is required. The present studies were, therefore, envisaged to obtain information on impact of phosphorus and planting geometry on growth, yield and quality of green pods in okra.

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 procured from the 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}) in main plots and three planting distances (i.e. 15, 30 and 45 cm) in subplots were tested. Distance between rows was kept constant as 60 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 fertilizers used were urea, DAP (Di-ammonium phosphate) and MOP (Murate of potash). The required amounts of these fertilizers were applied in each main plot in each replication. Entire dose of phosphate and potash and half dose of nitrogen were applied at the time of seedbed preparation. Rest of the half amount of nitrogen was applied at the time of flowering. Other cultural practices like irrigation, weeding etc. were uniform for all the plots. The data regarding days taken to initiate flowering were recorded by selecting ten plants randomly and observing how many days were taken to flower from sowing. Similarly, at the time of first flowering, height of 10 randomly selected plants in each treatment was recorded. Observations on length of green pod, number of green pods per plant and average weight per green pod were recorded on each pod harvested through out the pickings. The data on fruit yield per plant and per unit area were obtained on the basis of yield of green pods during 10 pickings. The protein content of the pods was estimated from nitrogen content, determined by Kjeldahl method (AOAC, 1970). The data collected were analyzed statistically by constructing analysis of variance tables. Differences among the treatment means were compared by using Duncan's multiple range test at 5% level of probability (Petersen, 1994).

RESULTS AND DISCUSSION

Days taken to first flowering. Number of days taken to flowering was not affected by various levels of phosphorus (Table I). However, it was significantly influenced by planting geometry. The plants spaced at 45 cm took minimum days to flower, while maximum days were recorded with plants spaced at 15 cm (Table II). Possible reason for delay of flowering at closer spacing might be high competition among the plants for nutrients, moisture and light. Different results were reported by Birbal *et al.* (1995), who found that plant spacing did not affect the number of days to 50% flowering. The effect of interaction between phosphorus levels and planting geometry was found non-significant (Table III).

Table I. Effect of various levels of phosphorus on growth, green pod yield and quality of okra cv. Sabz Pari

Parameters studied	Phosphorus level (kg P_2O_5 ha^{-1})		
	0	33	66
Days taken to first flowering	42.26 a*	44.63 a	46.21 a
Plant height at flowering (cm)	34.66 a	36.78 a	31.82 a
Length of green pod (cm)	11.86 b	13.10 a	11.65 b
Number of green pods per plant	14.54 a	15.23 a	15.79 a
Av. weight per green pod (g)	13.79 a	14.23 a	13.79 a
Green pod yield per plant (g)	203.11 b	218.33 a	219.04 a
Green pod yield per hectare (t)	12.38 b	13.82 a	14.06 a
Protein content of green pod (%)	14.29 b	15.75 a	16.72 a

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

Plant height at flowering. Effect of various levels of phosphorus on plant height at flowering was non-significant (Table I). While, plant height at flowering stage was significantly affected by planting geometry and the tallest plants were observed in 15 cm plant spacing. The plants spaced at 30 and 45 cm were significantly shorter in height and both the treatments behaved statistically alike (Table II). The maximum plant height in the closest spacing could be due to less space available, which discourages the lateral growth and plants grow upward in competition for light. Similar results were observed by Faraq and Damrany (1994) and Birbal *et al.* (1995), who after separate studies reported that the plant height was increased with increasing plant density. They also found that there was no appreciable difference between the phosphorus treatments. The plant height was also not affected by the interaction between phosphorus levels and planting geometry in the present study (Table III).

Table II. Effect of different plant spacings on growth, green pod yield and quality of okra cv. Sabz Pari

Parameters studied	15 cm	30 cm	45 cm
Days taken to first flowering	47.51 a*	44.17 b	43.42 b
Plant height at flowering (cm)	38.64 a	32.98 b	31.63 b
Length of green pod (cm)	12.16 b	11.72 c	13.01 a
Number of green pods per plant	13.78 c	14.95 b	16.84 a
Av. weight per green pod (g)	13.54 b	13.48 b	14.79 a
Green pod yield per plant (g)	173.34 c	201.51 b	265.63 a
Green pod yield per hectare (t)	19.41 a	11.19 b	9.83 c
Protein content of green pod (%)	16.33 a	15.20 a	15.30 a

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

Length of green pod. All the three sources of variation i.e. phosphorus levels, planting geometry and their interaction significantly affected the length of green pods. The longest pods were recorded in plants, which received 33 kg P_2O_5 ha^{-1} (Table I). Increase in pod length by the application of phosphorus has already been reported by Pandey and Dubey (1996). In case of planting distance, maximum pod length was recorded in those harvested from the plants spaced at 45 cm (Table II). These results are in accordance with Singh (1990), who reported that the longest pods were recorded with widest spacing. Interaction effect of phosphorus levels and plant spacings on pod length depicted that plants receiving 33 kg P_2O_5 ha^{-1} and spaced at 45 cm apart resulted in maximum pod length (Table III).

Number of green pods per plant. The effect of phosphorus levels on number of green pods per plant was non-significant (Table I) but the parameter was significantly affected by the planting geometry and its interaction with phosphorus levels. The widest spacing (45 cm) resulted in the maximum number of green pods per plant and the closest spacing (15 cm) in the minimum number (Table II). This was probably because in wider spacing, plant receives more nutrients and lateral growth takes place resulting in increased number of green pods per plant. These findings are in close conformity with the results of Birbal *et al.* (1995), they reported that with the increase in plant spacing, number of green pods per plant increased. Phosphorus and its interaction with planting geometry had significantly affected number of green pods per plant and plants spaced at 45 cm regardless the effect of various level of phosphorus resulted in maximum number of green 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.

Average weight per green pod. Phosphorus application had non-significant effect on average weight per green pod

Table III. Effect of phosphorus levels and plant spacings (interaction) on growth, green pod yield and quality of okra cv. Sabz Pari

Parameters	Phosphorus level (P_2O_5 kg ha^{-1}) 0			33			66		
	Plant spacing (cm)								
	15	30	45	15	30	45	15	30	45
Days taken to first flowering	46.60 a*	43.83 a	42.33 a	47.90 a	43.17 a	42.83 a	48.03 a	45.50 a	45.10 a
Plant height at flowering (cm)	39.80 a	32.67 a	31.50 a	42.17 a	35.10 a	33.07 a	33.97 a	31.17 a	30.33 a
Length of green pod (cm)	11.63 e	11.20 f	12.75 b	12.27 d	12.39 cd	14.63 a	12.58 bc	11.55 e	11.65 e
Number of green pods per plant	12.13 c	15.07 b	16.43 a	14.00 b	14.72 b	16.97 a	15.20 b	15.07 b	17.12 a
Av. weight per green pod (g)	12.02 f	13.63 c	15.71 ab	13.05 d	13.57 c	16.06 a	12.60 e	13.23 cd	15.55 b
Green pod yield per plant (g)	145.80 d	205.40 b	258.12 a	182.70 c	199.75bc	272.54 a	191.52bc	199.38bc	266.22 a
Green pod yield per hectare (t)	16.18 b	11.40 c	9.55 c	20.28 a	11.09 c	10.08 c	21.26 a	11.07 c	9.85 c
Protein content of green pod (%)	14.00 a	15.75 a	13.13 a	17.50 a	14.00 a	15.75 a	17.50 a	15.74 a	16.92 a

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

(Table I), while its interaction with planting geometry had significant effect. The effect of planting geometry was also found significant. Comparison of plant spacing means indicates that the average weight of single green pod was highest at 45 cm, which also statistically differed from other plant spacings (Table II). Similar results about highest average green pod weight at widest spacing have been reported by several workers (Albregts & Howard, 1974, 1976; Birbal *et al*., 1995). Phosphorus and its interaction with planting geometry also significantly affected the average weight per green pod. The means of interaction (phosphorus levels x plant spacings) revealed that the plants receiving 33 kg P_2O_5 ha^{-1} and spaced at 45 cm resulted in the highest average weight per green pod (Table III).

Green pod yield per plant. Green pods yield per plant was significantly affected by phosphorus application, plant spacings and their interaction. Comparison of phosphorus levels indicates that the green pod yield per plant increased significantly with the application of phosphorus. However, both the levels of phosphorus (33 and 66 kg P_2O_5 ha^{-1}) were statistically at par (Table I). This indicates that application of additional dose of fertilizer beyond a specific limit may not be productive. Comparison of plant spacings reveals that the widest spacing resulted in the highest green pod yield per plant (Table II). The possible reason could be that in wider spacing, plants receive more nutrients and lateral growth takes place. This results in more number of green pods and increased pod weight, which ultimately results in more green pod yield per plant. Similar results have been recorded by Albregts and Howard (1976) and Birbal *et al.* (1995). Comparison of means of interaction (phosphorus levels x plant spacings) depicted that green pod yield per plant was the highest at the combination of 33 kg P_2O_5 ha^{-1} x 45 cm, closely followed by the combinations 66 kg P_2O_5 ha^{-1} x 45 cm and 0 kg P_2O_5 ha^{-1} x 45 cm. The minimum green pod yield per plant was achieved from the combination 0 kg P_2O_5 ha^{-1} x 15 cm (Table III). The possible reason for higher green pod yield per plant at all the combinations of widest spacing with phosphorus levels might be more number of green pods in these combinations.

Green pod yield per hectare. Green pod yield per hectare was significantly affected by all the three sources of variation i.e. phosphorus levels, planting geometry and their interaction. Comparison of phosphorus levels indicates that the highest green pod yield per hectare was obtained from the plants receiving 66 kg P_2O_5 ha^{-1}, closely followed by those receiving 33 kg P_2O_5 ha^{-1} and both these phosphorus levels statistically stood at par. This indicates that the application of phosphorus to the okra crop resulted in increase in green pod yield per unit area (Table I). These results are in close conformity with the findings of previous workers (Reddy *et al.*, 1984; Arora *et al.*, 1991; Anjum & Amjad, 1999), who observed increase in green pod yield per unit area of okra by increased doses of phosphorus. Regarding the effect of planting geometry, the highest green pod yield per hectare was obtained when plants were spaced closely (Table II). The possible reason could be that when plant to plant distance is decreased, number of plants per unit area increases, ultimately resulting in higher green pod yield per hectare. Similar results have been reported by Singh (1990), who recorded highest green pod yield per hectare with the closest spacing of 40 x 20 cm. Interaction of phosphorus levels and planting geometry reveals that the highest green pod yield per hectare was recorded from the plants receiving 66 kg P_2O_5 ha^{-1} and spaced at 15 cm, closely followed by those receiving 33 kg P_2O_5 ha^{-1} and spaced at 15 cm. Both these combinations were statistically at par (Table III). This clearly indicates the supremacy of closest spacing in combination with phosphorus application for green pod yield per unit area.

Protein content of green pod. Pod protein content was significantly affected by the phosphorus application. The highest protein content of green pods was recorded in the pods harvested from the plants receiving 66 kg P_2O_5 ha^{-1}, followed by those receiving 33 kg P_2O_5 ha^{-1}. These both the phosphorus levels were statistically at par and significantly superior to protein content of the pods from the plants received no phosphorus (0 kg P_2O_5 ha^{-1}) (Table I). This indicated that the application of phosphorus increases the protein content of green pods. Similar results about the effect of phosphorus on green pod protein content have been reported by Arora *et al.* (1985) and Pandey and Dubey (1996). Pod protein content was not affected by the planting geometry (Table II) and the interaction between the two factors studied (Table III).

CONCLUSION

These findings lead to the conclusion that application of phosphorus in combination with nitrogen and potash to okra cv. Sabz Pari resulted in higher green pod yield per plant and per unit area and also higher protein content of green pods. However, both the levels of phosphorus behaved statistically alike. The pod length (a quality parameter) was the maximum at 33 kg P_2O_5 ha^{-1}. This is evident that phosphorus is essential in maintaining nutrient balance in okra crop. Secondly, okra yield and its pod quality can be manipulated by changing plant spacing. Green pod yield per unit area can be maximized with closer spacing but green pod yield per plant and quality parameters like length and weight of individual pod can be improved with wider spacing. The results of the present studies can serve as guiding index about balance use of fertilizers and proper crop geometry for obtaining higher yield and good quality of green pods in okra.

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. *Hort. Sci.*, 9: 400–2.

Albregts, E.E. and C.M. Howard, 1976. Response of four okra cultivars on mulch beds to plant density. *Hort. Sci.,* 11: 242–4.

Anjum, M.A. and M. Amjad, 1999. Response of okra (*Abelmoschus esculentus* L. Moench) to different levels of N, P and K fertilizers. *Pakistan J. Biol. Sci.,* 2: 794–6.

AOAC, 1970. *Official Methods of Analysis.* Washington.

Arora, S.K., N. Kumar, V.K. Thapar and D. Singh, 1985. Biochemical constituents in okra (*Abelmoschus esculentus* L. Moench) as affected by nitrogen and phosphorus fertilization. *Punjab Veg. Grw.*, 20: 35–7.

Arora, S.K., N. Kumar and B.R. Sharma, 1991. Effect of N and P fertilization on growth and yield components in okra (*Abelmoschus esculentus* L. Moench). *Haryana J. Hort. Sci.*, 20: 261–6.

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.

Faraq, I.A. and A.M. Damrany, 1994. The response of two okra cultivars to NPK levels and spacing on growth, yield and quality. *Assiut J. Agric. Sci.*, 25: 98–117.

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

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.

Reddy, P.S., R. Veeraraghavalah, M.G.R. K. Reddy and K. Subrahmanyam, 1984. Effect of nitrogen and phosphorus on fruit yield of okra. *South Indian Hort.*, 32: 304–5.

Singh, B.P., 1990. Effect of spacing on okra. *Indian J. Agron.*, 35: 439–41.

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.

(Received 02 September 2001;Accepted 14 September 2001)