PHOSPHORUS APPLICATION TO COTTON ENHANCES GROWTH, YIELD, AND QUALITY CHARACTERISTICS ON A SANDY LOAM SOIL

Maqshoof Ahmad[1], Abdul Hannan[2], M. Yasin[3], A.M. Ranjha[1] and Abid Niaz[4]
[1]Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad
[2]Directorate of Land Reclamation, Irrigation and Power Department
[3]Directorate General of Agriculture (Extension Wing)
[4]Soil Chemistry Section, AARI, Faisalabad
*Corresponding author's e-mail: maqshoof_ahmad@yahoo.com

Phosphorus (P) is the second most limiting nutrient in cotton (*Gossypium hirsutum* L.) production after nitrogen. Under wheat-cotton cropping system of Pakistan most of the farmers apply P fertilizer only to wheat crop. A field experiment was conducted to evaluate the effect of fertilizer P on the growth, yield and fibre quality of cotton on a sandy loam calcareous soil at farmer's field in cotton growing area of district Khanewal, Punjab. Five levels of P (0, 17, 26, 34 and 43 kg P ha^{-1}) along with 120 kg N and 53 kg K ha^{-1} were applied. The response of cotton growth parameters was greater than quality components to P addition in calcareous soil. There was significant increase in the growth and yield parameters with each additional rate of P. The response of number of bolls per plant, boll weight and seed cotton yield was to the tune of 88.23, 16.82 and 42%, respectively at P application rate of 34 kg ha^{-1}. Cotton quality components (lint %age, fiber length and fiber strength) improved from 2 to 5% where 43 kg P ha^{-1} was added. The lint and seed P concentration was little affected by P application as compared to stem and leaves showing its essentiality for cell division and development of meristematic tissue. Phosphorus use, thus not only valuable for wheat crop but also its application to cotton crop is of vital importance in improving both lint yield and quality.
Keywords: Seed cotton yield, lint, fibre quality, phosphorus

INTRODUCTION

Potential for crop production under intensive irrigation system in the Punjab is high because of its favorable environmental and edaphic factors. However, the yields of several agricultural crops are stagnant in Pakistan for the last many years most probably due to imbalanced use of fertilizers (NFDC, 2003). Reasons for low use of P in Pakistan are attributed to high prices, lack of promotional activities and reduced availability during peak demand period. High yielding varieties and intensive cultivation is another cause of depletion of P in our soils (NFDC, 2001; Yasin *et al.*, 2008)

Phosphorus is the second most limiting nutrient in cotton (*Gossypium hirsutum* L.) production after nitrogen. It is a constituent of cell nuclei, essential for cell division and development of meristematic tissue (Russell, 2001) and has a well known impact on photosynthesis as well as synthesis of nucleic acids, proteins, lipids and other essential compounds (Guinn, 1984; Taiz and Zeiger, 1991). About 80 to 90% soils of Pakistan are P deficient (Memon and Puno, 1992; NFDC, 2001). Deficiency limits growth of cotton plants, especially when plants are deprived of P at early stages of growth (Hearn, 1981). Deficiency reduces amino acid and protein synthesis. Correlated with this decrease in protein synthesis, there is often an accumulation of sugars in the leaf tissues, which favors phenol synthesis. The latter inhibits cell division and cell expansion as well as the development of plant tissues and organs (Noggle and Fritz, 1976). These growth problems tend to reduce the numbers of nodes, fruiting branches and leaves per plant.

Cotton crop in general showed tremendous response to nitrogenous fertilizers in all soil types, but its response to fertilizer P was erratic and variable in most areas (Malik *et al.*, 1996). However, there are cases where cotton response to P has been positive and economical (Gill *et al.*, 2000). Variable response of cotton to P fertilization is also reported in other parts of the world. In the United States, application of P produced significantly positive response to seed cotton yield on the sandy soils whereas little or no response was obtained on the fertile alluvium (Nelson, 1980). If more than 12 mg kg^{-1} available P is present in the soil, no fertilizer is required (Halevy, 1979). The P requirements of cotton are considered very low because of its deep root system and indeterminate growth habit (Malik *et al.*, 1996). Phosphorus application to cotton may also improve its quality parameters. Keeping in view the above facts, the present study has been intended to evaluate the effect of fertilizer P on growth, yield and fiber quality of cotton on sandy loam calcareous soil.

MATERIALS AND METHODS

The present experiment was conducted during 2007, at farmer's field in cotton growing area of district Khanewal. Soil samples were collected before planting crop to analyze physico-chemical properties of soil (Table 1) as described by Jackson (1962). Organic matter was determined by oxidation (Walkley and Black, 1934), calcium carbonate by calcimeteric method (Moodie *et al.*, 1959), available P with $NaHCO_3$ at pH 8.5 (Watanabe and Olsen, 1965) and extractable potassium with NH_4OAC (U.S. Salinity Lab. Staff, 1954). The soil was normal in reaction and no salinity or sodicity hazards were found. Moreover, organic matter, P and K status of soil was very low while $CaCO_3$ contents were high and texture was sandy loam.

Table 1. Physical and chemical characteristics of the experimental field (0-30 cm depth)

Soil Determinants	Units	Value
EC_e	dS m^{-1}	0.97
pH_s	-	7.64
$CaCO_3$	%	5.45
Organic matter	%	0.40
Available P	mg kg^{-1}	3.10
Available K	mg kg^{-1}	87
Sand	%	65
Silt	%	18
Clay	%	17
Textural Class	-	Sandy loam
Great group		Torripsaments

The P rates applied to cotton cv. CIM-496 were 0, 17, 26, 34 and 43 kg P ha^{-1}. The experiment was laid out using RCBD with three replications. Crop was planted on 1st week of May 2007 in rows. The plant density was maintained at row-to-row distance of 75 cm and plant-to-plant distance of 20-30 cm. The P as diammonium phosphate and K as sulphate of potash (53 kg K ha^{-1}) were broadcasted and incorporated in the soil at the time of seedbed preparation. All experimental units received nitrogen at 150 kg ha^{-1} in the form of urea in three splits i.e. at planting, flowering and peak flowering stages. The crop was irrigated with canal irrigation with EC of 0.34 dS m^{-1}, SAR of 4.23 mmoles and RSC being negligible. Standard cultural practices were followed during the growth period. The crop was protected from insects and pests through scheduled spray during growing period. Earlier, P was also applied to the wheat crop at recommended rate i.e. 110 kg ha^{-1}.

Data on dry matter yield, number of bolls per plant, boll weight, lint percentage and plant structural measurements (main stem height and sympodial branches) were recorded at maturity by harvesting 20 random plants from each experimental unit. The plant material was dried in oven at 70°C and analyzed for P concentration. Fiber quality was determined by employing suitable methods (Morton and Hearle, 1975). Analysis of variance (ANOVA) technique was used and Duncan's Multiple Range (DMR) test was applied to see the significance of differences among treatments means (Duncan, 1955).

RESULTS AND DISCUSSION

Yield components and seed cotton yield

All the yield components were improved significantly with P application. Number of sympodial branches increased from 31.50 (control) to the maximum of 37.75 where P was applied at the rate of 34 kg ha^{-1}. Further improvement was not observed with higher P rate. Plant height is a genetic trait but balanced nutrition showed positive effect. There was a gradual improvement in main stem height with different levels of P application. Though control treatment and 17 kg ha^{-1} were significant at probability (p) = 0.05 but overall there was a small effect of P rate with respect to main stem height. Main stem height varied from 134, 137, 140, 141 and 140 cm, respectively from control plot to treatment where 43 kg P was applied. Data indicated that dry matter yield increased from 3.04 Mg ha^{-1} (control) to the peak value of 5.89 Mg ha^{-1} with treatment where P was used at the rate of 43 kg ha^{-1}. There was a non-significant increasing trend from 26 kg P ha^{-1} to 43 kg P ha^{-1} plots. Similarly, control and 17 kg P ha^{-1} treatments were statistically at Par. The response of number of bolls $plant^{-1}$ to the P rate was significant at $p < 0.05$. It ranged from 17 No. of bolls $plant^{-1}$ in control to a maximum of 32 with 34 kg P ha^{-1} but thereafter a non-significant decrease was observed with 43 kg P ha^{-1} (32 No. of bolls $plant^{-1}$). Increase in this parameter was to the tune of 88.23% where P was added at 34 kg ha^{-1}. The response of boll weight to P application was low (Table 3) as compared to No. of bolls $plant^{-1}$. However increasing trend in boll weight was observed up to 34 kg P ha^{-1}. Boll weight increased to the highest value of 3.66 g with P application of 34 kg ha^{-1}. This increase was 16.82% as compared to control. The 17 kg P ha^{-1} was statistically at par with control.

The effect of P on seed cotton yield was positive (Table 3). Seed cotton yield ranged from 2705 kg ha^{-1} (control) to the plateau point of 4766 kg ha^{-1} with P application rate of 34 kg ha^{-1}. This treatment was statistically at par with 43 kg P ha^{-1}.

The positive response to added P to the cotton crop in the cotton belt of the Punjab has been reported by

Table 3. Effects of P rate on cotton quality

P rate (kg ha^{-1})	Lint (%)	Fiber length (mm)	Fiber strength (000 lbs inch^{-2})	Fruit shedding (%)
Control	34.06	26.13	93.30	68.95
17	34.84	26.37	93.70	63.74
26	35.25	26.37	93.87	58.94
34	35.30	26.38	94.37	57.46
43	35.32	26.40	94.63	54.75
LSD at p = 0.05	0.1331	0.2147	0.480	7.596

researchers (Malik *et al.*, 1996; Gill *et al.*, 2000; Makhdum *et al.*, 2001). P as a constituent of cell nuclei is essential for cell division and development of meristematic tissue, and hence it should have a stimulating effect on the plants, increasing the number of flowers and bolls per plant (Russell, 2001). Further, P has a well known impact on photosynthesis as well as on synthesis of nucleic acids, proteins, lipids and other essential compounds (Guinn, 1984), all of which are major factors affecting boll weight and consequently cottonseed yield. These results are confirmed by those of El-Debaby *et al.* (1995) and Abdel-Malak *et al.* (1997).

Cotton quality parameters

Phosphorus application also influenced lint percentage of cotton crop (Fig. 1). Though response appeared positive, least improvement in this parameter was noticed. Overall increase remained 3.50% with respect to control and average lint %age of all the treatments was 34.95. Increasing trend was observed in quality parameters with each level of added P. This trend indicated those higher P rates need to be tested to get the maximum potential of crop with respect to quality components. The response of fibre length and strength was similar as was discussed in lint %age (Table 2). Thus, the quality of fiber is less affected by the application of P fertilizer. The reason being that genetic and environmental factors apparently exert so much influence on fiber quality that little direct effect from P can be elucidated (Malik *et al.*, 1996; Makhdum *et al.*, 2001).

Phosphorus concentration in different parts of plant

Lint and seeds p concentrations were little affected by P application as compared to stem and leaves as is evident from Data (Table 4) showed that phosphorus is essential for cell division and development of meristematic tissue, and hence it should have a stimulating effect on the plants, increasing the number of flowers and bolls per plant (Russell, 2001).

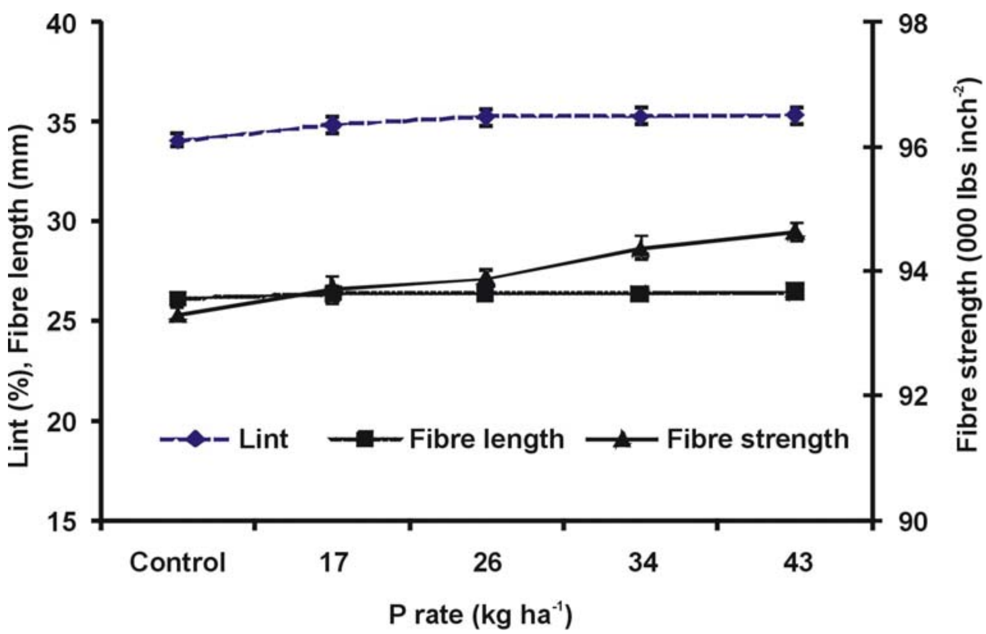

Fig. 1. Effect of P rate on cotton quality parameters

Table 2. Effect of P rate on yield components and seed cotton yield

P rate (kg ha^{-1})	Sympodial branches (No's)	Main stem height (cm)	Dry matter yield (mg ha^{-1})	Bolls plant^{-1} (No's)	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Control	31.50	134	3.04	17	3.15	2705
17	33.35	137	5.32	21	3.30	2992
26	35.95	140	5.76	27	3.59	4245
34	37.75	141	5.92	32	3.66	4766
43	37.05	140	5.89	32	3.66	4680
LSD at p = 0.05	1.566	4.540	0.3315	2.188	0.2148	157.5

Table 4. Effect of P rate on P concentration in different plant parts

P rate (kg ha^{-1})	Stem	Leaves	Seed	Lint
	(%)			
Control	0.25	0.29	0.32	0.24
17	0.33	0.32	0.35	0.26
26	0.39	0.35	0.37	0.26
34	0.42	0.38	0.39	0.27
43	0.43	0.40	0.39	0.26
LSD at p = 0.05	0.0595	0.0266	0.0326	0.0188

Table 5. P availability in soil versus increment of fertilizer P rate

P rate (kg ha^{-1})	Control	17	26	34	43
Olsen-P level after harvesting (mg kg^{-1})	3.0	3.0	6.75	8.40	9.70

Olsen P status in soils after harvesting

Phosphorus availability in soil increased with each increment of P dose. However, increase in availability was not proportionate to added amount (Table 5). The Olsen P level increased but it still requires P application for the next crop as it is recommended that if more than 12 mg kg^{-1} available P is present then there is no need to add fertilizer P (Halevy, 1979). Alkaline and calcareous soils are known to fix a sizeable portion of fertilizer P and reduce its availability in soil (Sharif *et al.*, 1974).

CONCLUSION

In the present study, 34 kg ha^{-1} P was found optimum to maximize the yield parameters (number of bolls per plant, boll weight and seed cotton yield) of cotton. In case of quality components positive but little response was noticed even at high P rate of 43 kg ha^{-1}.

Owing to significant response of both yield and quality of cotton crop to P application, extensive trials on P nutrition of cotton are required.

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