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# EFFECT OF PHOSPHORUS FERTILIZER ON GROWTH, YIELD AND FIBRE QUALITY OF TWO COTTON CULTIVARS

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**Abstract:** Studies were carried out on cotton cultivars varying in plant structure to find their responses to phosphorus fertilizer at Central Cotton Research Institute, Multan. The treatments consisted of two cotton cultivars (CIM-240 and MNH-147) and three phosphorus doses (0,50 and 100 kg $P_2O_5$ $ha^{-1}$) and were arranged in split plot design with four replications. The results showed significant increase in seed cotton yield due to phosphorus fertilizer application. Cultivar CIM-240 was more responsive to phosphorus fertilization than that of MNH-147.

**Keywords:** Cotton, cultivars, fibre quality, growth, phosphorus, yield.

## INTRODUCTION

Potential for crop production under extensive irrigation system in the Punjab is high, because of its favorable environmental and edaphic factors. However, increased crop yields through intensive cropping will require large amount of plant nutrients to sustain high production level.

Cotton growers face major problem of increase in production cost. There is a constant increase in prices of many inputs; raising production costs and wiping out profit margins. Fertilizer is one of many inputs, which raises production cost. Survey of various districts of the Punjab has shown that almost all cotton growers use nitrogenous fertilizer, however 85 % farmers use phosphatic fertilizer to increase crop production. Fertilizer costs were second largest variable costs and accounted for 22 percent of total production costs [Bickersteth and Walker 1988].

Soil tests carried out in Pakistan indicated a general lack of nitrogen, a wide spread deficiency of phosphorus and occasional deficiency of potassium [Wahhab 1985]. Cotton crop in general showed tremendous response to nitrogenous fertilizers in all soil types, but its response to phosphatic fertilizer was erratic and variable in most areas [Malik *et al.* 1996]. However, there are cases where cotton response to phosphorus has been positive and economical [Gill *et al.* 2000].

Variable response of cotton to phosphorus fertilization is obtained also in other parts of the world. In the United States, application of phosphorus 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]. In Israel, sodium bicarbonate extractable phosphorus is recommended as an index for fertilization of cotton crop. If more than 12 mg $kg^{-1}$ available P is present in the soil, no fertilizer is added [Halevy 1979]. The phosphorus requirements of cotton are considered very low because of its deep root system and indeterminate growth habit [Malik *et al.* 1996]. The present investigation therefore, intended to gain a better understanding of phosphorus requirement for cotton cultivars having different plant architecture and response of cotton to phosphorus fertilization.

## MATERIALS AND METHODS

The present investigations were conducted during 1993-95, at Central Cotton Research institute, Multan. Soil samples were collected before planting crop from plough layer of the experimental sites and analysis carried out as per methods [Jackson 1962]. The organic matter was determined by oxidation method, total nitrogen by modified kjeldahl method, calcium carbonate by neutralizing equivalence, available phosphorus extracted with $NaHCO_3$ at pH 8.5 and available potassium extracted with $NH_4OAc$. The physio-chemical characteristics are listed in Table 1.

**Table 1:** Physical and chemical characteristics of the experimental fields (0-30 cm depth)

| Characteristics | Range | Mean |
|---|---|---|
| $pH_s$ | 8.1-83 | 8.2 |
| $EC_e$ ($dSm^{-1}$) | 2.1-2.4 | 2.3 |
| Organic Matter (%) | 0.44-0.58 | 0.51 |
| $CaCO_3$ (%) | 4.9-6.8 | 5.9 |
| Total Nitrogen (%) | 0.03-0.04 | 0.04 |
| $NaHCO_3$-P (mg $kg^{-1}$) | 7.56-8.31 | 7.9 |
| $NH_4OAc$-K (mg $kg^{-1}$) | 120-139 | 130 |
| Textural Class | Silt Loam | |

The treatments consisted of two cotton cultivars (MNH-147 and CIM-240) having three phosphorus doses (0,50 and 100 kg $ha^{-1}$). The layout of experiment was split plot (main: phosphorus doses) with four replications. Crop was planted on 3rd June at a spacing of 75 cm between rows and 30 cm between plants. The area of each plot was 104 $m^2$. The whole quantity of phosphorus as a source of single super phosphate was broadcast and incorporated in the soil at the time of seedbed preparation. All experimental units also received 50 kg $K_2O$ $ha^{-1}$ in the form of sulphate of potash at planting and 150 kg N $ha^{-1}$ in the form of urea in three split doses i.e. planting, flowering and peak flowering stages. Standard cultural practices were followed during the growth period. The crop was protected from insects and pests through scheduled spray during growing period.

The phosphorus availability during the season was monitored by collecting five cores from each plot at 7, 30, 60, 90, 120 and 150 days after planting. The phosphorus was determined by $NaHCO_3$ extraction method [Watanabe and Olsen 1965].

Fruit production, dry matter yield and plant structure measurements were recorded at maturity by harvesting five random plants from each treatment. The plants were brought to laboratory and partitioned into leaves, stalks and fruit. The plant material was dried in forced air oven at 80$^{o}$C. Seed cotton yield was harvested and data calculated on hectare basis. Data on number of bolls per plant, boll weight and lint percentage were recorded on 10 random plants from each treatment at maturity. Fibre quality was determined by employing suitable methods [Morton and Hearle 1975]. Statistical analyses of data were done according to method of Gomez and Gomez [1984].

## RESULTS AND DISCUSSION

Phosphorus availability in soil increased with each increment of fertilizer dose. However, increase in availability was not proportionate to added amount (Fig.1). Alkaline and calcareous soils are known to fix a sizeable portion of fertilizer phosphorus and reduce its availability in soil [Sharif *et al.* 1974]. Phosphorus availability in soil also increased with advancement in crop age. This could be ascribed to increase in root activity in soil. Plant roots excrete organic acids and chelating organic compounds in rhizosphere. These compounds form multiple complex compounds with Ca, Mg and/or Fe and thereby increased phosphorus availability in soil [Tinker 1980].

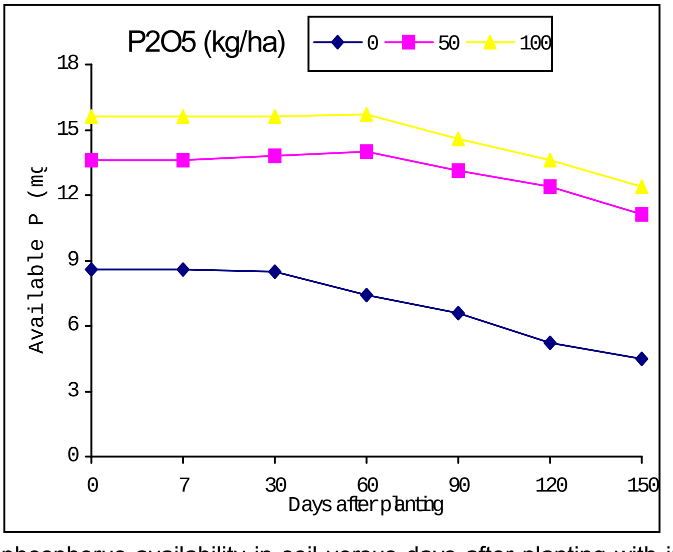


**Fig. 1:** Plot of phosphorus availability in soil versus days after planting with increment of fertilizer dose.

Total dry matter production, economic yield and plant structure are among some of the parameters often used to evaluate usefulness of fertilizer doses. Data presented in Table 2 indicate that dry matter yield and plant height increased with each increment of phosphorus dose. Increase in main stem node numbers was mainly responsible for plant height. Cultivar MNH-147 attained higher dry matter yield per unit land area and plant height compared to cv. CIM-240. These differences could be due to the reason that MNH-147 is more indeterminate in growth habit compared to CIM-240. Similar results have been reported that cotton cultivars differed significantly amongst themselves in response to phosphorus fertilization in trials conducted at different locations in the Punjab, Pakistan [Malik *et al.* 1996].

**Table 2:** Effects of different doses of phosphorus fertilizer on dry matter yield and plant structure (average of 2 seasons)

| $P_2O_5$ Doses Kg $ha^{-1}$ | Cultivars | | Mean |
|---|---|---|---|
| | MNH-147 | CIM-240 | |
| | (a) Dry matter yield (g $m^{-2}$) | | |
| 0 | 785 | 706 | 746 a |
| 50 | 815 | 714 | 765 b |
| 100 | 889 | 745 | 817 c |
| Mean | 830 a | 722 b | |
| | (b) Main Stem height (cm) | | |
| 0 | 168 | 128 | 148 a |
| 50 | 171 | 131 | 151 a |
| 100 | 177 | 134 | 156 ab |
| Mean | 172 a | 131 b | |
| | (c ) Main stem node number | | |
| 0 | 38 | 36 | 37 a |
| 50 | 39 | 36 | 38 b |
| 100 | 40 | 37 | 39 c |
| Mean | 39 a | 36 b | |
| | (d) Internodal length (cm) | | |
| 0 | 4.4 | 3.5 | 4.0 a |
| 50 | 4.4 | 3.6 | 4.0 a |
| 100 | 4.4 | 3.6 | 4.0 a |
| Mean | 4.4 a | 3.6 b | |

**Table 3:** Effects of different doses of phosphorus fertilizer on fruit production (average of 2 seasons)

| $P_2O_5$ Doses Kg $ha^{-1}$ | Cultivars | | Mean |
|---|---|---|---|
| | MNH-147 | CIM-240 | |
| | (a) Total number of fruiting positions per $m^2$ | | |
| 0 | 505 | 486 | 496 a |
| 50 | 519 | 495 | 507 a |
| 100 | 543 | 507 | 525 ab |
| Mean | 522 a | 496 b | |
| | (b) Total number of intact fruit per $m^2$ | | |
| 0 | 113 | 117 | 115 a |
| 50 | 114 | 118 | 116 a |
| 100 | 121 | 127 | 124 b |
| Mean | 116 a | 121 b | |
| | (c ) Fruit Shedding (%) | | |
| 0 | 78.8 | 76.2 | 77.5 a |
| 50 | 77.9 | 76.0 | 77.0 a |
| 100 | 76.6 | 74.8 | 75.7 b |
| Mean | 77.8 a | 75.7 b | |

Better plant growth in plots receiving phosphorus led to higher fruiting positions and intact fruit (Table 3). Cultivar MNH-147 produced greater number of fruiting position per unit land area compared to CIM-240. Fruit shedding decreased with each increment of phosphatic fertilizer dose in both cultivars, however, it was more in MNH-147 compared to CIM-240 at all fertilizer levels. These data clearly demonstrated the usefulness of phosphorus fertilization in augmenting reproductive development. Cultivar CIM-240 was more responsive to phosphatic fertilizer in utilizing its increased synthetic capacity into fruit production. Results indicated that phosphate fertilizer in addition to nitrogen was required for vigorous plant growth and higher boll setting in cotton. The positive response to added phosphorus in the cotton crop in the cotton belt of the Punjab has been repoted by researchers [Malik *et al.* 1996, Gill *et al.* 2000].

**Table 4:** Effects of different doses of phosphorus fertilizer on seed cotton yield and its components (average of 2 seasons).

| $P_2O_5$ Doses Kg $ha^{-1}$ | Cultivars MNH-147 | CIM-240 | Mean |
|---|---|---|---|
| | (a) Seed cotton yield (kg $ha^{-1}$) | | |
| 0 | 2121 | 2437 | 2279 a |
| 50 | 2238 | 2619 | 2429 b |
| 100 | 2317 | 2798 | 2558 c |
| Mean | 2225 a | 2618 b | |
| | (b) Number of bolls per plant | | |
| 0 | 22.1 | 23.5 | 22.8 a |
| 50 | 22.4 | 24.4 | 23.4 b |
| 100 | 23.3 | 25.2 | 24.3 c |
| Mean | 22.6 a | 24.4 b | |
| | (c ) Boll weight (g) | | |
| 0 | 3.42 | 3.56 | 3.49 a |
| 50 | 3.48 | 3.58 | 3.53 a |
| 100 | 3.55 | 3.62 | 3.59 b |
| Mean | 3.48 | 3.59 | |
| | (d) Lint (%) | | |
| 0 | 36.9 | 36.8 | 36.9 a |
| 50 | 36.7 | 36.7 | 36.7 a |
| 100 | 36.6 | 36.5 | 36.6 a |
| Mean | 36.7 a | 36.7 a | |

The benefit of vigorous plant growth and higher number of intact fruit was reflected in seed cotton yield. Phosphorus fertilization caused significant increase in seed cotton yield, number of bolls per plant and boll weight (Table 4). However, lint percentage was little affected due to phosphorus application. There was about 12% increase in seed cotton yield in crop fertilized with 100 kg $P_2O_5$ $ha^{-1}$ compared to crop where no phosphorus was added. Phosphorus fertilizer increased seed cotton yield in both cultivars. Cultivar CIM-240 gave significantly higher yield compared to MNH-147. The values of seed cotton yield ranged from 2121 to 2798 kg $ha^{-1}$. The differential response of cultivars to phosphorus nutrition is due to their inherent indeterminate growth habit and thereby efficiency in utilizing available and reserve nutrient resources. The plots maintaining extractable phosphorus in the range of 8-14 mg $kg^{-1}$ produced higher seed cotton yield compared to plots having $\leq$ 8.0 mg $kg^{-1}$ of soil during the season. It has been reported that cotton was likely to respond to phosphorus fertilization where extractable phosphorus was $\leq$ 14 mg $kg^{-1}$ of soil [Halevy 1979]. A significant increase in seed cotton yield in soils having phosphorus $\leq$ 12 mg $kg^{-1}$ of soil in the Punjab province has been reported [Gill *et al.* 2000, Makhdum *et al.* 2000].

Application of phosphatic fertilizer did not produce significant effects on quality of fibre (Table 5). The reason being that genetic and environmental factors apparently exert so much influence on fibre quality that little direct effect from phosphorus can be elucidated [Malik *et al.* 1996].

**Table 5:** Effects of different doses of phosphorus fertilizer on fibre (average of 2 seasons)

| $P_2O_5$ Doses Kg $ha^{-1}$ | Cultivars | | Mean |
|---|---|---|---|
| | MNH-147 | CIM-240 | |
| | (a) Fibre length (mm) | | |
| 0 | 26.1 | 26.1 | 26.1 a |
| 50 | 26.5 | 26.2 | 26.4 a |
| 100 | 26.3 | 26.4 | 26.4 a |
| Mean | 26.3 a | 26.2 a | |
| | (b) Fineness ($\mu g\ g^{-1}$) | | |
| 0 | 4.61 | 4.74 | 4.68 a |
| 50 | 4.58 | 4.58 | 4.58 a |
| 100 | 4.58 | 4.71 | 4.65 a |
| Mean | 4.59 a | 4.68 a | |
| | (c ) Uniformity ratio (%) | | |
| 0 | 46.1 | 46.7 | 46.4 a |
| 50 | 46.6 | 46.1 | 46.4 a |
| 100 | 46.6 | 46.7 | 46.7 a |
| Mean | 46.4 a | 46.5 a | |
| | (d) Fibre Strength (000 lbs $inch^{-2}$) | | |
| 0 | 94.3 | 95.4 | 94.9 a |
| 50 | 94.6 | 95.0 | 94.8 a |
| 100 | 95.0 | 95.5 | 95.3 a |
| Mean | 94.6 a | 95.3 a | |

## CONCLUSION AND RECOMMENDATION

Cotton crop responded to phosphorus fertilization in soils having available phosphorus 8.6 mg $kg^{-1}$ at planting time. Cultivar CIM-240 was more responsive to phosphorus fertilization than that of MNH-147.

It is proposed that extensive trials on phosphorus nutrition in cotton on different soil series and crop sequences may be conducted in the cotton belt of the Punjab. It would help in formulating fertilizer recommendations at broad perspective.

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