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EFFECT OF SPLIT APPLICATION OF P ON P UPTAKE IN COTTON FROM P^{32}-LABELLED SUPERPHOSPHATE

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The effects of split application of P on cotton yield and P uptake from P^{32}-labelled superphosphate were studied in the field. Phosphorus was applied at four levels (i.e. 10, 20, 30 and 40 kg P/ha) in a single dose at seeding and in two equal splits at seeding as well as 60 days after the seeding. A significant increase in yield was obtained at 20 kg P/ha level and above. The application of P significantly increased P percentage in leaves at all growth stages irrespective of its rate. However P percentage in bolls did not differ significantly due to its application. . Percent P derived from fertilizer (% P dff) in leaves and bolls increased significantly with the increase in its rate of application. Splitting the P application slightly improved %P dff but it did not benefit the yield of seed cotton. The correlation coefficient of % P dff in leaves to yield showed that % P dff in leaves upto 90 days after seeding was a better and direct measure of utilization of fertilizer P.

INTRODUCTION

Phosphorus is outstanding as a nutrient that is difficult to maintain in plant available form after it is added to the soil. To aggravate the problem the calcareous soils found in Pakistan, are very effective at fixing phosphorus thereby reducing the amount of available P for plants[1]. It is therefore, logical that phosphorus application should very closely coincide with plant utilization of P. Reports from Russia indicate that P should be applied to cotton in fractions (major portion at seeding and less at later growth stage) for higher yield of seed cotton[2]. However, it was concluded that split application of P to cotton (half at sowing and half at first irrigation or half at first irrigation and half at flowering) with usual recommended dose of N should be followed instead of applying all P at sowing to get the best economical results [3]. In this study the effects of split applications of P at different rates on P uptake in cotton and yield of seed cotton were investigated by using P^{32} labelled superphosphate.

MATERIALS AND METHODS

Field experiments were conducted on sandy loam soil with total N 0.03%, available P ($NaHCO_3$-extractable[4]) 4 ppm and pH 8.2. Ac–134 variety of cotton was grown at a distance of 75 cm from row to row and 25 cm from plant to plant. This spacing gave a plant population of 53333 plants/ha. Urea was applied at 84 kg N/ha; half of N was applied at seeding and half at flowering stage. The p^{32}-labelled superphosphate, containing 8.6% P and specific activity 0.46 mc/g P, was applied at 10, 20, 30 and 40 kg P/ha. Superphosphate was applied either in a single dose at seeding time or in two equal splits at seeding, and 60 days after seeding.

The treatments were arranged in a randomized block design with four replicates with 3 x 10m plots containing four rows of cotton plants.

Plant samples were collected at 30, 60, 90 and 120 days after seeding; an area of 1 x 1.5m was harvested for dry matter, yield and P concentration determination in leaf, stem and bolls. For final seed cotton yield an area of 1.5 x 9m was hand-picked and weight taken. Plant samples were dried at 70° and ground for analysis. A representative sample of the plant material was digested with HNO_3-H_2SO_4-$HClO_4$ ternary acid mixture following the Jackson procedure [4]. The P concentration was determined colorimetrically by vanadomolybdate procedure [5]. The activity of the digested material in solution was measured using Geiger-Mueller tube [6]. The fraction of the applied P absorbed by the plant was determined from the specific activities of the P in the plant and in fertilizer by the formula:

$$\text{P derived from fertilizer} = \frac{\text{Sp. activity of P in plant}}{\text{Sp. activity of P in fertilizer}}$$

RESULTS

P percentage in cotton leaves increased with the application of P-fertilizer, and varied with the growth of the cotton plant (Fig.1). The leaves of P-treated plants had higher % P at all stages of growth. The increase in % P with P-applications was significant compared to the control plants; the rates of P-applications were similar in this respect. Leaves at 60 days after sowing had the highest % P, which decreased with age after 60 days. At 120 days leaves had only 0.2% P (average for all the rates). Bolls at 120 days had higher % P than leaves or stems (Table 1). The percentages of P at this stage in bolls in the control as well as the P-fertilized plants were equal, whereas the leaves and stems of P-treated plants had higher % P than the control plants.

Percent P derived from fertilizer (% P dff) in leaves was significantly increased with P application rate upto 30 kg P/ha only and at 40 kg P/ha rate no further increase in % P dff was observed (Fig.2). The % P dff in leaves increased steadily with age of the plant upto 90 days and thereafter it sharply increased at all rates of P-application. Percent P dff in bolls (120 days after seeding) also increased with the increase of rate of application (P=0.05). The values of % P dff in bolls were 22.72 and 53.61 for 10 kg P/ha and 40 kg P/ha levels when P was applied in a single application at seeding (Fig.3). Percent P dff in bolls from split applications of P was 11.6 to 18.6% higher than that from single application. This increase was statistically non-significant. P application at 20 to 40 kg P/ha significantly increased the yield of seed cotton (Table 2; P=0.05). Splitting P application had no beneficial effect on yield of seed cotton.

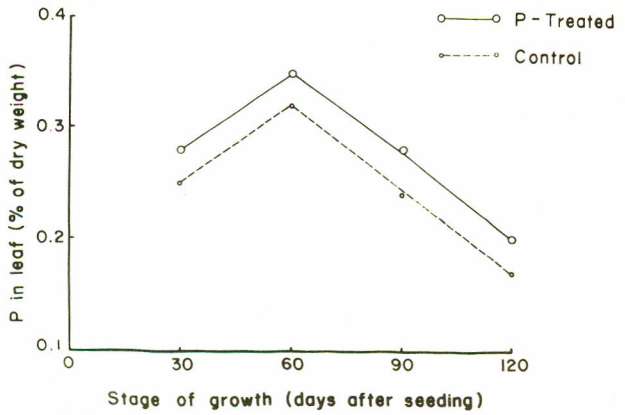

Fig. 1. Effect of stage of growth on P concentration (% P) in leaves.

The % P dff in leaves upto 90 days and in bolls at 120 days (Table 3) was significantly correlated to yield (P=0.05). The relationship of yield to % P dff in bolls (Fig.4) indicat-

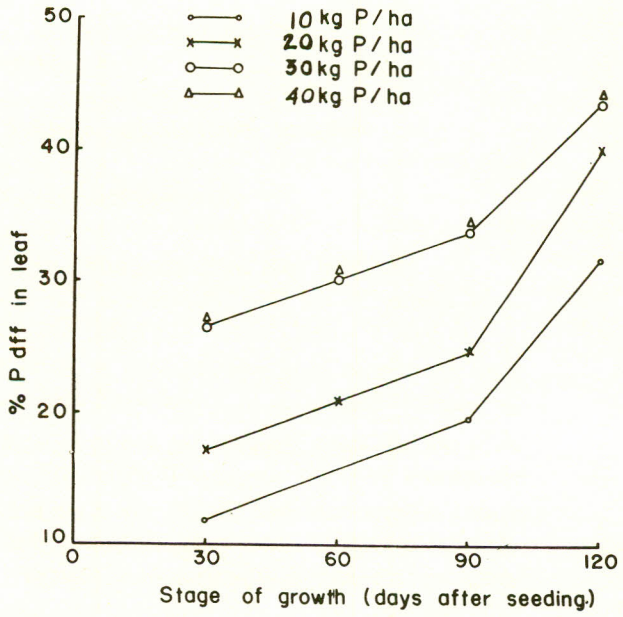

Fig. 2. Effect of stage of growth on per cent P derived from fertilizer (% P dff) in leaves at different rates of application.

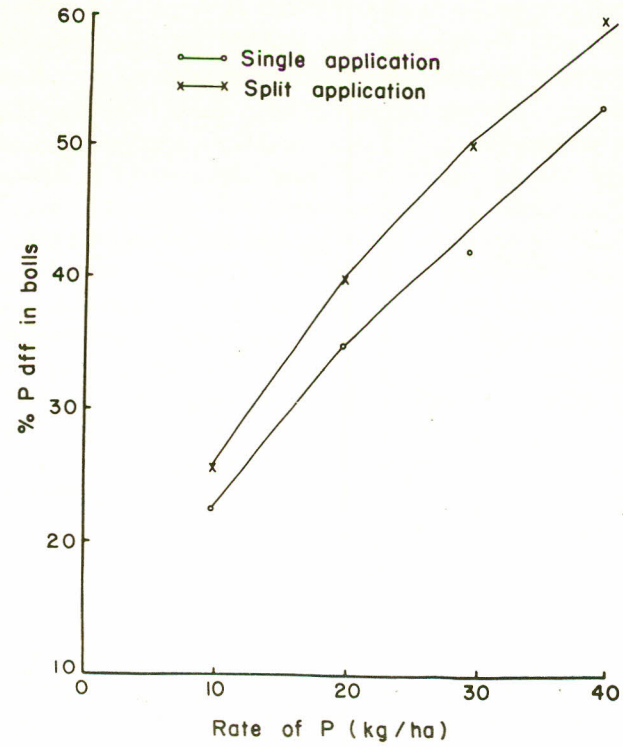

Fig. 3. Effect of rate of application on per cent P derived from fertilizer (% P dff) in bolls.

ed increase in the yield of seed cotton from 22 to 42% while P dff higher than 42% had no further beneficial effect on yield.

DISCUSSION

A significant effect of P application on cotton was to increase the P concentration in the leaves as compared to the check plants. The analysis of leaves sampled at different growth stages showed a pattern of P concentration with a maximum at 60 days after seeding. The pattern thus, differed from the one reported by Olson and Bledsoe [7] who had observed the highest P concentration in leaves at seedling stage i.e. upto 60 days,which could be explained as averaging the values for this period instead of showing two values. The P concentration of leaves decreased as the plant matured. This phenomenon could be due to dilution effect [8] and translocation of P from leaves to the fruiting parts. This dilution could occur as the relative rate of dry matter accumulation increased more rapidly than the rate of nutrient accumulation [9]. The values of P concentration at successive growth stages can be used to monitor the P status of the plant throughout the season and to evaluate the effectiveness of the fertilizer programme [10]. But there are some discrepancies on the P concentration in the leaves as the critical level of P in the leaves had earlier been worked out as 0.31% at early fruiting, 0.33% at late fruiting and 0.24% at maturity [11]. Whereas it was held at

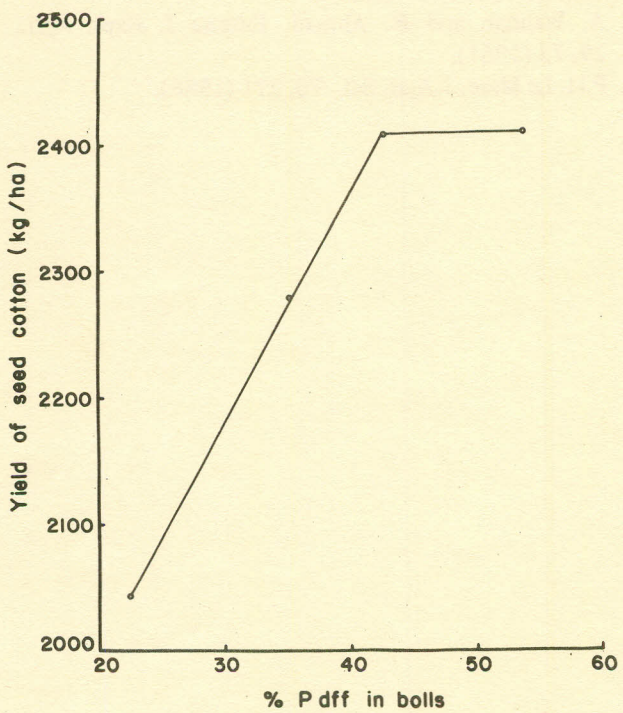

Fig. 4. Relationship of per cent P derived from fertilizer (% P dff) in bolls to yield of seed cotton.

Table 1. Effect of P application on P concentration in aerial parts of cotton plant (at 120 days).

Part of Plant	% P		L.S.D.	
	P-fertilized	Control	P=0.05	P=0.01
Bolls	0.25	0.23	0.056	0.076
Leaf	0.20	0.17	0.025	0.035
Stem	0.06	0.04	–	–

Table 2. Effect of single and split P application on yield of seed cotton.

Rate of P, kg/ha	Seed cotton, kg/ha	
	Single application	Split application
10	2047.1	2172.0
20	2280.4	2216.1
30	2412.6	2269.4
40	2414.5	2357.5
Control	2018.6	–
L.S.D.	P=0.05	214.1
	P=0.01	282.8

Table 3. Regression equation and correlation coefficients

Variable	Regression equations	Correlation coefficients (r)
% P dff in leaves (30 days) vs yield	Y=1967.99 + 16.08x	0.941*
% P dff in leaves (60 days) vs yield	Y=1962.17 + 13.91x	0.911*
% P dff in leaves (90 days) vs yield	Y=1958.93 + 12.28x	0.889*
% P dff in leaves (120 days) vs yield	Y=1965.50 + 8.44x	$0.811^{N.S,}$
% P dff in bolls (120 days) vs yield	Y=1969.4 + 8.61x	0.921*
Rate of P vs yield	Y=2003.2 + 11.57x	0.951*

*= Significant at P=0.05 N.S.=Non Significant.

0.2–0.29% P concentration of leaves being adequate for good growth [12]. In the present study P concentration ranging from 0.2–0.35% (in plants with P fertilizer) was adequate and 0.17–0.31% (in plants without P fertilizer) could be considered as critical levels for cotton at the respective growth stages. However, this and other studies [13] did not show any correlation of P concentration of leaves to yield of seed cotton. A significant positive correlation of % P dff in leaves upto 90 days and bolls at maturity, to yield observed under the present conditions, suggests that % P dff could be a better criterion for the assessment of efficiency of fertilizer P. This is contradictory to the conclusion of Skarlou *et al* [13], who obtained extremely low values of P dff. These discrepancies on P concentration and P dff could be attributed to varietal differences, moisture content, analytical techniques and soil and ecological conditions of growth.

The available P already in the soil is highly important in determining the yield of seed cotton. The soil of the present experimental site had 4 ppm available P, which was classified among P responsive soils [14]. In this soil a significant increase in yield was obtained at P-application rate of 20 kg P/ha and above; lower rate did not imporve the yield (an observation also reported by Le Mare [15]) because in soil P became quickly chemically fixed and unavailable to the plants. The higher values of % P dff obtained in our study support this thesis. From split applications the P dff was higher than that from single applications because in splitting the application the chances of fixation are reduced as compared to single application at seeding. Although fertilizer P uptake could be improved by splitting its application and applying at later growth stages but the P application 60 days after seeding did not make any significant contribution to seed cotton yield.

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