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Effect of Potash on N, P and K Content of Young Mature Leaves and Nitrogen Utilization Efficiency in Selected Cotton Varieties

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Abstract: A pot experiment was conducted in a glasshouse at National Agricultural Research Center (NARC), Islamabad to study the effect of potash levels viz. 100 and 200 K_2O ha^{-1} on Nitrogen, phosphorus, Potassium, chlorophyll and protein content of young mature leaves at flower initiation stage (50 days after seeding) in three resistant cotton varieties namely CIM443, CIM109, CIM446 during the year 1999. Potassium content was significantly increased with increasing K_2O levels and it was maximum at 200 kg K_2O ha^{-1} in all the varieties. Nitrogen content of young mature leaves decreased significantly with increasing K_2O levels while protein content of young mature leaves increased significantly with increasing K_2O levels and overall maximum increase of 37.5% was observed at 200 kg K_2O ha^{-1}. Phosphorus content of young mature leaves increased significantly with potash application and it was maximum at 100 kg K_2O ha^{-1}. In conclusion, application of potash did not affect the leaf chlorophyll content but significant differences in leaf chlorophyll content of different varieties were observed. However, an increase of 15.63% in leaf chlorophyll content was found with addition of 200 kg K_2O ha^{-1}.

Key words: Potash, Phosphorus, Potassium, Chlorophyll conclusion, Protein content

Introduction

Potassium requirement for cotton plants depends mainly on available level of its cations in the soil and on fixation capacity of the soil. Therefore the amount of Potassium required must be resident in the soil or must be added. Approximately two-thirds of the total K uptake occur during a 6 week period beginning at early flowering (Reddy *et al.*, 1996). Potassium content of cotton leaves is highly correlated with extractable soil K. If K is readily available to the roots, it accumulates in cotton leaves and other plant parts. This trait allows the crop to 'bank' a small portion of its total seasonal K requirement during vegetative growth and use these reserves later in the growing season when nutrient requirements are higher or uptake by roots cannot keep up with growth needs (Hsu, 1976). Adequate K may also be needed for the efficient use of N fertilizer with leaching of fertilizer NO_3^{-1} into ground water as a concern, producers and environmentalists are looking for crops, genotypes and production systems that make more efficient use of applied Nitrogen. Potassium could be involved with NO_3^{-1} uptake, the predominant form of soil N, through two processes. First K has been found to co-transport in the xylem with NO_3^{-1} as an accompanying cation from the roots to aerial plant parts and then recycle down the phloem with malate (Blevins, 1985) secondly, NO_3^{-1} is taken up by plant roots via an active process (Streeter and Barta, 1984). NO_3^{-1} may be affected through the influence of K on the translocation of photosynthetic assimilates, needed to support this active uptake process (Ashley and Goodson, 1972).

Potassium is well documented in photosynthesis, enzymatic activity, synthesis of proteins, carbohydrates and fats, translocation of photosynthates and enabling the plant to resist pest and diseases (Tisdale et al., 1993). Nitrogen plays a dominant role in growth processes as it is an integral part of chlorophyll molecule, a constituent of enzyme molecules, protein and nucleic acid (Marachner, 1986). According to Gopta *et al.* (1984) the accumulation of N, P and K in the leaves were increased with the advancement of stage of growth in cotton and accumulation of all the three nutrients were under genetic control. Chlorophyll content of young mature leaves increased with the application of potash and inadequate levels of potash resulted in reduction of total chlorophyll content in leaves (Oosterhuis, 1995 and Oosterhuis, 1997). Many of the a fore mentioned studies were conducted in growth chambers or greenhouses that may impose of quicker and more drastic alternation of the K level that would happen naturally under field conditions. In the field, adjustments in the K status are generally more gradual and subtle because the available K level is a reflection of reversible equilibria that exists between solution, exchangeable and non exchangeable forms of K

(Bertsch and Thomas, 1985). Keeping in view, the above mentioned importance of potash in cotton plants, present study was carried out to determine the effect of potash on Nitrogen, phosphorus, potash, chlorophyll and protein content of young mature leaves under controlled conditions.

Materials and Methods

Studies on the effect of various K levels on the Nitrogen, phosphorus, Potassium, chlorophyll and protein content of young mature leaves in three resistant cotton varieties were carried out in a glasshouse at National Agricultural Research Center (NARC), Islamabad at flower initiation stage of growth during July 1999 to December 1999. The experiment was conducted in pots in complete randomized design (CRD) with four replications. Seeds of three cotton varieties namely CIM443, CIM109 and CIM446 pretreated with fungicide pecton were planted at three K_2O levels (K_0, K_1 and K_2) at a depth of 2.5 cm (where as K_0 with no Potassium, K_1 with 100 kg K_2O ha^{-1} and K_2 with 200 kg K_2O ha^{-1}). Nitrogen (urea) was applied at the rate of 150 kg ha^{-1} and phosphorus (Potassium dihydrogen phosphate) at the rate of 75 kg ha^{-1} to all pots. Potassium was applied as Potassium chloride (KCl) at the rate of 100 kg K_20 ha^{-1} and 200 kg K_20 ha^{-1}. The amount of each fertilizer was calculated on the basis of 7 kg soil per pot. The calculated amount of each fertilizer was applied by dissolving the fertilizer grade in distilled water in each pot. All phosphorus and potash was applied at the time of sowing while Nitrogen was applied in four splits (at the time of sowing, 10 days after seeding, 25 days after seeding and at flower initiation stage). All other agronomic and cultural practices including plant protection measures were kept for all pots.

Plant leaves (young mature leaves) were sampled after 50 days of seeding (flower initiation stage) and washed with distilled water. Leaf blades and petioles were separated and oven dried at 70°C for 24 h. Oven dried samples were ground and analyzed for N, P and K concentration. Total Nitrogen and phosphorus was determined in acid digested (H_2SO_4/Se/H_2O_2) material by Kjeldhal method and acid molybdate/NSA using an autoanalyzer system II, respectively (Winkleman *et al.*, 1990). For analysis of K dry ashing was done (Jones and Case, 1990) and it was determined by flame photometer.

Chlorophyll content was estimated by method of Arnon (1949) modified by Kirk (1968).1g leaves were ground in mortar using 5 ml distilled water. 1 ml aqueous extract of chlorophyll was mixed with 4 ml of 80% (v/v) acetone. After through mixing, it was placed in dark for 10 min and then centrifuged at 4000 rpm for 10 min to clear the suspension. Absorbance was read at 645 and 663 nm on Beckman 35 spectrophotometer and total chlorophyll was determined by following equation given by Arnon (1949). Total chlorophyll = (20.2 x A645)+(8.02 x A663) = mg l^{-1}. Protein content of young mature leaves was estimated by Lowry *et al.* (1951) using Bovine serum albumin (BSA) as standard. 5 ml BSA stock solution (50 mg BSA/5 ml) was prepared and different amounts of BSA stock solution were taken in separate assay tubes and made the volume upto 1 ml with distilled water. 1.0 μl of freshly prepared Reagent C (Reagent A:2g Na_2CO_3, 0.4 g NaOH and 1 g sodium Potassium tartarate dissolve in 100 ml distilled water. Reagent B: 0.5 g of $CuSO_4.5H_2O$ in 100 ml of distilled water. Reagent C was prepared by mixing Reagent A and B in a ratio 50:1) was added in all test tubes, mixed and incubated for 19 min. Finally 0.1 ml of Reagent D (Folin phenol reagent 1:1 diluted with distilled water) was mixed and incubated for 30 minutes again. The absorbance of each tube was read at 650 nm using water blank to zero the spectrophotometer. Absorbance was plotted against the concentration of standard BSA solution and from the final calibrated BSA curve, protein concentration of leaf extract was determined. Whole data was analyzed by using analysis of variance technique (Steel and Torrie, 1984). Means were separated by using an LSD at P (0.05).

Results and Discussion

The effect of potash on Nitrogen content of young mature leaves indicated that Nitrogen content was significantly decreased with application of potash. Overall, the Nitrogen content decreased by 20.49% at 200 kg K_2O ha^{-1} (Table 1). The Nitrogen content was maximum (3.22%) in control plants and minimum (2.56%) at the maximum level of K_2O. The mean maximum Nitrogen content (3.23%) was observed in variety CIM443 and mean minimum Nitrogen content (2.58%) was in variety CIM446. Nitrogen content of young mature leaves was decreased significantly with increasing K_2O levels in all the varieties (Table 1). The interaction between varieties and K levels was highly significant for Nitrogen content of young mature leaves. While at flower initiation stage, the protein content of young mature leaves was increased significantly with application of potash. Overall, the protein content increased by 35.05% with the application of 200 kg K_2O ha^{-1} (Table 4). Protein content was maximum (64.99 $\mu g\ g^{-1}$) at the maximum level of K_2O and minimum in control plants. The mean maximum protein content (63.4 $\mu g\ g^{-1}$) was observed in variety CIM109 and mean minimum (44.38 $\mu g\ g^{-1}$) in variety CIM446. Application of 200 kg K_2O ha^{-1} resulted in maximum leaf protein content of 77 $\mu g\ g^{-1}$ in variety CIM109 and minimum in control plants. Similar trend was observed in other varieties (Table 4). The

Table 1: Effect of potash on n contents of young mature Leaves (%) of cotton

K_2O kg ha^{-1}/Varieties	N contents of young mature leaves (%) CIM443	CIM109	CIM446	Mean
0	3.92A	3.32B	2.43G	3.22A
100	2.93C	3.33B	2.73E	2.99B
200	2.83D	2.27H	2.58F	2.56C
Mean	3.23A	2.97B	2.58C	

C.V (%) 0.44
LSD (0.05) Varieties** 0.04
K levels** 0.01
Interaction** 0.02

Table 2: Effect of potash on p contents of young mature Leaves (%) of cotton

K_2O kg ha^{-1}/Varieties	P contents of young mature leaves (%) CIM443	CIM109	CIM446	Mean
0	0.24D	0.33AB	0.27C	0.28B
100	0.32B	0.33AB	0.28C	0.31A
200	0.28C	0.29C	0.34A	0.30A
Mean	0.28C	0.32A	0.29B	

C.V (%) 5.45
LSD (0.05) Varieties** 0.01
K levels** 0.01
Interaction** 0.02

Table 3: Effect of potash on k contents of young mature Leaves (%) of cotton

K_2O kg ha^{-1}/ Varieties	K contents of young mature leaves (%) CIM443	CIM109	CIM446	Mean
0	0.96DE	0.68E	0.68E	0.7C
100	1.24CD	2.16AB	1.39C	1.59B
200	1.21CD	1.92B	2.29A	1.81A
Mean	1.14B	1.59A	1.45A	

C.V (%) 14.04
LSD (0.05) Varieties** 0.22
K levels** 0.20
Interaction** 0.35

Table 4: Effect of potash on leaf protien contents ($\mu g\ g^{-1}$)

K_2O kg ha^{-1}/ Varieties	Leaf protein contents ($\mu g\ g^{-1}$) CIM443	CIM109	CIM446	Mean
0	51.28E	50.17E	40.80H	47.42C
100	66.40C	63.03D	44.13G	57.85B
200	69.77B	77.0A	48.20F	64.99A
Mean	62.48A	63.4A	44.38B	

C.V (%) 1.84 LSD (0.05)
Varieties** 1.73
K levels** 1.07
Interaction** 1.86

interaction between varieties and K levels was highly significant for protein content of young mature leaves. The Nitrogen content was decreased while protein content of young mature leaves was increased significantly with the application of 200 kg K_2O ha^{-1}. This indicates that potash increased the Nitrogen utilization efficiency in cotton plants as reported by Blevins (1985) that potash plays a significant role in protein metabolism in plants. Similar results have reported by Pettigrew and Meredith (1997) that Nitrogen content was decreased in the leaf tissue of K fertilized plants as compared to control plants.

Table 5: Effect of potash on leaf chlorophyll contents (mg l^{-1})

K_2O kg ha^{-1}/Varieties	Leaf chlorophyll contents (mg l^{-1}) CIM443	CIM109	CIM446	Mean
0	26.72C	20.13H	22.22F	23.02C
100	29.58B	21.96G	22.14FG	24.56B
200	30.14A	23.31E	26.42D	26.62A
Mean	28.81A	21.80B	23.59AB	

C.V (%) 29.63
LSD (0.05) Varieties** 5.605
K levels N.S.
Interaction N.S.

* Significant at 5% level of probability
** Significant at 1% level of probability
N.S. Non Significant

The phosphorus content of young mature leaves at flower initiation stage was increased significantly with the application of potash (Table 2). Phosphorus content increased by 10.71% with application of 100 kg K_2O ha^{-1}. Liang *et al.*, (1992) have reported that phosphorus content increased by 28% in cotton with K fertilization at flowering stage. Phosphorus content of young mature leaves was maximum (0.31%) at 100 kg K_2O ha^{-1}and minimum (0.28%) in control plants. The mean maximum phosphorus content (0.32%) was observed in variety CIM109 and the mean minimum (0.28%) in variety CIM443. Phosphorus content in variety CIM446 increased with increasing K_2O levels. However in other varieties, phosphorus content only with the application of 100 kg K_2O ha^{-1}. Further, addition of K in these varieties caused reduction in the phosphorus content of young mature leaves (Table 2). The interaction between varieties and K application was highly significant for phosphorus content of young mature leaves.

Potassium content of young mature leaves was increased significantly and overall, K content of young mature leaves increased by 135.06% with application of 200 kg K_2O ha^{-1} (Table 3). Similar results have reported by Hsu et al. (1978); Liang *et al.* (1992) and Pettigrew and Meredith (1997). Mean maximum Potassium content (1.81%) was observed at 200 kg K_2O ha^{-1} and the mean minimum (0.77%) in control plants. The mean maximum Potassium content (1.59%) was observed in variety CIM109 and the mean minimum (1.14%) in variety CIM443. Application of 200 kg K_2O ha^{-1} resulted in maximum Potassium content (2.29%) in variety CIM446 and the minimum (0.68%)in the control plants (Table 3). Similar trend in Potassium content with various K_2O levels was also observed in other varieties. The interaction between varieties and K levels was highly significant for Potassium content of young mature leaves.

A non significant effect of total chlorophyll content of young mature leaves was observed with the application of potash (Table 5). The total chlorophyll content in 200 kg K_2O ha^{-1} treatment was increased by 15.63%as compared to control plants. Oosterhuis (1995) and

Oosterhuis (1997) have reported similar results. The increased chlorophyll content of young mature leaves with potash application might be due to the increased pigment synthesis or a low rate of chlorophyll degradation as reported by Yeo and Flowers (1983), Sharma and Gopta (1986). The mean maximum chlorophyll content (26.62 mg l^{-1}) was at 200 kg K_2O ha^{-1} and minimum (23.02 mg l^{-1}) was found in control plants. Significant differences were observed in chlorophyll content of all varieties (Table 5). The interaction between varieties and K levels was non significant for leaf chlorophyll content at flower initiation stage. In conclusion, application of potash did not affect the leaf chlorophyll content at flower initiation stage but significant differences in leaf chlorophyll content of different varieties were observed.

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