Response of foliar application of KNO$_3$ on yield, yield components and lint quality of cotton (Gossypium hirsutum L.)

Ejaz Ahmad Waraich$^1$, R. Ahmad$^1$, Raja. G. M. Hur$^1$, Ehsanullah$^2$, A. Ahmad$^2$ and Nasir Mahmood$^3$

$^1$Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan.
$^2$Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.
$^3$Department of Fibre Technology, University of Agriculture, Faisalabad, Pakistan.

Accepted 13 October, 2011

Effect of potassium on fiber quality characteristics and nitrogen on vegetative growth tends to be more critical when deficiency is expected in a field. Foliar applications of potassium may be used to supplement soil applications to maximize yields and improve quality of cotton. A cotton variety NIAB-111 was sown at Crop Physiology Research area, University of Agriculture, Faisalabad to check the effect of KNO$_3$. Four different levels of KNO$_3$ were applied with a control and water in foliar applications varying the number of applications on different stages. The crop was sown in a randomized complete block design with split plot arrangement and was replicated thrice to observe the effect of potassium on growth yield and fiber quality of cotton. Plant height, biomass, number of bolls, number of leaves per plant and all fibre quality parameters were significantly affected by increasing concentrations of foliar potassium. In most of the cases, spraying 2% foliar potassium gave significant results. As number of leaves, number of sympodial branches, number of bolls, plant biomass, Ginning out turn (GOT%), fibre micronaire, fibre uniformity, fibre length and fibre strength were significant at 2% application of foliar potassium. But in case of boll weight, 2% spray of foliar potassium was dominated by 1.5% spray of foliar potassium. In some cases, like number of leaves, number of sympodial branches per plant, fibre strength, micronaire, fibre sci, fibre uniformity and ginning out turn, both concentrations 1.5 and 2% had statistically similar effects.

Key words: Potassium nitrate, foliar application, growth, yield, lint quality, cotton.

INTRODUCTION

Cotton occupies a prominent position in Pakistan's agriculture. It is the main raw material for the largest national industry, the textile industry, as well as the main source of locally produced cottonseed oil. It accounts for 8.6% of the value added in Agriculture and about 1.9% to GDP (Government of Pakistan, 2005, 2006). Cotton's indeterminate growth habit means that nutritional stress and imbalances affect both vegetative and reproductive metabolism and ultimately limit seed cotton yield as well as fibre and seed quality. Potassium plays an important role in photosynthesis, water balance, balance between mono and divalent cations, translocation of carbohydrates and resistance against insects and diseases (Brara and Tiwari, 2004). Effect of Potassium on fiber quality characteristics tended to be more critical than its effect on lint yield, especially when deficiency is expected in a field. Growth rate and maturity of cultivars were reported to be important factors with potassium and nitrogen and their effect on fiber quality. Foliar applications of potassium may be used to supplement soil applications to maximize yields of cotton (Gossypium hirsutum L.) (Pettigrew et al., 1996; Pettigrew, 1999).

In cotton culture, chemical fertilizers, particularly potassium, are one of the greatest production inputs. With increased environmental pressures, cotton producers

*Corresponding author. E-mail: uaf_ewarraich@yahoo.com. Tel: 92-0333-6504714. Fax: 92-041-9200764.
may need to improve the efficiency of nutrient fertilization. Including foliar applications in a cotton fertility program can improve potassium efficiency through improved application timing and flexibility (Robert et al., 2006). To maintain soil potassium at sufficient levels, it is sometimes necessary to supplement cotton fields with additional sources of potassium. The potassium needs of cotton can be met by foliar application of potassium and/or mid-season side dress applications. Unfortunately, the potassium and nitrogen requirements of various crops under our local conditions have not yet been studied. Available data show erratic responses to potassium and nitrogen under different soil-crop condition. Mullins and Burmester (1991) reported maximum daily potassium uptake rate of 2.2 to 3.5 lb per acre per day in cotton crop from flowering to boll development. When potassium fertilizers are added to the soil, its major part becomes unavailable to the plant. So, to fulfill high potassium requirements of cotton crop, foliar application seems to be necessary. Keeping in view this aspect, the present study is planned with the following objectives. 1) To determine the effect of potassium on growth and yield of cotton. 2) To check the effect of potassium on lint quality. 3) To evaluate the appropriate dose of potassium to obtain good quality cotton lint.

MATERIALS AND METHODS

The present study was conducted at the Crop Physiology research area, University of Agriculture, Faisalabad. The experiment was laid out in RCBD-split plot design with three replications. Four different levels of potassium were sprayed along with control and distilled water in two different blocks. In one block, only one spray on flowering and in the other block three times foliar spray: first at flowering, second and third at 14 days interval were applied on cotton variety NIAB 111 which was sown on 16th May. KNO₃ was used as a source of potassium. T₁ was control where no potassium was sprayed and T₂ was sprayed with water. T₃ was foliar spray of KNO₃ (once) 0.5%, T₄ was foliar spray of KNO₃ (once) 1.0%, T₅ was foliar spray of KNO₃ (once) 1.5%, and T₆ was foliar spray of KNO₃ (once) 2.0%. T₇ and T₈ were just like T₁ and T₂ in separate block but in T₂ water was sprayed thrice instead of once. T₉ was foliar spray KNO₃ (thrice) 0.5%, T₁₀ was foliar spray KNO₃ (thrice) 1.0%, T₁₁ was foliar spray KNO₃ (thrice) 1.5%, and T₁₂ was foliar spray KNO₃ (thrice) 2.0%. After preparation of land the crop was sown on beds manually by dibbling method. The spacing between plants was maintained at 22.5 cm and between rows was 75 cm as recommended for this variety here. Gap filling was done after seven days of sowing to avoid patchy crop stand. To maintain desired plant density, thinning was done when crop plants attained a height of 22 cm. Half of the nitrogen and full dose of phosphorus was applied at the time of seed bed preparation whereas the remaining nitrogen was applied at flowering stage. Three hand hoeings were made to keep the crop free of weeds. Adequate plant protection measures were adopted to save the crop from insects and diseases. All other agronomic practices were kept normal and uniform for all the treatments. The crop was harvested in single picking on November 15, 2006.

During growth of the crop and at maturity, different growth and yield parameters like number of bolls, leaves, sympodial branches and height of plant were recorded using standard procedures. Fibre quality parameters of cotton that is span length, uniformity ratio, fibre fineness, elongation and fibre strength were estimated by High Volume Instrument (HVI-9008 ASTM) fibre testing system manufactured by M/S Zellweger Uster Ltd (Switzerland) according to ASTM Standards 1997. The uniformity ratio was measured with the fibrograph-910 module using optical technique. The determination of the fibre strength took place simultaneously along with the fibre length measurement. Micronaire value was estimated on micronaire-920 module by measuring the escape of air flow through the plug of weighed cotton sample. The total fibre structure determines the resistance to air flow. The instrument was calibrated according to the method laid down in its instructional manual supplied by M/S Zellweger Ltd. (1995). The procedure of testing was adopted as given in ASTM Standards (1997).

The collected data was analyzed using the analysis of variance technique randomized complete block design with split plot arrangement (RCBD-Split plot) for research area, Department of Crop Physiology, University of Agriculture, Faisalabad. Computer software named MSTATC was used for statistical calculations. Then treatment means were compared by Least Significant Difference (LSD) test at 5% probability level (Steel and Torrie, 1984).

RESULTS

Yield parameters

The average effect of rate and time of potassium application on yield parameters is shown in Table 1. The number of sprays has significant effect on the number of bolls. The treatment where potassium was sprayed thrice showed more number of bolls (61.2) than that in which it was sprayed once (54.1). The rate of foliar potassium spray showed significant effect on the number of bolls, boll weight, yield per plant and GOT%. The maximum number of bolls, yield per plant and GOT% was obtained when 2% potassium was sprayed followed by 1.5% spray of potassium. Other treatments like 1 and 0.5% also significantly affected number of bolls per plant, yield per plant and GOT%. The lowest value was of the plot where no potassium was sprayed as Table 1 shows. But in case of boll weight, foliar spray of 1.5% potassium was the best level instead of 2%, although statistically both were similar in effect.

Fibre quality parameters

Foliar potassium had significant effect on fibre micronaire, fibre uniformity, fibre length and strength (Figures 1, 2, 4 and 6). Maximum values of fibre length, fibre strength and fibre uniformity were observed under 2% potassium sprayed. Micronaire of cotton fibre was most affected by 1.5% foliar application of potassium with respect to control. Minimum values were observed when no potassium was sprayed (Figures 1 to 6). The effect of time of sprays was non significant in its effect on fibre quality parameters. Interaction among rate and time of foliar potassium was also non significant on fibre micronaire and fibre strength but was significant to control in fibre length and uniformity. In fibre uniformity
Table 1. Effect of rate and time of foliar potassium nitrate application on seed cotton yield and its components.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of Sprays</th>
<th>Number of bolls (g)</th>
<th>Boll weight (g)</th>
<th>Yield per plant (g)</th>
<th>Ginning out turn (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1</td>
<td>54.1b</td>
<td>3.31</td>
<td>168</td>
<td>36.09</td>
</tr>
<tr>
<td>Water</td>
<td>3</td>
<td>61.2a</td>
<td>3.24</td>
<td>201</td>
<td>36.08</td>
</tr>
</tbody>
</table>

Concentrations of KNO₃ sprayed

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Number of Sprays</th>
<th>Number of bolls (g)</th>
<th>Boll weight (g)</th>
<th>Yield per plant (g)</th>
<th>Ginning out turn (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1</td>
<td>42.0f</td>
<td>2.97d</td>
<td>124e</td>
<td>35.05c</td>
</tr>
<tr>
<td>Water</td>
<td>3</td>
<td>50.0e</td>
<td>3.02d</td>
<td>151d</td>
<td>35.1c</td>
</tr>
<tr>
<td>0.5%</td>
<td>1</td>
<td>56.5b</td>
<td>3.21c</td>
<td>181b</td>
<td>35.9b</td>
</tr>
<tr>
<td>1.0%</td>
<td>3</td>
<td>61.8c</td>
<td>3.37b</td>
<td>208b</td>
<td>36.4b</td>
</tr>
<tr>
<td>1.5%</td>
<td>66.1a</td>
<td>3.57a</td>
<td>235a</td>
<td>36.9a</td>
<td></td>
</tr>
<tr>
<td>2.0%</td>
<td>69.6a</td>
<td>3.53ab</td>
<td>246a</td>
<td>37.01a</td>
<td></td>
</tr>
</tbody>
</table>

Interaction

<table>
<thead>
<tr>
<th>CxN</th>
<th>Significant</th>
<th>NS</th>
<th>Significant</th>
<th>NS</th>
</tr>
</thead>
</table>

Data within columns followed by different letters are significantly different at P < 0.05.

Figure 1. Effect of foliar KNO₃ concentrations on micronaire of cotton.

The best result were observed when one spray of 2% potassium was sprayed.

DISCUSSION

Yield parameters

In the present study, foliar application of potassium showed significant increase in number of bolls, boll weight and yield per plant and ginning out turn percentage.

The possible reason of decrease in number of bolls per plant may be the problem of boll shedding. Boll shedding is the problem which arises when there is nutrient deficiency and drought stress in cotton. Potassium is one of the important osmotica, which maintains plant turgor in drought conditions and makes plant withstand drought conditions. So, plants deficient in potassium could not retain their bolls in adverse environment condition of hot climate. The reason of decrease in boll weight and yield per plant in potassium deficient treatment is that potassium deficiency resulted in early abscission of
leaves and carbohydrates accumulated in main stem leaves, so the top bolls of cotton plant developed incompletely, and the boll weight and seed yield was lower in potassium deficient plants. The results of the present study are in line with Gormus (2002) and Da Silva et al. (1996). They argued that higher accumulation of potassium at the later stages of plant growth have been found to be related to high seed cotton yield and in their studies they found an increasing trend of seed cotton with increasing rate of potassium applications.

In this study, increase in the ginning out turn (GOT%) with increasing potassium application is in agreement with Reddy et al. (2004) and Read et al. (2006), they stated that this increase in boll weight may be contributed

Figure 2. Effect of foliar KNO$_3$ concentrations on fibre uniformity of cotton.

Figure 3. Interaction of rate and time of foliar spray of KNO$_3$ concentrations on fibre uniformity of cotton.
by additional potassium nutrition along with nitrogen. Pettigrew et al. (1996) found that the potassium deficiency reduced lint yield. Present results of increasing GOT% with increasing potassium concentrations are in line with Gormus (2002) and Abaye (1998). They observed that when all the potassium was applied at early boll development stage, it was better to that of split application of potassium. The possible reason of increased GOT% may be due to the cellulose synthesis and dry matter accumulation (Li et al., 1999).

**Fibre quality parameters**

In our studies, the Micronaire was not significantly increased with increase in potassium concentration. This lack of response of micronaire to varying time of potassium application is in contrast to the findings of Cassman et al. (1990) and Pettigrew et al. (1996), but in agreement with the findings of Minton and Ebelhar (1991) and Gormus (2002). Minton and Ebelhar (1991) in their study found that varying concentrations of potassium

---

**Figure 4.** Effect of foliar KNO$_3$ concentrations on fibre length of cotton.

**Figure 5.** Interaction of rate and time of foliar spray of KNO$_3$ concentrations on fibre length of cotton.
increased micronaire which confirms our results. Uniformity is related to fibre length in that the uniformity index is the ratio between the mean length and the upper one-half mean length of the fibre sample (USDA, 2001). Fibre uniformity significantly increased with potassium application. Present results of fibre uniformity are in contrast with the results of Gormus (2002), he found that fibre uniformity was non significant to rate and time of potassium application. For variation in these parameters of cotton fibre quality, Jones and Wells (1998) argued that the indeterminate growth habit of cotton, and cultivar variation in development rate, may cause fibre properties to vary in different studies.

On the same day, individual bolls may just be starting fibre elongation, others starting fibre thickening and others may be completely mature. Fibre elongation is the stage during which the fibre is lengthening, and occurs as a thin cell wall of carbohydrate polymers is deposited allowing the fibre to elongate (DeLanghe, 1986). Potassium in our study significantly increased fibre length. The reason for short fibre length in potassium deficient plants may be the less water pressure inside of the developing fibre in conjunction with the deposition of carbohydrate polymers which drives elongation. Cassman et al. (1990) stated that increasing potassium fertilization to cotton increases fibre length and Dhindas et al. (1975) argued that reduction in fibre length produced by potassium deficiency is consistent with potassium serving as an osmoticum, producing turgor pressure for fibre elongation.

Our results about fibre elongation oppose the results of Gormus (2002) in which he states that potassium has non significant increasing effect on fibre length. Same were the findings of Minton and Ebelhar (1991). The present results of fibre strength are similar to the findings of Gormus (2002) who reported significant increase in fibre strength by rate of potassium application and he also stated that split application had no significant effect on fibre strength, which confirms the results of our study, in which time of application is non significant. Minton and Ebelhar (1991) reported lower fibre strength under potassium deficiency which is in line with our results.

**REFERENCES**


