YIELD RESPONSE OF COTTON PLANT TO THE POTASSIUM STARVATION

TANGGAP STARVASI KALIUM TERHADAP HASIL KAPAS

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ABSTRACT

This experiment is required due to the cotton product symptoms. An experiment was conducted in natural environment with 660 pots. Cotton, cv. NUCOT 33B, was seeded on 15 May, 1997. There were three different treatments; first, a normal strength of Hoagland's nutrient solution; second, a complete nutrition except K from day 56 to 66 was followed by the K containing nutrient, and the last, a complete nutrition except K from day 56 to 86 was followed by the K containing nutrition solution was supplied. Dates of open flower and open bolls of 20 plants per treatment were tagged daily. Ten plants were harvested once each week to determine numbers of fruiting structures (squares and bolls), retained squares and bolls. Flowers and bolls were tagged on the day of anthesis and boll opening. Boll opening is defined when lint from the sutures of carpel was seen. The potassium limitation made the boll maturation period short. The longer the deficiency, the shorter the boll maturation period. The potassium starvation was not influence the weight of burr per boll, the growth rate of lint, seed number, weight of cotton seed, and boll growth.

ABSTRAK

Penelitian ini perlu sehubungan dengan simtomnya pada hasil kapas. Penelitian dilakukan pada kondisi alami yang menggunakan 660 pot. Benih kapas cv NUCOT 33B ditugalkan pada tanggal 15 Mei 1997. Ada tiga perlakuan terdiri atas 1) larutan nutrisi Hoaglands setengah dosis sampai akhir penelitian, 2) seperti perlakuan pertama kecuali antara hari ke 56 sampai 66 tanpa pupuk kalium, dan 3) seperti perlakuan pertama kecuali tanpa kalium antara hari ke 56 dan 86. Sepuluh tanaman dipanen tiap minggu untuk mengetahui jumlah square dan buah. Bunga dan buah diberi "tag" pada hari anthesisnya dan pada hari buah membuka. Membukanya buah adalah pada saat terlihat karpelnya membelah. Terbatasnya kalium membuat umur matangnya buah menjadi lebih pendek. Semakin lama defisiensi maka semakin pendek umur matang buah. Berkurangnya pemberian kalium tidak mempengaruhi berat burr per buah, laju pertumbuhan serat, jumlah biji, berat biji kapas, dan pertumbuhan buah.

INTRODUCTION

Potash serves many roles in plant growth and metabolism. For example, an enzyme responsible for starch synthesizes (starch synthetase) is activated by K. Potassium affects nitrate (NO_3) absorption and reduction. Rapid NO_3 uptake depends on adequate K in the soil solution. Potassium is required for every major step of protein synthesis (Kasemsap *et al*., 1997; Ruamrungsri, *et al*., 1996). K is required for stomata opening and closing (Richardson *et al*., 1993). The transport of all the cations was promoted by the increase of the K concentration (Song and Fujiyama. 1996). Under K deficiency, the amount of rubisco decreased (Osaki *et al*., 1993).

Cotton (*Gossypium hirsutum* L.) is sensitive to potassium (K) nutrition. The Cotton is more sensitive to low K availability than most other major field crops, and often shows signs of K deficiency on soils not considered K deficient (Oosterhuis *et al*., 1997; Cope, 1981). Little is known about cotton's ability to recover from periods of K deficiency (Pettigrew *et al*., 1996).

However, the K nutrition does not always increase yields. Grissom (1950) and Grissom and Spurgeon (1961), from Delta Mississippi, reported variable cotton responses to K fertilization. Similarly, Pettiet (1973) also reported variable responses to K fertilization on Mississippi River Delta Soils. Howard reported that cotton production at the Lexington soil (high K) was not increased by K fertilization in 1995. They were however, increased in 1996 by applying 60 lb K_2O equivalent per acre and in 1997 by applying 90 lb K_2O equivalent per acre. Extractable K was 207 and 246 lb K per acre respectively for soil fertilized with 60 and 90 lbs acre per acre. For the three years experiment with a Loring silt loam soil at the Milan Experiment Station, yields were increased when up to 90 lb per acre of K_2O equivalent was applied. Their high fertility rates corresponded to approximately 246 lb extractable K per acre (Howard**,** 1998).

Crop production is a function of many processes from cellular to canopy levels. Increasing production and yield requires knowledge of processes at all levels. In environments where the nutrients are not limiting, the K concentrations remain stable in the leaves during growth. But in field environments when soil becomes relatively dry, the K concentration changes in cotton leaves during the season. If this occurs during fruiting, the plants appear unable to recover leaf K concentrations even if the plants are watered. This increases the complexity of interpreting the nutritional status of crop (Reddy *et al*., 1998).

The widespread K deficiency in the US Cotton Belt is related to earlier-maturing, higher yielding, faster fruiting varieties. These characteristics create a greater demand for K than the plant root system is capable of supplying in many situations. Oosterhuis and Bednarz (1997) reported that the onset of K deficiency in growth chamber experiments was first detected in roots, followed by stems, petioles and leaves.

This research was conducted to determine the effect of K-deficiency on cotton yield. Yield components such as burr weight, lint weight, and seed weight and number, were measured.

MATERIALS AND METHODS

There were 660 pots of 12 L in volume containing washed fine sand were placed in six rows, each row contained 110 pots. Cotton plants were grown in those natural environment pots. The pots were filled with A 5-cm layer of gravel and a hole at the bottom of the pots allowed good drainage. Cotton, cv., NUCOT 33B, was seeded on 15 May, 1997. Four seeds per pot were planted and thinned at the first true leaf stage to one plant per pot. The pots were watered 3 times a day with half-strength Hoagland's nutrient solution until 56 days after planting. Then three different treatments of K nutrition provided. The treatments were: treatment 1 continued to supply a half-strength Hoagland's nutrient (complete nutrient) solution; Treatment 2 was a half-strength nutrient solution except K from 56 to 66 days after planting; Treatment 3 was a half strength nutrition solution except K from 56 to 86 days after planting. After day 66 (Treatment 2) and day 86 (Treatment 3) the complete nutrient solution was provided as before.

Dates of open flowers and open bolls were monitored on 20 plants per treatment by tagging those flowers and bolls daily. Boll opening is defined when lint could be seen through the sutures between carpels. Ten plants were harvested once each week to determine numbers of fruiting structures (squares and bolls) beginning from the first day of the potassium treatments (day 56). Measurements were designed to provide data of the yield component.

Data were analyzed using trend analysis with a standard error 0.05 using Sigma Plot Scientific Graphing Software.

RESULTS AND DISCUSSION

Squares

Thirty days of K-stressed plants significantly reduced square formation, while a 10 day-starvation did not. Cotton plants normally increased the number of squares produced until day 90 (Fig. 1). After day 90, few squares were still produced. Plants that were K-stressed for 30 days slowed their rate of square formation even more than those provided with K. The low K treatment may have blocked the production processes where squares were formed or it may have caused the squares to abscise.

Flowering period weighed considerably more than those produced late in the season. It looks like burrs produced in the very hottest period 40 to 42 were smaller and reached maturity earlier due to the Growing Degree Day theory (Reddy, et al., 1997a). The fruit under these temperatures reached the Growing Degree Day level (15^0C) as the boll had not yet reached maximum size. Burrs increased in size with age suggesting that growth in cooler conditions (when it takes longer to reach maturity) results in larger final size.

Lint weight

Bolls produced early in the season yielded greater amounts of lint than bolls produced later. Potassium deficiency did not affect the amount of lint produced per boll until late in the season. Since this was after much of the K in the leaves of K-starved plants had recovered, it is not apparent why the impact of potassium starvation on lint produced per boll was greatest long after the bolls had recovered. Perhaps the late season differences were caused by a shortage of photosynthate needed to growth late season lint was so much. Less photosynthate production would be expected in the K-deficient plants because of smaller leaf area and low chlorophyll available in those plants. It may have also been caused by delayed production of some flowers and the delayed bolls occurred at a time when all bolls were smaller. Thus, the average lint weight from these bolls was less.

Seed weight and number

There was not a significant difference in seed weight caused by the 10 days K-starvation , but the 30 days K-starvation did cause significantly less seed weight per boll flowered at day 90 and after. For example, seed produced from flowers formed late were smaller in the previously K-starved plants. This smaller seed may have been caused as an indirect effect of the K-starvation period. The K-starved plants slowed growth, including the rate of stem and leaf growth

Burr weight

Burr weight was not influenced by K starvation. production and they slowed production of new flowers. Thus, it seems likely that flowers produced late in the year were added to plants that had essentially reached the maximum number of bolls that could be supported on those plants resulting in the late bolls being small and having fewer seed. The number of seeds produced per boll was consistent with such an explanation. The 30 days potassium-starvation treatment significantly decreased lint growth and lint weight of young seeds. Seeds of equal age, no matter what K treatment they were provided, received a similar amount of dry matter. The 30 days K starvation lowered the growth of young seeds, whose age were from 1 to 8 days, while the 10 days K starvation did not.

Seedcotton weight

Seedcotton weight is a cumulative of cotton seed and lint weight. Bolls on which anthesis occurred at or after day 90, were statistically influenced by the potassium starvation treatments. Both 10 and 30 days K-starvation treatments significantly decreased the rate of younger seed cotton growth, but the effect was evenly eliminated because of the plant aged. Both figures show that the 30 day K starvation lowered the growth rate of young plants until 12 days flowering but did not decrease the final weight of seed cotton.

Boll weight and number

The weight of individual bolls, boll production efficiency, boll ratio and boll-square ratio were not significantly influenced by potassium starvation, respectively. The growth of the bolls of these three treatments were not different because of either10 or 30 days K-stress. The earlier the anthesis occurred, the greater the bolls produced . Both boll ratio and boll-square ratio, the boll weight or the boll-square weight per each total plant weight, respectively were also not different because of either 10 or 30 days K-deficiency. These results closely match a previous report that cotton bolls were least sensitive of the various plant organs to K limitations. Boll K may continue to be sufficient due to K movement from storage in other plant organs (Bednarz and Oosterhuis, 1995).

Potassium stress decreased the number of bolls produced. Plants in both 10 and 30 day-K-deficiency treatments had significantly fewer bolls than the plants not K-stressed. This result suggests that the number of abscised significantly higher than the number abscised from plants grown in a completed Hoagland's nutrient solution. The effect of 30 days K-starvation significantly decreased the number of bolls. Even the 10 days K-deficiency treatment decreased the number of bolls. Since we do not know the reason squares abscise, it is not known what the K-starvation caused that resulted in square abscission. Reddy reported that extremely K-deficient plants had more locked bolls than plants with an adequate K (Reddy *et al.*, 1997). Therefore, it may be that K-starved plants simply produce less vegetative structure and therefore fewer fruiting sites. Previously, Reddy *et al*. (1997) reported that the potassium deficiency from the first square to the end of experiment significantly decreased total sites, boll number, boll weight, lint weight and seed weight.

CONCLUSIONS

Potassium starvation did not influence yield components such as burr weight, the amount of lint produced per boll and a boll weight. The K-stressed plants produced smaller bolls late in the season. There were no significant effects the 10 days K-starvation to seed weight until near the end of the season, but the 30 days K-starvation did. Bolls produced early in the season yielded greater amounts of lint

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