# Upland Cotton Response to Soil and Foliar Applied Potassium Fertilizer, 1991

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## *Abstract*

*A single field experiment was conducted near Gila Bend, Arizona in 1991 to evaluate the effects of both soil and foliar applied potassium (K) fertilizersto Upland (Gossypium hirsutum L.) cotton to a soil testing 315 ppm K (high). Soil applied K fertilizer at rates of 0, 75, 150, and 225 lbs. $K_2O$/acre as $K_2SO_4$ were broadcast and preplant incorporated before listing. Foliar applications were made in all combinations with the various soil applied K treatments and consisted of four applications of 4.6 lbs. $K_2O$/acre as $KNO_3$ (10 lbs. $KNO_3$ /acre) over the first fruiting cycle, by a ground applicator with approximately 25 gallons per acre as carrier. No differences among treatments were detected by any plant growth measurement taken, plant tissue analyses, lint yield or lint quality determinations which were made over this experiment. Conclusions (preliminary) based upon these results indicate that K fertilization was not warranted under the conditions characterized in this single field experiment.*

## Introduction

Potassium (K) is commonly recognized as an essential nutrient for plant growth and development, and is considered as a macronutrient similar to nitrogen (N) and phosphorus (P) in terms of total amounts required by plants. Total K in many soils is often between 0.5 to 2.5%, and commonly is about 1.2% (Tisdale et al., 1985). Soil K is commonly classified as being part of four general fractions 1) mineral, 2) nonexchangeable, 3) exchangeable, and 4) soil solution K. In terms of the K that is available to a plant over the period of a crop production season, the mineral and nonexchangeable forms of K are generally not included as an immediately available form of K, but are brought into the exchangeable and soil solution phases over time through soil mineral weathering (Tisdale et al., 1985). The actual mineral composition of a soil is known to dictate to a large degree the actual K fertility status that a soil realizes (Rich, 1968 and Tisdale et al., 1985). For example, mica is known to be a relatively K rich soil mineral and can render a large K supplying power to plants over time. Vermiculite is another important K mineral, in that it has a strong K - fixing capacity. The fixation of soil K often refers to the placement of K within the actual lattice structure of soil clay minerals, which renders the K so fixed in a form that it is not directly available to plant roots. Feldspars are also considered as soil minerals which harbor a high natural reserve supply of K. Agricultural soils of the Sonoran Desert regions of Arizona commonly have parent materials originating from igneous rocks, which upon weathering and soil forming processes often produce soil minerals such as mica and biotite, that are K bearing soil minerals (Hendricks, 1985).

Potassium is important to cotton plants for many physiological processes, but it has received considerable attention in it's relation to fiber development. The development of individual fiber cells are dependant upon the maintenance of adequate turgor pressure within the cell (in the vacuole), which is controlled by a $K^+$ malate solute system (Dhindsa et al., 1975). Over the years many experiments have been conducted which have studied the effects of K fertilizers on cotton (Kerby and Adams, 1985).In the San Joaquin Valley (SJV) of California, Cassman and his colleagues have documented positive responses of Acala cottons grown on vermiculitic soils to K fertilization with regard to yield and fiber quality (Cassman et al., 1990). In this work they have shown the relationship in the cotton response pattern to the soil mineralogy and the vermiculitic nature of the soils in question which have a high K fixation capacity (Cassman et al., 1989b), the distribution of the root systems of two varieties of Acala cotton (Gulick et al., 1989), and then of the differential response of the two Acala varieties to K fertilization (Cassman et al., 1989a). This recent work done in the SJV has also documented the anomalies earlier described concerning K deficiency symptoms by Stromberg (1960); in that the foliar symptoms of K deficiency on cotton are not typical of other common crop plants, where symptoms on cotton commonly occur on young rather than older leaves and often appear at a time when sink demand (boll load) becomes great. Another interesting feature from this work is that no consistent relationships between lint yield and soil K availability indices have been developed for affected soils in the SJV (Cassman, 1986).

Further east in the U.S. cottonbelt, recent research on K fertility of cotton have shown responses in Alabama (Mullins et al., 1991), Mississippi (Tupper et al., 1991a and Tupper et al., 1991b), and Arkansas (Oosterhuis et al., 1991). Most of the responses to K fertilization were found with soil applied treatments (Mullins et al., 1991 and Tupper et al., 1991a). However, responses to foliar applications of potassium nitrate ($KNO_3$) have also been reported (Oosterhuis et al., 1991).

Due to the increasing importance and interest in cotton lint quality and therefore in fiber development, there has been an increasing level of interest concerning K fertility of cotton grown in Arizona. This interest has also been propelled by the positive responses found elsewhere, as noted by the aforementioned research in various parts of the U.S.. Agricultural soils of the Sonoran Desert regions of Arizona are commonly high in available K (as determined by soil extractions such as ammonium acetate) and in total K based upon common soil mineralogy. The soil conditions in other parts of the country where cotton responses to K fertilization are found usually differ quite drastically to those soils found in cotton producing areas of Arizona. However, due to a limited amount of information describing the responses of cotton in Arizona to K fertilization, a project was initiated in 1990 to evaluate cotton producing soils and their potential K fertility provisions. The first part of this project includes a survey of 12 common agricultural soils of southern Arizona and a complete characterization of the chemical and physical composition of the soils relative to K fertility, similar to a study conducted by Parker et al. (1989). The second part of this project involves field experimentation to measure the response of cotton to K fertilization. As a first step to the field experimentation component of this project, a single field experiment was initiated in 1991 with the objective of evaluating the response of cotton crop growth, in-season fertility status, lint yield and lint quality to soil and/or foliar applications of K fertilizer.

## Methods

A single field experiment was established in 1991 on a Gilman loam soil (coarse-loamy, mixed (calcareous), hyperthermic Typic Torrifluvent) on the Paloma Ranch in western Maricopa County. Initial soil test results (0-8 inch depth) revealed the following characteristics of the study area: exchangeable Ca = 6060 ppm, Mg = 330 ppm, Na = 606 ppm and K = 315 ppm (by a 1 N ammonium acetate extraction); P = 18 ppm (sodium bicarbonate); Zn = 0.66 ppm (DTPA); $NO_3^-$-N = 15.7 ppm (selective ion electrode); pH = 7.9 (1:1 soil/water); $EC_e$ = 4.0 mmhos/cm (electrical conductivity), and ESP = 7.2% (calculated exchangeable sodium percentage). Exchangeable K levels (ammonium acetate extraction) in the second, third, and fourth feet in the soil profile were 240, 187, and 144 ppm K, respectively. The treatments imposed (Table 1) were arranged as a split plot within a randomized complete block design in the field with four replications. Soil applied treatments were broadcast and preplant incorporated as $K_2SO_4$. Soil applied treatments were arranged as mainplots, and foliar treatments as subplots. Mainplots consisted of 20, 36 inch rows which extended the full length of the irrigation run (1200 ft.). Each mainplot area was split into two, 10 row subplots, also extending the full length of the irrigation run. The field was planted to DPL 90 and watered-up on 12 April 1991. All irrigation, pest management, and fertilization inputs (other than K), were provided on an as-needed basis throughout the season.

Routine plant measurements consisting of plant height, number of mainstem nodes, bloom counts per unit area (75 $ft^2$), number of nodes from the top white bloom to the terminal (NAWB), percent canopy closure, and plant mapping analyses were carried out for each treatment on regular intervals throughout the season. Plant tissue samples were taken at the same time each group of plant measurements were taken by collecting the upper-most, fully developed whole leaf blade and the attached petiole from approximately 50 randomly selected plants from each plot. Tissue samples were subsequently analyzed for nutrient concentrations, including K. Foliar applications of $KNO_3$ fertilizer were made at four dates throughout the first fruiting cycle of the crop to the entire subplot areas by a groundrig applicator at a carrier rate of 25 gallons per acre (Table 2). First bloom occurred on 15 June and plots were progressing into cut-out based upon NAWB and bloom counts by 19 August (Figure 1). The final irrigation was applied 31 August. Yield estimates were made by mechanically picking the entire center eight rows of each subplot area on 24 October. Subsamples of seedcotton were subsequently ginned for lint turnout determinations and preparation of lint samples for HVI analysis. Statistical analyses of all resultant data collected in this experiment were performed in accordance to procedures outlined by the SAS Institute (1985).

## Results

Visual symptoms which would indicate any K nutritional problems were never apparent with this crop. All plant measurements collected over the study period revealed no significant differences due to treatment effects. Fruit retention levels taken from each treatment area (Figure 2) indicated a favorable fruit retention pattern over the season. The height (inches): mainstem node ratios also were descriptive of a favorable vegetative/reproductive balance maintained by the crop (Figure 3). Analyses performed on all plant tissue samples collected (whole leaf and petiole) revealed no response in leaf K concentration to any K fertilization regime (treatment). Similarly, yield results (Table 3) indicated that there were no significant effects due to K fertilization in this experiment. The observed significance levels (OSL) for the soil applied and foliar applied K main effects were 0.8598 and 0.1062, respectively. The OSL for the soil*foliar applied interaction term was 0.1377. The HVI analyses performed on lint samples from each treatment revealed no differences among K fertilization treatments with respect to any of the HVI measurements.

This single field experiment certainly does not provide the final definitive case for K fertilization and K fertility maintenance for cotton in Arizona. However, it does provide an important first step in the process of developing sufficient information needed to clearly outline cotton production conditions common in Arizona and K fertility. Each additional field experiment conducted in the course of developing this project will require a complete characterization of the soil conditions, crop development patterns, and the quantity and quality of fiber produced in response to various K treatment regimes.

It seems reasonable that circumstances which may result in potential responses to K fertilization on cotton would include low soil test K ($< 150$ ppm K), a coarse soil texture, the development of a strong nutrient sink (boll load), and also possibly the sequence in crop rotation; such as a cotton crop closely following an alfalfa crop due to the high K removal tendencies of a forage crop like alfalfa. Further work in this area is needed and will be pursued by this research program.

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Table 1. Soil and foliar applied K treatments utilized at Paloma Ranch experiment, 1991.

| Soil Applied * | Foliar Applied ** |
|---|---|
| --lbs. $K_2O$/acre-- | |
| 0 | O |
| 0 | F |
| 75 | O |
| 75 | F |
| 150 | O |
| 150 | F |
| 225 | O |
| 225 | F |

* Applied broadcast, preplant incorporated as $K_2SO_4$.

** Foliar treatments consisted of: F) four applications of 4.6 lbs. $K_2O$/acre as $KNO_3$ (see Table 2), and O) no foliar K applications.

Table 2. Dates of foliar K applications, Paloma Ranch experiment, 1991.*

| Date | HUAP ** | Rate |
|---|---|---|
| | | -- lbs. $K_2O$/acre-- |
| 26 June | 1420 | 4.6 |
| 16 July | 1957 | 4.6 |
| 6 August | 2515 | 4.6 |
| 27 August | 3107 | 4.6 |

* All applications made by a groundrig applicator with approximately 25 gallons per acre carrier, using $KNO_3$ (10 lbs. $KNO_3$/acre).

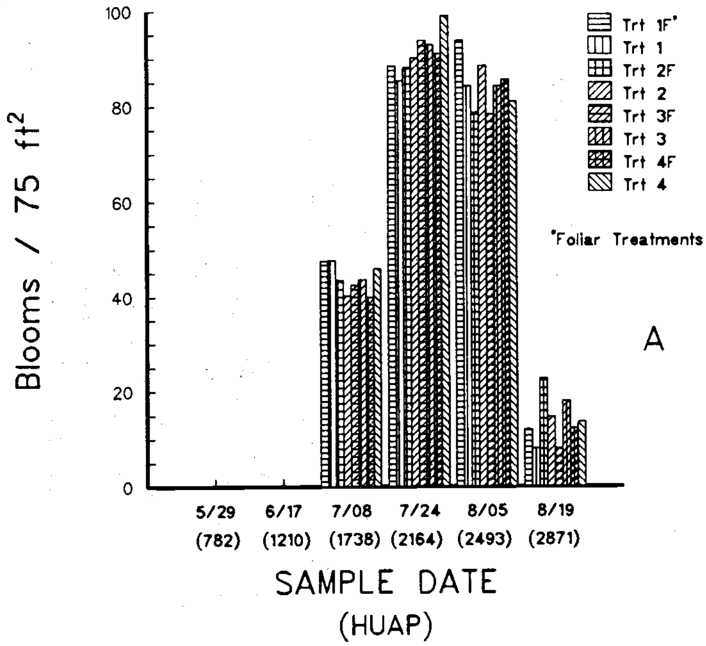
** HUAP, Heat Units (86/55°F thresholds) accumulated after planting (12 April, 683 HU after 1 January).

Table 3. Lint yield means for K fertility experiment, Paloma Ranch, 1991.

| Treatments | | Yield | |
|---|---|---|---|
| Soil Applied<br>-lbs $K_2O$/acre- | Foliar§ | ----------lbs.lint/acre-------- | |
| 0 | O | 1578 | a* |
| 0 | F | 1599 | a |
| 75 | O | 1687 | a |
| 75 | F | 1683 | a |
| 150 | O | 1608 | a |
| 150 | F | 1542 | a |
| 225 | O | 1639 | a |
| 225 | F | 1668 | a |
| CV (%) | 2.4 | | |

§ Foliar treatments consisted of: O) no foliar applications and F) a series of our foliar applications of 4.6 lbs. $K_2O$/acre as $KNO_3$.

* Means followed by the same letter within a column are not significantly different according to single degree of freedom orthogonal contrasts.



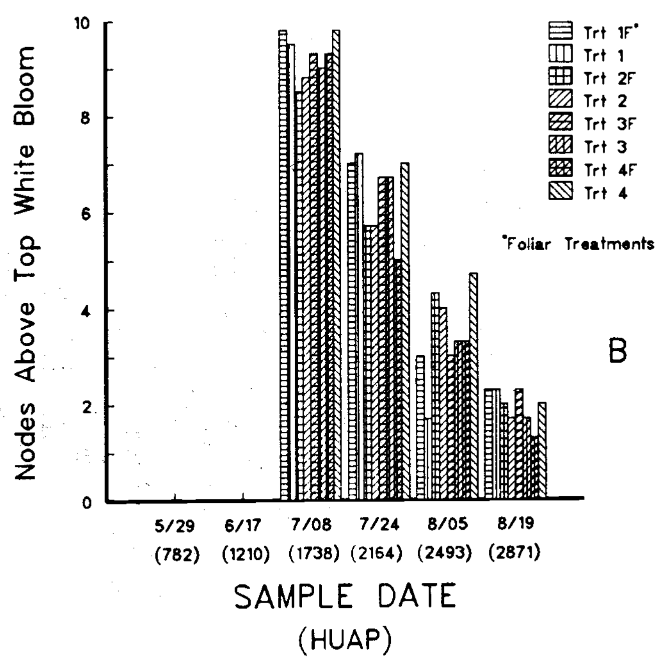
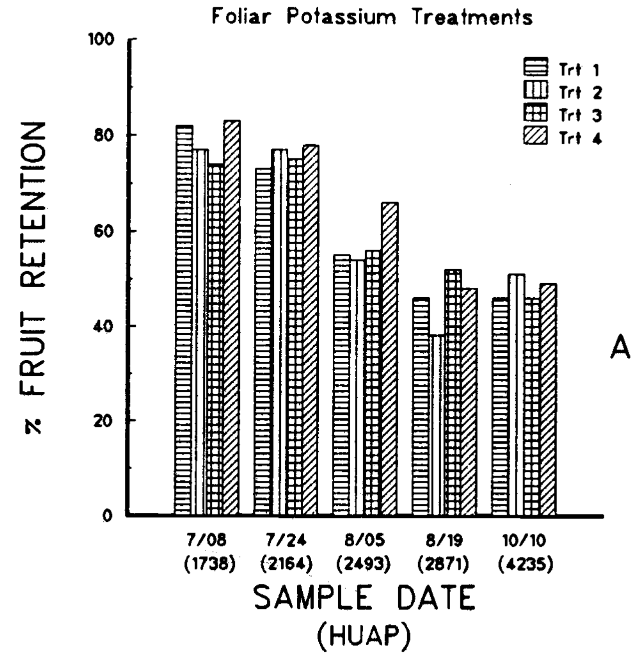




Fig. 1. A) Blooms / 75 $ft^2$, and B) nodes above top white bloom, Paloma, 1991.



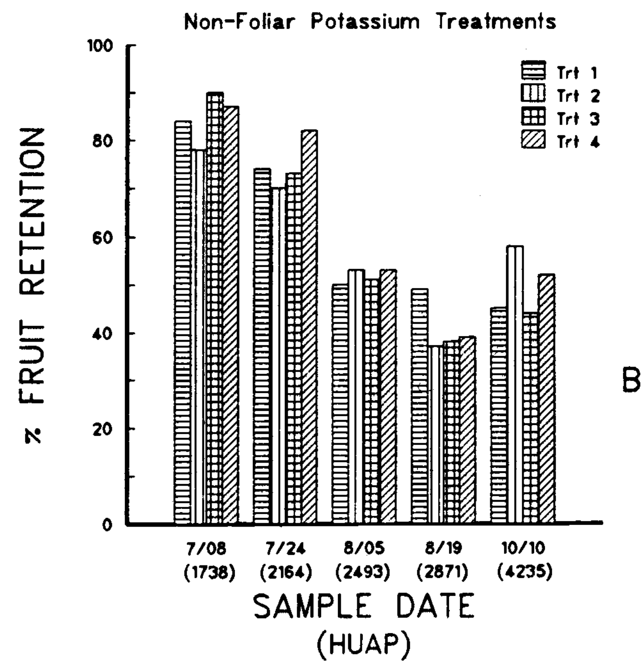




Fig. 2. Percent fruit retention for Potassium treatments A) foliar, and B) non-foliar, Paloma, 1991.

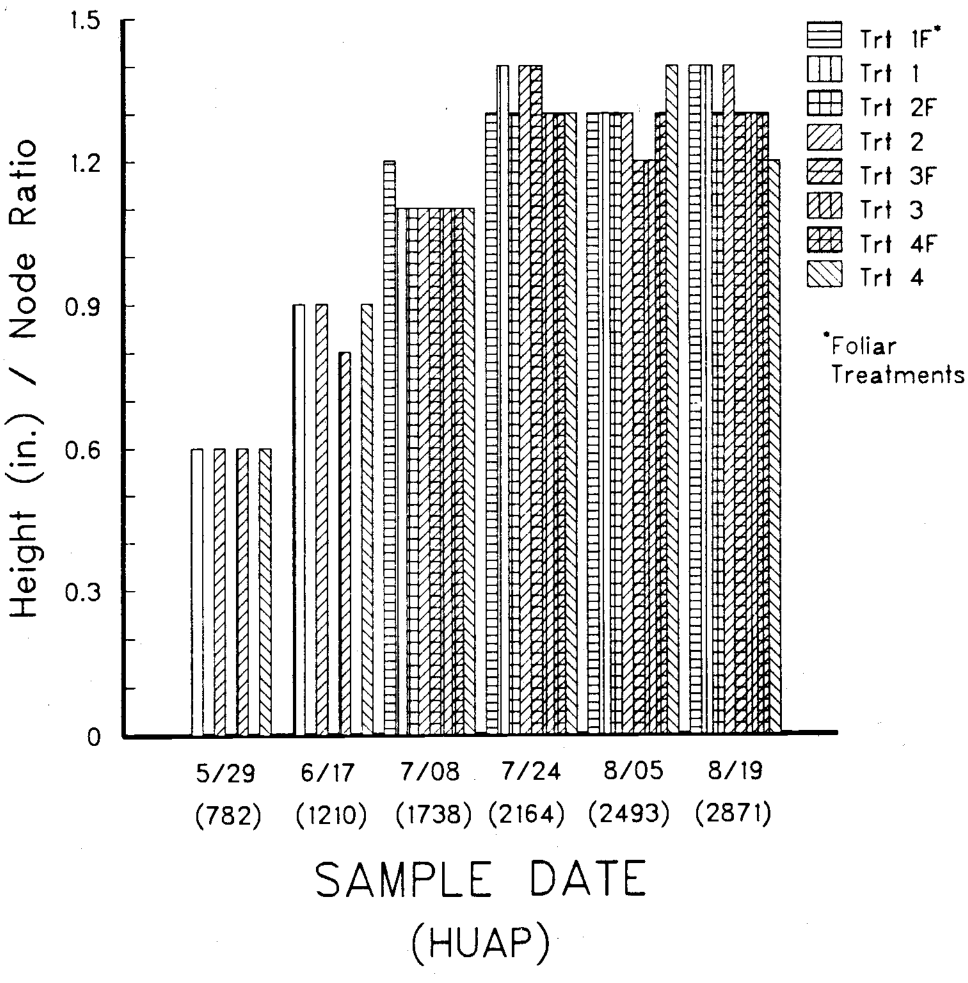



Fig. 3. Height (inches) / node ratio, Paloma, 1991.