# EVALUATION OF FOLIAR FERTILIZATION IN NUTRIENT DEFICIENT COTTON

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## Abstract

Nutrient deficiencies in cotton may significantly impact plant health and yield. Soil properties may cause or exacerbate problems of water and or nutrient availability. When in-season nutrient deficiencies are detected, foliar applications may present the only remedial option. Foliar applications of supplemental nutrients are controversial due to relatively high costs and inconsistent yield responses. A single foliar treatment of nitrogen and or potassium applied near 1st bloom was compared against no foliar treatments in two N- and K-deficient, no-till fields with fine-textured soils and high levels of Magnesium. No significant differences were observed in post-treatment concentration of K or N in leaf tissues, plant growth response, or yield ($p_{crit} = .05$). Foliar fertilization can be a viable option to remedy nutrient deficient crop scenarios; however sensitivity to factors that may otherwise limit a positive yield response may continue to limit its performance and widespread adoption. Leaf tissue sampling appears to be an effective tool for identifying nutrient deficiencies in-season and evaluating post-treatment effectiveness.

## Introduction

Crop fertility is a key to maximizing yield and profits in cotton. Nutrient deficiencies cost producers' potential yield and profit. Costs of supplemental fertilization vary widely, depending on the formulation and method of application. Pre-season fertilizer treatments are typically preferred due to lower costs of nutrient formulations, ease of application, and predictability of response. Several factors, such as pH, soil compaction, soil nutrient content, excessive rainfall, or others may lead to problems of nutrient availability and deficiencies later in the season. Remedial options are few to correct late-season nutrient problems.

One method often employed to remedy shortfalls is foliar feeding. However, cotton yield response to foliar fertilizers is difficult to predict and applications often do not show positive yield benefit (Abaye, 2009) and or profit. To test the effectiveness of supplemental foliar nutrients in cotton, fields with known fertility problems were chosen to be the most likely scenario to demonstrate a response.

Methods for determining appropriate fertilizer composition and rates typically focus on evaluation of pre-season soil samples. Although generally a very useful tool, soil analyses may reflect the presence of nutrients rather than their availability. Plant tissue sampling may be used in-season to identify actual plant nutrient status at a defined plant development stage. Discrepancies between soil and tissue tests may exist, e.g., a soil test shows adequate K, but a tissue test shows a deficiency, suggesting there may be factors affecting nutrient availability. Combining results of the two sampling methods may present a more accurate picture than one alone (Campbell, 2000; p.6). Identification of an in-season deficiency could allow a grower to take advantage of an opportunity for remedial action that might otherwise be missed (Abaye, 2009).

## Field Situation

In 2010, poor growth and crop color in two dryland, no-till fields near Wellington, Kansas, suggested a shortage of nitrogen. Soil and tissue samples were taken in mid-August to confirm or dispel the diagnosis of deficiency. Tissue samples revealed deficiencies of N. Moreover, significant deficiencies of K were also revealed, which was a surprise. The soil samples taken at the same time showed low levels of N, approximately 10 lbs/acre in the top six inches, while levels of K appeared adequate, i.e., 161ppm (medium) and 213ppm (high), respectively (Midwest Laboratories analysis). The deficiency observed in tissue analyses suggested that a problem of nutrient availability, potassium in particular, may exist. Further evaluation of the soil tests indicated high to very high levels of magnesium, i.e., 492ppm and 1118ppm in both fields, respectively (Midwest Laboratories analysis).

Typical fertility practices in this area include pre-season application of 60 to 80 units actual N for yield expectations of 600 to 650 lbs. lint/acre. No potash is applied due to apparently adequate levels of K (Eric Watts, pers. Communication). Application of foliar fertilizers with N and K were selected to address the problem in 2010, but an ongoing period of hot, dry weather discouraged treatments due to a high risk of chemical burn. The above cases were the inspiration for this study to investigate yield response to supplemental foliar K and N in 2011, since traditional fertility practices alone may not be adequate to meet crop needs in this area.

## Materials and Methods

### Field sites

Two fields with fine-textured soils and high levels of magnesium were selected to evaluate foliar fertilizer treatments. Site locations were Field 1: 5 miles SW of Wellington, KS, and Field 2: 2.5 miles NE of Wellington, KS. Both fields are classified as Kirkland silty loam. Tillage practices were no-till at both sites, following sorghum and cotton in fields 1 and 2, respectively. Row spacing was 30 inches. Standard practices were followed for pre-season fertilizer, except that 35 lbs/acre potash was included due to K shortages observed in 2010. Planting dates were May 27, and May 24 in fields 1 and 2, respectively, which are within normal planting dates for the region. Supplemental foliar N and K were applied on July 26 as a one-time, over-the-top treatment near 1$^{st}$ bloom.

### Experimental Design

The experimental design was a 2x2 Factorial of foliar treatments of N (-,+) and K (-,+) in a Randomized Complete Block with three replications, duplicated at two field sites. Plot size was six rows x 300', with the center four rows receiving the fertilizer treatment and outside rows receiving none.

### Foliar Fertilizer

Products selected for nutrient supplements were chosen based on recommendations from Eric Watts, agronomist from Farmers Cooperative, Wellington, Kansas, as products currently in use and readily available. The Nitrogen source was "Gradual®-N" (25-0-0-.5B), by Winfield Solutions, LLC; the Potassium source was "LoKomotive®" (potassium acetate) (2-0-25), by Loveland Products. The fertilizer was applied via a pickup-mounted, pull-type sprayer, using 6504 nozzles, 50 psi, at 5 mph (target rate = 17.7 gal/ac finished spray). Fertilization rates were to be mid-label dosages, but due to problems with the sprayer, only about half the target rate was actually applied (approx. nine gal/ac finished spray). Gradual N was applied at approximately 1 gal/ac (= 2.46 lbs actual N) and LoKomotive at 2 qts/ac (= 1.35 lbs actual K2O).

### Soil and Tissue Sampling

Baseline values for soil nutrient levels were taken via sharp-shooter shovel prior to application of pre-season fertilizer at four sites across the vicinity of the experiment. Samples were taken to a depth of eight inches. Mid-season leaf nutrient concentration was taken from leaf tissue samples near 1$^{st}$ bloom, on 25 July. The blade from the first fully mature leaf, e.g., the 5$^{th}$ node down from the first opening leaf, was removed and collected from approximately 35 plants from the center two rows of each test plot. The tissue samples were taken the day before foliar treatment, and repeated two weeks later, to evaluate nutrient concentration before and after treatments. Analyses of the soil and tissue samples were conducted by Mid-West Laboratories, Inc., Omaha, Nebraska.

### Plant measurements

One day prior to foliar treatments, each test plot was sampled for Fruiting Branches Below White Flower (FBBWF) and Nodes Above White Flower (NAWF) to document the timing of treatment with respect to the physiological target of 1$^{st}$ bloom and general crop status. NAWF was taken again after two weeks to indicate relative changes in crop maturity at the time of the second leaf tissue samples.

Prior to harvest, measurements of final plant height (in inches) and total bolls per plant were taken from five consecutive plants in each of two center rows (ten plants total per plot). Any surviving boll containing at least one lock of lint was included in the counts.

### Harvest

Two sub-plots of 1000$^{th}$ acre (i.e., 17.4' on 30" rows) within each treatment plot for harvest were determined by projecting a line across a "typical" portion of the experimental site. The seedcotton in the two center rows of each plot was then harvested by hand, bagged and labeled. Seedcotton samples were taken back to the gin facility, weighed, and data recorded. Sub-samples from each were placed in grocery bags and shipped to Eric Best, Agronomist for DeltaPine Seed Company, Lubbock, for ginning and grading for quality.

**Data Analysis**

Test data were analyzed by Dr. Kraig Roozeboom of Kansas State University, Manhattan, Kansas, using SAS Factorial ANOVA. Variables analyzed included grams seedcotton, final plant height, bolls per plant, and % concentration N and K (before treatment, after treatment, difference between before and after).

## Results and Discussion

Weather played significantly into 2011 field performance. Above-average heat and localized, often spotty or insignificant (e.g., 0.1 to 0.25 inches) rain showers dominated the season over most of the region, affecting some fields more than others. However, one area-wide rain storm on 7/13 dropped three inches of precipitation that allowed most fields to produce a crop, although yield was extremely variable throughout the region. Field 2 in our study was particularly hard hit by the heat and lack of rainfall, especially evidenced in very low seedcotton yield. Glyphosate-resistant Common Waterhemp, *Amaranthus rudus*, was not controlled in much of Field 2, although yield samples were not affected.

At the time of the first leaf tissue samples on 7/25, Fruiting Branches Below First White Flower (FBBWF) and Nodes Above White Flower (NAWF) data showed that Field 1 was treated approximately 1 Main Stem Node (MSN) above the First Fruiting Branch and Field 2 was treated approximately 3 MSNs above the FFB (Table 1). Both fields were not yet at cut-out (cut-out = 5 NAWF), with NAWF of 6.6 and 6.2 in Fields 1 and 2, respectively.

Table 1. Plant status at time of tissue samples and foliar treatment.

| | PRE-TRT (7/25) | | POST-TRT (8/8) |
|---|---|---|---|
| | FBBWF | NAWF | NAWF |
| FIELD 1 | 1.0 | 6.6 | 3.0 |
| FIELD 2 | 2.9 | 6.2 | 1.9 |

At the time of the second tissue sample on 8/8, both fields were showing some visual signs of drought stress, although Field 2 much more so, as was evidenced by pale leaf color and poor leaf turgidity. A sharper drop in NAWF was observed in Field 2, with 3.0 and 1.9 NAWF in Fields 1 and 2, respectively (Table 1).

Drought stress was also evidenced by the plants used for the tissue samples. In sampling the 5$^{th}$ leaf down on 8/8, often another plant had to be sampled because the 5$^{th}$ leaf was already gone from the previous sample on 7/25, indicating a complete lack of growth and new leaf and main stem node production during the two-week period between samples.

Concentrations (ppm) of N and K were not statistically different in treated and untreated plots before or after treatments, however the difference between ppm (before) and ppm (after) was significant for K in Field 1 at p =.0843 (Table 2). A positive value of the difference indicates a net gain in concentration following treatment. Regardless of significance, the net gain in potassium appears marginal and levels in the leaves remained deficient after treatments of foliar K. With respect to nitrogen, the percent concentration declined over the two week interval between tissue samples. At best, if the N was absorbed, it was used up and then some, showing a net loss in concentration; at worst, none was absorbed. The stressed condition of the plants and the leaf node sampled may have contributed to the lack of observed response, as drought and leaf maturity can adversely affect nutrient absorption and tissue concentration of foliar K (Campbell, 2000, p.5). With respect to nitrogen, the percent concentration declined over the two week interval between tissue samples. At best, if the N was absorbed, it was used up and then some, showing a net loss in concentration; at worst, none was absorbed. No significant treatment effects (p=.05) were observed on plant height, bolls per plant or seedcotton yield (Table 3).

Table 2. Main Factor effects on % Concentration (ppm) of N and K.

| | | PRE-TRT | POST-TRT | DIFFERENCE |
|---|---|---|---|---|
| **Field 1** | Foliar N = “-“ | 3.96 | 3.48 | -0.46 |
| | Foliar N = “+” | 4.08 | 3.51 | -0.57 |
| | | ns | ns | ns |
| **Field 2** | Foliar N = “-“ | 4.62 | 3.53 | -1.09 |
| | Foliar N = “+” | 4.66 | 3.73 | -0.93 |
| | | ns | ns | ns |
| **Field 1** | Foliar K = “-“ | 0.75 | 0.72 | -0.03a |
| | Foliar K = “+” | 0.70 | 0.71 | +0.02b |
| | | ns | ns | p<.10 |
| Field 2 | Foliar K = “-“ | 1.32 | 1.13 | -0.19 |
| | Foliar K = “+” | 1.33 | 1.16 | -0.17 |
| | | ns | ns | ns |

Table 3. Foliar N and K effects on Plant Height, Bolls per Plant and Seedcotton yield

| FIELD | Treatment | Plant Ht. (Inches) | Bolls per Plant | g Seedcotton per 1000$^{th}$ Acre |
|---|---|---|---|---|
| **Field 1** | Foliar N = “-“ | 17.0 | 7.2 | 538.4 |
| | Foliar N = “+” | 16.6 | 6.5 | 533.3 |
| | P=.05 | ns | ns | ns |
| **Field 2** | Foliar N = “-“ | 18.0 | 4.2 | 254.3 |
| | Foliar N = “+” | 18.5 | 4.4 | 219.5 |
| | P=.05 | ns | ns | ns |
| **Field 1** | Foliar K = “-“ | 17.3a | 7.2a | 545.4 |
| | Foliar K = “+” | 16.4b | 6.5b | 526.3 |
| | P=.05 | p<.10 | p<.10 | ns |
| **Field 2** | Foliar K = “-“ | 18.4 | 3.8 | 217.8 |
| | Foliar K = “+” | 18.1 | 4.8 | 256.4 |
| | P=.05 | ns | ns | ns |

Ginning data was collected to see if any gross differences might be observed in seed turnout, however, data were not taken in a way that permitted statistical analysis. Lint and seed turnout are reported in Table 4.

Table 4. The effect of foliar N and K on % lint and % seed turnout

| | | **% Lint Turnout** | **% Seed turnout** |
|---|---|---|---|
| **Field 1** | Foliar N = “-“ | 40.82 | 58.16 |
| | Foliar N = “+” | 41.85 | 59.19 |
| **Field 2** | Foliar N = “-“ | 39.33 | 60.68 |
| | Foliar N = “+” | 39.43 | 60.58 |
| **Field 1** | Foliar K = “-“ | 41.63 | 58.37 |
| | Foliar K = “+” | 41.03 | 58.97 |
| **Field 2** | Foliar K = “-“ | 39.42 | 60.59 |
| | Foliar K = “+” | 39.34 | 60.67 |

## Summary

The unusually hot, dry season was the most dominant factor affecting the 2011 crop performance. Crop stress and physiological “slow-down” were occurring over much of the season, especially later, during boll fill. Additional factors may have also contributed to the lack of foliar fertilizer response, e.g., a dose that was too low or perhaps too late to be useful, or some other unidentified factor. To address these possibilities, the study is to be repeated in 2012, with increased foliar rates of both N and K. Hopefully temperatures and rainfall will provide conditions more conducive to normal production levels in the area. Tissue sampling appears to be a potentially very useful tool in identifying nutrient shortfalls in-season, as well as evaluating nutrient capture after treatments, to help determine product efficacy.

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