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 (5.2 lbs actual N) and or potassium (2.7 lbs actual potash) applied near 1st bloom was compared against no foliar treatments in two dryland, no-till fields with problems of high levels of Magnesium. At these rates, no significant differences were observed between treated and untreated plots in post-treatment concentration of K or N in leaf tissues, bolls per 1000th ac, bolls per plant, or g seedcotton per 1000th ac. (p=.10). High temperatures and droughty conditions through late July and all of August may have prevented a positive crop response. With costs of a minimum of $15 (N alone) to a maximum of $34/ac (N+K; not including application) for these fertilizer treatments with no benefit to yield, risks may not justify the expense of this approach in dryland cotton production. Remediation of nutrient deficiencies may then be best accomplished by increased pre-season application in the subsequent season. 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; Friesen and Nichols, 2012) 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 developmental 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 and tissue samples revealed deficiencies of N as well as significant deficiencies of K, which was a surprise. The soil samples taken at the same time showed low levels of N, 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 potassium availability may have existed. 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). In 2011, a study was conducted to test the effect of a single foliar feeding of nitrogen and or potassium at 1st bloom on N or K concentration in leaf tissues, plant growth, and or yield. Rates of N (2.6 lbs actual N) and K (1.35 lbs actual potash) were applied at 1st bloom. No significant responses were observed in any variables (Friesen and Nichols, 2012). The lack of response may have been due to inadequate rates, sub-optimal plant condition at the time of application (i.e., mildly drought stressed), ongoing heat and droughty conditions post treatment, or some other unidentified source.

The lack of response to foliar applications of N and K in the 2011 study led to a repeat of the study in 2012. However, fertilizer treatment rates were increased and the timing of the treatments was moved up a bit to improve the likelihood of a response to the treatments.

Methods and Materials

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. In Field 1, 51 lbs/ac actual N was the only pre-season fertilizer applied. In Field 2, 60 lbs/ac actual N, 23 lbs/ac actual phosphate, and 30 lbs/ac actual potash were applied. Planting dates were 10 and 11 May, and 18 May in fields 1 and 2, respectively. Supplemental foliar N and K were applied on 6 July at 1st bloom, as a one-time, over-the-top treatment.

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 150 feet, with the center four rows receiving the fertilizer treatment and two 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 an ATV-mounted sprayer, using 6504 nozzles, 50 psi, at 5 mph (target rate = 12 gal/ac finished spray). Gradual N was applied at 2 gal/ac (= 5.2 lbs actual N; cost = $15.50/ac) and LoKomotive at 1 gal/ac (= 2.7 lbs actual K2O; cost = $17.82/ac).

Soil and Tissue Sampling

Baseline values for soil nutrient levels were taken via sharp-shooter shovel prior to application of pre-season fertilizer at three sites across the vicinity of the experiment. Samples were taken to a depth of 10 inches. Leaf nutrient concentration was taken from leaf tissue samples at initiation of 1st bloom, on 6 July, and follow-up samples one week later, i.e., 13 July. The blade from the first fully mature leaf, e.g., the 4th 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 of the foliar treatment, and repeated one week later, to evaluate nutrient concentration before and after treatments. All leaves from the post-treatment samples were washed with distilled water and dried to remove any potential contaminants. Analyses of the soil and tissue samples were conducted by Mid-West Laboratories, Inc., Omaha, Nebraska.

Harvest

Field 1 was harvested on 24 October. Field 2 was not harvested, as yield potential was severely affected by the heat and drought. In Field 1, two sub-plots of 1000th acre (i.e., 17.4’ on 30” rows) from the middle two rows of each treatment plot were determined by projecting a line across a “typical” portion of the experimental site. Within the sub-plots, the total number plants and total number of bolls were counted. The seedcotton from each sub-plot was then harvested by hand, bagged and labeled. Seedcotton samples were taken back to the gin facility, weighed, and data recorded. Because the quantity of seedcotton harvested was so low (due to drought), the samples were not sent away for ginning and processing.

Data Analysis

Test data were analyzed by Dr. Kraig Roozeboom, of Kansas State University, Manhattan, Kansas, using SAS Factorial ANOVA. Variables analyzed included % concentration N and K (before treatment, after treatment, difference between before and after), and plants/1000th ac, bolls/1000th acre, bolls/plant, and grams seedcotton/ac.

Results and Discussion

Weather played significantly into 2012 field performance. Near-record heat and drought from May through September, e.g. 2920 DD60 and 9.75” precipitation, versus 2542 DD60 and 22.6” rainfall (15 year averages) severely impacted the entire region. July and August were particularly hot and dry. One area-wide rain storm on 25 August dropped three-to-four inches of precipitation that helped some, but was too late to correct significant plant growth retardation, fruit shed and reduced boll size. The “big rain event” did, however cause a flush of new foliage and late season squares that did not contribute to yield. Field 2 in our study was particularly hard hit by the heat and lack of rainfall, so that the test plots were not harvested.

At the time of the first leaf tissue samples on 6 July, both fields appeared to be in good shape with regards to a lack of visible heat and drought stress symptoms. At the time of treatment, there were no blooms present in Field 1 and blooms were very rare in Field 2. When leaf samples were taken one week later on 13 July, most plants had 1 bloom plus 1-2 small bolls. Plants had added one main stem node from 6 to 13 July in Field 1, which indicates that plant growth was going on but was not particularly vigorous. Field 2 was more questionable with respect to active growth.

Pre- and post-treatment leaf concentrations of N in Fields 1 and 2 were actually in excess of normal ranges of 4.0-4.5% (Table 2). Pre-treatment leaf concentrations of K were twice as high in Field 2 as in Field 1 (Table 1), but both were severely deficient when compared to normal desired range of 4.3-5.0% concentration (MidWest Laboratories). The relatively elevated levels of potassium in Field 2 may have been due to the added potash prior to planting. Leaf concentrations (ppm) of N and K were not statistically different in treated and untreated plots before, after, or difference between post and pre-treatments (Table 1). A positive value of the difference of AFTER – BEFORE, would indicate a net gain in concentration following treatment. With respect to nitrogen, in Field 1 the percent concentration declined in both the untreated and the treated plots over the one week interval between tissue samples, which indicates that physiological activity had been occurring (this corresponds with visual observations). In the post treatment samples in Field 2, there was none to only a slight increase in N concentration in both the untreated and treated plots, which suggests that no physiological activity was occurring [this field was beginning to exhibit visible signs of drought stress by the week after treatment]. The condition of the plants and leaves sampled may have contributed to the lack of observed response, as drought and leaf maturity can adversely affect nutrient absorption and tissue concentration (Campbell, 2000, p.5).

Table 1. Main Factor effects on % Concentration of N and K.

		BEFORE (PRE-TRT)	AFTER (POST-TRT)	DIFFERENCE (AFTER – BEFORE)
Field 1	Foliar N = "-"	5.63	4.93	-0.70
	Foliar N = "+"	5.65	5.17	-0.48
		ns	ns	ns
Field 2	Foliar N = "-"	5.15	5.23	0.08
	Foliar N = "+"	5.32	5.32	0.00
		ns	ns	ns
Field 1	Foliar K = "-"	0.75	0.78	0.03
	Foliar K = "+"	0.73	0.82	0.09
		ns	ns	ns
Field 2	Foliar K = "-"	1.51	1.08	-0.43
	Foliar K = "+"	1.50	1.06	-0.44
		ns	ns	ns

No significant treatment effects (p=.10) were observed on bolls/1000th ac, bolls/plant or g seedcotton/1000th ac (Table 2). Plants / 1000th ac were significantly different by K treatments (Table 3), but this effect is obviously not a true result of the treatment, but rather arbitrary variation in the stand (note: stand uniformity is a common problem for no-till fields in South-Central Kansas).

Table 2. Field 1. Foliar N and K effects on Plants/1000th ac, Bolls/1000th ac, Bolls/Plant, and g Seedcotton/1000th ac

Treatment	Plants / 1000th ac	Bolls / 1000th ac	Bolls / Plant	g Seedcotton / per 1000th Acre
Foliar N = "-"	21.8	113.2	5.2	344.9
Foliar N = "+"	22.7	109.8	5.0	344.2
	ns	ns	ns	ns
Foliar K = "-"	**23.8**	116.6	4.95	352.9
Foliar K = "+"	**20.5**	106.3	5.25	336.2
	p=.0981	ns	ns	ns

Summary

The unusually hot, dry season was the most dominant factor affecting the overall 2012 crop performance. Crop stress and physiological "slow-down" occurred over the latter part of July through late August, covering late fruit set through boll fill. The condition of the plants in the test fields was good when they were treated with foliar N and or K, but high temperatures and lack of significant rainfall following treatments no doubt played a part. Evidence of nutrient uptake or fruit or yield response from the foliar treatments was absent. Additional factors may have also contributed to the lack of response. In 2013, the study will shift focus to a range of dosages of foliar potassium to determine rates necessary to significantly affect growth and yield, and assess economic feasibility of doing so. Studies from 2011 and 2012 suggest that in dryland cotton production, foliar fertilization may not be economically justifiable, where late season high heat and drought can nullify any potential for positive response. Risks of non-performance due to uncertainty in seasonal weather patterns may be too high to overcome the approximately $15-$34 per acre to treat (N alone, to N+K, not including application). If that is the case, then a more economically viable option would be to wait until the next season to address nutrient deficiencies with heavier applications of pre-season fertilizer. Regardless, tissue sampling appears to be a 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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