Effects of Foliar Fertilizers Containing Calcium on Early June Planted Cotton in the Palo Verde Valley, 2000

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Abstract

Three foliar fertilizers containing calcium were applied at first bloom to evaluate effects on late planted (June 1) cotton in the Palo Verde Valley. Application of Calcium Metalosate resulted in increased retention percentages when compared with other foliar fertilizers at 21 days post treatment as well as more nodes/plant and calculated fruiting structures/plant. Yields did not reflect these differences however, as highest overall yields were from the untreated check, which yielded about 100 lbs. of lint/acre more than foliar fertilizer treatments. Foliar treatments did result in numerically lower micronaire and longer fibers from first pick cotton. Cotton from the first pick Calcium Metalosate treatment was strongest, but similar to other treatments. Foliar treatments did result in increased cotton value/acre by $65-95/acre, but differences noted were not consistent across field. Increased value noted for fertilizers was associated with areas of field with lowest retention rates in the untreated check at three weeks post application, and further reduction in lint quality value of untreated cotton, due perhaps to crop stresses.

Introduction

A number of plant stresses, including salt stress, have been reported to cause increases in anti-oxidant levels in cotton (Rajguru et al., 1999 and references therein). Production of anti-oxidants trigger ethylene production which in turn form abscisic acids that can result in abscision of leaves and potential fruit.

Heat is one form of stress that has been shown to affect cotton yields in the desert southwest. Two stress levels (1 and 2) have been identified for low desert grown cotton. Level 1 stress, defined as average daily temperature for the cotton plant of 82.4ºF-86ºF, results in low to moderate reductions in fruit retention, reduced fertilizer efficiency, and smaller bolls (Brown and Zeiher, 1997). A heavy and prolonged fruit shed is a common response to Level 2 stress conditions, defined as cotton plant average daily temperature above 86ºF (Brown and Zeiher, 1997). High night-time temperatures, caused in part by high levels of moisture which increase dew-points, are often associated with these stresses and are not uncommon during the cotton production season in the desert southwest.

Calcium has recently been discovered to be involved and thought to limit stress induced production of anti-oxidants (Banks et al., 2001). Calcium is an essential component of plant cell walls. Although most plant nutrients can be translocated from older to newer tissues, calciumis considered to have little, if any, translocation in the plant as calcium is bond in plant structures. Newly developing tissues must be supplied calcium via root uptake. Calcium is also known to be 'tied-up' in soils with pH above 7.5 by interacting with phosphates to form an insoluble compound. Most low desert soils are above 7.5 in pH and may experience this calcium/phosphate interaction over time unless acid has been added to reduce the soil pH.

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Developing leaves may receive more calcium than formed or forming reproductive structures. Observations indicate that fruiting structures are more likely to abscise (abort) under stress conditions than are leaves.

This project was initiated to determine if calcium applied via foliar fertilizers to cotton would have any effects on cotton fruiting structure retention and subsequent yields.

Methods and Materials

Three foliar fertilizers that contained calcium and other nutrients were applied the morning of August 7, 2000, approximately seven days after first flower. A John Deere 6000 high boy sprayer applied 12 gpa of solution at 60 psi. The sprayer utilized seven T-Jet 8002 nozzles per row (3 per each side, 1 over the top) to late planted cotton (June 1, 2000, variety 'SureGro521BR') that had begun bloom approximately July 31. Plots were replicated four times in a randomized complete block design and each plot was approximately 2.5 acres in size (twelve rows (40" centers) wide by field length of approximately 2,680 ft). Field length varied on the east edge of the field slightly. Several days prior to application a number of fifth leaves below terminals were removed from plants, and sent to Albion Laboratories (Clearfield, Utah) for nutritional level analyses. Soil pH was not collected across the field.

One quart per acre of the Calcium Metalosate® and the Ele-MaxPhosCal-Zin FL® were applied, while two quarts per acre of the Ele-Max PhosCal LC® were applied as this product contained the lowest percentage of calcium of the foliar fertilizers in the experiment.

Plant mapping data were obtained on August 28 (21 days post treatment), as controlled environment studies have suggested that fruit shed may be delayed 7-10 days following a level 2 stress event and require 15-21 days to recover from such (Brown and Zeiher, 1997).

Ten plants/plot were used for plant mapping; data collected included height, nodes, fruiting branches, and fruit retention. Fruit retention was collected from sites 1-3 from each fruiting branch. Fruiting structures per plant were also calculated.

Plots were first harvested with cotton pickers (first pick) on December 20-21, 2001. Two plots of the same treatment were combined in a module for ginning, resulting in two modules per treatment. Plots were then harvested with a Rood harvester on December 21-24, and all 'ground' cotton for all four plots of a treatment were placed in the same trailer for ginning. All cotton was then ginned by Modern Gin (Blythe, CA), which provided data for yields, classing, and value. Yields and values per acre for each treatment, based on quality for each quantity of cotton lint harvested, were then calculated.

Data means were separated and analyzed using a Fishers least significant difference (Statgraphics Plus for Windows). Data were limited for cotton picker collected yield and quality due to combining two replicates into a module for harvest, thereby reducing replicates from four to two for all yield and quality statistical analyses. Ground cotton was collected into a single trailer/treatment and no attempt was made to gather data from the individual plots.

Results

The summer of 2000 was very unusual in that night-time temperatures were very cool, and very little, if any, heat stress was noted. This resulted in high retention rates and very high yields for early (March) planted cotton. Some humidity was present in early August which slightly elevated night-time temperatures to 81° and 82° F on August 6th and 7th respectively at the Palo Verde (CIMIS #72) station located a few miles away from the field.

Level 2 stress was not thought to be involved in this study although irrigation effects upon actual field temperatures were not recorded. Level 1 stresses may not have occurred either or were perhaps very limited. Results noted in this experiment are thought to be due to be primarily due to soil-root interactions with very limited interaction of night-time temperature stress. Because no in-field temperatures were recorded, Level 1 stresses can not be entirely dismissed however.

Floral/fruiting structure retention

Significant differences existed at three weeks post treatment for floral/fruiting structure retention rates at the second position site on each branch (Table 3), with plants treated with Calcium Metalosate having significantly more than other foliar fertilizers. The untreated check had fewer than the Calcium Metalosate but more (on a percentage basis) than the other foliar fertilizers. This also held true for combined positions 1+2 as well, although these differences were not as defined statistically. The exact reason for the increases noted with Calcium Metalosate is not completely understood but thought to be partially due to the amino acid chelation of this product, which allowed more rapid infusion into the plant and increased cell wall strength at the fruiting structure sites. Adequate amounts of nutrients were noted in plants prior to application (Table 2) with high amounts of calcium noted but this calcium may have been bound in cell walls. Calcium uptake by roots and availability in soil to plants was not measured.

Retention for position 3 was slightly higher in the untreated check than in treated cotton at approximately three weeks after application (Table 3); this may have continued at positions 4+ (although these sites were not mapped). One possible reason for the shift in retention may be that increased retention of fruiting structures closer to the main stem (positions 1, 2) in certain treatments may have resulted in increased nutrient needs and usage at these sites This increased nutrient 'sink' closer to the main stem may have also resulted in lower nutrient concentrations available for retention and growth at positions further from the main stem.

Differences existed across the field with the west replicates having about 10% higher retention rates than the eastern two replicates in the field (74.45% vs. 63.63% for site 1; 64.75% vs. 55.1% for sites 1+2). The western half of the field consisted primarily of three soils (approximately 39% Imperial silty clay, 24% Ripley clay loam, 35% Meloland fine sandy loam, and 2% Gilman fine sandy loam), while the eastern 1/2 of the field had seven soils present (approximately 9% Imperial silty clay, 19% Holtville silty clay, 25% Ripley silty clay loam, 19% Cibola silty clay loam, 21% Meloland fine sandy loam, 5% Gilman fine sandy loam, and 2% Rositas fine sand).

Effects on numbers of nodes

Application of Calcium Metalosate resulted in a significant increase in number of nodes per plant (Table 4) and as well as taller plants. Height to node ratios were almost identical for all treatments however. The increased height and nodes per plant in the Calcium Metalosate treatment resulted in a higher number of calculated fruiting structures/plant than other treatments at three weeks post treatment, however, yield increases from this treatment were not noted at harvest (Table 6).

Yields

Highest lint yields were obtained from the untreated check (Table 6), which averaged almost 100 lbs/acre more lint than did cotton treated with fertilizers containing foliar calcium. Total lint yields from the three foliar treatments were almost identical. Plots treated with Ele-Max Phos Cal had very little lint as ground cotton and had the most lint as first pick cotton. Differences noted for first pick lint were not statistically different, perhaps in part due the combining of the two replicates into a module for harvest.

Why did the untreated check have higher yields? One reason may be that cotton in the untreated plots compensated on the outer fruiting sites or later during the season. Retention for fruiting site #3 was slightly higher in the untreated check than in any of the foliar treated cotton at approximately three weeks after application and this could have continued at sites 4+ (sites not mapped). Increased retention rates for the untreated check in comparison with the treated cotton may have also occurred later in the season as well as cotton plants were only mapped once during the experiment.

Quality

Calcium treatments were noted to positively affect cotton quality (Table 5) in this experiment, primarily due to an increase in fiber length of first pick cotton. Slightly lower micronaire values were also noted for foliar treated first pick cotton than the untreated check in addition to increases in fiber length, leafiness, uniformity and color score value. Differences noted for quality characteristics were not statistically different with the exception of leafiness in first pick cotton, partially due to two replicates being combined together at harvest. Fiber strength was almost identical with the exception of the Calcium Metalosate treatment which resulted in stronger fibers at first pick.

Value

Foliar treated cotton had higher value (Table 6) than did the untreated check, primarily due to longer fiber length of first pick cotton (Table 5) that of the untreated cotton in the eastern half of the field. The shorter fibers in the untreated cotton (as well as other factors) resulted in a deduction of $0.342 per lb. lint from this half of the field. Little difference was noted for fiber length when comparing treatments from the western half of the field. Fiber strength also appears to be a factor for further value differentiation among foliar fertilizers tested.

The eastern half of the field was documented as having approximately 10% less retention at plant mapping at three weeks post treatment than the western half of the field. Foliar calcium applications also resulted in longer fibers in the eastern half of the field than the check. These two events (lower retention rates, fiber length reduction in untreated plots) are assumed to be correlated and thought due to some type of stress. The reason that foliar fertilizers containing calcium increased fiber length when compared with the untreated check in the eastern half of the field is not understood at this time, but may be related to calcium limiting anti-oxidant activity in stressed cotton while also functioning as an integral aspect of seed development as a function of soil types and differences in nutrient availability.

Literature Cited

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Rajguru, S. N., S. W. Banks, D. R. Gossett, M. C. Lucas, T. E. Fowler, Jr., and E. P. Millhollon. 1999. Antioxidant response to salt stress during fiber development in cotton ovules. J. Cotton Sci. 3: 11-18.

Table 1. Foliar fertilizers in experiment

Product	Formulation & wt (lbs/gal)		Manufacturer	Amount/acre
Ele-Max Phos Cal LC	3-23-0, 3% Ca	(10.95)	Helena Chemical Co.[1]	2 qts (0.164 lbs. Ca)
Ele-Max PhosCal-Zin FL	4-15-0, 13% Ca, 7.8% Zn (12.82)		Helena Chemical Co.[1]	1 qt (0.416 lbs. Ca)
Calcium Metalosate	2-0-0, 6% Ca	(10.00)	Albion Laboratories[2]	1 qt (0.15 lbs. Ca)

[1] 6075 Poplar Avenue, Suite 500, Memphis, TN 38119
[2] 101 North Main Street, Clearfield UT 84015

Table 2. Nutritional levels of 5th leaves from cotton terminals on August 3, 2000, after initiation of flowering.

		Recommended adequate ranges	
Nutrient	**Percent**	**Auburn U.**	**Albion Laboratories**
Nitrogen (N)	3.5	3.50-4.5	3.5-4.5
Phosphorus (P)	0.59	0.3-0.5	0.3-0.5
Potassium (K)	2.72	1.5-3.0	1.5-3.0
Sulfur (S)	1.44	0.25-0.8	0.3-0.8
Calcium (Ca)	4.17	2.0-3.0	2.0-3.0
Magnesium (Mg)	0.61	0.3-0.9	0.3-0.8
Sodium (Na)	0.126		< 0.1
	Parts/ Million		
Nitrate N (NO_3)	750		
Iron (Fe)	80	50-250	50-250
Aluminum (Al)	5		< 250
Manganese (Mn)	101	25-300	30-200
Boron (B)	82		20-80
Copper (Cu)	11		8-25
Zinc (Zn)	43		20-50

Table 3. Fruit retention percentages for fruiting positions sites one through three at three weeks post treatment.

	Percent retention at positions 1-3				
Foliar fertilizer	1	2	3	1-2	1-3
Ele-Max PhosCal-Zin FL	65.25a	45.50 c	33.50a	55.50 b	48.00 b
Ele-Max Phos Cal LC	67.76a	47.75 bc	39.75a	58.50 b	52.25ab
Calcium Metalosate	74.50a	56.50a	41.50a	65.75a	57.50a
Untreated check	67.25a	52.50ab	42.75a	60.00ab	54.25ab

Means in columns followed by the same letter are not significantly different at the p<0.05 level (Fisher's least significant difference).

Table 4. Nodes per plant, nodes with fruiting structures, cotton plant height, height:node ratios, and calculated fruiting bodies/plant at 21 days post treatment with three calcium containing foliar fertilizers.

					Calculated	
	Plant	Nodes		Height:	Fruiting structures/plant	
Foliar fertilizer	ht (cm)	per plant	with flowers	Node ratio	Pos. 1-2	Pos. 1-3
Ele-Max PhosCal-Zin FL	116.3a	17.0 b	16.35 b	2.69a	18.2 b	23.5 b
Ele-Max Phos Cal LC	123.3a	17.3 b	16.25 b	2.81a	19.1 b	25.5 b
Calcium Metalosate	125.8a	18.4a	17.65a	2.70a	23.3a	30.5a
Untreated check	120.2a	17.1 b	16.15 b	2.66a	19.5 b	26.4 b

Means in columns followed by the same letter are not significantly different at the p<0.05 level (Fisher's least significant difference).

Table 5. Mean lint quality values of June planted cotton treated with calcium containing foliar fertilizers on August 7, 2001 (one week post first bloom), Palo Verde, CA.

Foliar fertilizer	Micronaire 1st pick	Micronaire Ground	Length (1/100") 1st pick	Length (1/100") Ground	Strength (g/tex) 1st pick	Strength (g/tex) Ground
Ele-Max PhosCal-Zin	5.15a	4.7	106.06a	105.67	25.65a	26.70
Ele-Max Phos Cal LC	5.15a	4.9	105.41a	105.0	25.80a	27.50
Calcium Metalosate	5.09a	4.6	105.45a	106.0	26.86a	28.20
Untreated check	5.20a	4.53	104.61a	108.33	25.75a	28.13

	Leafiness 1st pick	Leafiness Ground	Uniformity 1st pick	Uniformity Ground	Color 1st pick	Color Ground
Ele-Max PhosCal-Zin FL	2.26 b	3.0	82.0	82.0	81.19	79.0
Ele-Max Phos Cal LC	2.04ab	3.0	82.0	82.0	81.32	79.0
Calcium Metalosate	1.95ab	3.0	81.85	82.0	81.28	76.7
Untreated check	1.89a	3.0	81.0	81.67	80.59	78.0

Means in sub-columns followed by the same letter are not significantly different at the P<0.05 level (Fisher's least significant difference).

Table 6. Cotton lint yield and economic values of cotton treated with calcium containing foliar fertilizers.

Foliar fertilizer	Pounds of lint/acre 1st pick	Ground	Total	Value ($/acre) based on quality factors @ $0.55 base 1st pick	Ground	Total	vs. Check
Ele-Max PhosCal-Zin FL	949a	152	1,101	$ 414a	$ 61	$475	+ $65
Ele-Max Phos Cal LC	1,050a	49	1,099	$ 458a	$ 22	$480	+ $70
Calcium Metalosate	952a	155	1,107	$ 427a	$ 78	$505	+ $95
Untreated check	1,042a	160	1,202	$ 338a	$ 72	$410	-----

Means in columns followed by the same letter are not significantly different at the P<0.05 level (Fisher's least significant difference)