Fertility Management and Calibration Evaluations on Upland and Pima Cotton

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Abstract

Various field experiments were conducted during the 1997 and 1998 cotton season involving macro and micronutrient fertilization. A total of six experiments were conducted at various locations in Arizona. Each of the field experiments studied the effects of different nutrients and nutrient combinations on both Upland and Pima varieties. The purpose of these experiments were to evaluate University of Arizona fertility guidelines with respect to soil test results and to possibly fine-tune or calibrate these guidelines for common Arizona soils and cotton growing regimes. Results from these experiments based on soil test information, quantitative plant measurements, and lint yield showed no significant difference due to treatments for all the studies except for a phosphorus study conducted in Graham County.

Introduction

In cotton (*Gossypium spp.*) production there are many nutrients that are integral to a successful yield and profit base. The use of nutrient management is important to optimize plant response and yield. The basic construct of nutrient studies should include guidelines for soil and plant tissue analysis. These guidelines have been generally established through soil test and plant tissue correlation and calibration, but they are often not utilized in developing nutrient management recommendations. The purpose of soil test calibration is to describe the soil test results in easily understood terminology and to simplify the process of making fertilizer recommendations by placing soils in response categories (Dahnke and Olson, 1990). For example, $NaHCO_3$ extractable levels of phosphorus (P) $\geq$5 ppm are usually considered sufficient for cotton production, and levels below 5 ppm are indicative of possible deficient levels of P (Silvertooth et al., 1991). However, fertilizer P is often applied under conditions where ($NaHCO_3$ extractable) levels of P > 5 ppm. Past field experiments on cotton have shown no significant response in lint yield to the addition of a P fertilizer (Silvertooth et al., 1989, 1990, 1991) This illustrates the need for further calibration of soil extraction test levels for P in this state.

The Bollset study conducted in Buckeye, AZ looked at the effects of adding calcium (Ca) and zinc (Zn) to the crop during the monsoon season when the cotton plants have a tendency to abort bolls due to heat stress (Brown, 1997). Guidelines for developing recommendations for Zn fertilization on cotton often use a baseline of 0.5 ppm Zn (DTPA extraction). Below this level, cotton may experience a yield limiting deficiency (Silvertooth, et al. 1989).

Potassium (K) fertility requirements for cotton have been a matter of concern due to increasing interest and emphasis on fiber quality and numerous reports of K deficiencies in various cotton producing regions to the east and west of Arizona (Unruh et al., 1993). The plant available forms of soil K are a function of soil mineralogy. (Unruh et al., 1993) found that the majority of soils used for agricultural production in Arizona contain K-bearing mica and very little vermiculite. Vermiculite is a soil mineral that has a tendency to fix K. Thus, we can conclude that as mineral weathering continues, K should not be deficient in most of the soils in agricultural production areas in Arizona.

For the studies examined in this report, we commonly evaluated a comparison between a check and that of a given fertilization treatment in which all other nutrients were at an adequate level. Evans (1987) discussed this aspect of soil test calibration as an essential ingredient for successful fertilizer recommendations to be valid. Following this approach allows us to analyze the validity of soil test information and its use in fertility management for the soil types and cotton production systems common to Arizona.

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The soil critical levels for micronutrients are not real well documented for Arizona soils. Many of these soil test levels were taken from different regions other than Arizona. Further studies possibly involving the calibration of soil test extractions for various micronutrients may be needed. The objective of this study was to evaluate the effects of P, Ca, Zn, K and other micronutrients such as iron (Fe), manganese (Mn), boron (B) and copper (Cu) on the growth, development, and nutrient status of Upland (*G. hirsutum L.*) and Pima (*G. barbadense L.*) varieties.

Materials and Methods

To study the effects of the addition of a specified nutrient, each study utilized a randomized complete block design during both the 1997 and 1998 growing seasons. For most cases, the experimental design was replicated at least four times. The soil test analyses are presented in Tables 2, 5, 8, 11, 14, 17, and 20, for each field experiment. The soil and foliar treatments for the various studies can be found in Tables 1, 4, 7, 10, 13, 16, and 19. All of the studies were conducted on Upland varieties except for the studies conducted in Graham County in 1998, where the Pima variety HTO was used.

Different soil test extraction standards were used for the various nutrients studied. Soil test levels for P were determined by $NaHCO_3$ extractable P (Olsen and Sommers, 1982). The K soil test levels were determined by ammonium acetate (CH_3COONH_4) (Knudsen et al., 1982). Calcium soil test levels were also ascertained using ammonium acetate (CH_3COONH_4) (Lanyon & Heald, 1982). Micronutrients such as Zn, Fe, and Mn were extracted with DTPA (Lindsay & Norvell, 1978). Soil B levels were determined using the hot water extraction method (Mahler et al., 1984). Soil samples were collected from the field prior to planting. Twenty-five to thirty random samples were taken to a depth of 6-10 inches at various locations around the field and mixed thoroughly into a composite sample. Lab samples were then taken from these composite samples for lab analysis.

Plant measurements were initiated at all sites early in the season to monitor crop growth and development. Multiple, 1-meter samples were taken within each plot at approximately 14-day intervals. Measurements included: plant height, number of mainstem nodes, number of flowers per 50 feet of row, percentage canopy closure, and the number of nodes from the top fresh flower to the terminal (NAWF). The purpose for these measurements was to detect any possible differences in plant growth and development that may have resulted from the fertilizer treatments. Plant tissue samples were also collected at several dates during the season in each experiment. Samples of both the leaf blade and petiole of the uppermost fully developed leaf on a plant were taken from a random selection of 40-50 plants within each plot. All of the plant tissue analysis data (expressed in figures in this report) were taken from petioles in effort to monitor in-season plant nutrient status.

All plots were harvested by use of a two-row or six-row mechanical picker in the center rows of each plot to minimize border effects.

All experimental yield data were subjected to analysis of variance procedures and an LSD multiple comparison test, as outlined by (Gomez and Gomez, 1984) and (SAS Institute, 1996).

Results

Fruit retention (FR) and height to node ratio (HNR) results for all the studies are presented in Figures: 1, 3, 8, 10, 12, 14, and 16. Lint yield results for all the studies can be found in the following Tables: 3, 6, 9, 12, 15, 18, and 21.

Bollset Study, Buckeye, Maricopa County

The Bollset study was comprised of 1X and 2X rates of Bollset and were compared to a check plot (Table 1). Plants in the Bollset study experienced low fruit retention (FR) levels in the latter part of the season as compared to University of Arizona (UA) baselines (Silvertooth and Norton 1998) (Figure 1). Plant vigor (HNR) levels decreased very slightly in the latter part of the season. Table 1 describes the treatments applied in this study. Table 2 shows that soil test levels for Ca and Zn were at 5600 ppm Ca and 1.6 ppm Zn. The concept behind the foliar application of Bollset is to help curb fruit abortion losses during heat stress (Brown, 1997) that may be associated with Ca and

or Zn deficiencies. The FR graph in Figure 1 illustrates that there were similar FR levels between the check and the treatments. Figure 2 shows that there were higher amounts of Ca in the petioles of the check plot versus the treated plots and more petiole Zn in the treated plots than the check. No significant differences in lint yield were expressed among the treatments ($P \leq 0.05$) with an observed significance level (OSL) of 0.1090 as seen in Table 3.

Micronutrient Study, Coolidge, Pinal County

Figure 3 shows that plants in this study had relatively uniform FR and HNR values all season among all treatments. Figure 4, 5, 6, and 7 show the levels of nutrients in the petioles of the sampled plants. The levels of the nutrients in the plants were relatively uniform throughout the season for all nutrients. No significant differences in lint yield were found between the control and treatments 3,2,7,4,5 and 6 (Table 6). There were significant differences between treatment 5 and treatments 4 and 6 ($P \leq 0.05$) with an OSL of 0.0110. However, it is most important to understand that the lint yield in the check was not significantly different from any of the other treatments.

Phosphorus Study, Layton, Graham County

Fruit retention and HNR levels were both below the average baseline as seen in Figure 8. The soil test results for P in this study were 6.8 ppm P (Table 8). Treatment 2 received a pre-plant application of 114 lbs P_2O_5/acre (Table 7). There were no significant differences in lint yield between the two treatments ($P \leq 0.05$) (Table 9). Figure 9 shows that more P was actually found in the petioles of the check than in the petioles of the P treated plots.

Potassium Study, La Palma, Pinal County, 1997

The FR and HNR levels from the production conditions in 1997 were more favorable compared to the studies conducted in 1998 (Figure 10). Table 11 shows that preseason soil tests for K were 490 ppm K. Table 10 shows that 100 lbs/acre K-Mag (22 lbs K_2O/acre) was applied at preplant. The petiole concentrations of K varied towards the end of the season for the different treatments (Figure 11). There were no significant differences in lint yield between the treatments ($P \leq 0.05$) (Table 12).

Phosphorus Study, Claridge, Graham County

The FR and HNR values were more favorable for the studies conducted in Graham County for the 1998 season than with other studies conducted in other parts of the state (Figure 12). The weather patterns were much more favorable in the Safford area in 1998. The treatments are described in Table 13. Petiole concentrations of P were similar for the treatments throughout the season (Figure 13). Table 14 shows that preseason soil tests were 7.6 ppm P. There were significant differences between the control and other treatments (Table 15). The added preplant N did not have a significant effect on yield. There was a significant difference between the check and treatments 2, 3, and 4 ($P \leq 0.05$) with an OSL of 0.0126.

Phosphorus Study, Coolidge, Pinal County

The FR and HNR levels for this study were close to normal for the 1998 season in central Arizona (Figure 14). The FR pattern revealed a general decline towards the end of the season, while the HNR levels had an increasing trend. The generally unfavorable weather conditions of 1998 resulted in a loss of the fruit load and more vegetative growth. Twenty gallons 10-34-0/acre was applied to the treated areas (Table 16). The check plot exhibited more P in the petioles than the treated plot (Figure 15). There were no significant differences in lint yield between treatments ($P \leq 0.05$) (Table 18). Sodium bicarbonate extractable P and Zn (DTPA extractable) levels were both below the UA soil test guideline critical levels (Table 17). There may be a concern that a crop response to P cannot be determined with Zn levels below the described critical level.

Zinc Study, Coolidge, Pinal County

The FR dropped rapidly towards the lower baseline early in the season (about 1000 heat units after planting (HUAP) 86/55 ^{o}F thresholds), and at this same time the HNR experienced a steep increase (Figure 16). Treatment 2 received 10 gal UN 32/acre plus 10 lbs Zn/acre as Nulex Zn (16-0-0, 20 Zn)(Table 19). The preseason soil test detected 0.40 ppm Zn. (Table 20). Figure 17 shows that there were similar concentrations of Zn in the petioles throughout the season for both treatments. There were no significant differences in lint yield between the treatments ($P \leq 0.05$) (Table 21). The C.V. (%) was relatively high for this experiment with a value of 21.53. The yield for this experiment was indicative of the lower yields that were common throughout Arizona during the 1998 season

Conclusion

In conclusion, the Claridge P study in Graham County was the only site of the seven field experiments conducted in 1997 and 1998 that showed significant differences in lint yield in response to the applied nutrients in question. The soil test results showed there was 7.6 ppm P in the soil at this Graham County location. Under traditional Arizona soil test extraction calibration interpretation, this amount of P in the soil wouldn't necessarily warrant a phosphorus application. The Layton P experiment in Graham County showed no response to applied P when the soil test extraction level was also between 5 ppm and 10 ppm. No significant yield was found at a P soil test level of 6.8 ppm for the Layton P study. The phosphorus study in Coolidge allowed us to study the effects of having a soil test level of extractable P and Zn below the critical level. No significant difference in lint yield was found with having a preseason soil test level of 3.5 ppm P. This illustrates a need for further study with respect to P soil test calibration for cotton in Arizona to better determine the possibility for a cotton crop response to P and or Zn fertilization.

The Bollset study confirmed that with soil test extractions for both Ca and Zn above their respective UA critical levels, sufficient levels of these nutrients were apparently available and able to meet cotton crop needs during high heat stress conditions. The Zn study conducted in Coolidge found preseason soil test levels of around 0.40 ppm Zn and no yield response was found.

The K study from 1997 had a soil test level of 680 ppm K, which is higher than the UA critical level of 150 ppm extractable K. No significant differences in lint yield between the treatment and the check were detected. The soil test levels of micronutrients for the study conducted in Coolidge were above the critical level for the Zn and Mn. While the soil test levels for B and Fe were below or right at the critical level. It is hard to ascertain what particular nutrient in these packages had positive or negative effects on yield. Further studies concerning micronutrients should be carried out with respect to the comparison of a single nutrient versus a check plot.

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Table 1. Agronomic information for Boll Set study, Buckeye, AZ, 1998**.**

Soil Type	**Antho sandy loam / Laveen sandy loam complex**
Variety	**Deltapine 33B**
Planting Date	**4 May 1998**
Harvest Date	**9 November 1998**

Treatment information for Boll Set* Study, Buckeye, AZ, 1998**.**

Treatment 1	**Check – No Application of Boll set**
Treatment 2	**1 Application of Boll set – 18 July**
Treatment 3	**2 Applications of Boll set – 18 July and 3 August**

***1 application of Boll set consists of the following: Foligro Maximize (2 qts./acre), Potassium nitrate (8.5 lbs./acre), Biolator (4 oz/acre), and Sylgard 309 (0.4 oz/acre).**

Table 2. Soil Test Results – Boll Set Study, Buckeye, AZ, 1998

pH	**8.5**	**Copper**	**0.68 ppm**
Calcium	**5600 ppm**	**Salinity**	**3.0 dS/ m**
Magnesium	**420 ppm**	**Nitrate-N**	**19.8 ppm**
Sodium	**450 ppm**	**Phosphorus**	**27.0 ppm**
Potash	**350 ppm**	**ESP**	**5.7**
Iron	**4.3 ppm**	**Sulfate-S**	**80 ppm**
Zinc	**1.6**	**Boron**	**1.4 ppm**
Manganese	**6.2**	**Free Lime**	**High**

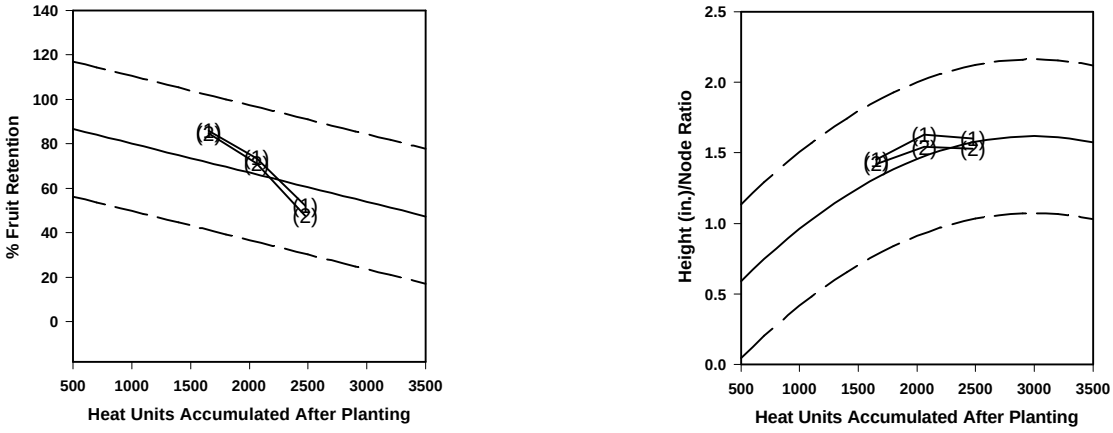
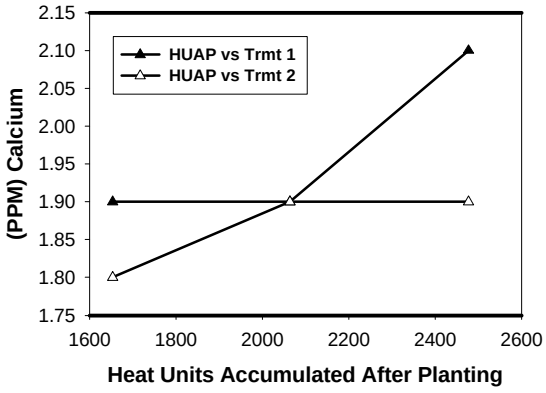


Figure 1. Fruit Retention Results and height to node ratio results, Bollset Study, Buckeye, AZ, 1998
Treatment numbers correspond to those found in Table 1.



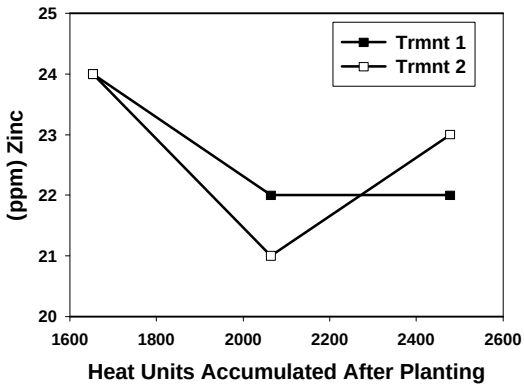


Figure 2. Plant tissue results for calcium and zinc, Bollset Study, Buckeye, AZ, 1998

Table 3. Yield Results for Bollset Study, Buckeye, AZ, 1998

Treatment	Lint Yield (lbs./acre)
2	1212 a*
1	1195 a
3	1151 a
LSD**	NS
OSL†	0.1090
C.V. (%)‡	1.299

***Means followed by the same letter are not significantly different according to a Fisher's mean separation test.**
**** Least Significant Difference**
† Observed Significance Level
‡Coefficient of Variation

Table 4. Agronomic information for Micronutrient study, Skousen, Coolidge, AZ, 1998.

Soil Type	**Laveen Loam**
Variety	**Deltapine 33B**
Planting Date	**4 May 1998**
Harvest Date	**27 October 1998**

Treatment information for Micronutrient* study, Skousen, Coolidge, AZ, 1998.

Treatment 1	**80 lbs N/acre (Urea) pre-plant**
Treatment 2	**Meister + 1 qt HM9424 at planting**
Treatment 3	**Same as 2 + 1 qt HM9014 + 1 qt HM9664 At PHS and at PHS + 2 weeks + 4 qt HM9716 at peak bloom**
Treatment 4	**Meister (95 lbs N/acre) pre-plant**
Treatment 5	**80 lbs N/acre (Urea) + 1 qt HM9424 at planting**
Treatment 6	**Same as 5 + 1 qt HM9014 At PHS and at PHS + 2 weeks**
Treatment 7	**Same as 6 + 4 qt HM9716 at peak bloom**

***Products have the following analysis:**
Meister: slow release nitrogen (poly-coated) 40-0-0
HM9716: (Coron) slow release liquid nitrogen 28-0-0
HM9424: (Asset) soil applied 6-20-5 + 0.02% B, 0.05% Cu, 0.1% Fe, 0.05% Mn, 0.05% Zn, 0.0005% Mo
HM9014: (Bayfolan) foliar applied 11-8-5 + 0.02% B, 0.0005% Co, 0.05% Cu, 0.1% Fe, 0.05% Mn, 0.05% Zn, 00005% Mo
HM9664: (Empower) foliar applied 5-0-0 + cytokinins, trace amounts of B and Mo

Table 5. Soil Test Results – Micronutrient Study, Skousen, Coolidge, AZ, 1998

pH	**8.5**	**Copper**	**7.1 ppm**
Calcium	**6200 ppm**	**Salinity**	**1.4 dS/m**
Magnesium	**340 ppm**	**Nitrate-N**	**22..2 ppm**
Sodium	**230 ppm**	**Phosphorus**	**42 ppm**
Potash	**360 ppm**	**ESP**	**2.8**
Iron	**4.4 ppm**	**Sulfate-S**	**27 ppm**
Zinc	**1.3 ppm**	**Boron**	**0.50 ppm**
Manganese	**9.2 ppm**	**Free Lime**	**High**

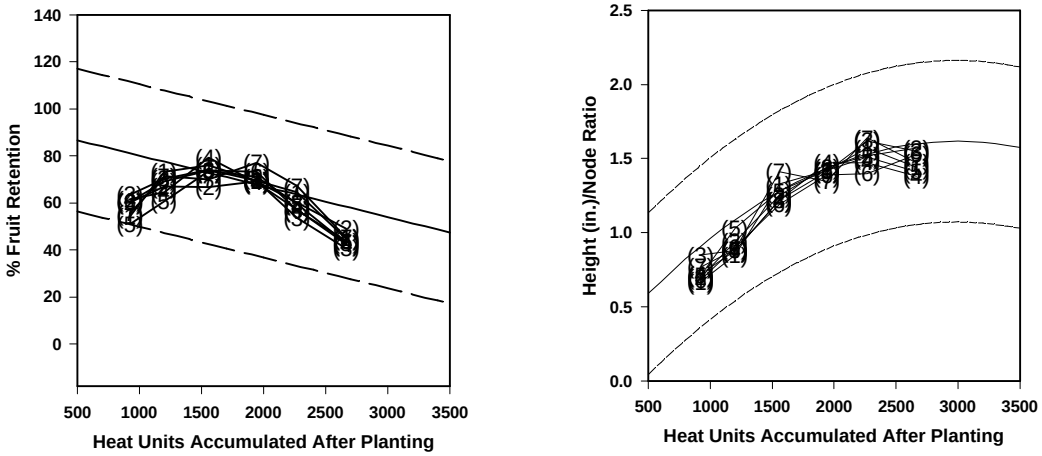


Figure 3. Fruit retention and height to node ratio results, Micronutrient Study, Coolidge, AZ, 1998

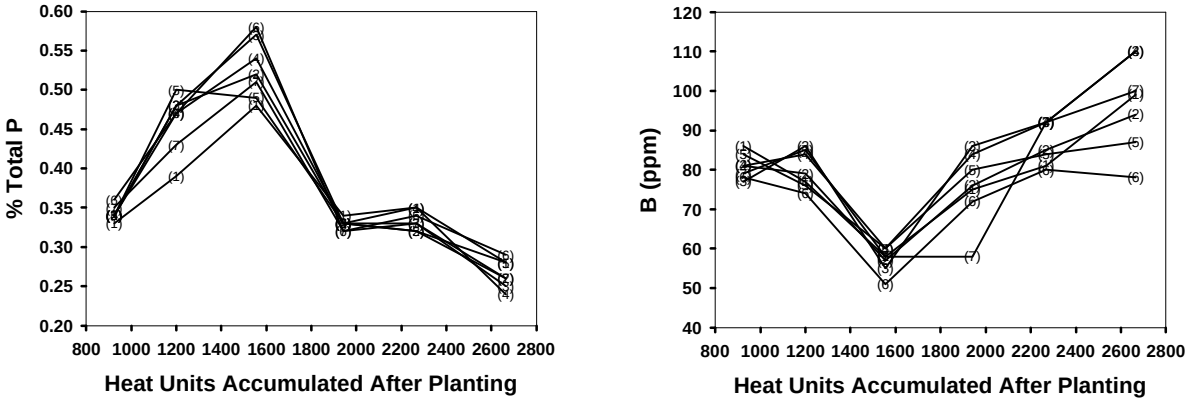


Figure 4. Plant tissue analysis results for phosphorus and boron, micronutrient study, Coolidge, 1998

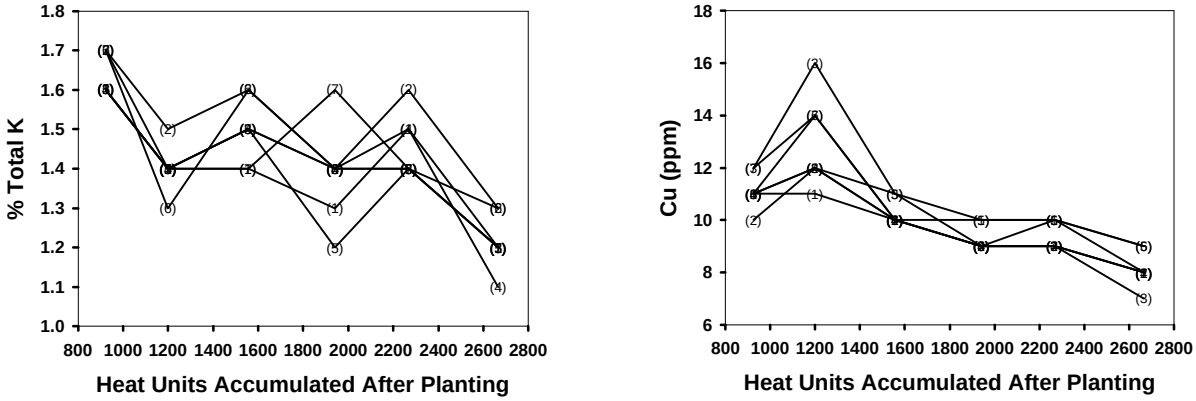


Figure 5. Plant tissue analysis results for potassium and copper, micronutrient study, Coolidge, AZ, 1998

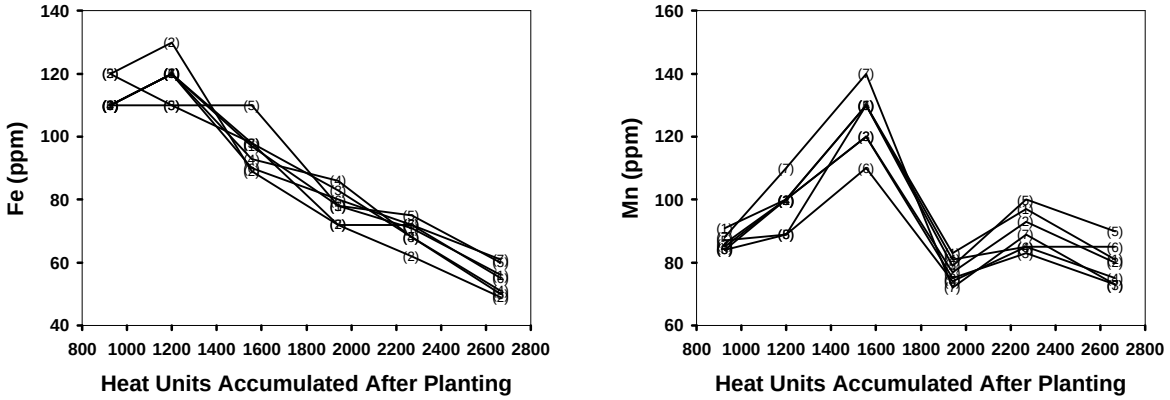


Figure 6. Plant tissue analysis results for iron and manganese, micronutrient study, Coolidge, AZ, 1998

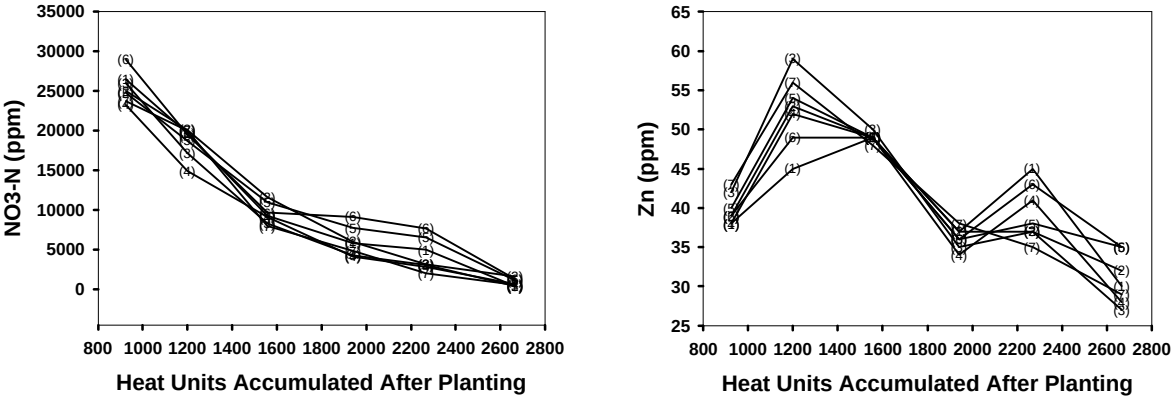


Figure 7. Plant tissue analysis results for nitrate nitrogen and zinc, micronutrient study, Coolidge, AZ, 98

Table 6. Yield results , micronutrient study, Coolidge, AZ, 1998

Treatment	Lint Yield (lbs./acre)
5	**1748 a***
1	**1617 ab**
3	**1583 ab**
2	**1518 ab**
7	**1518 ab**
4	**1441 b**
6	**1391 b**
Critical Range	**177**
OSL	**0.0110**
C.V. (%)	**7.73**

***Means followed by the same letter are not significantly different according to a Fisher's mean separation test.**
**** Least Significant Difference**
† Observed Significance Level
‡Coefficient of Variation

Table 7. Agronomic information for Layton phosphorus study, Graham County, AZ, 1998.

Soil Type	**Grabe clay loam / Anthony sandy loam complex**
Variety	**Pima HTO**
Planting Date	**21 April 1998**
Harvest Date	**23 October 1998**

Treatment information for Layton phosphorus study, Graham County, AZ, 1998.

Treatment 1	**Check – No Application of P**
Treatment 2	**Application of 11-52-0 (114 lbs P_2O_5 /acre) Pre-plant**

Table 8. Soil test results for phosphorus study, Layton, Graham County, AZ, 1998

pH	**7.9**	**Copper**	**9.5 ppm**
Calcium	**7200 ppm**	**Salinity**	**6.8 dS/ m**
Magnesium	**580 ppm**	**Nitrate-N**	**212 ppm**
Sodium	**720 ppm**	**Phosphorus**	**6.8 ppm**
Potash	**530 ppm**	**ESP**	**6.9**
Iron	**6.5 ppm**	**Sulfate-S**	**92 ppm**
Zinc	**0.66 ppm**	**Boron**	**0.72 ppm**
Manganese	**11.0 ppm**	**Free Lime**	**High**

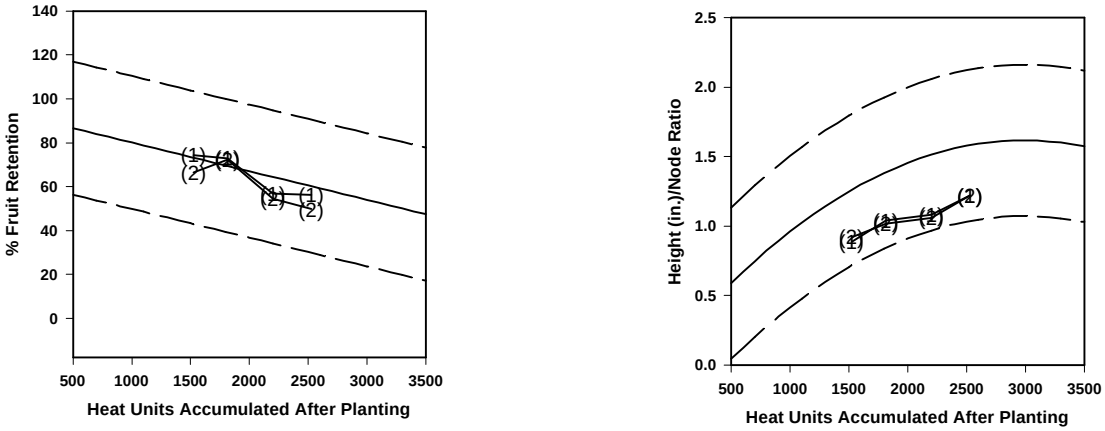


Figure 8. Fruit retention and height to node ratio results for phosphorus study, Layton, Graham County AZ, 1998

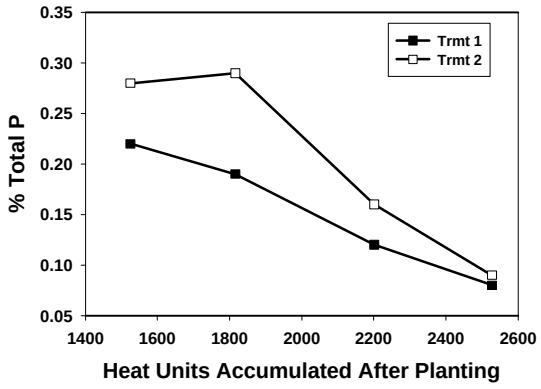


Figure 9. Plant tissue analysis results for phosphorus study, Layton, Graham County, AZ, 1998

Table 9. Yield results for phosphorus study, Layton, Graham County, AZ, 1998

Treatment	Lint Yield (lbs./acre)
1	812 a*
2	868 a
LSD**	NS
OSL†	0.3713
C.V. (%)‡	10.32

*Means followed by the same letter are not significantly different according to a Fisher's mean separation test.
** Least Significant Difference
† Observed Significance Level
‡Coefficient of Variation

Table 10. Agronomic information for potassium study, Cockrill, Coolidge, AZ, 1997.

Soil Type	Toltec fine sandy loam
Variety	Deltapine 33B
Planting Date	23 April 1997
Harvest Date	30 October 1997

Treatment information for potassium study, Cockrill, Coolidge, AZ, 1997.

Treatment 1	Check – No Application of K
Treatment 2	100 lbs/acre K-Mag (preplant – broadcast)

K-Mag = (0-0-22S – 11Mg)

Table 11. Soil test results for potassium study, Coolidge, AZ, 1997

pH	8.3	Copper	
Calcium		Salinity	2.0 dS/m
Magnesium		Nitrate-N	17 ppm
Sodium		Phosphorus	10 ppm
Potash	490 ppm	ESP	
Iron	6.2 ppm	Sulfate-S	
Zinc	0.6 ppm	Boron	
Manganese		Free Lime	

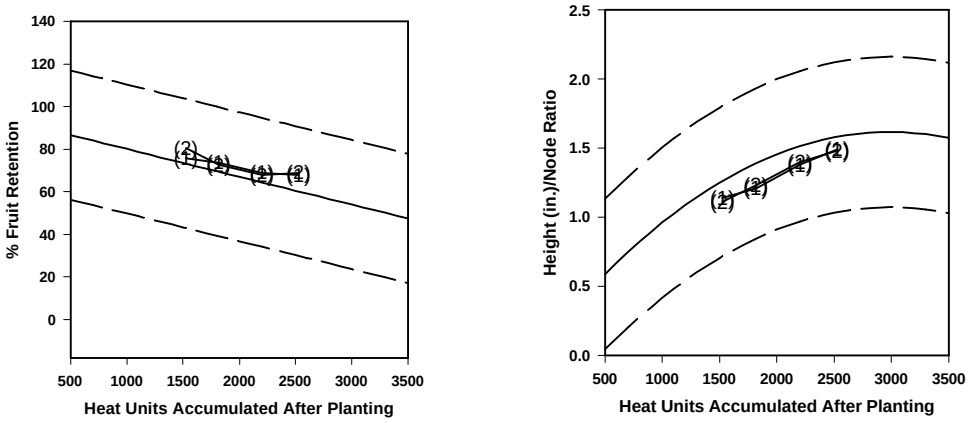


Figure 10. Fruit retention and height to node ratio results, potassium study, Coolidge, AZ, 1997

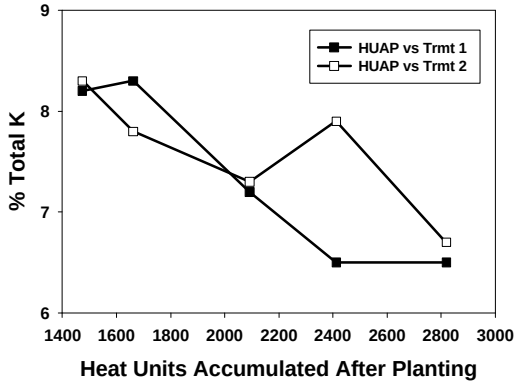


Figure 11. Plant tissue analysis results for potassium, potassium study, Coolidge, AZ, 1997

Table 12. Yield results for potassium study, Coolidge, AZ, 1998

Treatment	Lint Yield (lbs./acre)
1	1431 a*
2	1381 a
LSD**	NS
OSL†	0.7346
C.V. (%)‡	13.31

***Means followed by the same letter are not significantly different according to a Fisher's mean separation test.**
**** Least Significant Difference**
† Observed Significance Level
‡Coefficient of Variation

Table 13. Agronomic information for Claridge phosphorus study, Graham County, AZ, 1998.

Soil Type	**Grabe clay loam**
Variety	**Pima HTO**
Planting Date	**20 April 1998**
Harvest Date	**10 November 1998**

Treatment information for Claridge phosphorus study, Graham County, AZ, 1998.

Treatment 1	**Check – No Application of P**
Treatment 2	**10 gal/acre (9-26-0: 30 lbs/ P_2O_5) pre-plant**
Treatment 3	**10 gal/acre (9-26-0: 30 lbs/ P_2O_5) pre-plant + 12 gal/acre UAN32 (42.5 lbs N)**
Treatment 4	**10 gal/acre (9-26-0: 30 lbs/ P_2O_5) pre-plant + 25 gal/acre UAN32 (88.5 lbs N)**

Table 14. Soil test results for phosphorus study, Claridge, Graham County, AZ, 1998

pH	**8.2**	**Copper**	**19 ppm**
Calcium	**6700 ppm**	**Salinity**	**1.2 dS/ m**
Magnesium	**770 ppm**	**Nitrate-N**	**17 ppm**
Sodium	**440 ppm**	**Phosphorus**	**7.6 ppm**
Potash	**680 ppm**	**ESP**	**4.4**
Iron	**10 ppm**	**Sulfate-S**	**14 ppm**
Zinc	**1.3 ppm**	**Boron**	**0.52 ppm**
Manganese	**9.7 ppm**	**Free Lime**	**Medium**

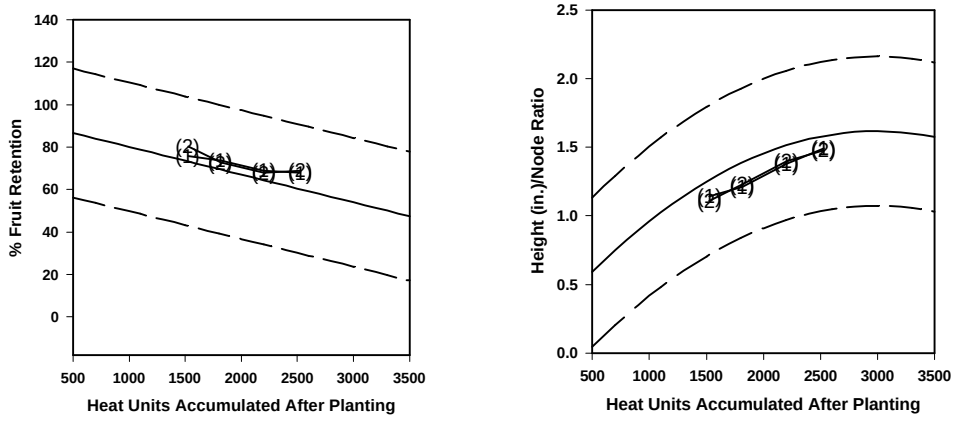


Figure 12. Fruit retention and height to node ratio results, phosphorus study, Claridge, Graham County, 1998

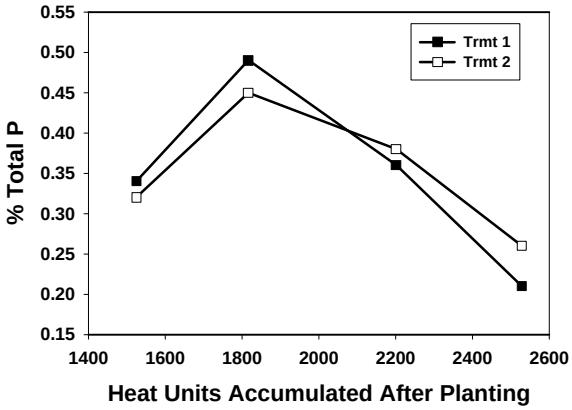


Figure 13. Plant tissue analysis results for phosphorus, phosphorus study, Claridge, Graham County, AZ, 1998

Table 15. Yield results for phosphorus study, Claridge, Graham County, AZ, 1998

Treatment	Lint Yield (lbs./acre)
1	1103 b*
2	1198 a
3	1192 a
4	1202 a
LSD**	59.901
OSL†	0.0126
C.V. (%)‡	3.189815

***Means followed by the same letter are not significantly different according to a Fisher's mean separation test.**
**** Least Significant Difference**
† Observed Significance Level
‡Coefficient of Variation

Table 16. Agronomic information for phosphorus study, Ollerton, Coolidge, AZ, 1998.

Soil Type	**LaPalma sandy loam**
Variety	**Deltapine 9834BRR**
Planting Date	**12 May 1998**
Harvest Date	**17 November 1998**

Treatment information for phosphorus study, Ollerton, Coolidge, AZ, 1998.

Treatment 1	**Check – No Application of P**
Treatment 2	**20 gal/acre (10-34-0)**

Table 17. Soil test results, phosphorus study, Coolidge, AZ, 1998

pH	**8.5**	**Copper**	**.44 ppm**
Calcium	**6000 ppm**	**Salinity**	**.7 dS/m**
Magnesium	**330 ppm**	**Nitrate-N**	**6.0 ppm**
Sodium	**140 ppm**	**Phosphorus**	**3.5 ppm**
Potash	**320 ppm**	**ESP**	**1.8**
Iron	**1.7 ppm**	**Sulfate-S**	**5.3 ppm**
Zinc	**.27 ppm**	**Boron**	**.23 ppm**
Manganese	**4.4 ppm**	**Free Lime**	**High**

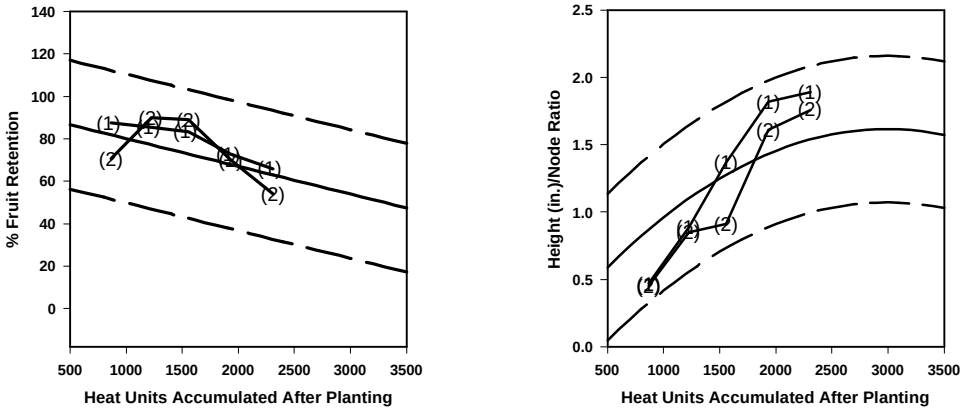


Figure 14. Fruit retention and height to node ratio results, phosphorus study, Coolidge, AZ, 1998.

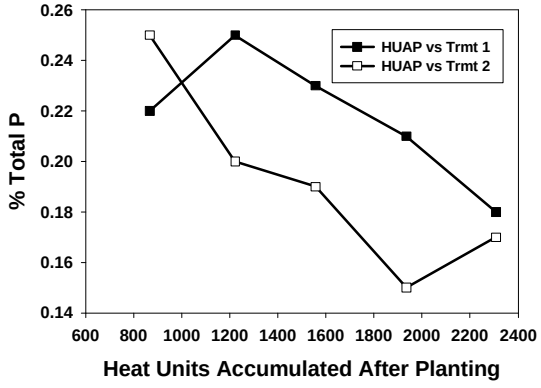


Figure 15. Plant tissue analysis results for phosphorus, phosphorus study, Coolidge, AZ, 1998.

Table 18. Yield results for phosphorus study, Coolidge, AZ, 1998

Treatment	Lint Yield (lbs./acre)
1	1026 a*
2	950 a
LSD**	NS
OSL†	0.2986
C.V. (%)‡	8.73

***Means followed by the same letter are not significantly different according to a Fisher's mean separation test.**
**** Least Significant Difference**
† Observed Significance Level
‡Coefficient of Variation

Table. 19 Agronomic information for zinc study, Ollerton, Coolidge, AZ, 1998.

Soil Type	**LaPalma sandy loam**
Variety	**Deltapine 90**
Planting Date	**30 April 1998**
Harvest Date	**15 November 1998**

Treatment information for zinc study, Ollerton, Coolidge, AZ, 1998.

Treatment 1	**Check – No Application of Zn**
Treatment 2	**10 gal/acre (UN32) + 50 lbs/acre Nulex Zn 10lbs Zn/acre**

Zn = Nulex Zn (16-0-0, 20 Zn)

Table 20. Soil test results for zinc study, Coolidge, AZ, 1998

pH	**8.7**	**Copper**	**.67 ppm**
Calcium	**5900 ppm**	**Salinity**	**1.1 dS/m**
Magnesium	**420 ppm**	**Nitrate-N**	**2.8 ppm**
Sodium	**160 ppm**	**Phosphorus**	**5.7 ppm**
Potash	**600 ppm**	**ESP**	**2.0**
Iron	**1.8 ppm**	**Sulfate-S**	**20 ppm**
Zinc	**.40 ppm**	**Boron**	**.37 ppm**
Manganese	**5.5 ppm**	**Free Lime**	**High**

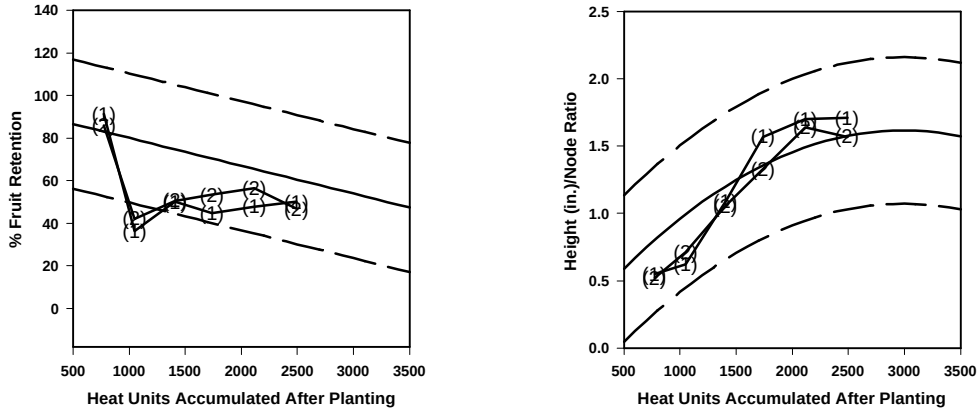


Figure 16. Fruit retention and height to node ratio results, zinc study, Coolidge, AZ, 1998.

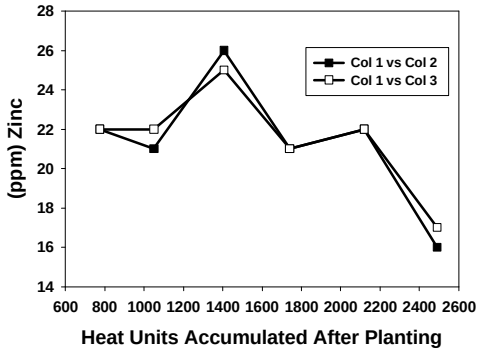


Figure 17. Plant tissue analysis results, zinc study, Coolidge, AZ, 1998

Table 21. Yield results for zinc study, Coolidge, AZ, 1998

Treatment	Lint Yield (lbs./acre)
1	536 a*
2	555 a
LSD**	NS
OSL†	0.837
C.V. (%)‡	21.53

***Means followed by the same letter are not significantly different according to a Fisher's mean separation test.**
**** Least Significant Difference**
† Observed Significance Level
‡Coefficient of Variation