A Look At Placing P and K At Multiple Depths

Data indicate 2x2 placement increased early growth in cotton.

Dr. William Hunter Frame and Austin Brown

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***Summary:** At the TAREC location, the 2x2 band of phosphorus (P) and potassium (K) increased early-season plant height compared to standard nutrient management systems. Unfertilized control had the highest P concentrations in cotton petioles throughout the bloom period. The high petiole P concentration may be related to nitrogen (N) deficiency and if this proves to be true then N status will have to be evaluated before making in-season management decisions based on petiole P concentrations. When comparing the 2x2 band and deep placement across multiple application rates, the 2x2 band produced 144 lbs. of lint/acre more than the deep placement of P and K. The 2x2 band containing NPK Sulfur(S) significantly increased early-season vigor of cotton and increased lint yield over the deep placement strategy alone.*

This study was conducted during the 2013 growing season to evaluate the placement and application rate of P and K in upland cotton production systems. The trial was implemented at two locations, one at the Tidewater Agricultural Research and Extension Center in Suffolk, VA (TAREC) and the other at the North Carolina department of Agriculture's Peanut Belt Research Station in Lewiston, NC.

Objectives

Objectives of this study were to:

- Determine the impact on early-season development of upland cotton (Gossypium hirsutum) through first square, nutrient status during the first nine weeks of bloom, and lint yield and quality of placing a fluid P and K fertilizer at multiple depths below the seed during strip-till cultivation
- Evaluate selected combinations of P and K placed at multiple depths in the strip-till process in combination with 2x2 banding of P and K solutions at planting on crop establishment, growth through first square, nutrient status during the first nine weeks of bloom, and lint yield and quality.

Site characteristics

Soil type at the TAREC location was an Eunola loamy sand (fine-loamy, siliceous, semi-active, thermic Aquic Hapludults). The soil type at Lewiston was a Rains sandy loam (fine-loamy, siliceous, semi-active, thermic Typic Paleaquults).

Soil samples were taken from both locations to a total depth of 12 inches (30cm) and split into depths of 0-3, 3-6, 6-9, and 9-12 inches.

Soil test. The Mehlich I soil test levels for each location can be found in Table 1.

Fertilizer rates. The base (100%) preplant P and K rates were 40 lbs P2O5/acre and 40 lbs K_2O/acre and based on Mehlich I soil test levels. All other agronomic practices were conducted according to Virginia extension recommendations.

Experimental Design

The study was conducted using four-row plots measuring 12 feet wide by 40 feet long at two locations. Each treatment was replicated four times in a randomized complete block design. The cotton variety grown was Phytogen 499 WRF, a mid-maturing variety with a high yield potential. Thirteen treatments evaluated placement of P and K fluid fertilizers (Table 2). Treatment 1 was an unfertilized P and K control. However, at TAREC, unfertilized plots did not receive N or S, while the unfertilized check at Lewiston received 80 lbs. N per acre in a sidedress application.

Two agronomic control treatments were implemented to simulate the current nutrient management systems in Virginia:

- All of the required P and K was broadcast prior to planting
- 100 lbs of ammonium polyphosphate solution (10-34-0) per acre was applied in a 2 x 2 band at planting with the K broadcast prior to planting (Table 2).

Treatments 4 through 9 evaluated the response to P and K fluid fertilizer applied in a 2 x 2 band at planting and deep placement during strip-tillage at 50, 100, and 150 percent of the recommended rate based on soil tests.

Table 1: Mehlich I extractable phosphorus and potassium at 0-3, 3-6, 6-9, 9-12 inch depths at TAREC and Lewiston

Depth inches	TAREC		Lewiston	
	P	K	P	K
	ppm			
0-3	49 (H+)¶	99 (H-)	30 (H)	126 (H)
3-6	31 (H)	86 (M+)	18 (H-)	59 (M)
6-9	20 (H-)	73 (M)	13 (M)	37 (L+)
6-12	19 (H-)	68 (M)	7 (M-)	33 (L+)

¶ Indicates the soil test level based on Virginia's soil test calibration

Table 2. Treatment List for 2013 Locations

Trt	Placement	Description
1	Unfertilized Control	No P or K Fertilization
2	Broadcast Agronomic Control	P + K Broadcast – Soil test recommendation‡
3	Starter Agronomic Control	100 lbs /acre† of 10-34-0 in 2X2 band + Remaining P+K broadcast
4	2X2 Band	50%P + 50%K¶
5	2X2 Band	100%P + 100%K
6	2X2 Band	150%P + 150%K
7	Deep Placement	50%P + 50%K
8	Deep Placement	100%P + 100%K
9	Deep Placement	150%P + 150%K

† 100 lbs/acre of 10-34-0 is the recommended rate for cotton placed in a 2X2 band at planting in by North Carolina State University Cooperative Extension.
‡ Recommended nutrient application rates applied based on Mehlich 1 extractable phosphorus and potassium and Virginia Cooperative Extension Recommendations
¶ Percentages represent the proportion of recommended nutrient application rates applied based on Mehlich 1 extractable phosphorus and potassium and Virginia Cooperative Extension Recommendations.

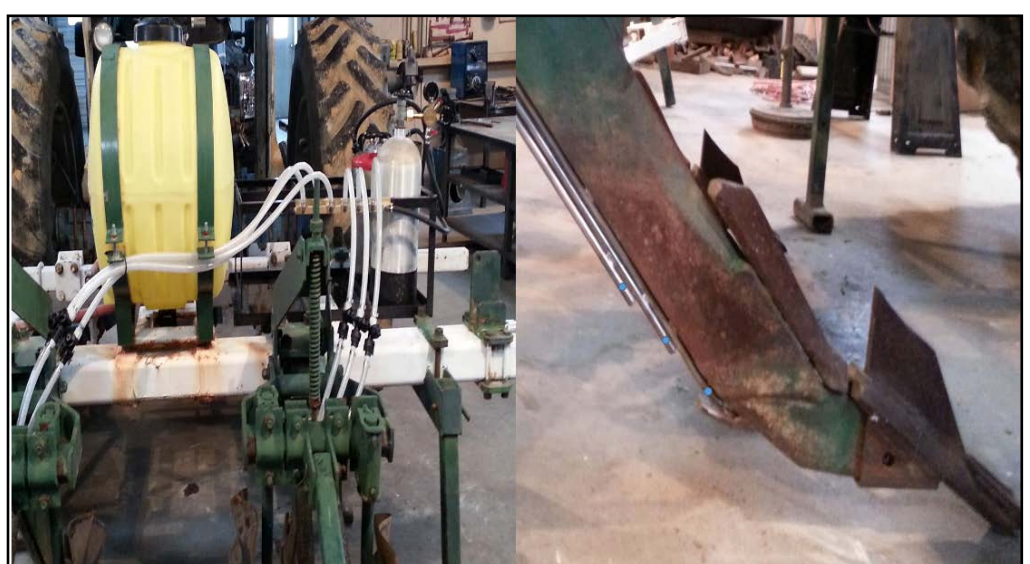

Figure 1: *Picture of the strip-tillage fertilizer systems and shank to place fluid phosphorus and potassium fertilizers at 6, 9, and 12 inches below the soil surface during strip tillage.*

Treatment application

Deep placement treatments were applied with a two strip-tillage implement three days prior to planting at TAREC and 14 days prior to planting at Lewiston. Fertilizer placement with strip-tillage was accomplished with an apparatus depicted in Figure 1. To dispense fluid fertilizer at 6, 9, and 12 inches below the soil surface, holes drilled 90o to the direction of travel allowed the fluid fertilizer to exit each down-spout and maximize contact with the soil at the targeted depths. The 2 x 2 banded fertilizer was applied at planting, using a double disk opener mounted on the toolbar of a two-row Monosem planter. The application rate for the fluid P and K sources was controlled by a carbon dioxide pressurized system and the application rates were controlled using inline orifices (Figure 1).

The broadcast P and K were applied on the same day as the strip tillage cultivation and deep placement of P and K for both locations. Diammonium phosphate (DAP, 18-46-0) and muriate of potash (0-0-60) were used as the P and K sources for the broadcast agronomic control treatment. The liquid phosphate source applied was ammonium polyphosphate (10-34-0) (APP) and the fluid potassium source was potassium thiosulfate (0-0-25-17S).

The potassium thiosulfate supplied 40.8 lbs. S/acre when applied at the 150 percent rate, which is greater than the recommended agronomic S rates in cotton. Ammonium thiosulphate (12-0-026S) (ATS) was used to balance the S rate among treatments. In the treatments where a combination of placement techniques was implemented, the added S was applied using deep placement to prevent any potential injury to cotton seedlings. Preplant N was balanced at the same level as the broadcast agronomic control, plus additional N from ATS. The preplant N rate for the P and K fertilized treatments was 35 pounds N per acre. The N was balanced using the fluid urea-ammonium nitrate (UAN 30-0-0). The total N application rate was set at 115 lbs N/acre, with the remaining 80 lbs N being applied in a sidedress application using a 24-0-03S at TAREC and UAN30 at Lewiston, applied at match-head square. At TAREC, the unfertilized control treatment received no sidedress N or S, while at Lewiston the unfertilized plots received the full 80 lbs of N/acre sidedress application rate. Other nutrients were applied based on the soil test recommendations.

In-season development

Plant population was measured by counting the number of emerged seedlings in two ten-foot sections of row. Plant population counts were taken at 7, 10, 14, and 21 days after planting. Plant heights were measured weekly beginning with the appearance of the second true leaf and measured from the ground to the apical meristem on five randomly selected cotton plants per plot. At the appearance of the first square, the total number of nodes were counted weekly on five randomly selected plants per plot. Plant height and total node measurements ceased with the appearance of the first white flower at each location.

Tissue sampling

Beginning the first week of bloom, twenty-four cotton petioles were sampled from the first and fourth rows of each plot. The fourth leaf and petiole down the main stem of the cotton plant were sampled and separated immediately. Petioles were sampled weekly for the first nine weeks of bloom. Petioles sampled during the seventh through ninth weeks of bloom were taken from the third leaf down the main stem as there were not enough leaves in the fourth position for a complete sample. The maturity level of the leaves was thought to be similar as vegetative growth had ceased prior to this stage of development. The plant tissue samples were sent to Water's Agricultural Laboratories (Camilla, GA) for analysis. The petioles were analyzed for nitrate-N, P, and S. Nutrient concentrations in petioles were plotted against time. Leaf samples were collected during the first and fifth weeks of bloom only, and a complete nutrient analysis was conducted on the leaf tissue.

Defoliation

Defoliation timing of cotton varies, depending on the growing season and development of the crop. The trial was defoliated when 50 to 60 percent of the bolls were opened.

Harvesting

Seed cotton was harvested using two-row commercial cotton pickers modified for small plot harvesting. The center two rows of each plot were harvested and plot weights recorded.

Cotton lint

A one pound subsample of seed cotton was ginned on a 10-saw micro-gin to determine lint percentage. Seed cotton weights were multiplied by the lint percentage to calculate lint yields. Cotton lint was sent to the USDA cotton quality lab in Florence, SC for lint quality analysis. The lint was analyzed using a High Volume Instrument (HVI) to determine fiber length (staple), strength, micronaire, color, and leaf (trash) grade.

Statistical analysis

The data set separated into two separate data sets and analysis of variance (ANOVA), using PROC MIXED in SAS 9.3, was used to determine differences among treatments. The first data set consisted of the different nutrient management systems tested at the 100 percent P and K rate based on soil test recommendations. The nutrient management systems were analyzed as single treatment factors in a randomized complete block design. The second data set was used to determine the effect of P and K rate and placement on each of the measured dependent variables. The data set was analyzed as a 3 x 2 factorial treatment design in a randomized complete block design, using ANOVA. Differences among treatments in each analysis were determined using the Tukey-Kramer HSD at $\alpha = 0.1$ level of significance.

Results

General comments. The 2013 growing season was very unique in the upper Southeast coastal plain of the United States. A cool wet May delayed cotton planting for up to two weeks and cooler than normal temperatures prevailed for much of the growing season. The shortened cotton season seemed to have little impact on yield in Virginia as the two study locations produced exceptional yields. The Lewiston location was planted later than was expected and suffered sand burn damage very early in the growing season (Figure 2). The decision was made not to abandon the location since treatments had been applied. Luckily, the first sampling for plant population had been conducted before the damage and another plant population count was conducted after the damage. With the two plant population sampling intervals it was found that, on average, the injury reduced plant populations by two plants per ten feet of row. This is not an insignificant loss of stand and represents a decrease in the plant population of 2,904 plants per acre. The cotton was slow to recover from the damage and in-season plant measurements were affected by the variation introduced by the sand burn damage at Lewiston.

The delay in development of the cotton at Lewiston allowed the first initial petiole results to come in for TAREC. The petiole results indicate elevated P concentration in petiole for the unfertilized checks, as well as N deficiency. The decision was made to apply sidedress N at Lewiston and test the hypothesis that N deficiency produces elevated P concentration in cotton petioles. If this hypothesis is proven to be true, then decisions about P management in cotton cannot be made off petiole concentrations if there is a known N deficiency. For growers looking to improve nutrient use efficiencies with petiole testing, this knowledge will increase the efficacy of their in-season nutrient management decisions.

Nutrient management

Plant growth. In-season plant growth measurements were initiated seven days after planting with plant population counts. Among the nutrient management systems there were no differences in plant population at any sampling intervals (data not shown). Emergence

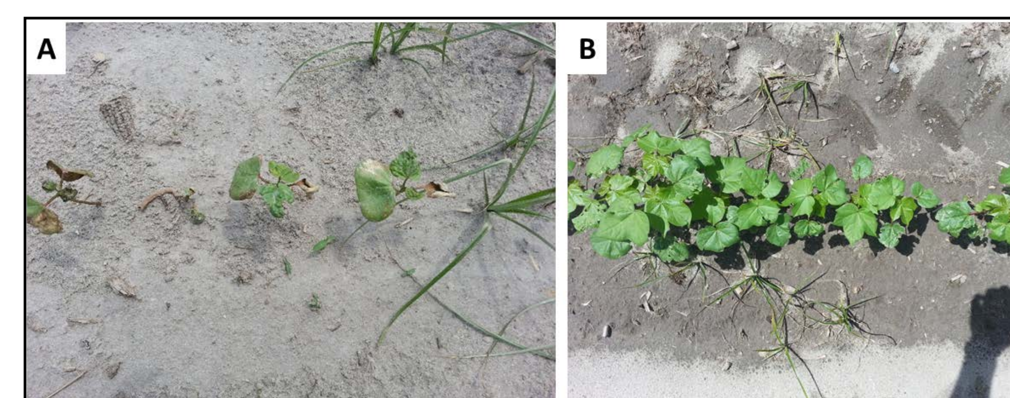

Figure 2: *Sand-burn injury 6/17 (A) and 7/2 (B)*

Table 3: Early season plant height of cotton grown under different nutrient management systems at TAREC						
Treatment	**Plant Height (in.)**					
	4-Jun	13-Jun	20-Jun	26-Jun	3-Jul	10-Jul
Unfertilized Check	4.8	7.4 c¶	9.4 c	13.2 d	18.0 c	22.0 b
Broadcast Control	4.8	8.5 ab	10.5 bc	15.4 c	22.4 b	29.6 a
Starter Control	5.0	9.6 a	11.1 ab	17.8 ab	24.1 ab	31.4 a
2 x 2 Band (100%)	5.2	9.4 ab	12.1 a	18.6 a	25.9 a	32.0 a
Deep Placement (100%)	4.9	8.7 ab	11.3 ab	16.9 bc	23.9 b	30.9 a
ANOVA (Pr > F)	NS*	0.0033	0.011	< 0.0001	< 0.0001	< 0.0001

* The overall ANOVA was not significant at α=0.1
¶ Values with the same letter are not significantly different at α=0.1

was 50 to 60 percent of the final plant population seven days after planting at TAREC and was nearly 100 percent of the final plant population ten days after planting at TAREC (data not shown). Emergence was similar at Lewiston up to the sand-burn injury, which reduced plant populations by two plants per ten row feet (data not shown).

Plant heights were very responsive to nutrient management systems at every sampling interval, except one (Table 3). The plant heights in TAREC were not significantly different on the first sampling interval, however by the second sampling interval all fertilizer treatments produced taller plants than the unfertilized check (Table 3). Plant heights were significantly taller using the 2 x 2 band (100%) program (12.1 in.) than the unfertilized check (9.4 in.) and broadcast program (10.5 in.) on June 20 (Table 3). Plant heights were significantly taller using the broadcast program than the unfertilized control on June 20. The 2 x 2 band (100%) program produced the tallest plants in each of the remaining sampling intervals.

The 2 x 2 band (100%) program produced significantly taller plants than deep placement (100%), broadcast control, and unfertilized check on the June 26 and July 3 sampling intervals (Table 3). Both the deep placement (100%) and broadcast control resulted in taller plants than the unfertilized control on June 26 and July 3.

The data indicate that the 2 x 2 placement of nutrients promotes early-season growth compared to the other placement strategies at the TAREC location. Sidedress N was applied at TAREC on June 27 and plant growth regulators were applied to the rest on June 28 and helps explain why observed differences in plant heights at TAREC on fertilized plots were reduced after the June 26 sampling date. No plant height differences were observed among nutrient management systems at the Lewiston location and were most likely due to the early sand-burn injury (data not shown).

Petiole/tissue analysis. Petiole and tissue testing allow producers and consultants to gain insight into the nutrient status of cotton during the growing season. The bloom period is when cotton is actively fruiting and establishing bolls, which determines the amount of harvestable lint at season's end. Petiole and leaf tissue were monitored during the bloom period with petiole tested weekly for the first nine weeks of bloom and leaf tissue sampled during the first and fifth weeks of bloom. At TAREC, all nutrients monitored in cotton petioles decreased throughout the bloom period (Figure 3). The overall ANOVA p-value was significant for petiole P among nutrient management systems during every week except the second week of bloom at TAREC (Figure 3B). The unfertilized check had the highest petiole P concentrations of the nutrient management systems, which was surprising as no P was applied. Nitrate –N concentrations in cotton petioles differed in four out of the first five weeks of bloom, the unfertilized control had the lowest nitrate-N values during this time period (Figure 3C). Sulfur concentrations in cotton petioles increased from the first to the second week of bloom and then decreased for the remaining bloom period sampling intervals (Figure 3D). Sulfur petiole concentrations were lowest in the unfertilized control to begin the bloom period, however late in the bloom period the unfertilized control had the highest S concentrations (Figure 3D).

At the Lewiston location, the unfertilized control received an N application at sidedress, whereas the unfertilized control at TAREC received no in-season N application. Petiole nutrient concentrations at Lewiston were affected by the early-season sand-burn damage. However, certain trends are apparent in the data. At Lewiston, the unfertilized control had lower numerical K, P, and S concentrations in cotton petioles than the fertilized treatments (Figure 4A-D). The variability introduced from the early-season injury most likely masked any effect of nutrient management on petiole K, P, and S. Fertilizing with N at Lewiston lowered the K, P, and S concentrations compared to the fertilized treatments. Also, the damage suffered early in the season seems to delay the peak nutrient content of N and K for a week and peak P levels were delayed 4 to 6 weeks (Figure 4A-C). Nitrate-N, among nutrient management systems, did not differ during any of the first nine weeks of bloom. The nitrate-N concentrations had less variability among nutrient management systems than the other petiole nutrients tested at Lewiston.

The petiole results from both locations during the 2013 growing season indicate that the N status of the cotton plant will influence petiole K, P, and S concentrations. If the hypothesis is true then in-season decisions based on petiole nutrient concentrations must start with the N status of the crop. If N is deficient, then accurate inferences about K, P, and S status for the cotton crop cannot be made due to elevated nutrient levels resulting from N deficiency. This seems to be especially true for petiole P concentrations. Also, the early season injury at Lewiston seemed to delay the time of peak nutrient concentrations, which is also helpful if using the strategy to manage in-season nutrient applications. If a producer knows the crop was severely stressed early, then testing petioles during the first week of bloom may produce a false negative nutrient concentration as the plant is still recovering physiologically from the injury. That producer may want to wait and test during the second and third week of bloom before making a management decision as the petiole nutrient concentration may increase.

Results from the leaf tissue analyses reinforced the petiole tissue sampling program. Nitrogen concentrations in leaf tissue were highest in the 2 x 2 band (100%) and significantly higher than the deep placement (100%) and unfertilized control (data not shown). The deep placement (100%) program did produce significantly higher leaf N than the unfertilized control (data not shown). Differences in leaf N between nutrient management systems during the first week of bloom indicate that deep placement of preplant N with strip-tillage significantly limits the availability of N up to the first week of bloom. Differences in leaf P were observed only during the fifth week of bloom at TAREC and reinforce the petiole results as the unfertilized control had significantly higher leaf P than the broadcast and starter agronomic control treatments (data not shown). The overall ANOVA was significant for leaf K at α= 0.1 level. However, the Tukey-Kramer HSD procedure did not separate the nutrient management systems as being significantly different (data not shown). Leaf S concentrations differed at TAREC during the first week of bloom with the unfertilized control having significantly lower S concentration than the fertilized

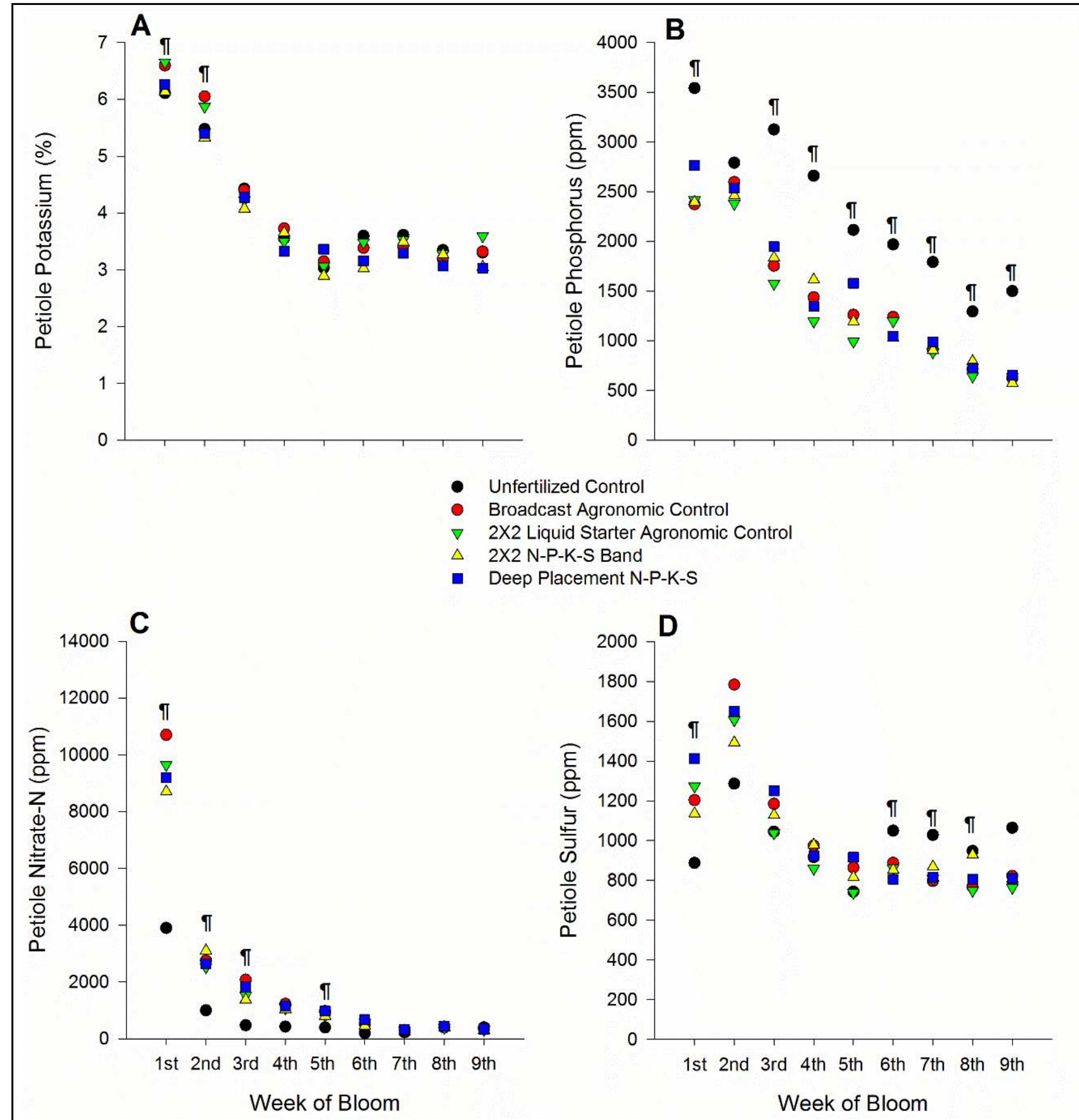

Figure 3: *Potassium (A), phosphorus (B), nitrate (C) and sulfur (D) concentrations at TAREC.*

treatments.

There were no leaf N or P differences between nutrient management systems at the Lewiston location (data not shown). The unfertilized control received 80 lbs. of N at sidedress to provide a location where N was not limiting. Leaf K levels at Lewiston differed during the first week of bloom. However, there was no clear trend in the differences. The unfertilized control did have the lowest leaf K levels (1.09%) and the 2 x 2 band (100%) (1.25%) produced the highest leaf K levels during the first week of bloom at Lewiston. The only other leaf tissue differences observed at Lewiston were for sulfur concentrations during the first and fifth weeks of bloom. The unfertilized control was significantly lower in leaf S concentration than the 2 x 2 band (100%) treatment during both sampling intervals.

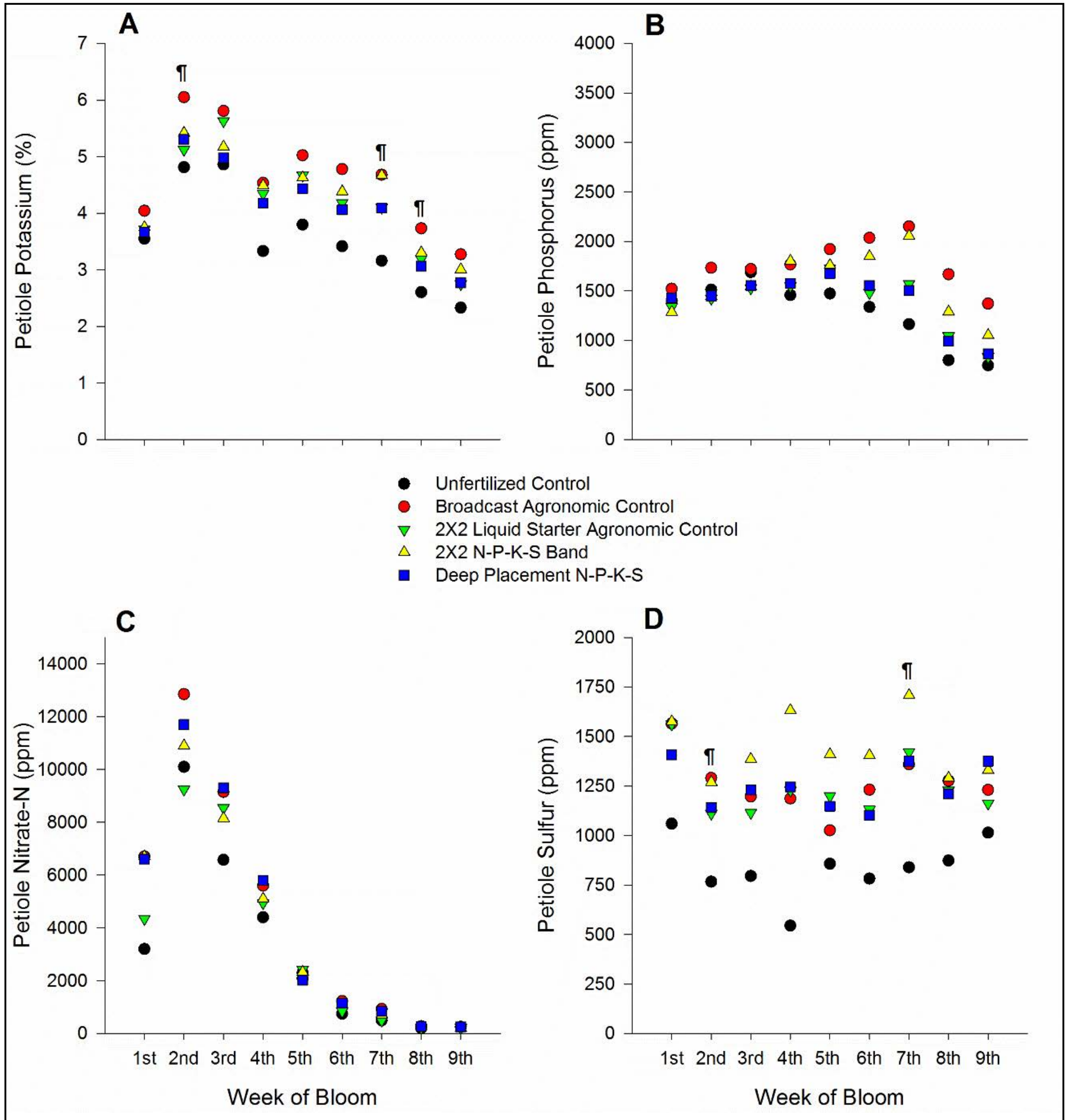

Figure 4: *Potassium (A), phosphorus (B), nitrate (C) and sulfur (D) concentrations at Lewiston.*

Table 4: Phosphorus (P) and potassium (K) application rate and placement on stand establishment and early season plant height at TAREC

Placement	P and K Rate†	Plant Population (plants / 10 ft row)				Plant Height (in.)					
	%	17-May	21-May	24-May	31-May	4-Jun	13-Jun	20-Jun	26-Jun	3-Jul	10-Jul
-	50	16.87	28.8 b¶	29.8	29.7	5.0	8.7	11.0	16.5 b	24.1	31.2
-	100	18.25	31.1 a	30.9	31.3	5.1	9.1	11.7	17.7 ab	24.9	31.5
-	150	17.43	29.6 ab	29.9	31.1	5.1	9.3	11.6	18.1 a	25.0	31.9
2X2 Band	-	18.5 a	30.3	30.8 a	31.3 a	5.1	9.2	11.5	17.9 a	25.5 a	32.0 a
Deep Placement	-	16.5 b	29.4	29.6 b	30.1 b	5.0	8.8	11.4	17.0 b	23.9 b	30.9 b
2X2 Band	50	18.0	29.3	31.1 ab	31.1	4.9	8.7	10.6	16.4	24.8	31.3
2X2 Band	100	20.0	31.4	30.4 ab	31.8	5.2	9.4	12.1	18.6	25.9	32.0
2X2 Band	150	17.5	30.3	30.8 ab	30.9	5.2	9.5	11.7	18.7	25.8	32.8
Deep Placement	50	15.8	28.3	28.4 b	28.3	5.1	8.7	11.3	16.7	23.5	31.0
Deep Placement	100	16.5	30.9	31.4 a	30.9	4.9	8.7	11.3	16.9	23.9	30.9
Deep Placement	150	17.4	29.0	29.1 ab	31.3	5.0	9.1	11.6	17.4	24.2	30.9
	ANOVA (Pr > F)										
P and K Rate		NS*	0.0303	NS	NS	NS	NS	NS	0.0591	NS	NS
Placement		0.0545	NS	0.0675	0.0942	NS	NS	NS	0.0919	0.0009	0.0214
Rate*Placement		NS	NS	0.0466	NS	NS	NS	NS	NS	NS	NS

¶ Values with the same letter are not significantly different at α=0.1
* The ANOVA for that fixed effect in the model was not significant at α=0.1
† 100% of the recommended rate is equal to 40 lbs P2O5 and 40 lbs K2O per acre

Lint yields at both locations were exceptional, considering the 2013 growing season and the planting date at Lewiston, NC, in conjunction with the early-season injury. Yields at TAREC ranged from 1,184 to 2,024 lbs. per acre and Lewiston yield ranged from 1,100 to 1,469 lbs. lint per acre. The only yield difference observed between nutrient management systems tested at the 100 percent P and K application rates occurred at TAREC (Figure 5). The unfertilized control produced significantly less lint per acres than the fertilized systems. There were no differences in fiber quality characteristics at either location during the 2013 growing season.

P and K Placement

Plant growth. In-season plant measurements were less responsive in preplant P and K application rates than placement during the study. Plant populations were affected by P and K rate at ten days after planting (May 21) at TAREC (Table 4). Plant population was significantly impacted by placement in three out of the four sampling intervals. The 2 x 2 band placement produced significantly higher plant populations 7, 14, and 21 days after planting (Table 4). On average, the 2 x 2 placement produced two more plants per row foot than deep placement. Faster emergence rates would be beneficial in Virginia cotton production as weather patterns in May can be highly variable. A key question is, if there is enough root growth present at time of emergence to take advantage of the 2 x 2 band placement, can this effect be replicated over multiple locations and years?

Plant height. No differences in plant heights were observed between P and K rates and placement methods until June 26 (Table 4). On June 26 plant heights for the 150 percent P and K rates were significantly higher than the 50 percent P and K rate at TAREC (Table 4). This was the only sampling interval where plant heights differed among P and K rates. The 2 x 2 band placement produced taller plants from June 26 through July 10 at PAREC (Table 4). Plants grown using the 2 x 2 band placement at TAREC consistently showed increased early-season vigor throughout the 2013 study.

Leaf tissue analysis was more sensitive to differences among placement and application rates of P and K at Lewiston than petiole nutrient concentrations (data not shown). Phosphorus concentrations in leaf tissue differed during the first week of bloom with the deep placement having higher P concentrations than the 2 x 2 band at Lewiston (data not shown). The difference in P concentration was not observed during the fifth week of bloom at Lewiston. Potassium concentration in cotton leaves differed among application rates and placement during the first and fifths weeks of bloom (data not shown). Lewiston had the lowest soil test levels of K out of the two locations and was why the location was more responsive to K rate than TAREC. Leaf K concentrations increased as application rate increased during both sampling intervals at Lewiston (data not shown). The 2 x 2 band also increased leaf K concentration during both sampling intervals (data not shown). These findings suggest that the leaf tissue analysis may be more sensitive to changes in plant K status than petiole testing. Also, K concentrations in the leaf tissue are more stable than petiole K concentrations throughout the bloom period in cotton. Leaf K concentrations may be more indicative of K status of cotton during the bloom period than petiole K.

Lint yield was not affected by P and K application rates at either location during 2013. At TAREC, lint yields were increased with the 2 x 2 band placement compared to the deep placement of P and K (Figure 6A). The 2 x 2 band produced 2,002 lbs. of lint at TAREC while the deep placement of nutrients yielded 1,858 lbs. of lint at TAREC. At Lewiston, lint yields with the 2 x 2 band were not significantly different from the deep placement system, however there was a 79 lb. lint difference between the two treatments, with 1,333 lbs. lint/ acre and 1,254 lbs. lint/ acre, respectively. No differences in fiber quality were observed between the 2 x 2 band and deep placement at either location (data not shown).

Summing up

The 2013 growing season in Virginia presented challenges to cotton producers. However, the lint yields were an exception for the study. Sand-burn injury at Lewiston introduced variability, which ultimately could not be overcome during the growing season. However, the injury did provide some data on nutrient status of cotton under early-season stress and this could be valuable to producers and consultants when making management decisions in the future. The TAREC data indicate that the 2 x 2 placement of a complete nutrient blend increased early-season growth. In areas such as Virginia, early-season vigor is extremely important in cotton production, due to temperature changes and insect pressure. The experiment also demonstrated that placing fluid fertilizers under the row with strip-tillage could be achieved and performance with this technique was similar to current nutrient management systems. When comparing the 2 x 2 band to deep placement, the 2 x 2 band increased early season growth and higher yields at TAREC during 2013. More data are needed to confirm the findings of the 2013 study, but preliminary results indicate that nutrients placed in banded zones, especially a 2 x 2 band, are equal to current nutrient management systems.

Dr. Frame is Field Crops Agronomist in the Department of Crop and Soil Environmental Sciences, Suffolk, Virginia, and Austin Brown is Graduate Research Assistant in the Department of Crop and Soil Environmental Sciences, Virginia Tech.

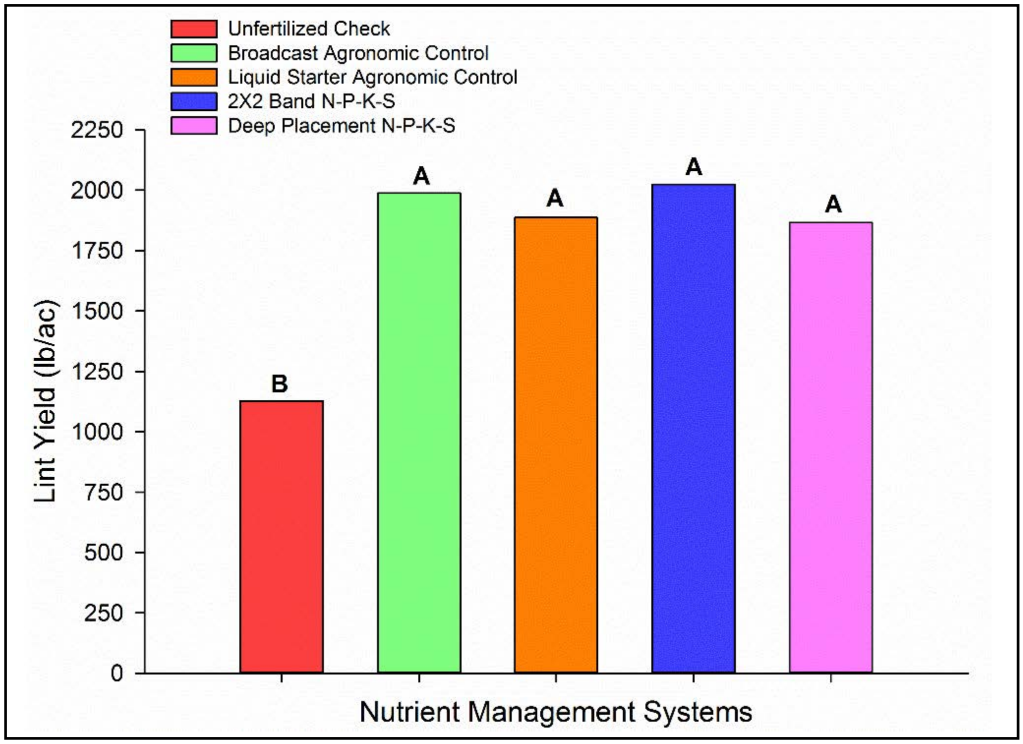

Figure 5: *Lint yield and nutrient management systems at TAREC.*

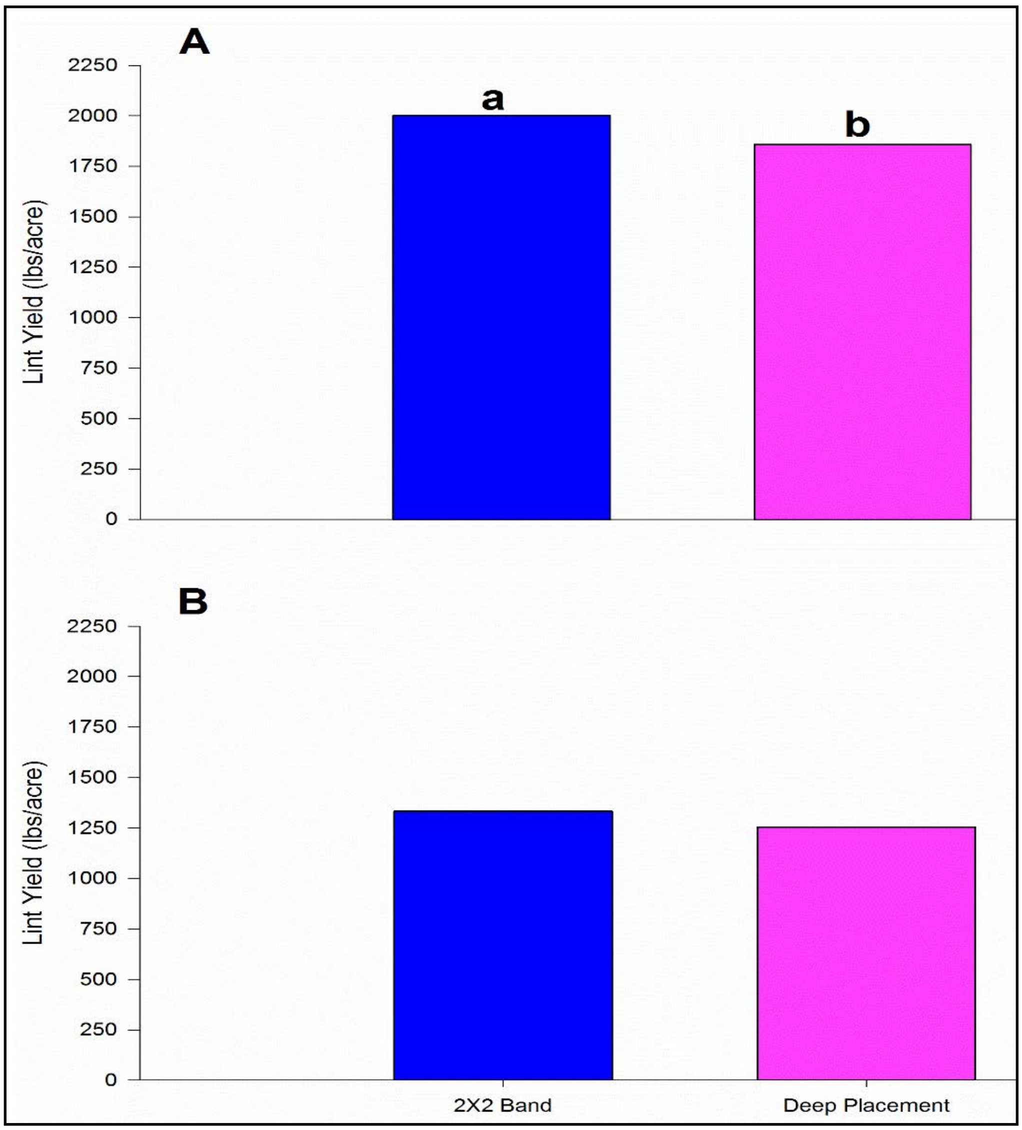

Figure 6: *Lint yield when phosphorus and potassium are placed in 2 x 2 band.*