Fluid JOURNAL

Official Journal of the Fluid Fertilizer Foundation

Winter 2015 • Vol. 23, No. 1, Issue #87

Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Winter 2015 • Vol. 22, No. 1, Issue #83

ARTICLES

THE FLUID JOURNAL - MISSION

The Fluid Journal is published by the Fluid Fertilizer Foundation. The FFF is a non-profit organization committed to researching and providing information about fluid fertilizer technology. Since its formation, the FFF has funded over $3 million in fluid fertilizer research. We have accumulated thousands of pages of research data. The main goal of the Fluid Journal is to transfer this technical information into easy to read form to farmers and dealers so they may be better informed as to the technological advancements that the fluid fertilizer industry has achieved.

FOCUS

The Fluid Journal is focused on disseminating fluid fertilizer technology to universities, dealers, equipment manufacturers and fertilizer producers. Our editorial matter focuses on several areas:

- Evaluate the agronomics of fluid fertilizers in the production of maximum economic crop yields
- Evaluate application techniques for fluid fertilizers.
- Investigate and inform our readers of innovative uses of fluid fertilizers under varied cultural, pest control and water management practices.
- Evaluate the efficiencies and conveniences of fluid fertilizer systems.
- Evaluate methods of controlling environmental problems with fluids.

From The Publishers

Timing, concentrations, and placement in use of fluid fertilizers stressed.

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Winter 2015 • Vol. 23, No. 1, Issue #87

The four articles in this issue of the Fluid Journal deal with varying crops, nutrient concentrations, and placement methods to achieve high yields with fluid fertilizers. They represent on-going research promoted by the Fluid Fertilizer Foundation (FFF) to achieve and promote the well-advised goal of using our resources to achieve ever higher crop yields to feed an ever-growing world population. It furnishes our dealers, their grower customers, our member companies, and the vast worldwide audience we reach on our website with information they can use in the battle against world hunger.

In the leading article on improving alfalfa yields--using NPK fluid fertilizers--the responses were impressive, bringing 2:1 economic returns. Yield improvements, with 6-24-6, provided over a 3-ton (@65% moisture) improvement over the grower standard practice of 20.5 tons, compared to 23.3. The 2014 study by J. R. Simplot, a current FFF member, continued via ongoing applications and measurements to build a better understanding of how to effectively use the nutrients we have.

The objective posed in the second article is to identify the fertility program components most critical for high-yield corn, including the right fertilizers to use and what combinations and application forms are best. DuPont/Pioneer, leading the study, identifies the importance of starter fertilizers, the banding of nutrients, the use of multiple N applications, including post-tassel applications of N. It claims its production clinics have facilitated high early adoption rates of practices described in its article.

> **“Timing, concentrations and placement in use of fluid fertilizers are stressed.”**

The third article stresses the importance of ear-leaf nutrient balance and concentration in corn leaf tissues. Among the objectives of this University of Nebraska study are accessing tissue concentrations in corn, whether or not existing reference concentrations are still appropriate, and seeing how sufficiency ranges change with growth stage, hybrid, and geographical location. The take-home lesson cited by the soil scientist in charge of this study is when evaluating tissue testing data, make sure the ear-leaf N concentrations are adequate before drawing any conclusions about the adequacy of other nutrients.

The final article takes a look at placing P and K at multiple depths. Cotton lint yields were an exception to the study. The experiment 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 2 x 2 band placement to deep placement, the 2 x 2 band increased early-season cotton growth and produced higher yields. The conclusion of the agronomists managing the study is more data are needed to confirm their findings.

Yields Improve In Irrigated Alfalfa Using NPK Fluids

Improvements of yields were impressive with both 3-18-18 and 6-24-6.

Drs. Terry A. Tindall and Galen Mooso

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Winter 2015 • Vol. 23, No. 1, Issue #87 ▼ DOWNLOAD

Summary: *Yield improvements were impressive with 6-24-6, providing over a 3 ton (@65 percent moisture) improvement over the grower standard practice of 20.5 tons, compared to 23.3. Improvements with these types of applications for both years have encouraged the Cooperating Farm Managers to incorporate these applications into many of the alfalfa fields for the future.*

Alfalfa continues to be the world class leader for feed value for North American production agriculture. This is especially true for areas within the inter-mountain West. Acre numbers, while not at historical highs, are still high enough to make these areas either the number 1 or 2 largest cropping sites in each of these states. Forages, including alfalfa, are enjoying some of the greatest economic returns that have been observed for many years.

A lot of this is related to changes in population in these areas, diets of international customers, and markets. There continues to be a growth in dairy markets with larger and larger dairy operations at feed yards.

All of these contributing factors have pushed the price of alfalfa well beyond expectations from just a few years ago. These changes are bound to get the attention of producers and prompt more questions regarding increased production strategies.

The Fluid Fertilizer Foundation continues to have an interest in developing a better understanding of how to more effectively improve nutrient use efficiency (NUE) with the applications of two salt fluids.

Proper nutrition

Yield of all crops, including alfalfa, will always be dependent on amount and quality of irrigation water in the desert areas of this geography. However, proper nutrition related to available fertility becomes of primary importance. This is especially true for phosphorus (P) use as growers push for high yields and high relative feed value, while also being conscientious about environmental constraints. As Dr. Glenn Shewmaker, Extension Forage Specialist and Professor at the University of Idaho, says, “Phosphorus is the most common fertilizer input for alfalfa across the Western U.S. It is essential for optimum alfalfa production and quality, but may also create concerns for the environment.”

Potassium (K) is also a nutrient that is heavily used by rapid-growing alfalfa and in many growing conditions needs to be managed similar to P fertilizer. In the author’s experience, if P and K are both limiting, P should be applied first to resolve the issue and then apply K. In many production fields, although P and K may test adequately in the soil, there may very well be factors that limit the availability to access these primary nutrients in a timely manner to maximize yield and improve alfalfa quality.

Objective

This unique study explores the potential of addressing in–season application of low salt fluid NPK delivered to alfalfa at the right time within a growing season and between cuttings. Many farmers and researchers focus only on dosage or rate of nutrients applied when other parts of nutrient management criteria should also be explored: namely, timing and form of nutrient delivery.

Foliar applications

Foliar applications of low salt NPK fertilizers were applied to established irrigated alfalfa during the 2012, 2013, and into the 2014 growing season. Applications were made when the regrowth was about 6 to 8 inches tall. In 2012, applications were made with a commercial sprayer and made between the 2nd and 3rd cuttings. The NPK fluid applications at that time were 3-18-18. Rates of application included a total of 0, 2.5 or 5.0 gallons per acre for each cutting.

Irrigation was allowed to be stopped for 24 hours to assure adequate drying on the foliage of the alfalfa. Each treatment was laid out with anticipation of harvest and determining yields.

Changes made

Applications of foliar nutrients applied in season increased yields during the 2012 season for each of the cuttings. These yield improvements were able to deliver an economic improvement for the forage being used. Kent Frisch, who is the Farm Manager for this area for Simplot, said, “It looks as if these applications are something we should be pursuing. However, the system needs changing for ease of applications.” Therefore, changes were made in 2013 and 2014 to address farmer concerns.

Trials for the in-season applications were expanded to three pivots.

Each pivot covered 120 acres and included treatments of 3-18-18 applied by aircraft. Applications of 6-24-6 were through center pivots and each was compared to the grower standard practice (GSP) where no additional nutrients were applied.

Liquid NPK's were applied when the crop had a regrowth of 6 to 8 inches. Rates included 3, 5, and 5 gallons per acre for each of the respective cuttings.

Each pivot was harvested with commercial swathers. Trucks were weighed with hay quality samples

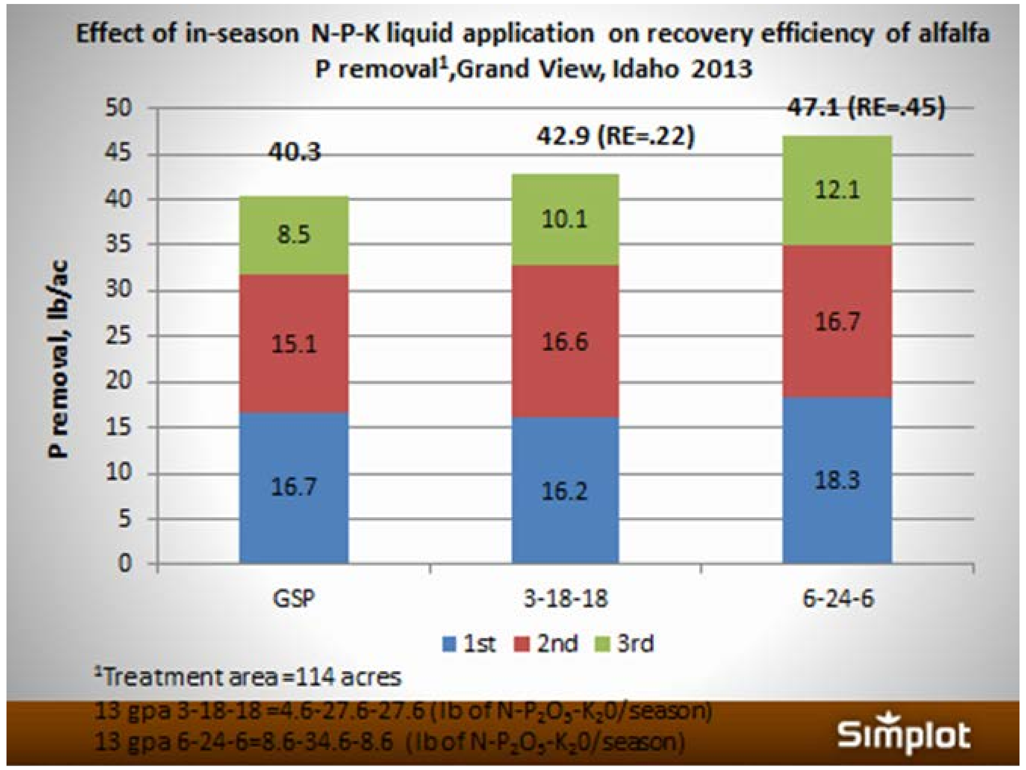

Figure 1. *Phosphorus recovery from in-season applications of NPK fluid fertilizer to irrigated alfalfa.*

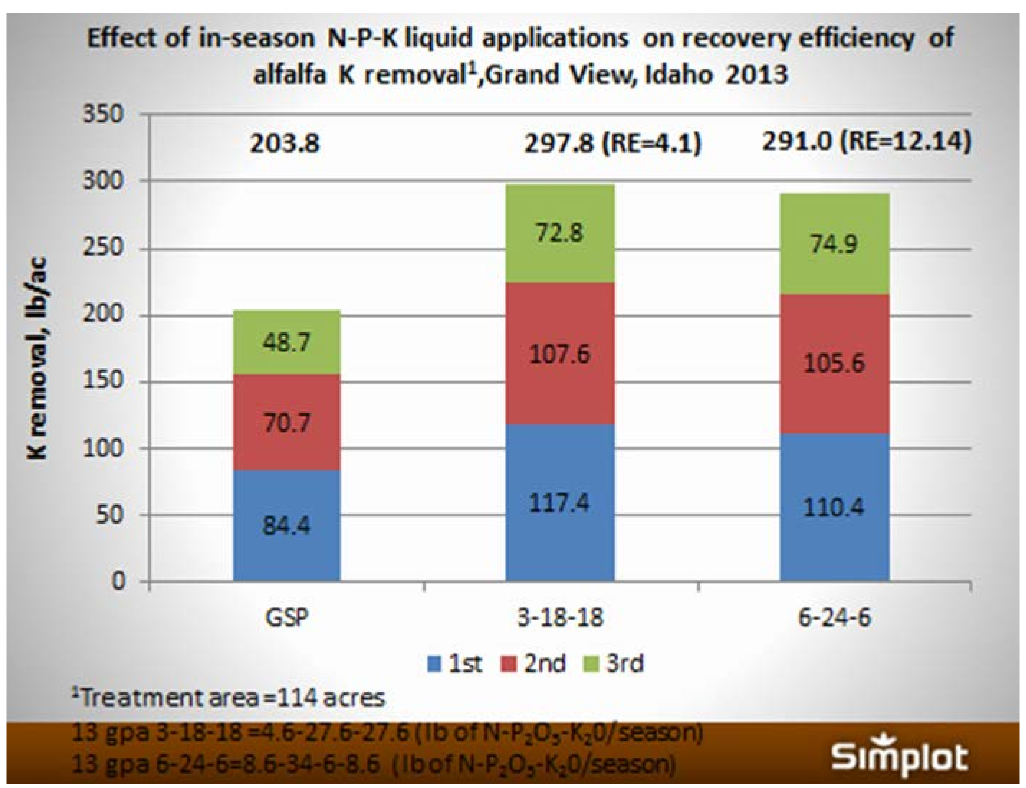

Figure 2. *Potassium uptake and recovery from in-season applications of NPK fluid fertilizer to irrigated alfalfa.*

removed for quality analysis. In total there were about 600 trucks weighed and sampled, providing a very good evaluation of treatment responses.

The main objective of the Simplot alfalfa is for it to be used as livestock feed. All was green-chopped with a moisture content of 65 percent. The 2013 trials indicated a very positive response to in-season NPK applications.

Improvements in nutrient content of P and K were both remarkable (Figures 1 and 2). It is interesting to note the changes in tissue concentration and removal from relatively low applications for both P and K.

Three times as much removal of these nutrients was observed compared to the application totals.

While not shown in this article, there was an improvement in relative forage quality and it could be attributed directly to increased nutrient uptake as a result of these in-season low salt NPK fluid fertilizers being applied.

Yields up

Yield improvements were positive for both the 3-18-18 and the 6-24-6. However, the applications applied through the center pivot tended to be higher. Improvements of yields were impressive with 6-24-6 providing over a 3 ton (@ 65% moisture) improvement over the grower standard practice of 20.5 tons compared to 23.3. Improvements with these types of applications for both years have encouraged the Cooperating Farm Managers to incorporate these applications into many of their alfalfa fields for the future.

Observes Kent Frisch: "If we can consistently see these types of responses and the materials can improve our alfalfa production benefits-to-cost by at least 2:1, our alfalfa production will be seeing more of these applications."

Our goals

The J.R. Simplot Company continues to improve on nutrient management as it applies to both new products as well as a better understanding of how to use the nutrients we have. It should also be noted that improvements in Relative Feed Quality were also positively influenced and especially with the 3-18-18 applications. This may have been related to the higher concentration of tissue K that resulted from this particular NPK low-salt foliar application. The positive nature of improvements to alfalfa production with in-season applications of NPK fluids is a great example of addressing the current needs for growers and crop advisors.

Looking ahead

It should be noted that because of this very involved set of data conducted on these large fields and the positive measurable response (to meet the 2:1 economic returns) that almost 8,000 acres of alfalfa being irrigated by center pivot are currently receiving similar in-season applications of 6-24-6 being injected through pivots. We will also continue applications and measurements through 2014.

Dr. Tindall is Senior Agronomist for the J.R. Simplot Company in Boise, Idaho, and is also a member of the FFF Board of Directors and its Fluid Journal Editorial Committee. Dr. Mooso is the Agronomy Manager for Simplot and member of the FFF R&E Committee.

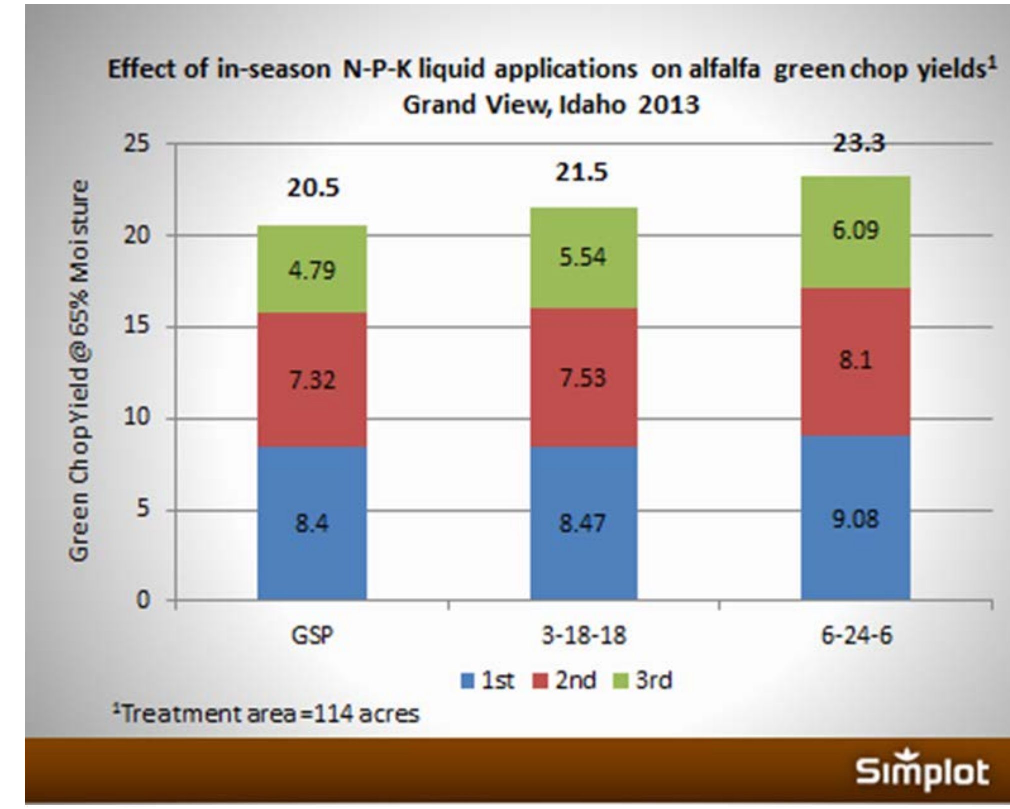

Figure 3. *Yield improvements with application of liquid NPK to established alfalfa (65% moisture) GSP (grower standard practice)*

Right Fertility Components Critical In High-Yield Corn

Study includes fertilizers used and application methods.

Russell French, Robert Bowling, Alyssa Abbott , and Mike Stewart

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Winter 2015 • Vol. 23, No. 1, Issue #87 **▼ DOWNLOAD**

Summary: *The rapid adoption of new methods and technologies that preserve profitability is important for the economic sustainability of farmers in the High Plains. The work and investigation summarized in this article will demonstrate the use of spatial and temporal observations to identify best management practices for multiple nitrogen (N) applications through corn development.*

Corn is grown on an estimated 600,000 irrigated acres in the Texas and Oklahoma Panhandles, northern New Mexico, and southwest Colorado. Corn production in these areas involves intense management and numerous inputs to achieve yield goals. Over the past 20 years, producers in these areas have faced fluctuating markets, increased input costs, environmental shifts including extreme heat, exceptional drought, declining groundwater and surface water, and state-mandated pumping restrictions. These changes have driven corn producers to improve operational efficiencies to maintain or improve production and profits.

The adoption of new methods and technologies that preserve profitability is important for the economic sustainability of farmers in the High Plains. University research is a traditional method of identifying best management practices that may improve grower productivity and profit. However, dissemination and implementation of research across broad geographies can be a measured process. The scientific method often precludes investigation across a diverse set of variables common within and across farms. Private industry can augment implementation of profitable best management practices, discovered in traditional research, by employing resources necessary for plot placement and demonstrations across wide geographies over multiple years. Furthermore, spatial and temporal investigations can be instrumental in prompt identification of processes and practices that improve producer efficiencies and/or profitability.

Objective

The objective of this study was to identify the fertility program components that are most critical for high yield corn. It involves:

- What fertilizer is best for high yields, especially in no-till and strip-till?
- What combinations of pop-up and 2 x 2 or 2 x 0 are best, especially in no-till or strip-till or early planting in cold weather soils?
- What form of application is best for positional availability in strip-till and no-till?

Methodology

Test plots. Plot width varied, but most strips were 6-, 8-, or 12- rows wide and spacing between rows was approximately 30 inches. Row length usually ranged from approximately 2,600 to slightly over 5,200 feet.

Trials. On-farm trials were established using cooperator field equipment and management practices, or management suggestions offered by DuPont Pioneer sales professionals. Production practices and certain environmental details, important for corn development, were recorded by DuPont Pioneer sales representatives, field agronomists, and account managers in fields where test plots were planted (Table 1).

Harvesting. Strips were harvested with cooperator or custom harvester equipment. Corn grain from each strip was weighed using a weigh wagon. These data were recorded and archived in computer programs and in written form for comparison following harvest.

Hybrids. Yield comparisons among hybrids and management practices were made to identify a hybrid or trend in a practice(s) that may improve on-farm production or efficiencies in management practices. Trends identified as practices that may enhance production were applied to multiple fields to determine the reproducibility of the plot data.

Results

Management practice revisions by Texas, Oklahoma Panhandle, Southwest Colorado, and northern New Mexico irrigated corn farmers have demonstrated the value of processes already discussed.

Banding nutrients is better than broadcasting for positional availability in strip-till and no-till. For example, numerous demonstrations comparing tillage practices have shown improved corn yield with strip-till and no-till, compared to conventional tillage. The value of reduced tillage was enhanced during periods of drought and limited availability of irrigation water owing to declining aquifer levels or state mandated water allocations.

Furthermore, these programs display soil moisture preservation, reduced soil erosion by wind, reduced soil compaction, plus aids in water filtration by leaving residue on the soil surface.

Starter fertilizer. Producers were taught (in clinics) about the importance of starter fertilizer as a component of high-yield corn, especially in strip-till and no-till systems where soils warm slowly when covered by residue. On-farm test plot evaluations were made for surface banding starter fertilizer two inches from the seed slice (2x0 placement). The results of this study and educational efforts have increased the usage of 2x0 starter fertilizer among High Plains corn producers. Combinations of pop-up and 2x2 or 2x0 are best or pop-up and a "hot" band 6 to 8 inches below the seed applied preplant, especially in no-till or strip-till or early planting in cold wet soils. These efforts have illustrated the ease of application and low set-up costs, compared with traditional 2x2 starter fertilizer placement.

Table 1. Variables Recorded for On-Farm Test Plots

Planting Date	Fertilizer Rate
Seeding Rate	Fertilizer Placement
Irrigation Capacity	Fertilizer Timing
Irrigation Water Applied	Fertilizer Products
(inches/acre)	Previous crop
Precipation (inches)	Tillage Practices
High and Low Daily Temperature	Herbicide (Product and Timing)
Elevation	Fungicide (Applied or not Applied)
Soil Type	Insecticides
Soil Fertility Tests (Plot)	Miticides

Table 2. N Rate Adjustments Based on Timing and Method of Application

N Application Timing and Method	N Rate to Produce a Bushel of Corn
100% Pre-Plant Broadcast	1.3 lbs
100% Pre-Plant Band	1.2 lbs
100% Fertigation	1.1 lbs
50% Pre-Plant and 50% Side-Dress	1.0 lbs
Pre-Plant/Starter/Side-Dress	0.9 lbs
Pre-Plant/Starter/Side-Dress/Fertigation/Post-Tassel	0.8 lbs

Another benefit of the 2x0 practice was that wet soils did not affect starter fertilizer placement that typically hampered traditional fertilizer coulters during planting. Precision guidance systems have made possible the latest fertilizer trend among growers. This program involves banding preplant fertilizer 8 to 10 inches deep during strip-till, followed by planting over the band and using in-furrow pop-up starter fertilizer to achieve the highest yields.

Nitrogen. Multiple applications of N are more efficient and result in higher yields (preplant, starter, pre-tassel applications through pivot or sidedress, and post-tassel applications). N rates of 1.2 to 1.3 lbs per bushel of grain, used by many soil testing labs, remain a standard when 100 percent of the N is applied prior to planting the crop. However, the International Plant Nutrition Institute (IPNI) has emphasized the interconnectedness of the 4Rs of nutrient stewardship and how rate, time, source, and placement of fertilizer are interdependent. Thus, N rate can be adjusted based on timing and placement without affecting grain yield. Our test plot data confirm this (Table 2). Growers, who apply a portion of their N preplant followed by starter, sidedress, or via pivot at V4 to V6 stage, along with R2 to R4 stage N application via center pivot, were able to produce a bushel of grain with 0.8 lbs of N. This practice can increase producer profitability because it allows adjustment of N rates based on in-season price fluctuations of N fertilizer, corn, or growing conditions. For example, high corn yields may not be possible for producers with limited available irrigation water in the absence of favorable growing conditions and precipitation. These growers can be conservative with fertilizer inputs and make in-season adjustments of N rates when growing conditions favor increased potential for grain yield. This practice also allows producers to reduce or eliminate N application following a catastrophic weather event, such as hail. Furthermore, single high-rate application of N increases the probability of stalk rot when environmental conditions favor these diseases. Multiple application of N fertilizers through the season helps reduce potential for stalk rot organisms to infect corn stalks. Tables 3 and 4 also witness to the importance of N timing on yield. Figure 1 shows a dramatic difference of post-tassel UAN in corn ear size compared to no late N. Post-tassel (post-flowering) applications of N can increase yields by increasing kernel depth and test weight. The newest corn hybrids use more N post-tassel than older hybrids of several years ago. Modern corn hybrids can respond well up to 33 percent of N goal going on between brown silk and dough stage. Finally, Figure 2 presents a 5-step ladder on the importance of proper corn N management.

Monitoring

Monitoring soil and plant N during the season has been a successful practice for farmers, particularly where manure or compost is the major source of N. This program entails sampling soil to a 30-inch depth from V4 to V6 and again from V14 to VT growth stages to determine nitrate and ammonia forms of N. Plant tissue samples are also collected following protocols established by Servi-Tech Laboratories.

The protocol for estimating corn yield entails collecting ears in representative areas of the field at R1 to R2 stage. The number of kernels per ear is determined by multiplying the number of kernels per row by the number of rows. The test weight is considered to determine the factor used for estimating yield for each hybrid. Other factors considered when estimating yield include insect and disease pressure, soil moisture, weed control, and the 10-day weather forecast. Additional N can be applied in cases where soil N is inadequate at VT or R1 growth stages. Our test plot results have demonstrated a yield increase when N is applied from tassel to R4 growth stages.

Monitoring N, along with R1 growth stage yield estimates, ensures the producer's crop has adequate N at critical growth stages. The benefit to producers is a potential reduction in N expenditures if tests show levels are sufficient, and the possibility of applying additional N if manure conversion provides less than expected available N. This practice also allows for additional N when yield estimates exceed the producer's original yield goal. A lower stalk nitrate test, developed by Blackmer and Mallarino, can be made on stalks collected at black layer to three weeks after black layer to determine the success of in-season N applications.

In 2013, an N monitoring project managed by DuPont Pioneer personnel was implemented on a 6,000-acre irrigated corn farm in the Texas Panhandle. Compost and manure are used extensively as a primary N source on these acres. The yield goal across these acres was 250 bu/A. Nitrogen recommendations were based on field and environmental conditions and lab results from soil and plant samples collected in mid-June (V5) and in mid-July (VT). Adjustments in N applications were made when needed, based on the condition of the crop. For example, fields damaged by hail received reduced rates of N and, conversely, fields with yield potential above 250 bu/A received additional N. The yield average across the 6,000 acres was 253 bu/A based on dry weight determined by a local grain elevator. One 120- acre field averaged 300 bu/A. Lower stalk nitrate tests revealed the majority of fields were in optimum to slightly excessive range with only a few fields in the marginal or excessive range.

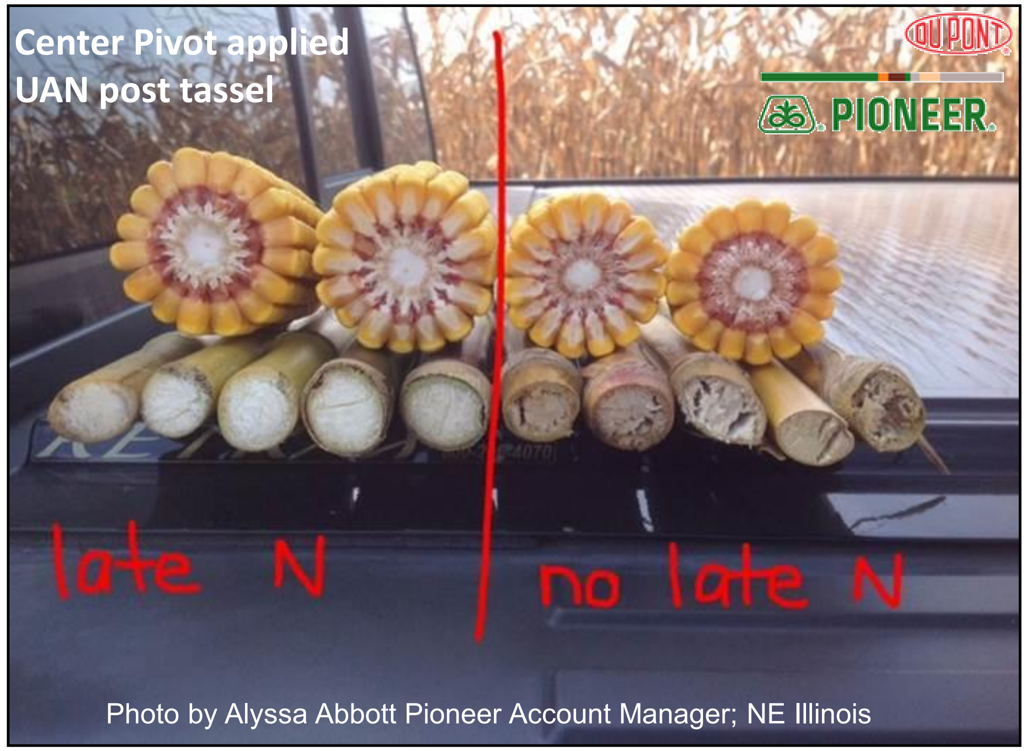

Figure 1: *Center pivot applied UAN post-tassel.*

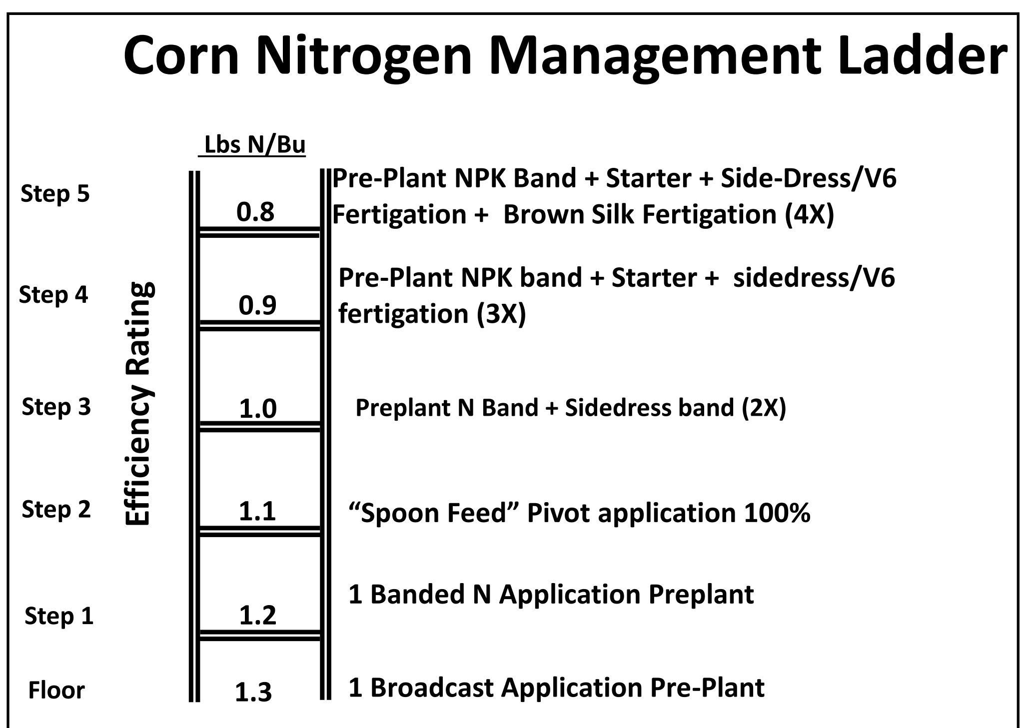

Figure 2: *Corn nitrogen management ladder.*

These proven principles from the Texas Panhandle have demonstrated positive results when replicated on an irrigated field in northeastern Illinois in 2013. Corn receiving the post-tassel N treatment had increased kernel depth, test weight, and stalk quality when compared with grain from the check that did not receive a post-tassel N application.

Summing up

Producer attendance at crop production clinics has increased over time through the use of private industry resources and coordination efforts with university Extension Specialists. Production clinics have facilitated high early adoption rates of practices described here, which we emphasize with our customers and include:

1. The importance of starter fertilizers in producing high yields, especially in no-till and strip-till. Combinations of pop-up and 2x2 or 2x0 are best or pop-up and a "hot" band 6 to 8 inches below the seed applied preplant, especially in no-till or strip-till or early planting in cold wet soils.
2. Banding nutrients is better than broadcasting for positional availability in strip-till and no-till.
3. Multiple applications of N are more efficient and result in higher yields (preplant, starter, pre-tassel applications through pivot and sidedress and post-tassel applications).
4. Post-tassel (post-flowering) applications of N can increase yields by increasing kernel depth and test weight. The newest corn hybrids use more N post-tassel than older hybrids of several years ago. Modern hybrids can respond well up to 33 percent of N goal going on between brown silk and dough stage.

Table 3. 2010 Plot Averages by Nitrogen Timing

No Post-Tassel Nitrogen	Nitrogen Applied Brown Silk
19 Plots	21 Plots
Avg Yield 217 bu/acre	Avg Yield 248 bu/acre
Low Yield: 170 bu/acre	Low Yield: 183 bu/acre
High Yield: 269 bu/acre	High Yield: 302 bu/acre
3 Plots over 240+ bu/acre	14 Plots over 240+ bu/acre

Table 4. Nitrogen Uptake, Timing and Quantities for Old and New Hybrids

Era of Hybrid Release	N at	N at	Post-Flowering	Increase in Post-Flowering
	R1	R6	N Uptake	N Uptake
	----------lbs. N/Acre----------			%
Old (1940 to 1990)*	102	145	43	28
New (1991 to 2011)	97	152	55	
Old (1970) **	125	162	37	40
New (2000)	125	177	52	

* Ciampitti and Vyn, 2012
** Haegele, et al, 2013

Specific practices that have been rapidly and widely adopted include strip-till and no-till, increased starter fertilizer use as a result of 2x0 surface banding, and movement away from 100 percent preplant N application to sidedress and fertigation applications. Other practices that have shown high adoption rates include in-season N application to fine tune N inputs and an increase in banding of immobile nutrients such as P and K in lieu of broadcast applications. A promising new practice that is currently being explored is center pivot applied N fertilizer at the R2 to R4 growth stages to improve corn yield through increased kernel depth and increased test weight. This practice allows later in-season adjustments of N application when environmental conditions favor higher yield potential, especially where water available for irrigation is limited by declining water tables or state mandated regulations.

Russell French is CCA and DuPont/Pioneer Account Manager, Robert Bowling is a DuPont/Pioneer Field Agronomist, Alyssa Abbott is a DuPont/Pioneer Account Manager, and Mike Stewart is Central and Southern Plains Regional Director for IPNI.

Nutrient Concentrations And Balance Important

Make sure ear-leaf N concentrations are adequate in corn leaf tissues.

Dr. James Schepers

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Winter 2015 • Vol. 23, No. 1, Issue #87

▼ DOWNLOAD

Summary: *From preliminary observations when evaluating tissue testing data, make sure the ear-leaf nitrogen (N) concentrations are adequate before drawing conclusions about the adequacy of other nutrients.*

Tissue testing is a well-established science that has a growing data base. Interpretation of tissue testing results is based on and referenced to historical results (chemical concentrations) from studies where crops were considered to have an adequate supply of all nutrients. Information about weather (temperature and water) and soils (pH, CEC, etc.) is lost when tissue concentration data are extracted from the various reports. Compiled reference concentrations for a given nutrient and crop, result in a range of adequacy values that is typically based on relative yield for a given study. For example, tissue concentrations that result in 95 to 100 percent of maximum yield are typically considered "sufficient" or adequate. Yields that are 80 to 95 percent of maximum yield are considered "low." Yields that are <80 percent of maximum are considered "deficient." Nutrient concentrations that are considerably greater than the "sufficient" range are considered "high" and could be toxic or result in other problems because of nutrient interactions within plants.

Objectives

The objective of this research was to:

- Begin assessing if and how tissue concentrations in modern high-yielding corn hybrids might have changed over time
- See if existing reference concentrations are still appropriate
- See how sufficiency ranges change with growth stage, hybrid, and geographical location (basically, origin of top soil).

Methodology

Irrigated corn hybrid demonstration plots at Shelton and York, Nebraska were used in the second year of this study. The Shelton study (14 hybrids) was managed by a local Pioneer Hi-Bred representative and the York study (16 hybrids) was managed by the Pioneer staff at the York Research Station.

Three additional studies at Johnston, IA, and Bloomington, IL (both rain-fed) and York, NE (irrigated) involved two hybrids that were fertilized at five N rates (0, 50%, 70%, 100% and 130% of recommended). Studies in Iowa and Illinois involved four replications.

All plots were sampled at silking (VT growth stage) by removing the ear leaf from 12 representative leaves. Samples were dried and ground before sending to A&L Great Plains Lab for analyses.

Results

Even though there was considerable variability in nutrient concentrations across hybrids at Shelton (i.e.: B, Mn, and Cu), Mg was the only nutrient found to be potentially low (mean 0.14%, range 0.12 to 0.20%) at VT with a CV of 16 percent across hybrids.

Ear-leaf Mg concentrations across hybrids at York also had a CV of 16 percent, but none of the samples were deemed deficient according to industry guidelines (equal to or greater than 0.13%). Figure 1 illustrates the variability in ear-leaf Mg concentrations at the Shelton location. Even though some of the ear-leaf Mg concentrations were considered to be "low," the average yield was 259 bu/A (range from 241 to 279 bu/A) and yield was poorly correlated with Mg concentration (r2 = 0.19).

The remainder of the 2013 study, following up on observations made in 2012 at York, NE, showed an apparent increase in micro-nutrient concentrations with an increase in ear-leaf N concentrations. Five fertilizer N rates at three locations were used in 2013 to create a range in soil N availability for two Pioneer brand hybrids (P33D53 and P1498). The Nebraska location was under sprinkler irrigation while the Iowa and Illinois locations were both rain fed. Yields increased with ear-leaf N concentration (N rate) as expected.

The yields ranged from 39 to 196 bu/A across these three locations for P33D53 (Figure 2) and from 44 to 190 bu/A for P1498. Data in Figures 2 and 3 illustrate that not only did N rate affect yield, but so did the apparent availability of water. Seasonal rainfall amounts are not available for the Iowa and Illinois locations. It should be noted that the commonly accepted sufficiency-level for ear-leaf N concentration at silking is 2.75%. Water deficit had a strong influence on ear-leaf N concentration in Iowa and Illinois, even though the highest fertilizer N rate was 30 percent higher than recommended for maximum yield at these locations. Also note that the zero-N rate treatment under irrigation in Nebraska yielded 68 and 84 percent of the maximum yield for P33D53 and P1498, respectively. Hybrid P1498 is an AquaMax hybrid that typically performs quite well under limited water conditions. This characteristic is commonly attributed to a more extensive rooting system. Data indicate that the rooting system of P1498 was also more effective in extracting N from soil than P33D53 (Figure 2).

"Make sure ear-leaf N concentrations are adequate."

The effect of ear-leaf N concentration on nutrient

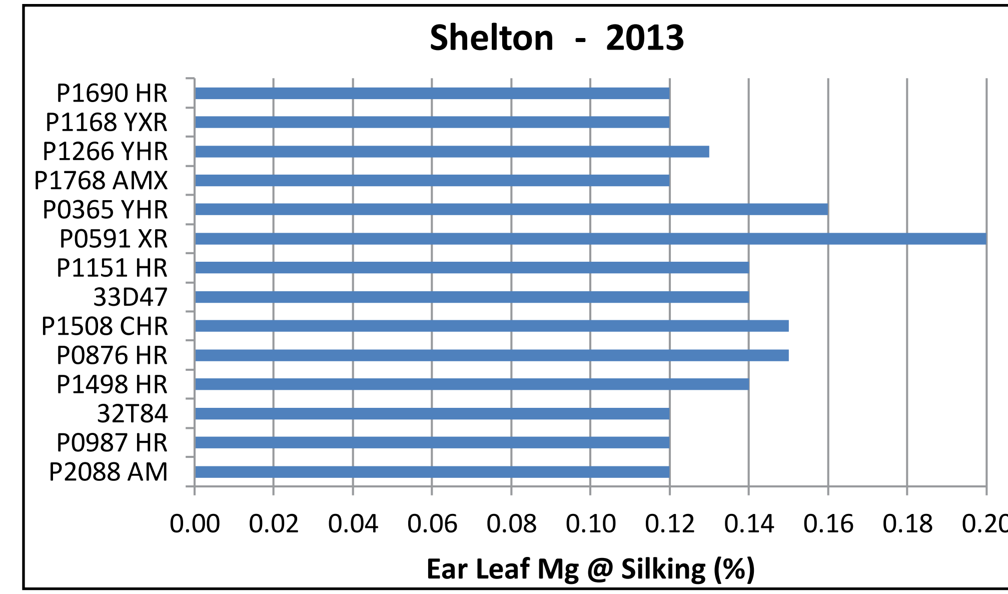

Figure 1. *Ear-leaf Mg concentrations for fourteen corn hybrids at Shelton, NE in 2013. Values between 0.9 and 0.13% ae considered "low".*

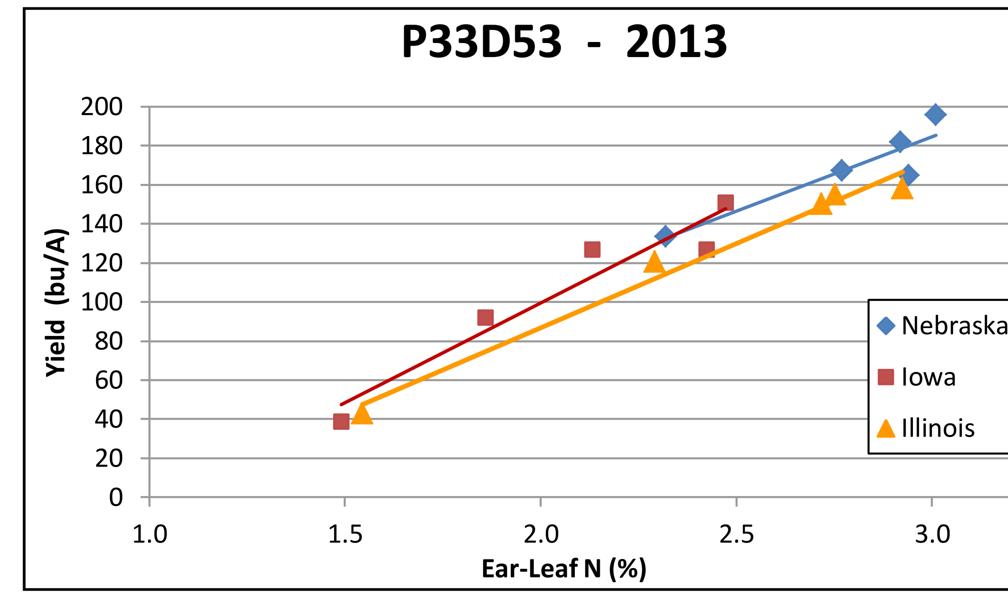

Figure 2. *Effect of ear-leaf N concentration at silking on corn yield for P33D53 at three locations in 2013.*

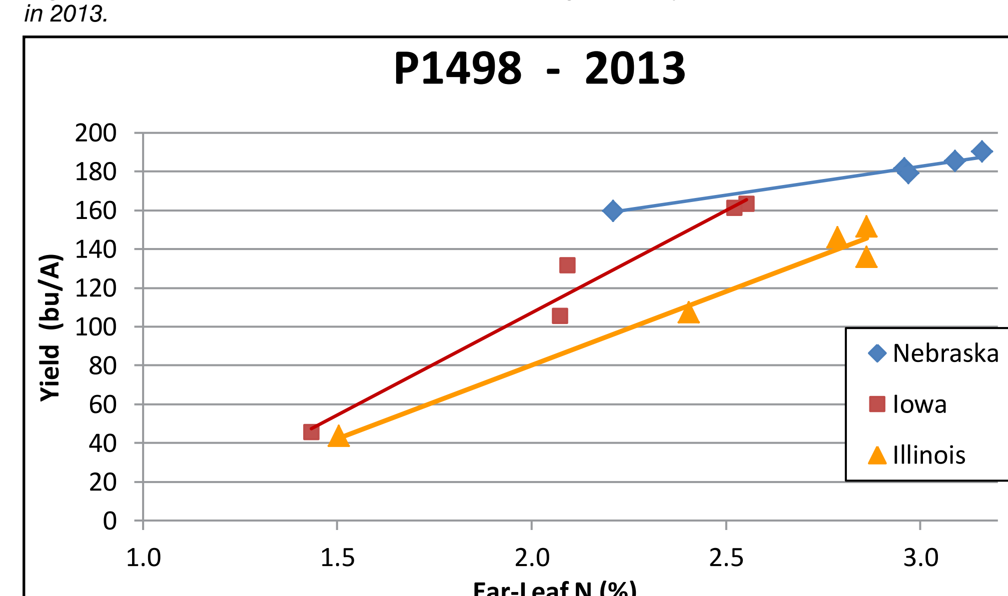

Figure 3. *Effect of ear-leaf N concentration at silking on corn yield for P1498 at three locations in 2013.*

concentration is illustrated in Figures 4 and 5. Data from Iowa are used to illustrate these relationships. While the slope of the relationships is between ear-leaf N concentration, and that of the various nutrient concentrations was unique for each element, the two hybrids performed similarly. The relationships for Iowa were linear in all cases, and generally similar for Illinois. Relationships between ear-leaf N versus P, K, and S were insignificant.

The above relationships in Figures 4 and 5 for Iowa compliment the data from the Illinois and Nebraska locations. In general, nutrient concentrations increased as ear-leaf N concentration increased up to the point of N adequacy (i.e., 2.75% N). Figure 6 illustrates that nutrient concentrations tended to reach a plateau when ear-leaf N concentrations exceeded 2.75 percent N. Perhaps these plateau concentrations could serve as reference values when using the DRIS approach for assessing nutrient adequacy.

Be Careful

One might be tempted to conclude that increasing fertilizer N rates should increase yields because it increases the concentrations of other nutrients. In fact, one might also conclude that a little N fertilizer (approaching the 130 percent N rate) might even compensate for small deficiencies in other nutrients. This conclusion is probably erroneous because when N ions (nitrate or ammonium) are taken up, plants must also take up a companion ion with the opposite net charge.

Summing up

The second year of this study, funded by the Fluid Fertilizer Foundation, confirmed preliminary observations made in 2012. The take-home lesson might be that when evaluating tissue testing data, make sure the ear-leaf N concentrations are adequate before drawing conclusions about the adequacy of other nutrients.

Dr. James Schepers is soil scientist emeritus at the University of Nebraska.

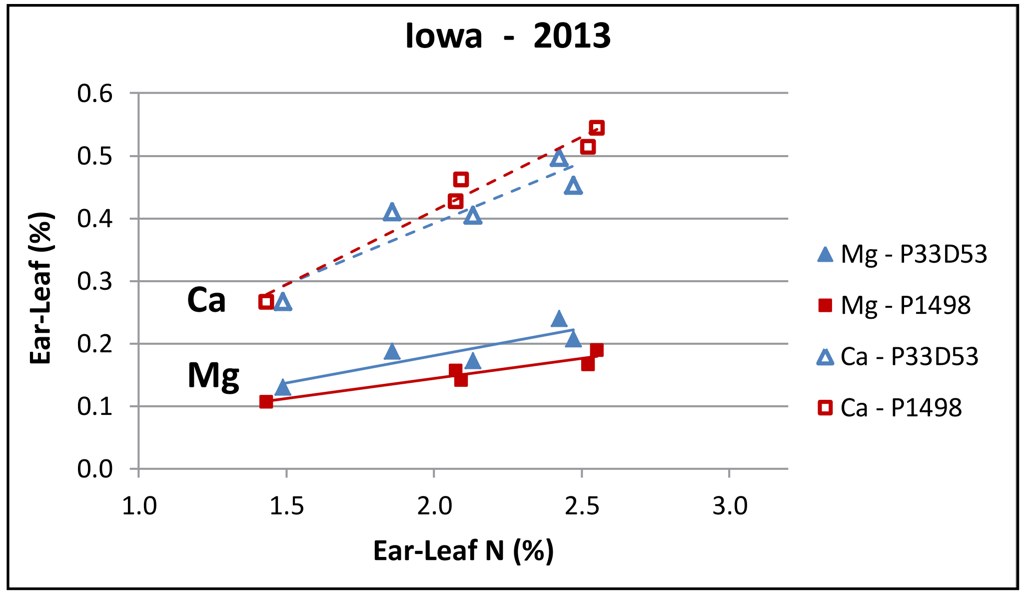

Figure 4. *Effect of ear-leaf N concentration on Mg and Ca concentrations at silking for two Pioneer brand hybrids in Iowa in 2013.*

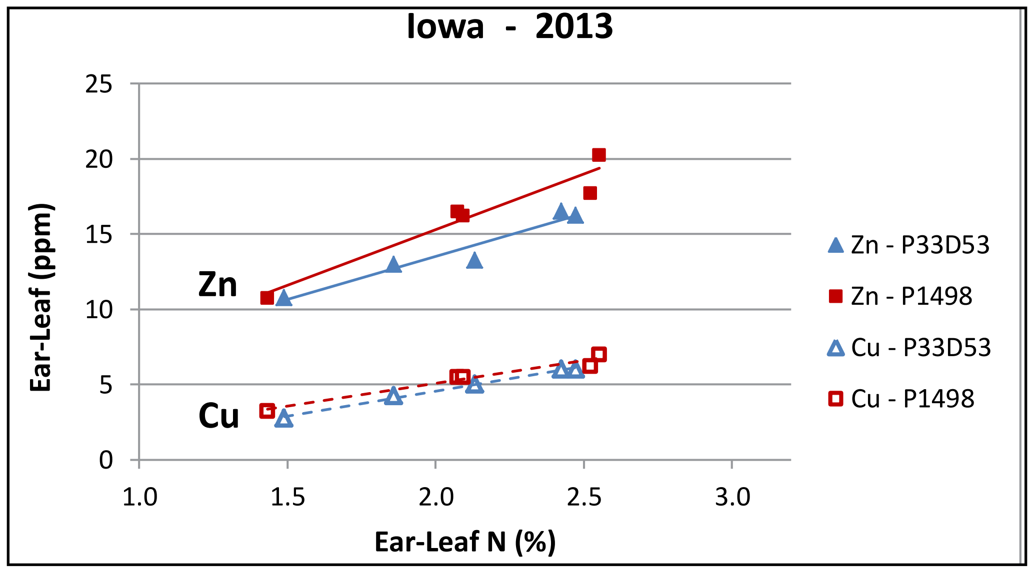

Figure 5. *Effect of ear-leaf N concentration on zn and Cu concentrations at silking for two Pioneer brand hybrids in Iowa in 2013.*

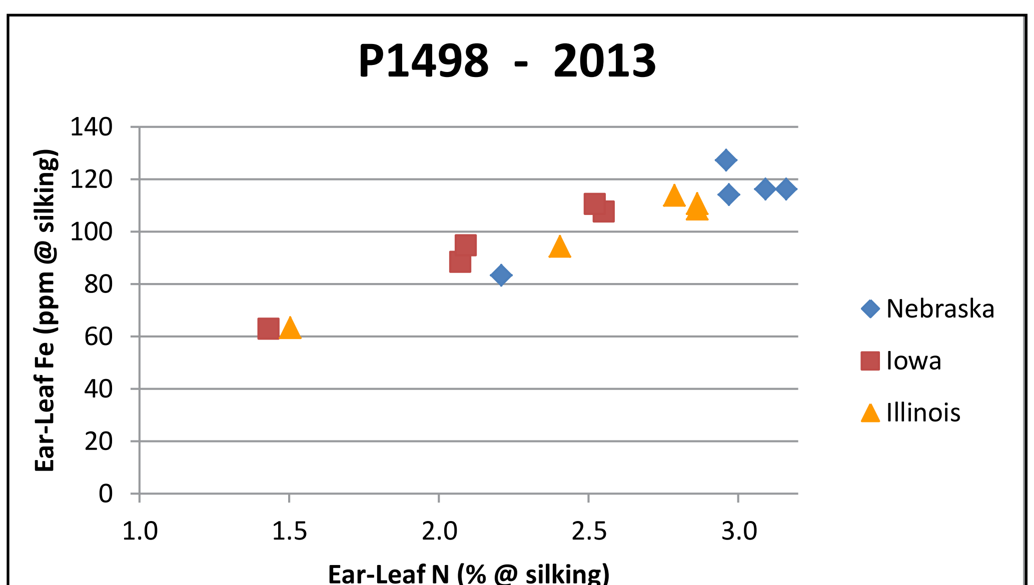

Figure 6. *Effect of ear-leaf N concentration on Fe concentration at silking for P1498 at three sites in 2013.*

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

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Winter 2015 • Vol. 23, No. 1, Issue #87

▼ DOWNLOAD

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

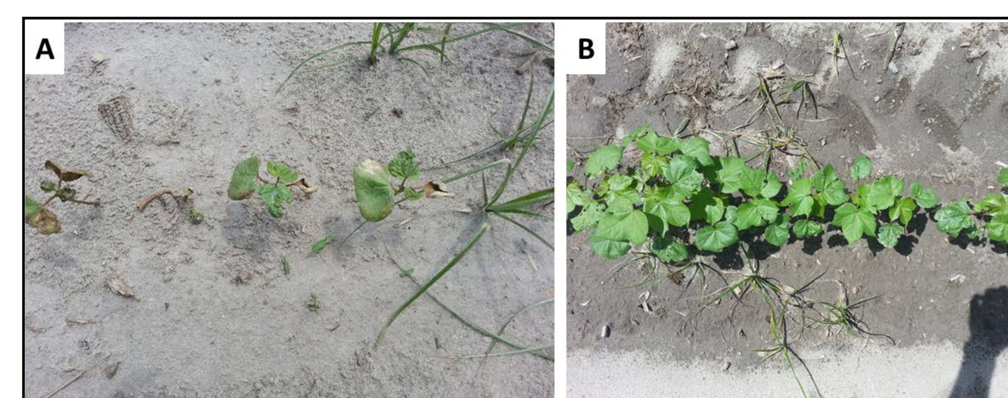

Figure 2: *Sand-burn injury 6/17 (A) and 7/2 (B)*

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

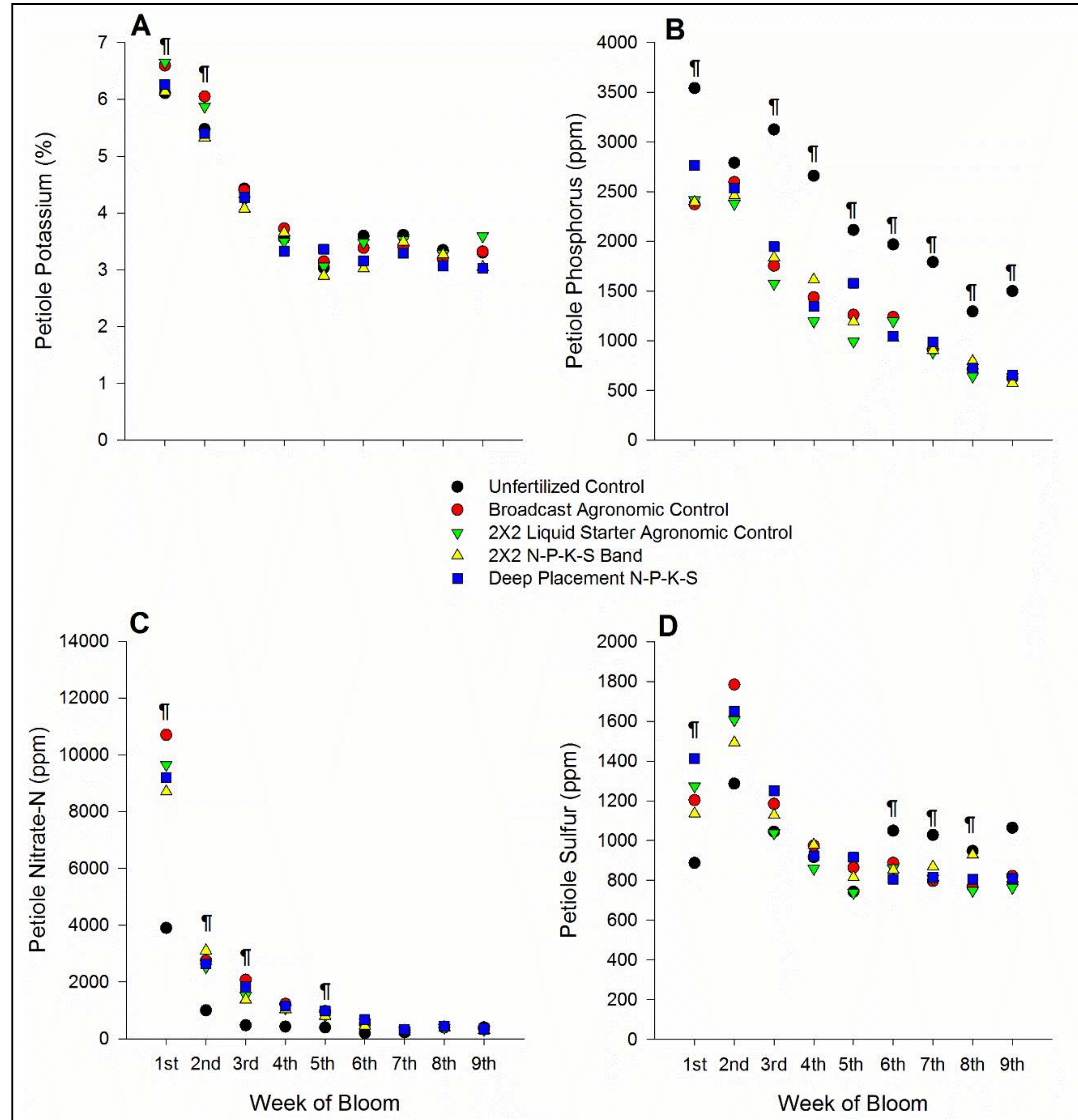

Figure 3: *Potassium (A), phosphorus (B), nitrate (C) and sulfur (D) concentrations at TAREC.*

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.

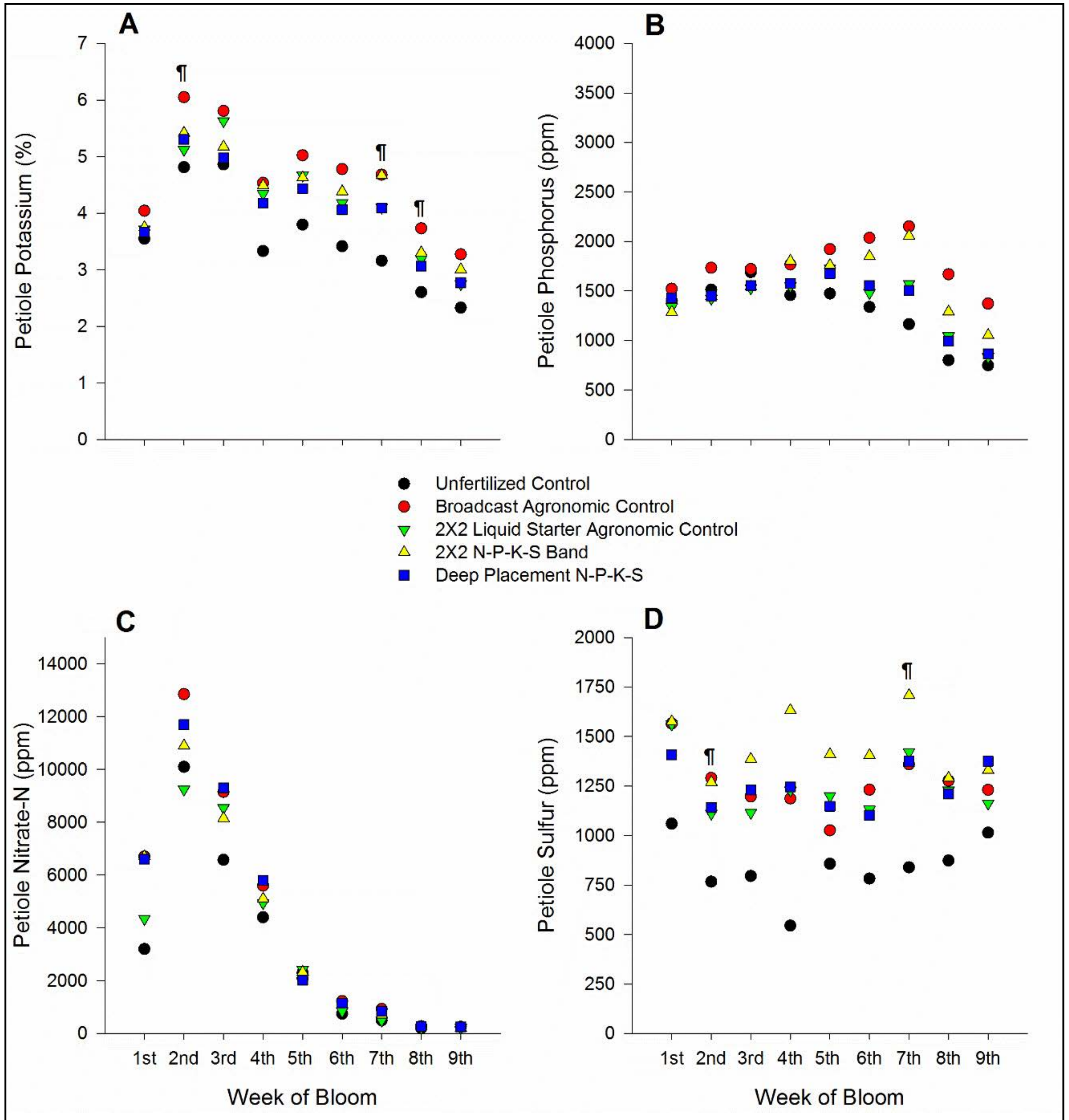

Figure 4: *Potassium (A), phosphorus (B), nitrate (C) and sulfur (D) concentrations at Lewiston.*

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.

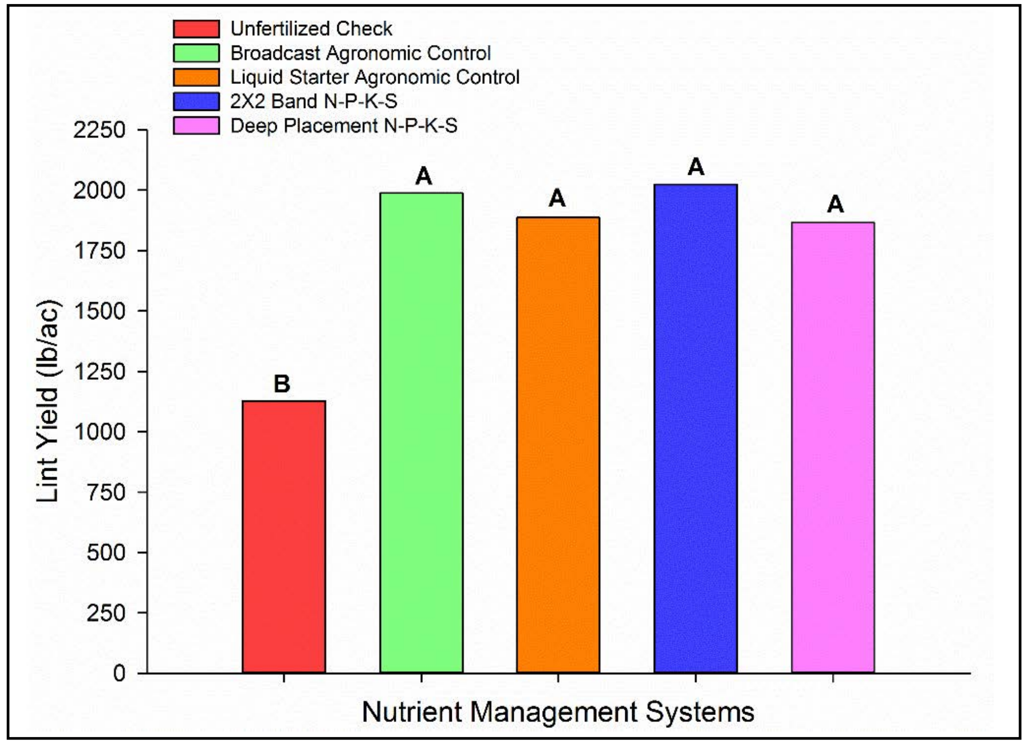

Figure 5: *Lint yield and nutrient management systems at TAREC.*

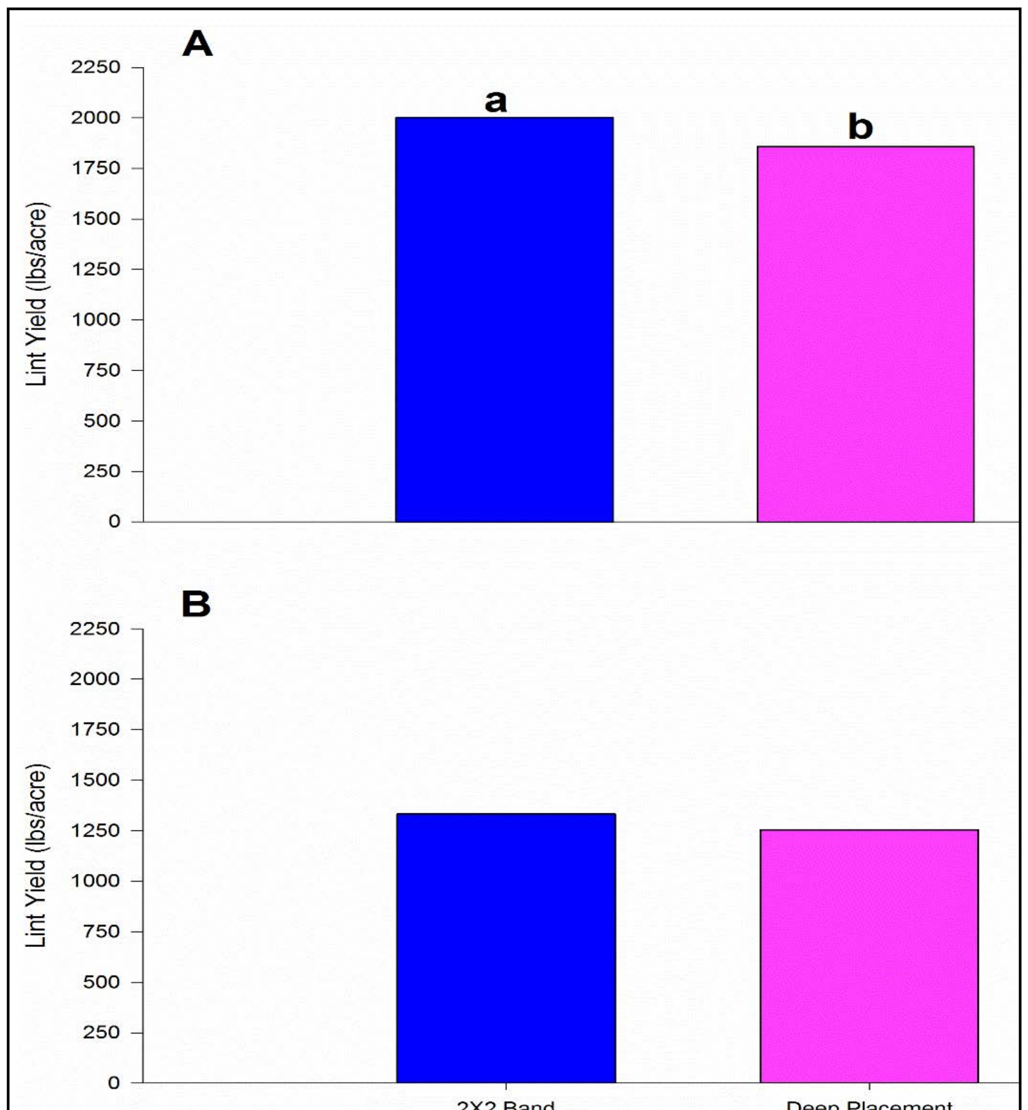

Figure 6: *Lint yield when phosphorus and potassium are placed in 2 x 2 band.*