

NEWS & VIEWS

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Dr. C.S. (Cliff) Snyder,
Southeast Director
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Part 2 of 2

2005 Research Program Summaries—Southeast Region: Cotton, Citrus, Forages, Forestry, and More

The objective of the Potash & Phosphate Institute (PPI) and Foundation for Agronomic Research (FAR) program in the Southeast Region is to expand the science and knowledge of optimum plant nutrient management practices, while protecting environmental resources. This work is made possible by the partnership between cooperating scientists, and funds provided by PPI and FAR contributors. This *News & Views* includes reports from a portion of the 24 projects supported in the region in 2005.



These summaries provide a brief overview of each project. Please consider contacting the research project leader for more details. You can also view the full annual reports of each project (current and past), when available, at the website:

><http://www.ppi-ppic.org/research><. Once at this website, research project information can be viewed by state abbreviation and project title, or by a topic area.

Arkansas



Cotton Response to Combinations of Nitrogen and Potassium

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The objective of this study was to evaluate the effect of combinations of nitrogen (N) and potassium (K) fertilization on cotton yield, soil nutrients, and petiole $\text{NO}_3\text{-N}$ and K concentrations. This (2005) was the first year of this 3-

year field study at the University of Arkansas Cotton Branch Experiment Station in Marianna. Cotton cultivar 'DPL444' was grown using cultural practices recommended by the University of Arkansas Cooperative Extension Service. Experimental treatments were five rates of N ranging from 0 to 160 lb/A (in 40 lb/A increments as urea) and five rates of K_2O ranging from 0 to 150 lb/A (in 30 lb/A increments as muriate of potash) arranged in a factorial structure. Seed-cotton yield was increased by soil application of urea. Seed-cotton yield for the cotton that was not fertilized with any N was 1,677 lb/A; for the cotton fertilized with 120 lb N/A, yield was 3,532 lb/A. However, application of K_2O did not increase the seed-cotton yield regardless of K_2O rate, suggesting that the native soil K was high enough to sustain optimum cotton yield, even at high N application rates. This is supported by the high soil test levels in samples collected before the application of any fertilizer. Petiole $\text{NO}_3\text{-N}$ and petiole K concentrations increased with increasing rate of N or K_2O application and tended to decrease as the cotton plant developed. In summary, application of N fertilizer almost doubled the seed cotton yield and increased the petiole $\text{NO}_3\text{-N}$ and K concentrations. At the high soil test K levels at this study site, no yield benefit to application of K was observed in 2005, across the wide range of N rates evaluated. *AR-29F*

Florida



Phosphorus and Potassium Soil Test Calibration and Effects on Fresh Citrus Fruit Quality

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Some Florida citrus growers apply phosphorus (P) fertilizer on a regular basis, but tree response is rare



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because residual soil P is usually sufficient. It is important to judiciously use P fertilizer due to environmental concerns of P loss. Producers want to use soil testing to guide fertilization, but no true calibration exists. Unlike P, K leaches readily in Florida's sandy soils, so K fertilization almost always provides a positive response. The objectives of this project are to calibrate a citrus soil P test and to determine the effects of K fertilizer rate on yield and fresh fruit quality of grapefruit and oranges. Our research grove was planted November 1998 and we have monitored it annually.

In the 2004-05 season, grapefruit leaf tissue P concentration was low where Mehlich-1 soil test P was ≤ 1 mg/kg (ppm), suggesting that a leaf P-soil test P correlation is developing. Lowest orange yields occurred where soil test P was < 20 mg/kg, so a threshold may be developing. Grapefruit yield or quality factors (juice brix and acid; fruit height/diameter ratio; peel thickness) were not correlated with soil test P. As K fertilizer rate increased, the following response factors increased: leaf tissue K concentration; grapefruit yield; fruit size; fruit height/diameter ratio; peel thickness; juice brix; and juice acid. The optimum K rate for grapefruit yield and juice brix was between 100 and 200 lb K_2O/A , but lower K rates provided more marketable fruit shape and peel thickness. Severely K-deficient grapefruit trees suffered substantial twig die-back. Orange yield did not respond to K fertilizer rate, and the die-back symptom was not observed. As the orange trees approach mature size, they continue to be sensitive to K, but not to P.

FL-19F



Soil Fertilization of Perennial Pasture Systems

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Better forage fertility management may improve dryland forage hay production, quality, and tolerance to diseases without compromising environmental quality. Field studies (2004 through 2006) are being conducted at three Florida locations, using three forage species (bermudagrass, bahiagrass, and perennial peanut) to compare potassium (K as KCl) with and without supplemental potassium magnesium sulfate (K-Mag[®]) on forage yield, quality, and tissue mineral content. Soil cores are being taken to determine fertilization effects on nutrient movement over time. The five treatments consist of a control (N at 60 lb/ton harvested

biomass and P_2O_5 fertilizer, per soil test recommendation), low K_2O (24 lb/ton harvested biomass following each clipping), high K_2O (48 lb/ton harvested biomass following each clipping), low K_2O with 25% provided as K-Mag[®], and high K_2O with 25% provided as K-Mag[®]. Check plots (no fertilizer) were also included.

In 2004, fertilizer treatments resulted in sporadic minor yield improvements with K-Mag[®] fertilization for bermudagrass and bahiagrass. However, perennial peanut showed no fertilization response in 2004 or 2005. In 2005, bermudagrass plots in south Florida became S deficient, which was expressed visually as leaf chlorosis and a 50% drop in forage yield. Sulfur was the only nutrient consistently deficient in the affected bermudagrass tissue in 2004 and 2005 and in 2004 soil samples. The 2005 soil samples are being processed. *Helminthosporium* leaf spot was observed in all bermudagrass plots, but severity was greatest in the plots receiving N only fertilization. Bahiagrass plots in south and north-central Florida became infected with dollar spot (*Sclerotinia homoeocarpa* F.T. Benn.) and fertilization aggravated the symptoms. In mixed Pensacola/Argentine bahiagrass plots, the Pensacola variety appeared more susceptible. In 2006, we will continue to observe the effect K-Mag[®] fertilization has on yields and disease susceptibility and compare root biomass among treatments. FL-22F

Georgia



Enhancing Pine Straw Production, Wood Volume, and Product Class Distribution with Fertilization of Old-field Planted Slash and Loblolly Pine Stands

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Project Cooperators: David Moorhead, Bryan McElvany

Fertilization studies were installed in three former old-field planted loblolly and slash pine stands in 2000-2001 in southeast Georgia (Dodge, Toombs, and Washington counties). The objectives are to: 1) quantify the magnitude and duration of response to fertilizer combinations (NP, NPK, and NPKMgSBCu) applied one-time (late winter at all sites) when compared to control plots, 2) measure tree product class volume changes over time, 3) measure pine straw production response, and 4) determine the economics of fertilization over a 4-year period. The Dodge County site had a 12-year-old slash pine stand growing in a former old-

Please refer to the first News & Views (Part 1 of 2) for a report from other studies conducted in the Southeast Region in 2005.

field that showed foliar N, P, and Cu deficiencies at the time of fertilization. This stand was thinned one-year post-treatment due to a black turpentine beetle outbreak. The Toombs County site had an unthinned 9-year-old slash pine stand growing on a former Vidalia onion field with high fertility and good soils, but showed a foliar Cu deficiency. The Washington County site had a thinned 15-year-old loblolly pine stand growing on a former old-field with good soils, but showed foliar P, K, and Cu deficiencies.

There were no statistically significant differences in mean tree growth parameters between the fertilizer treatments and the control at the three study areas over a 4-year period. There was a significant first pine straw rake gain with fertilization 17- or 24-months post-treatment at the Toombs County and Dodge County slash pine stands, respectively, but no significant pine straw production gains in subsequent years. Pine straw production was not measured in the Washington County thinned loblolly stand. Rainfall patterns, especially during the growing seasons, in 2000, 2001, and 2002 were significantly below the 50-year running average normal for these locations, possibly having an adverse effect on the response to fertilization. Of the three sites, the Dodge County thinned slash pine stand had the largest economic gain with fertilization: a \$170/A wood value increase with NPK fertilization and a \$20/A pine straw value increase between March 2000 and 2005. Using 2000 southeast Georgia fertilizer prices for urea, diammonium phosphate (DAP), and muriate of potash (MOP) and an application cost of \$0.06/lb of fertilizer, the cost for the NPK fertilizer plus application was \$96/A. The NPK fertilization economic rate of return in the Dodge County case was 12%, while the economic gain on the other two sites was negligible. Forest landowners should continue to use established fertilization diagnostic tools of leaf area index (LAI) estimates, soil sampling for available P, foliar tissue nutrient sampling, and soil series knowledge for cost-effective fertilization prescriptions. *GA-21F*



Enhancing Thinned Slash Pine Volume Production and Product Class Distribution with Competition Control and Fertilization on Flatwoods Spodosols

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Fertilization and competition control studies were installed in two thinned slash pine stands in southeast and south Georgia (Ware and Wayne counties) in 2001. The objectives are to quantify the magnitude and duration of response to lime, fertilization (200 lb N/A + 50 lb P/A + 50 lb K/A), competition control using herbicides or mowing, burning, competition control, lime+NPK, and NPK+competition control when compared to control plots.

Diameter distribution and tree product class volume changes over time are being evaluated, and the economics of these activities over a 5- to 8-year period. Both thinned slash pine stands are growing on low pH (3.8 to 4.2), low fertility (deficient in N, P, K, and Mg based on soil-P and foliar N, P, K, and Mg) Spodosols.

The 2-year post-treatment results on the Ware County thinned slash stand are: a) no significant diameter growth (0.31 in. for the herbicide+burn to 0.49 in. for the NPK treatment), live crown ratio (2.4% for the herbicide+burn to 4.4% for the lime+NPK treatment), percent mortality (0% for the control to 3.8% for the herbicide+burn treatment), basal area (3.5 ft²/A for the herbicide+burn to 8.2 ft²/A for the lime+NPK treatment), total volume (201 ft³/A for the herbicide+burn to 331 ft³/A for the lime+NPK treatment), and chip-n-saw volume (300 ft³/A for the herbicide+burn+NPK to 487 ft³/A for the lime+NPK treatment) growth increments, and b) a significant height increment increase for the herbicide+burn (4.6 ft.), burn+herbicide+burn+NPK (4.4 ft.) over the lime (3.1 ft.), NPK (2.9 ft.) and control (2.6 ft.). Ware County slash pine data seem to indicate that the fertilizer treatments are rebuilding crown rather than increasing height growth in the first 2 years post-treatment, but the treatments may be increasing diameter, total volume and chip-n-saw volume slightly. The 4-year results will better address growth differences due to the treatments on this site.

The 2-year post-treatment differences on the Wayne County slash pine stand include: a) significantly greater diameter growth with herbicide+NPK (0.88 in.), NPK (0.75 in.), and mow+NPK (0.82 in.) than the control (0.58 in.), b) a 13.3 ft²/A basal area increment for the herbicide+NPK compared to the control (10.9 ft²/A), c) total volume increment on 309 for the control, 322 for the NPK, 423 for the herbicide+NPK, and 360 ft³/A for the mow+NPK treatments, and d) 3.3 for the control, 5.4 for the NPK, 4.9 for the herbicide+NPK, and 5.9 cords/A for the mow+NPK, although treatment differences in b), c), and d) parameters were non-significant. The 4-year treatment mean differences will be compared in mid-2006 for the Wayne County slash pine stand. *GA-24F*



Loblolly Pine Stand Fertilization at Mid-rotation to Increase Small and Large Sawtimber Volume

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Many private non-industrial forest (NIPF) landowners are seeking good economic returns to forest management. Many loblolly and slash pine plantations in the South have

nutrient limitations. A fertilizer trial was installed in a randomized complete block design in two Charlane Plantation thinned loblolly pine stands (planted in 1978) in Twiggs County, Georgia, in 2004. One-time fertilizer application levels in the thinned loblolly pine, marginal fertility, stands were 200 lb N/A + 50 lb elemental P + 80 lb elemental K + 60 lb S and 5 lb Cu/A (Bullard Bluff East tract, 8 plots; 2 replications of NP, NPK, NPKSCu, and a control; Bullard Bluff West tract, 15 plots; 3 replications of NP, NPCu, NPKCu, NPKCu, NPKSCu, and a control). The N sources are urea and diammonium phosphate (DAP), the P source is DAP, the K source is KCl, the Cu source is copper sulfate, and the S source is ammonium sulfate. The major objectives are: 1) quantify the magnitude and duration of wood volume response to the fertilizer combinations; 2) determine changes in product class distribution; 3) the cash flow and rate of return for each fertilizer combination compared to unfertilized control plots; 4) discern when fertilizers are to be re-applied to maintain wood volume gain. The funded project duration is 5 years. The fertilizer materials were applied in February 2005 to randomly-assigned plots to establish each respective treatment. Rainfall patterns were good soon after application and remained relatively consistent through August 2005. Pre- and first year post-treatment surface soil, foliage sampling, and leaf area index (LAI) estimations have been made. Gross treated plots are each one-half acre with the internal permanent measurement plots being one-fourth acre, centered within the gross treated plots with 40 ft. of buffer between plots. All living loblolly pine trees were tagged with aluminum markers, numbered, and measured for dbh (diameter @ 4.5 ft.), total height, live crown ratio, height to fork, stem canker, or other defects, with each tree being merchandised into a product class (based on dbh and presence/absence of a visible defect). The same growth parameters will be re-measured every other winter (Jan-Feb 2007, 2009) to determine diameter class distribution, volume/tree, and volume/A by product class. GA-26F



Chloride and Chloride Sources for Reducing Foliar Diseases and Improving Onion Yield and Flavor

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Onions are among the top five vegetable crops in the U.S., with production at nearly 145,000 acres and a farm-gate value of \$750 million. Optimum mineral nutrition plays an important role in maintaining onion productivity, quality, and plant health. Recent data and observation suggest that chloride (Cl) and K nutrition may be under-utilized or misapplied. The objectives of this study are to determine the Cl affects on onion bulb pungency and bulb

yield. In the first experiment, plants of “Sweet Vidalia” were seeded in October of 2004 and grown under greenhouse conditions for 6 weeks. In mid-December, plants were transplanted into 1x1x0.4 m boxes filled with washed river sand using four treatments: 1) 400 ppm CaCl₂ applied weekly at 1 L, 2) 400 ppm KCl applied weekly at 1 L, 3) 400 ppm KCl for 4 weeks then 400 ppm CaCl₂ for 4 weeks at 1 L (March 7, 14, 21 and 28 KCl, then April 4, 11, 18, and 25 CaCl₂ and 4) control (no additional Cl). Plant growth was similar for the different Cl treatments, although the plants receiving both Cl sources appeared to be healthier and slightly larger throughout the growing season. The lowest pungency was found using KCl only with 3.7 umols pyruvic acid development and was significantly different than the no additional Cl control group. The highest pungency (4.7) was found with the KCl and CaCl₂ treatment, possibly because these plants grew much better throughout the experiments, and achieved greater mass. Soluble solids was unaffected by Cl treatments. Bulb weight was significantly increased and greatest when both Ca and K sources of Cl were used.

A field study was also conducted in the Vidalia growing regions in Georgia using the “Georgia Boy” variety and commercial practices for Vidalia onions. Beginning in January, additional Cl (KCl and CaCl₂) was applied at 20 lb Cl/A, using 2-acre blocks per plot. Plot treatments were: 1) four monthly applications, 2) three monthly applications, 3) two monthly applications, 4) one monthly application, and 5) no additional Cl. Onions were ready for harvest on May 5, 2005, and were undercut and allowed to field cure for three days. Four replicates of 50 bulbs each were then sub-sampled, weighed and analyzed for bulb pungency and soluble solids. Control plots were slightly more yellow in appearance than the plants that received chloride. We now know that Cl is deficient in the Vidalia area and what we were observing was a growth response to fertilization with Cl. There was higher bulb pungency in the control (no additional Cl) when compared to all of the treatments that received at least one additional Cl application, but no significant differences among any of the Cl application frequencies. This suggests the Cl effect on bulb pungency was the result of Cl just before harvest. Soluble solids was unaffected by Cl application. The greatest bulb yields were found with the higher Cl applications and the lowest bulb yield resulted from no additional Cl. These results suggest Cl fertilization will be beneficial to the Vidalia onion crop, both in lowering pungency and increasing bulb yield. GA-27F

Missouri



Fescue Sulfur Fertilization— Hay and Pasture

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Project Cooperator: David Dunn

In the last decade, coal-burning power facilities have significantly reduced sulfur dioxide emissions into the atmosphere. This has resulted in less delivery of S in rainfall to agricultural crops. A project was begun in 2004 at West Plains, Missouri, to determine the effects of S fertilizer on fescue hay and pasture and to study economics of short-term P and K soil build-up programs vs. a standard Missouri 8-year build-up program. Four rates of S were evaluated (0, 9, 12, and 24 lb S/A) in an 8-year P and K build-up program. The 2005 growing season was unusually hot and dry in south central Missouri. No significant hay yield response from S was found in 2005. Fescue hay with no S yielded 1.89 t/A total from two cuttings on June 2 and November 10. The highest numerical hay yield was 2.01 t/A from 12 lb S/A. In 2004, the 12 lb S/A treatment also produced the highest hay yield. Averaged across both years, annual fescue hay yields were 2.11, 2.29, 2.34, and 2.25 t/A from applications of 0, 9, 12, and 24 lb S/A, respectively. *MO-27F*



Use of Ammonium Sulfate on Tall Fescue Pastures to Reduce Costs and Improve Forage Quality in Missouri

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About half of Missouri's 12 million acres of tall fescue receive N fertilizer either in the spring or late summer to increase yields. Use of ammonium nitrate (AN) is decreasing and urea presents some NH₃ volatilization management challenges. Our objectives of this research were: 1) compare ammonium sulfate (AS) to AN, urea, coated urea products, and mixtures of AS with urea and coated urea products as N sources for tall fescue in spring and late-summer; and 2) determine the optimum rate and N use efficiency for each product. Plots were established at the Forage Systems Research Center (FSRC) and at the Southwest Missouri Research and Education Center (SWC). A rate of 75 lb N/A was applied in mid-March. Forage was harvested in late May, late July, and mid-October. To compare these N products for stockpiling tall

fescue, the same treatments were applied to different plots at the same locations in mid-August and harvested in early December. Preliminary data indicate that at both locations, only the May harvest responded to N applied in March. We hypothesized that the "coated urea" products might have yielded greater in the summer and perhaps fall because of their slow N release activity. No N product was overwhelmingly consistent in producing the highest yields. The AS ranked in the top producing group at nearly all harvests and locations. The AN provided no better yields than urea in this first year. Lack of precipitation may have prevented efficient soil incorporation of the N products.

For the fall experiment, all of the products applied in late summer yielded equally and nearly 2 times greater than the unfertilized control at FSRC. Total rainfall of 1.35 in. fell there within 3 days of the N being applied. So, volatilization of ammonia from the N sources was apparently not an issue. At Mt. Vernon, there were treatment differences for the fall experiment. Urea and three mixtures with urea yielded less than AN and three AS treatments. Ammonia volatilization may have been the cause for these treatment differences, since only 0.27 in. of rainfall had been received by 6 days after the N was applied. *MO-30F*

Mississippi



Determination of Potassium, Magnesium, and Sulfur as Limiting Factors in Cotton Production on Blackland Prairie Soils

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The objectives of this study are: 1) determine individual response functions of cotton leaf K, Mg, and S levels and lint yield to varying rates of K₂O, Mg, and S, and 2) compare combined K, Mg, and S response (K-Mag[®] treatment) to individual nutrient responses. This project was established April 2004 and the proposed length of study is through the 2006 growing season. Treatments include K₂O at rates of 0, 36, 72, and 108 lb K₂O/A as muriate of potash; Mg at rates of 0, 9, 18, and 27 lb Mg/A as magnesium nitrate; S at rates of 0, 18, 36, and 54 lb S/A as ammonium sulfate; and K-Mag[®] supplying rates of K₂O-Mg-S at 0-0-0, 36-9-18, 72-18-36, and 108-27-54 lb/A, with 50% of the K₂O derived from muriate of potash. Total N applied to all treatments was 120 lb N/A.

Lint yield increased from 1,229 up to 1,328 lb/A with an increase in fertilizer K₂O from 0 to 36 lb/A. At 72 lb K₂O/A, yield was only slightly greater than with no K₂O and may be related to the decrease in tissue Mg below the critical value of 0.25%. Response to Mg was negative at the two higher rates, although leaf tissue K did not show a concomitant

decrease. Lint yield increased from 1,220 to 1,292 lb/A with increasing KMag[®] rates from 0 to 164 lb/A. Tissue K increased with K-Mag[®] application rate, while Mg did not decrease as much as when only K₂O was applied. In summary, there appears to be a beneficial response to supplying both K and Mg on soils having marginal Mg supplying capacity, and with continued use of no-till, the effect may be accentuated with time. *MS-13F*

South Carolina



Potassium Uptake, Distribution, and Yield Response by Modern Cotton Cultivars

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Project Cooperator: James Camberato

During the past several years, late-season K deficiencies have been observed in many cotton fields across South Carolina. Current K fertilizer recommendations in South Carolina are based on pre-season K levels of the topsoil that is adjusted by depth and K content of the subsoil. Research was conducted to determine if current soil testing procedures and recommendations are valid to optimize yield of modern cotton varieties. A replicated field experiment was conducted in 2004 and 2005 at the Pee Dee Research and Education Center located in Florence, on a Norfolk-Bonneau soil complex identified as K deficient last growing season. Potassium fertilization rates were 0, 50, 85, 120, 155, 190, and 225 lb K₂O/A applied broadcast to a sandy Norfolk-Bonneau soil prior to planting. Five modern cotton cultivars...DPL 555BR, ST 5599BR, FM 989BR, DPL 444BR, and PM 1218BR...were evaluated. Leaf and petiole samples were obtained during flowering to monitor K status of plants. Soil test K levels in the Ap-horizon ranged from 30 to 57 lb/A Mehlich I extractable K, depending on prior year K application rates and differences in soil properties. After 3 years of fertilization with high rates of K, there was some accumulation of K in the Ap- and B-horizon of this sandy soil. Cotton cultivars responded similarly to supply in the 2005 growing season, unlike 2004 when DPL 555BR and DPL 444BR reacted differently to K supply than ST 5599BR, FM 989BR, and PM 1218BR. Increased K supply increased leaf and petiole K, reduced premature defoliation, and increased lint yield. Increased soil test K of 50 lb/A was about twice as effective as K fertilization at 50 lb K₂O/A for affecting leaf and petiole K and premature defoliation. Surprisingly, soil test K was nearly 10-fold more effective than K fertilization at affecting yield. Other soil factors associated with high residual K levels may have been responsible for the greater effectiveness of soil K than fertilizer K. *SC-13F*

Tennessee



Nitrogen and Potassium Effects on Physiology and Yield Components of Contrasting Cotton Varieties

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Project Cooperators: C.C. Craig, Jr., Carl Michaud, Tracy Bush

Cultivar differences in yield response to N and K nutrition have been observed in modern cultivars, but the physiological basis for these differences needs explanation. Three interrelated studies continued in long-term no-till N and K fertility plots in a Memphis-Loring silt loam soil at Jackson: 1) variety response to K; 2) variety response to N at different K levels; and (3) response of an indeterminate cultivar to extremes of K fertility. The cultivars, PM1218 BG/RR and DP555 BG/RR, were planted in 4-row plots on May 5, 2005. Plots were spindle-picked at 140 and 155 days after planting, and earliness was measured as percent of total yield picked at first harvest. In plots receiving 60 and 120 lb K₂O/A annually, dry matter partitioning was determined at early bloom and cutout.

Total shoot dry weight of PM1218 was higher than DP555, as more biomass was partitioned to reproductive structures in PM1218. The 120 lb K₂O/A rate reduced the proportion of reproductive biomass at cutout in DP555 compared to PM1218. First harvest lint yields did not differ significantly, but total lint yield of DP555 was 9% higher than PM1218 due to later maturity of DP555. The 60 and 120 lb K₂O/A treatments did not significantly affect yield or earliness. In a companion study, however, 60 or 90 lb K₂O/A/yr. significantly increased total lint yields relative to 30 lb K₂O/A/yr. The 90-lb rate delayed maturity relative to the 30-lb rate. Variety-by-K interaction was due to a greater total yield response from 30 to 90 lb K₂O/A/yr in PM1218 than DP555. Variety-by-N interaction was due to DP 555 yielding more total lint at 160 lb N/A/yr than PM 1218, but not at 80 lb N/A. In a companion study, 150 or 180 lb K₂O/A/yr increased total lint yields 71% over zero-K, but significantly delayed maturity. Maturity delay with high K fertility may be related to greater biomass partitioning to vegetative tissue in the more indeterminate cultivar (DP555 BG/RR). Additional research is needed to determine the fate of photosynthate partitioned to vegetative tissue, and yield effects of K-induced maturity delay in the event of a killing freeze before harvest. *TN-19F* ■