2003 BELTWIDE COTTON CONFERENCES, NASHVILLE, TN – JANUARY 6-10

DEFINING THE POTASSIUM REQUIREMENTS OF COTTON VARIETIES

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Abstract

Late-season potassium deficiencies have occurred in many cotton fields across South Carolina over the past several years, with some varieties showing deficiency symptoms more frequently than other varieties. New, higher-yielding earlier-maturing cotton varieties appear to develop more of their total boll load over a shorter period of time, which leads to a more condensed boll filling period and an increased demand for the uptake and mobilization of potassium from the soil and leaf to the developing lint. Southeastern Coastal Plain soils typically have accumulations of potassium in clayey subsoil layers due to leaching of potassium incorporated into sandy surface soil layers. The extent of downward potassium movement during the growing season and access to subsoil potassium may govern potassium availability in Coastal Plain soils. Current potassium fertilizer recommendations in South Carolina are based on pre-season potassium levels of the topsoil that is adjusted by depth and potassium content of the subsoil. The data establishing the subsoil adjustment to fertilizer recommendations preceded development of these high potassium demanding cotton varieties. 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 2002 at the Pee Dee Research and Education Center located in Florence, SC, on a Norfolk-Bonneau soil complex identified as potassium deficient last growing season. Potassium treatments were broadcast applied prior to planting at 0, 50, 75, 100, and 125 lb K_2O/acre. Five cotton varieties released between the years 1919 and 2001 (Dixie Triumph, DPL 90, DES 119, Paymaster 1218BR, and DPL 555BR) were evaluated.

No differences in flowering occurred among varieties fertilized with 0, 50, 75, 100, and 125 lb K_2O/acre. As expected, varieties differed in their flowering patterns. PM 1218BR developed the majority of its flowers during the first 3 to 4 weeks of the flowering period. The other four varieties did not reach peak bloom until week 5 or 6 of the flowering period. Leaf and petiole potassium levels were positively related to the sum of the initial soil potassium level of the A-horizon plus 50% of the potassium fertilization rate. Including E- or B-horizon potassium levels and/or a higher or lower percentage of potassium fertilization rate did not improve these relationships. Leaf potassium was a better indicator of potassium supply than petiole potassium. Leaf potassium concentrations were low throughout boll development (especially with the low potassium fertilizer treatments), attaining deficiency levels of less than 1.5% at early bloom and less than 0.75% at cutout. Although leaf potassium concentrations were at or below sufficiency levels during boll development, no differences in lint yield or fiber quality due to potassium fertilization rates occurred. No significant potassium rate or potassium x variety interactions were found for lint yield or lint quality, but visible differences in deficiency symptoms in the field occurred among varieties and potassium rates. All varieties responded favorably to increased levels of leaf potassium, with recently released higher-yielding varieties such as PM 1218BR and DPL 555BR responding more to potassium than older, lower-yielding varieties such as Dixie Triumph, DES 119, and DPL 90. Differences in variety maturity levels appeared to be less important when compared to the yield capacity of the variety during the season.

Rationale and Background

Late-season potassium deficiencies have occurred in many cotton fields across South Carolina over the past several years, with some varieties showing deficiency symptoms more frequently than other varieties. New, higher-yielding earlier-maturing cotton varieties develop more of their total boll load over a shorter period of time, which leads to a more condensed boll filling period (Oosterhuis et al., 1991). This fast-fruiting characteristic of newer varieties has resulted in an intense demand for the uptake and mobilization of potassium from the soil and leaf to the developing lint – from 2 to 4 lb K/acre/day (Halevy, 1976; Mullins and Burmester, 1991). However, Pettigrew et al. (1996) found no differences in response to K deficiency among cotton varieties with varying genetic backgrounds and maturity ranges in the Mississippi Delta. Since potassium is the primary osmotic for fiber development and provides the turgor pressure necessary for fiber elongation (Dhindsa et al., 1975), optimum cotton yields and fiber quality are highly dependent upon an adequate supply of potassium throughout the growing season. Late-season potassium deficiencies appear to be extremely detrimental to cotton, with reduced fiber quality (especially fiber length, strength, and micronaire) and lint yield (Pettigrew, 1996; Bauer et al., 1998) often occurring as a result of late-season potassium deficiencies.

Early research in the Mississippi Delta region found that deep placement of potassium was needed to provide sufficient potassium for maximum boll filling of improved varieties (Tupper et al., 1993). Excessive drying of the upper soil layers renders potassium unavailable to the crop, and deep soil layers have little potassium because downward leaching of potassium is limited in relatively high cation exchange capacity soils (Pate et al., 1994). Soils in the Coastal Plain region of South Carolina are much different than those in the Delta, and the distribution and availability of potassium is also quite different. Coastal Plain soils typically have accumulations of potassium in clayey subsoil layers due to leaching of potassium incorporated into sandy surface soil layers. The extent of downward potassium movement during the growing season and access to subsoil potassium may govern potassium availability in Coastal Plain soils. Current potassium fertilizer recommendations in South Carolina are based on pre-season potassium levels of the topsoil that is adjusted by depth and potassium content of the subsoil (Woodruff and Parks, 1980). The data establishing the subsoil adjustment to fertilizer recommendations preceded development of these high potassium demanding cotton varieties. Research was conducted to determine if current soil testing procedures and recommendations are valid to optimize yield of modern cotton varieties.

Research Objectives

To define the potassium requirement of modern varieties with heavy boll loading tendencies to that of older varieties, and to determine if current soil testing procedures and recommendations are still valid.

Materials and Methods

A replicated field experiment was conducted in 2002 at the Pee Dee Research and Education Center located in Florence, SC, on a Norfolk-Bonneau soil complex identified as potassium deficient last growing season. The plow layer, upper 8 inches of the E-horizon, and upper 8 inches of the B-horizon were sampled prior to initiating of the experiment and analyzed for Mehlich-I potassium and soil pH. Depth to the B-horizon was also determined. An attempt was made to optimize yields utilizing a center-pivot irrigation, a split application of 120 lb N/acre, and intense pest control.

Potassium treatments were broadcast applied prior to planting at 0, 50, 75, 100, and 125 lb K_20/acre. Five cotton varieties released between the years 1919 and 2001 (Dixie Triumph, DPL 90, DES 119, Paymaster 1218BR, and DPL 555BR) were evaluated. The experimental design was a split-plot with potassium fertilization rate as the whole plot (20 rows wide by 40 foot long) and variety as the split plot (4 rows wide by 40 foot long). Only the center two rows were used for plant tissue and lint harvest. Leaf and petiole samples were obtained every 2 to 3 weeks from first bloom through cutout to monitor potassium status of the cotton plant. The sap from 20 petioles was squeezed out, and potassium determined with a Cardy K^+ meter. Leaf tissue was dried, ground, and analyzed for nutrient content by standard laboratory procedures. Weekly white bloom counts from one middle row were conducted. Destructive plant sampling (0.3 m of row) occurred at matchhead square and at cutout in order to determine changes in dry matter partitioning, boll development, and relative maturity levels. At harvest, plants were mapped to assess changes in fruit distribution throughout the canopy, and plots were machine-harvested. Lint yield, gin turnout, and fiber quality was determined. Response to potassium fertilization was examined in relation to potassium fertilization rate and intensity of the boll-filling period (old to new varieties) as it is altered by the supply and distribution of soil potassium.

Summary

1) No differences in flowering occurred among varieties fertilized with 0, 50, 75, 100, and 125 lb K_20/acre (Fig. 1).
2) As expected, varieties differed in their flowering patterns (Fig. 2). PM 1218BR developed the majority of its flowers during the first 3 to 4 weeks of the flowering period. The other four varieties did not reach peak bloom until week 5 or 6 of the flowering period.
3) Leaf and petiole potassium levels were positively related to the sum of the initial soil potassium level of the A-horizon plus 50% of the potassium fertilization rate (Figs. 3 and 4). Including E- or B-horizon potassium levels and/or a higher or lower percentage of potassium fertilization rate did not improve these relationships. Leaf potassium (Fig. 3) was a better indicator of potassium supply than petiole potassium (Fig. 4).
4) Leaf potassium concentrations were low throughout boll development (especially with the low potassium fertilizer treatments), attaining deficiency levels of less than 1.5% at early bloom and less than 0.75% at cutout (Fig. 3).
5) Although leaf potassium concentrations were at or below sufficiency levels during boll development, no differences in lint yield or fiber quality due to potassium fertilization rates occurred (Table 1).
6) No significant potassium rate or potassium x variety interactions were found for lint yield or lint quality, but visible differences in deficiency symptoms in the field occurred among varieties and potassium rates (See photos below). All varieties responded favorably to increased levels of leaf potassium, with recently released higher-yielding varieties such as PM 1218BR and DPL 555BR responding more to potassium than older, lower-yielding varieties such as Dixie Triumph, DES 119, and DPL 90 (Figs. 5 and 7). Differences in variety maturity levels appeared to be less important when compared to the yield capacity of the variety during the season (Fig. 6).

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Acknowledgements

This research supported in part by the South Carolina State Support Program and the South Carolina Cotton Board.

Table 1. Cotton lint quantity/quality associations in response to varying potassium rates and cultivars in 2002 at Florence, SC. Camberato and Jones.

Variable	Seed Cotton (lb/A)	Lint Yield (lb/A)	Gin Turnout (%)	Bolls Number (bolls/m^2)	Boll Size (g/boll)	Micro-naire	Strength (g/tex)	Length (in.)	Uniformity (%)
(K Rate)									
0	2202	876	39.7	45	3.4	4.3	26.4	1.06	81.2
50	2012	798	39.3	46	3.5	4.4	26.7	1.04	80.8
75	2257	883	38.9	50	3.5	4.7	26.0	1.06	81.2
100	2576	1011	39.2	54	3.9	4.5	26.1	1.05	81.2
125	2064	807	39.1	46	3.8	4.6	26.2	1.05	81.2
LSD(0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns
(Cultivar)									
Dixie Triumph	1789	613	34.2	40	3.7	4.4	23.4	0.91	78.1
DPL 90	2173	845	39.0	53	3.5	4.2	28.6	1.10	81.2
DES 119	2329	900	38.8	59	3.2	4.5	27.3	1.09	82.4
PM 1218BR	2351	962	41.2	36	4.2	4.8	25.4	1.05	82.3
DPL 555BR	2469	1056	43.0	52	3.4	4.5	26.7	1.10	81.6
LSD(0.05)	310	114	1.4	10	0.3	0.2	0.8	0.01	0.6
KXC LSD(0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns

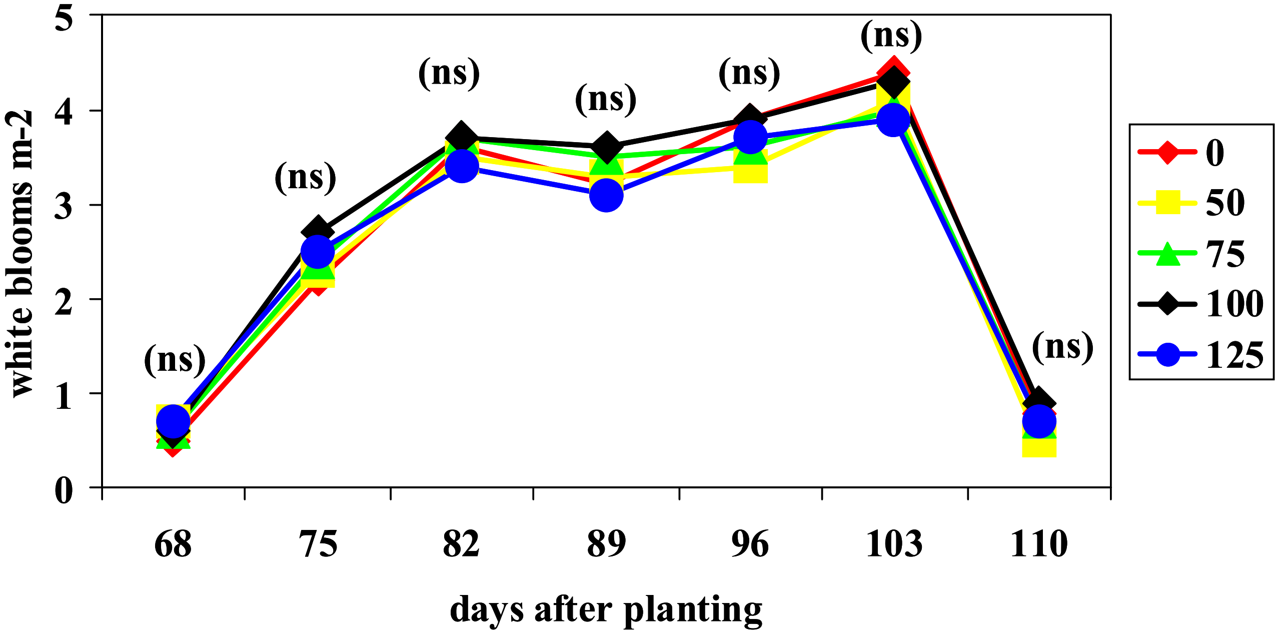

Figure 1. Flowers per meter per day as a function of days after planting for cotton grown at 0, 50, 75, 100, and 125 lb K/A in 2002. Numbers in parentheses indicate the least significant difference among K rates at the 0.05 level of probability; (ns) indicates no significant differences among K rates at the 0.05 level of probability.

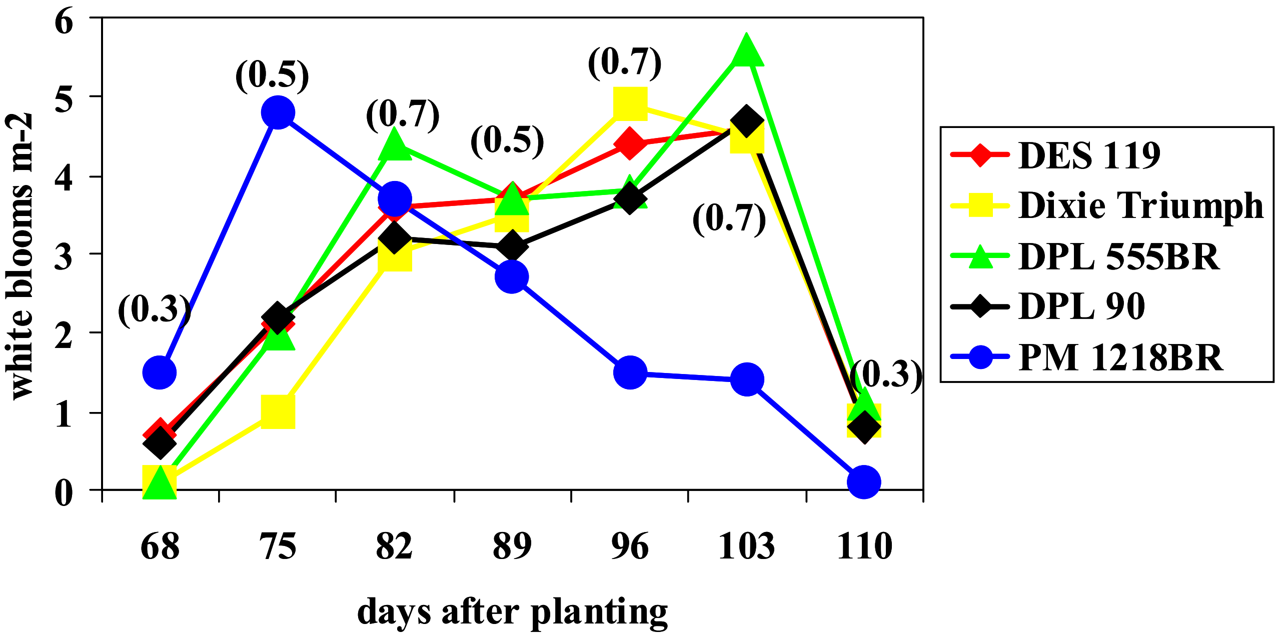

Figure 2. Flowers per meter per day as a function of days after planting for all cotton varieties studied in 2002. Numbers in parentheses indicate the least significant difference among K rates at the 0.05 level of probability; (ns) indicates no significant differences among K rates at the 0.05 level of probability.

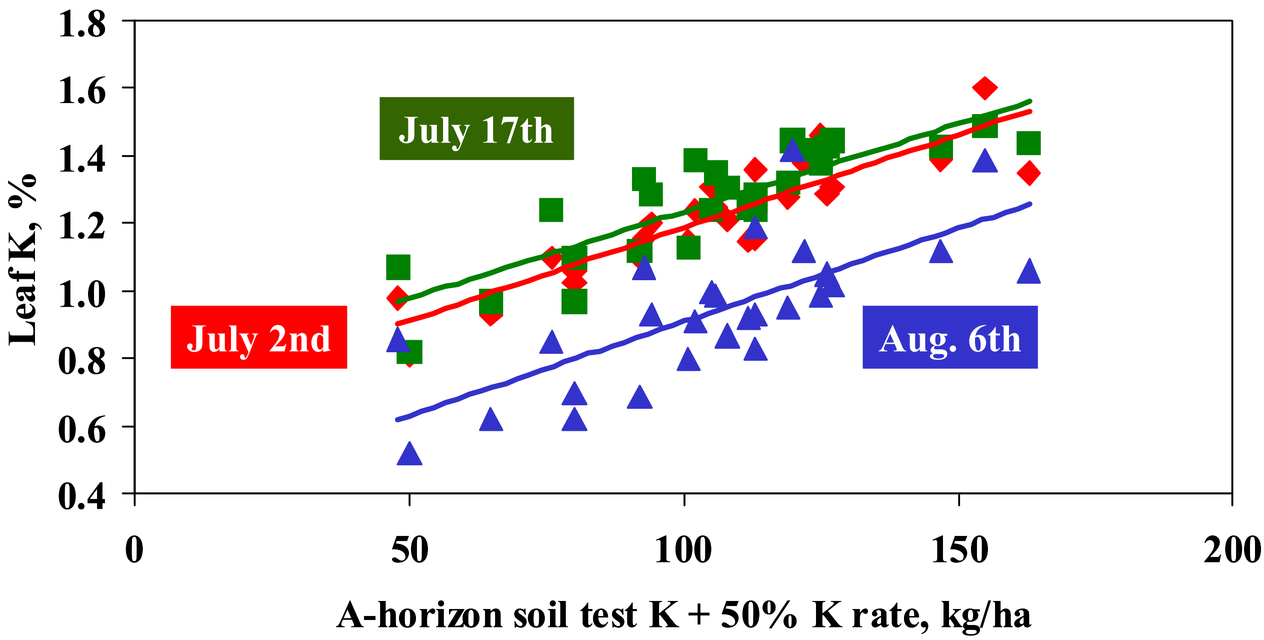

Figure 3. Relationship between soil K in the A horizon + 50% applied K rate and percent leaf K at early bloom (7/2/02), peak bloom (7/17/02) and cutout (8/6/02) for all varieties studied. July 2nd sample date ($y = 0.006x + 0.638$ $R^2 = 0.78$); July 17th sample date ($y = 0.005x + 0.719$ $R^2=0.72$); August 6th sample date ($y = 0.006x + 0.358$ $R^2 =0.53$).

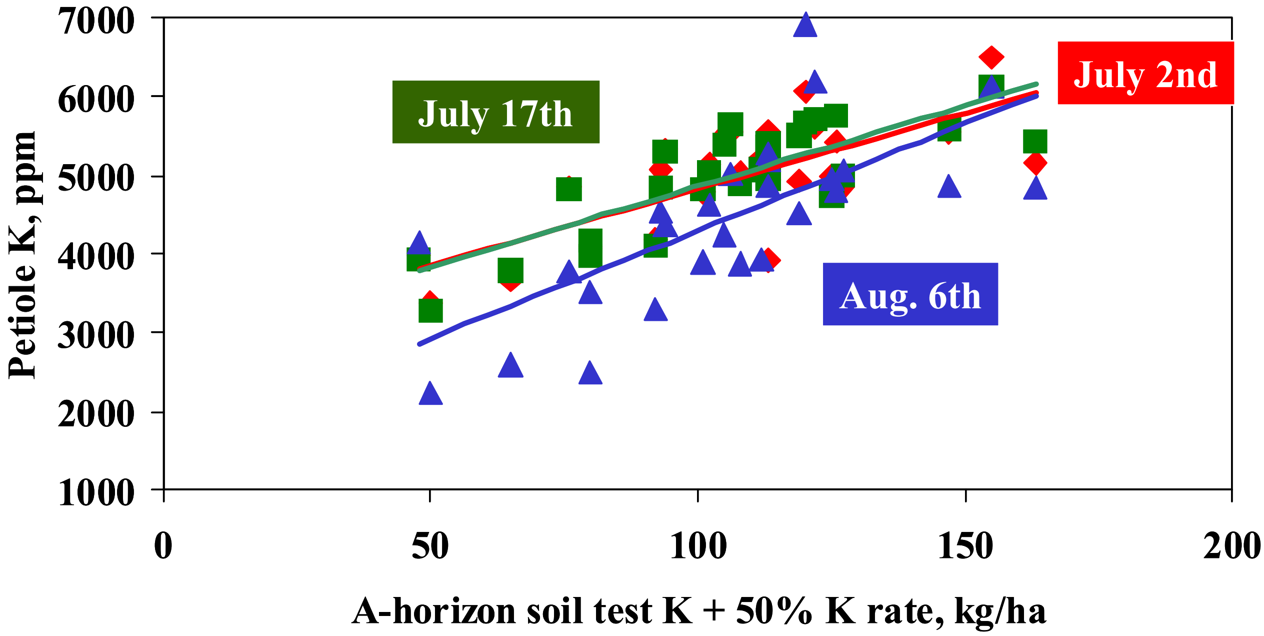

Figure 4. Relationship between soil K in the A horizon + 50% applied K rate and petiole K (ppm) at early bloom (7/2/02), peak bloom (7/17/02) and cutout (8/6/02) for all varieties studied. July 2nd sample date ($y = 19.43x + 2887.80$ $R^2 = 0.54$); July 17th sample date ($y = 20.65x + 2794.20$ $R^2=0.68$); August 6th sample date ($y = 27.33x + 1563.40$ $R^2 =0.50$).

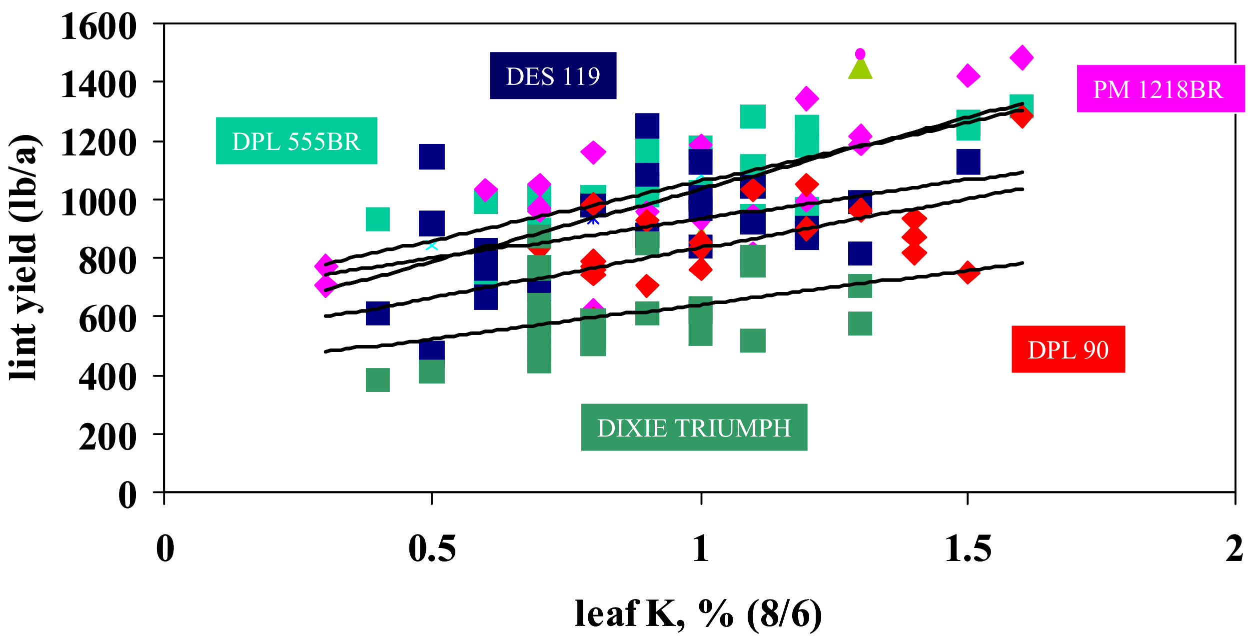

Figure 5. Relationship between lint yield and percent leaf K at cutout (8/6/02) for all varieties studied. DPL 555BR (y = 376x + 678 R^2 = 0.49); PM 1218BR (y = 491x + 543 R^2=0.48); DES 119 (y = 267x + 666 R^2 =0.20); DPL 90 (y = 337 + 497 R^2=0.39); Dixie Triumph (y = 233x + 409 R^2=0.16).

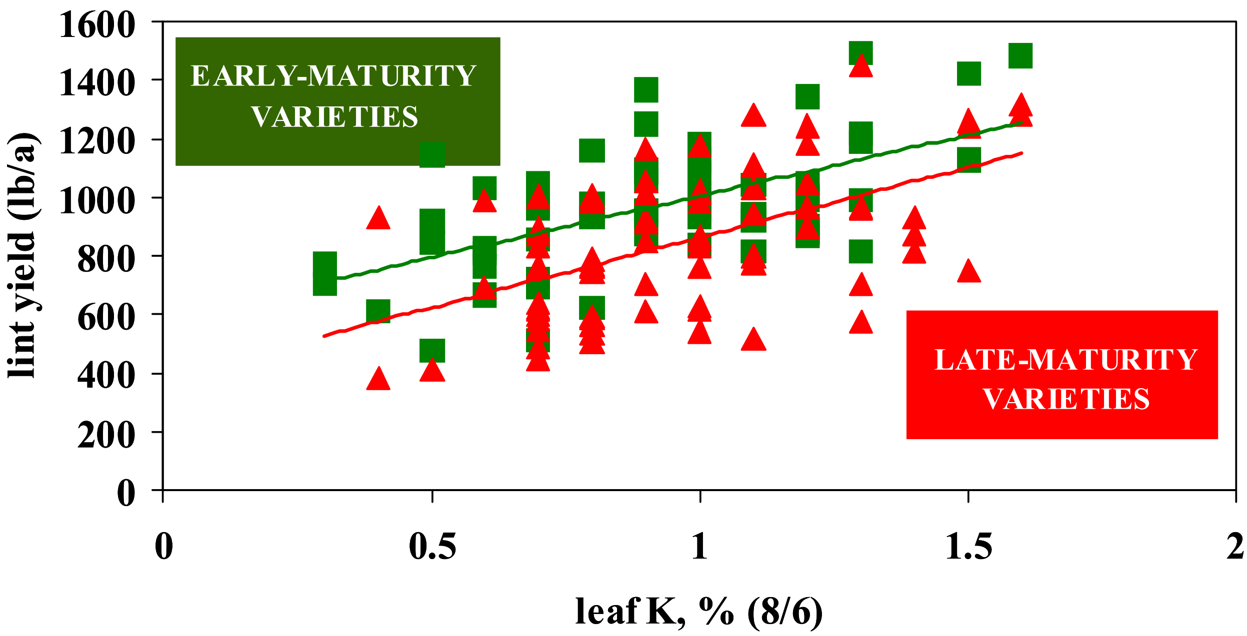

Figure 6. Relationship between lint yield and percent leaf K at cutout (8/6/02) for all varieties studied. Early-maturity varieties (y = 418x + 586 R^2 = 0.34); Late-maturity varieties (y = 479x + 384 R^2=0.30).

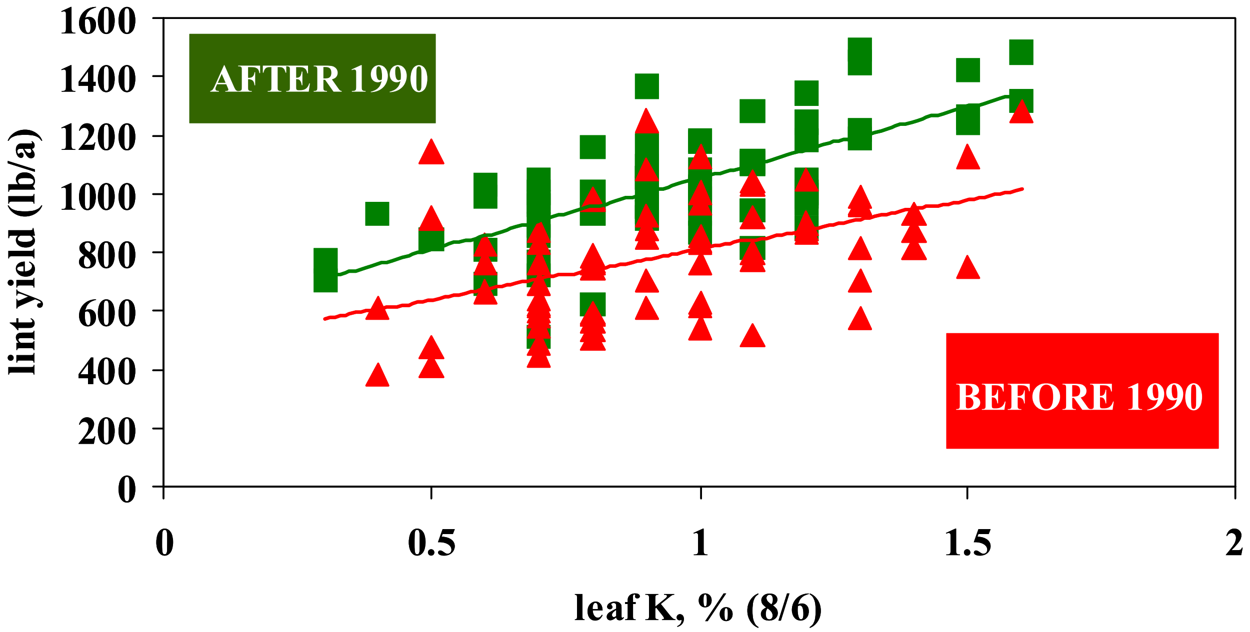

Figure 7. Relationship between lint yield and percent leaf K at cutout (8/6/02) for all varieties studied. Varieties released before 1990 (y = 341x + 470 R^2 = 0.22); Varieties released after 1990 (y = 486x + 567 R^2=0.49).


Dixie Triumph
0 K2O/A
7/24/02