NORTH CAROLINA

Tracking Phosphorus Response of Cotton

By C.R. Crozier, B. Walls, D.H. Hardy, and J.S. Barnes

Dramatic crop responses to phosphorus (P) gradients highlight the need for adequate P fertility. Leaf tissue analysis should be a useful indicator of the effectiveness of a fertilization strategy based on soil testing, and may serve to identify conditions where either a sufficiency level or a build-maintenance strategy is most appropriate.

Current P management recommendations for cotton in North Carolina are based on soil test levels. Although P responses have been characterized for numerous crops, there is very little information from North Carolina, or other states, regarding cotton yields at different Mehlich-3 extractable P levels. Plant tissue analysis is primarily used to assess the nitrogen (N), potassium (K), sulfur (S), and micronutrient status, but can also provide useful information concerning P sufficiency. We are interested in the degree to which the P fertilization program in North Carolina successfully avoided P limitations. This information might help producers decide whether or not a sufficiency level strategy is adequate or a build-maintenance strategy is warranted.

Our work characterized response of cotton to P gradients at three long-term soil fertility sites (**Table 1**).

Soil test P

Fertilizer treatments resulted in readily detectable soil fertility gradients and lint yield responses for all site-years (**Figures 1a, 1b, 1c, 1d, 1e**). We used a linear-plateau regression procedure to mathematically define the break point (critical level) between two portions of the response relationship: a region of linear yield increase and a plateau region. Yield plateaus were identifiable for 4 of these 5 site-years (**Table 2**). In some cases, since few sample points existed beyond the plateau level, additional data are needed to clearly demonstrate critical levels. The mean Mehlich-3 soil P level at which the yield plateau was attained was 40 parts per million (ppm) at the Tidewater site and 21 ppm at the Peanut Belt site. Higher yields at the Tidewater site, and perhaps soil differences, may have been responsible for differences between these sites. No yield plateau was observed at the Piedmont site. Yields at this site suffered from drought stress, and it had been abandoned from the research

TABLE 1. Field sites and characteristics. North Carolina experiments reported here were conducted 1998-2002.[1]

Research station	Soil series[2]	Date established	P treatments, lb P_2O_5/A	Mehlich-3 soil test P gradient[3], ppm[4]
Peanut Belt	Goldsboro	1982	0, 20, 40, 80	8 to 95
Piedmont	Hiwassee	1985	0, 20, 40, 80	0 to 14
Tidewater	Portsmouth	1966	0, 20, 40, 80, 120	20 to 109

[1]P treatments were applied intermittently over years, but annually during the years reported here, 1998-2002.
[2]Goldsboro = Aquic Paleudult; Hiwassee = Rhodic Kanhapludulf; Portsmouth = Typic Umbraquult.
[3]Range of soil test values observed at most recent sampling date.
[4]ppm is equivalent to mg/kg.

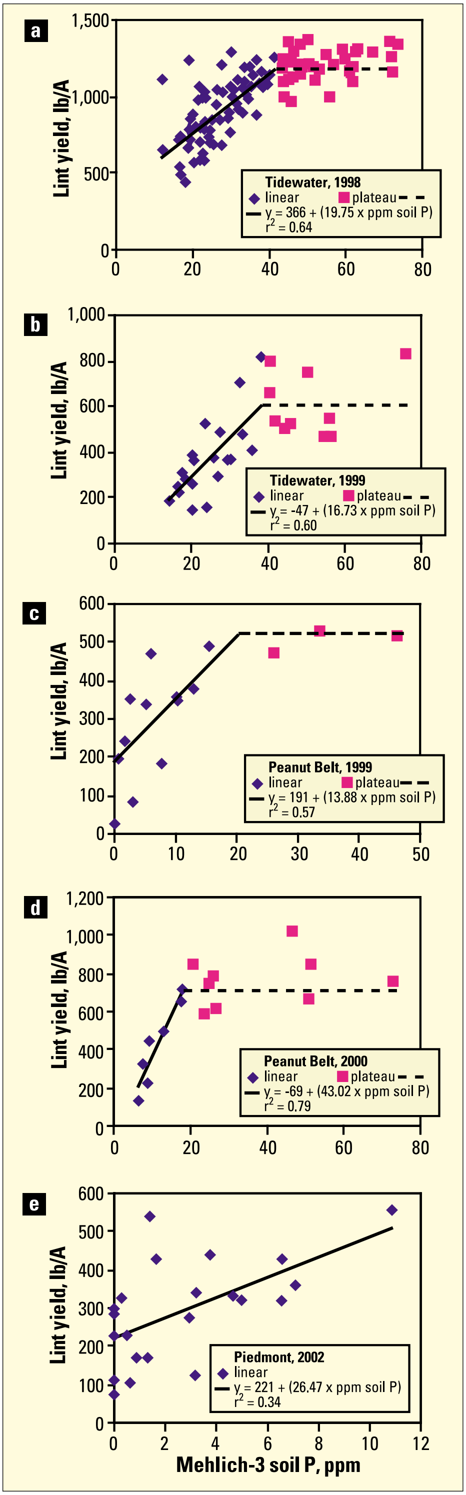

TABLE 2. Mehlich-3 soil P levels at yield response plateau (critical level) based on linear-plateau regression models. Symbols (---) indicate no yield plateau was observed.

Site	Year	Soil P concentration at yield plateau, ppm
Tidewater	1998	41.8
Tidewater	1999	38.3
Peanut Belt	1999	22.1
Peanut Belt	2002	19.1
Piedmont	2002	---

treatments for several years prior to the 2002 crop. Additional P applications may be needed to expand the range of soil test P levels at the Piedmont site.

Leaf P

Likewise, yield increased as leaf P concentration increased, with critical levels or plateaus also identified for 3 of the 5 site-years based on leaf samples collected one week after first bloom (**Figure 2a, 2b, 2c, 2d, 2e**).

Mean leaf P levels at which yield plateaus were attained declined from 0.31% P the week prior to first bloom, to 0.20% five weeks after first bloom (**Table 3**). In contrast to differences between sites observed for soil data, yield responses to leaf P gradients appeared similar for the Tidewater and Peanut Belt sites. As with the soil test P response, no yield plateau was observed at the Piedmont site in response to leaf P concentration.

Although there are not many published critical levels and there is variation among the reports, our responses seem similar to values reported previously. A recent study reported a critical soil test P level of 12 ppm at the Peanut Belt site, which was lower than

Figure 1. Yield response of cotton to soil Mehlich-3 P levels at (a) Tidewater Research Station 1998, (b) Tidewater Research Station 1999, (c) Peanut Belt Research Station 1999, (d) Peanut Belt Research Station 2002, and (e) Piedmont Research Station 2002.

TABLE 3. Leaf P levels at yield response plateau based on linear-plateau regression models. Leaf sampling dates are relative to first bloom. Symbols (- - -) indicate no yield plateau was observed.

Site	Year	Sampling date	Concentration at yield plateau, %
Tidewater	1998	+1 week	0.242
Tidewater	1999	+1 week	0.208
Peanut Belt	1999	+1 week	0.225
Peanut Belt	1999	+3 week	0.254
Peanut Belt	1999	+5 week	0.181
Peanut Belt	2002	-1 week	0.310
Peanut Belt	2002	+1 week	- - -
Peanut Belt	2002	+3 week	- - -
Peanut Belt	2002	+5 week	0.223
Piedmont	2002	-1 week	- - -
Piedmont	2002	+1 week	- - -
Piedmont	2002	+3 week	- - -
Piedmont	2002	+5 week	- - -

our results (**Table 4**). Yield potential in the previous study (Cox and Barnes, 2002) may have been limited by inadequate K, which is now being applied at higher rates for our work. Mehlich-1 extractable critical P levels summarized by Chapman (1966) ranged from 8 to 12 ppm for sandy Coastal Plain regions. Higher production levels with adequate overall fertility levels, newer crop varieties, and the use of different soil extractants may explain differences among studies. Our leaf tissue data reflect a similar trend of declining P over time as in the currently used sufficiency ranges for the Southeast (Mitchell and Baker, 2000): 0.20 to 0.65% for the vegetative/early bloom stage; 0.15 to 0.60% for the late bloom stage. They are also similar to data summarized by Chapman (1966), suggesting a critical level of 0.28% at first square and

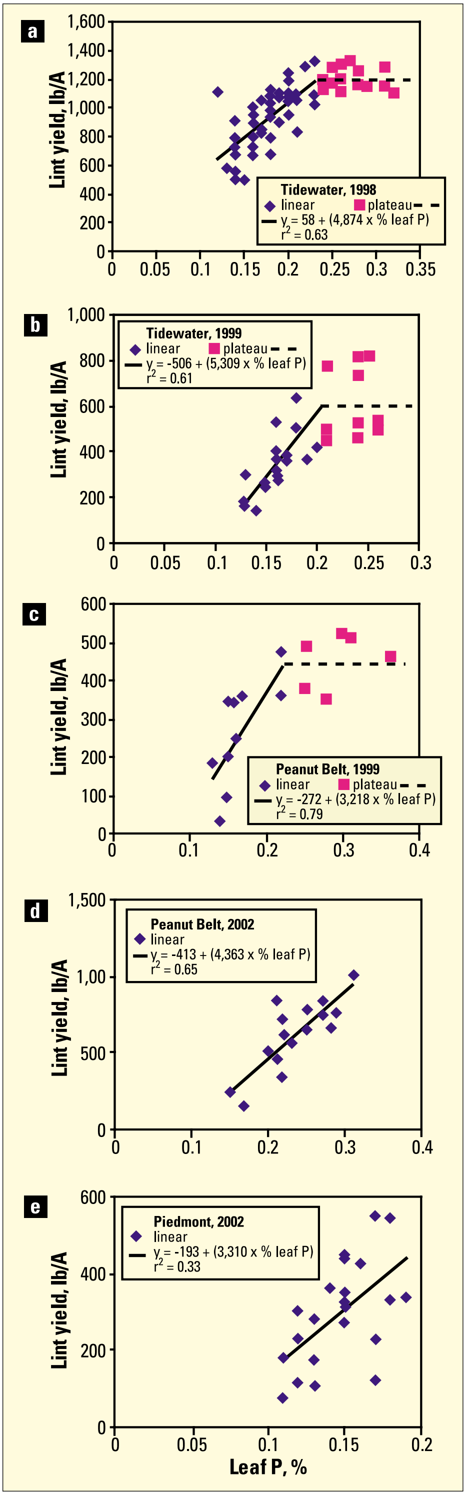

Figure 2. Yield response of cotton to leaf P levels in samples collected 1 week after first bloom at (a) Tidewater Research Station 1998, (b) Tidewater Research Station 1999, (c) Peanut Belt Research Station 1999, (d) Peanut Belt Research Station 2002, and (e) Piedmont Research Station 2002.

TABLE 4. Soil and leaf critical P levels for optimal yields or sufficiency ranges based on this study and other references.

Parameter	Our work[1]	NC Coastal Plain study, Cox & Barnes, 2002	Southern region guidelines, 2000	Literature review, Chapman, 1966
Soil P, ppm	Tidewater: 40 Peanut Belt: 21 (Mehlich-3)	12 (Mehlich-3)	- - -	Clays: 6 to 7 Sands: 8 to 12 (Mehlich-1)
Leaf P, %				
-1 week	0.310	- - -		0.28[2]
+1 week	0.225	- - -	0.20-0.65[3]	- - -
+3 week	0.254	0.210		0.20[4]
+5 week	0.202	- - -	0.15-0.60[5]	- - -

[1]Response plateau not identified all site-years. [2]First square. [3]Early bloom. [4]Flowering. [5]Late bloom/maturity.

0.20% during the flowering period.

Conclusions/Future Directions

Dramatic crop responses to soil test and leaf tissue P gradients highlight the need for adequate P fertility. Leaf tissue analysis should be a useful indicator of the effectiveness of a fertilization strategy based on soil testing, and may serve to identify conditions where either a sufficiency level or a build-maintenance strategy is most appropriate.

Our leaf data appear very similar to previously published values, while our soil data suggest higher P levels may be warranted for the Tidewater region soils than indicated in other studies limited to the sandy Coastal Plain environment. Differences between our results and previous publications illustrate the value of maintaining these long-term soil fertility tests: they permit periodic reassessment of fertilizer recommendations with newer varieties, new management practices, and different soil regions. Results from long-term studies encourage better cooperation among researchers to understand what might cause differences in crop responses.

There are only a limited number of similar long-term research sites in other states, which represent an opportunity for regional coordination to enhance understanding of the relationship among soil test concentrations, plant tissue concentrations, and crop yield.

Better fertilizer rate decisions made possible through such research should enhance farm profits and reduce any negative environmental impacts of farming. BC

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