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# Does N-P Starter Composition Affect Phosphate Availability in Cotton Soils?

Louisiana researchers find that N-P starters increase soil supply of phosphate even in soils that test very high, and that the amount of phosphate in the material, rather than the N:$P_2O_5$ ratio, is important.

***Summary:*** *Applications of N-P liquid starters may significantly increase cotton lint yields at some locations in some years. Likelihood of a response is greater if added material increases the soil supply of N, P, and other nutrients and/or stimulates cotton root growth. Research on ten diverse soils in Louisiana, Mississippi, and Arkansas cotton fields. showed that addition of N-P starter increased both solution and solid phase phosphate, even in soils initially testing very high in available phosphate. Increase in soil phosphate supply varied among soils, but tended to he a function of the total amount of phosphate in the starter rather than the* N:$P_2O_5$ *ratio. However, the* N:$P_2O_5$ *ratio affected the concentrations of K, S, and Zn in soil solution. Since nutrients in soil solution are those most readily available to plant roots, availability of these other elements can he affected by starter applications.*

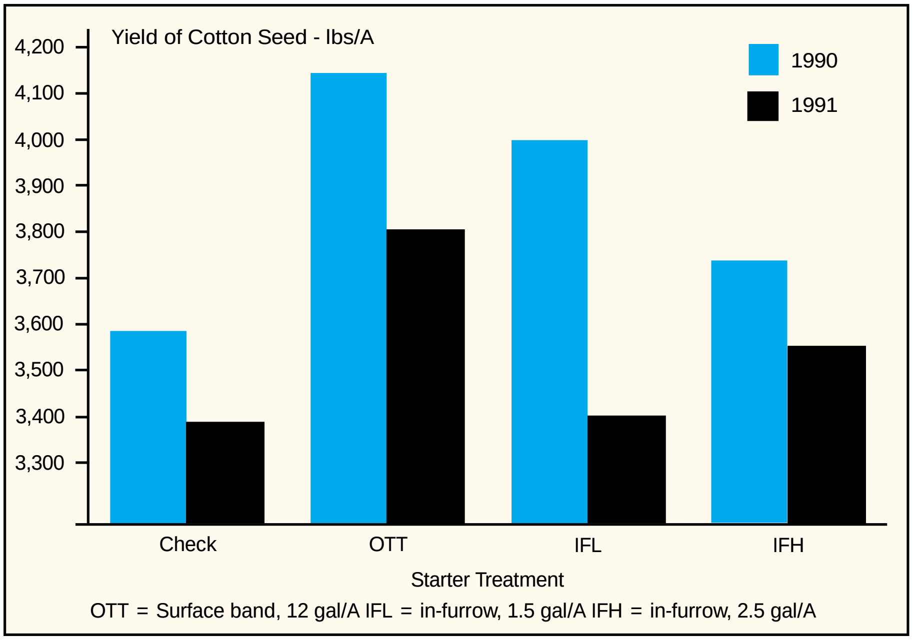
*Soil phosphate supply data were used in the Barber mechanistic model to predict phosphate uptake by young cotton plants. Results showed that the effect of the starter fertilizer was directly related to the relative increase in solution phosphate concentration after fertilizer application.*

Interest in starter fertilizer for cotton grown in the mid-South has increased during the last several years. Research in Louisiana, Mississippi, and Alabama has shown that applications of fertilizers containing nitrogen and phosphorus can significantly increase cotton lint yields. However, yield increases do not occur in every location each year (Figure 1). Due to these inconsistent responses, research continues on liquid starters for cotton grown in Louisiana and surrounding states.

In numerous studies, various N:$P_2O_5$ ratios (i.e., amounts of each nutrient) were added to different soils. This variation may have influenced root growth and distribution, and subsequent nutrient uptake by the crop. Research with other crop species, such as corn and soybeans, has shown that phosphate and nitrogen are able to stimulate root growth and, therefore, enhance nutrient uptake and grain yield in some soils. A similar response by cotton has been

**Table 1.** Grades of fluid starters and their N:$P_2O_5$ ratios, Kovar and Funderburg, Louisiana State University.

| Grade | N:$P_2O_5$ ratio |
|---|---|
| 0-0-0 | unfertilized |
| 15-7.5-0 | 2:1 |
| 15-15-0 | 1:1 |
| 7.5-15-0 | 1:2 |
| 5-15-0 | 1:3 |
| 15-15-5-2S-0.5 Zn | complete |



OTT = Surface band, 12 gal/A IFL = in-furrow, 1.5 gal/A IFH = in-furrow, 2.5 gal/A

Figure 1. Effect of ammonium polyphosphate (11-37-0) starter application rate and placement on cotton yields, Kovar and Funderburg, Louisiana State University.

reported at a limited number of locations. Yield increases also have been observed when potassium, sulfur, and other nutrients were included in the starter.

## Approach

*Prediction.* In order to predict response of cotton to an application of N-P starter on a wide variety of soils, we focused on changes in the soil supply characteristics of phosphate resulting from the fertilizer addition. Soil supply of phosphate can be affected by soil type, inherent phosphate levels, interaction of the added nitrogen and phosphate, and the effect of other nutrients applied with nitrogen and phosphate. For example, S added as ammonium thiosulfate (12-0-0-26S) causes acidification in the fertilized zone of high pH soils, which can result in greater phosphate availability. In general, when the soil supply of phosphate increases as a result of starter application, the probability of an early growth response also increases.

**Table 2.** Predicted uptake of phosphorus for three selected soils, Kovar and Funderburg, Louisiana State University.

| Soil | Treatment | Predicted P Uptake | Relative Increase |
|---|---|---|---|
| | N:$P_2O_5$ | micro-moles | |
| Commerce | Unfertilized | 138.5 | —— |
| | 2:1 | 193.3 | 0.39 |
| | 1:1 | 194.4 | 0.40 |
| | 1:2 | 194.3 | 0.40 |
| | 1:3 | 194.4 | 0.40 |
| | Complete | 194.6 | 0.40 |
| Gigger | Unfertilized | 58.1 | —— |
| | 2:1 | 91.1 | 0.57 |
| | 1:1 | 112.3 | 0.93 |
| | 1:2 | 114.8 | 0.98 |
| | 1:3 | 114.9 | 0.98 |
| | Complete | 118.0 | 1.03 |
| Gigger-Gilbert | Unfertilized | 26.9 | —— |
| | 2:1 | 46.7 | 0.74 |
| | 1:1 | 73.3 | 1.73 |
| | 1:2 | 74.2 | 1.76 |
| | 1:3 | 79.1 | 1.94 |
| | Complete | 86.2 | 2.21 |

**Table 3.** Concentrations of phosphorus, potassium, sulfur, and zinc in soil solution of three selected soils. Data are means of three replicates, Kovar and Funderburg, Louisiana State University.

| | | Soil solution concentration | | | |
|---|---|---|---|---|---|
| Soil | Treatment | P | K | S | Zn |
| | N:$P_2O_5$ | ppm | | | |
| Commerce | Unfertilized | 0.19 | 49.0 | 39.1 | 0.17 |
| | 2:1 | 3.76 | 142.7 | 30.5 | 1.43 |
| | 1:1 | 12.46 | 147.4 | 50.8 | 1.33 |
| | 1:2 | 11.76 | 97.8 | 51.1 | 0.80 |
| | 1:3 | 13.91 | 85.0 | 57.1 | 0.41 |
| | Complete | 23.88 | 160.0 | 962.2 | 1.62 |
| Gigger | Unfertilized | 0.06 | 21.8 | 18.8 | 0.07 |
| | 2:1 | 0.31 | 75.7 | 8.3 | 0.39 |
| | 1:1 | 0.93 | 81.9 | 13.6 | 0.39 |
| | 1:2 | 1.26 | 44.5 | 29.1 | 0.17 |
| | 1:3 | 1.27 | 41.9 | 32.2 | 0.06 |
| | Complete | 2.61 | 111.1 | 942.2 | 1.11 |
| Gigger- | Unfertilized | 0.03 | 20.4 | 12.8 | 0.04 |
| | 2:1 | 0.15 | 76.2 | 5.5 | 0.45 |
| | 1:1 | 0.54 | 83.5 | 10.2 | 0.42 |
| | 1:2 | 0.58 | 43.5 | 12.6 | 0.18 |
| | 1:3 | 0.74 | 35.4 | 19.0 | 0.11 |
| | Complete | 1.43 | 98.3 | 1,256.8 | 0.42 |

*Sampling.* The procedure used was to collect samples of various soil types from a number of areas where cotton is grown, measure the effect of fertilizer application with a range of N:$P_2O_5$ ratios on soil supply of phosphate, and then use a mechanistic uptake model, such as that developed by Barber and his co-workers, to predict response. Calculation To calculate uptake, the model mathematically relates: I) size and morphology of the root system, 2) ability of the roots to absorb nutrients, and 3) soil supply of nutrient ions to the root by mass flow and diffusion. In the model, soil supply of nutrients is described by three parameters: 1) the initial ion concentration in soil solution, 2) buffer power (which is the ability of solid phase ions to maintain the concentration of ions in solution as they are absorbed by roots), and 3) the effective diffusion coefficient of the ion (which describes the movement of the ion through the soil to the root surface). Addition of various amounts of nitrogen and phosphate, as well as other nutrients, affects these soil supply parameters. By holding root growth and phosphate absorption parameters constant and measuring the changes in soil supply parameters, calculated uptake will reflect only soil differences.

*Soils/treatments.* We collected ten surface soils representing those on which cotton is grown in Louisiana, Arkansas, and Mississippi. Initially available phosphate, as determined by Bray 2 extraction, varied from a medium level (82 ppm) to a very high level (518 ppm) among the soils. Solution fertilizers were sprayed onto the soil in the grades shown in Table 1. Soil and fertilizer were thoroughly mixed.

*Sources.* Fertilizer sources were ammonium polyphosphate (11- 37-0) as a phosphate source, UAN (32-0-0) as a nitrogen source, and ammonium thiosulfate (12-0-0-26S) as a sulfur source. Potassium hydroxide (47% $K_2O$ and Sequestrene zinc (14.2% Zn) were the other source materials used.

## P soil supply

After a 21-day incubation, treatments were analyzed for amount of phosphate in soil solution. Soil solution was displaced with a displacement column method. Amount of phosphate adsorbed on the solid phase of the soil was determined with anion exchange resin, Buffer power and effective coefficients for phosphate then were calculated for each treatment.
Addition of starter fertilizer increased both solution and solid phase phosphate for all soils in this study. The increase in both solution phosphate and solid phase phosphate tended to be a function of the total amount of phosphate in the starter, rather than the $N:P_2O_5$ ratio. An obvious exception was the concentration in solution displaced from treatments that had complete starter fertilizer applied. Sulfate in this material had an acidifying effect; therefore, additional phosphate was released into solution. Since phosphate in solution is the most readily available form, this may affect phosphate uptake. It's worthwhile to note, however, that solid phase phosphate was not affected by sulfate addition.

## Predicting uptake

Soil supply data for phosphate were used in the Barber mechanistic model to predict phosphate uptake by young cotton plants (Table 2). The relative increase in phosphate uptake due to starter applications was calculated for each treatment.

Effect of the starter was directly related to the relative increase in solution phosphate concentration after fertilizer application. Although total uptake was greatest for Commerce silt loam, the relative increase in phosphate uptake was less, due to the greater inherent solution phosphate concentration. The relative increase in phosphate uptake was greatest for the Gigger-Gilbert complex, which had less inherent solution phosphate.
Considering previous research on effectiveness of phosphate placement, these results can be expected. However, total phosphate required to improve cotton growth and yield may be greater than can be supplied by the Gigger-Gilbert com-plex, even though available phosphate (as predicted by the model) was increased by starter application. In this case, benefit from starter application would be more effective use of applied phosphate, rather than a significant yield increase.

## Nutrient interactions

In order to determine overall effect of starter applications, interactive effects were also considered. Data in Table 3 show the effect of starter application on concentrations of P, K, S, and Zn in soil solution. The $N:P_2O_5$ ratio obviously affected the concentrations. Since nutrients in soil solution are those most readily available to plant roots, availability of other elements also was affected by the starter applications. As expected, highest concentrations were measured in treatments with complete starter applications.

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