TEXAS

# A Closer Look at Phosphorus Stratification in Soils

By C.G. Coffman

Average corn grain yields have increased markedly in the U.S. since the mid-1930s. The development of hybrid corn in the late 1930s gave rise to a significant increase in corn grain yields. Another major contributing factor to the yield increases experienced after the early 1950s was the rapid adoption and increased use of commercial fertilizer on corn fields. Phosphorus fertilizer had a significant role in the yield increases experienced by corn producers.

In an effort to address concerns about phosphorus (P) fertilizer recommendations, soil samples were collected at various depth increments from seven fields across much of Texas. The samples were then analyzed for P, using different extractant procedures. This article presents and discusses the results of these analyses relative to the stratification of P in Texas soils.

Soil testing laboratories at the land grant universities across the U.S. aided in the assessment of the need for P fertilization of corn fields. Some fields were inherently low in available P, while others were adequately supplied with this essential plant nutrient. When P was needed on Texas corn fields, applications generally were made by broadcasting the fertilizer on the soil surface prior to primary tillage operations. During the past decade or two, there has been an increasing number of crop producers applying P fertilizer in-furrow at planting or near the seed.

Seedbed preparation in most corn fields across Texas, until the early 1980s, included relatively deep (8 to 12 inches) primary tillage operations. However, during the last fifteen years, conservation of crop residue on the soil surface and reduced tillage have been adopted extensively by corn producers. During this period of time, an increasing number of complaints have been received by the Soil Testing Laboratory at Texas A&M University concerning the perceived lack

**TABLE 1.** Phosphorus concentrations of soil samples collected from seven farms analyzed using the "Acidified Ammonium Acetate" procedure at Texas A&M University.

| Soil depth, inches | Phosphorus concentrations of soil samples, ppm | | | | | | |
|---|---|---|---|---|---|---|---|
| | Donaldson Farm | Luling Farm | Baker Farm | Fleming Farm | Ejems Farm | Price Farm | Patman Farm |
| 0-3 | 170 | 73 | 66 | 85 | 41 | 121 | 129 |
| 3-6 | 168 | 68 | 53 | 59 | 16 | 37 | 67 |
| 6-9 | 102 | 42 | 29 | 26 | 12 | 14 | 39 |
| 9-12 | 67 | 24 | 28 | 22 | 10 | 14 | 33 |
| 12-18 | 67 | 16 | 28 | 22 | 12 | 15 | 25 |
| 18-24 | 70 | 14 | 27 | 22 | 13 | 18 | 20 |

**TABLE 2.** Phosphorus concentrations of soil samples collected from seven farms analyzed using the "Weak Bray" procedure at Kansas State University.

| Soil depth, inches | Phosphorus concentrations of soil samples, ppm | | | | | | |
|---|---|---|---|---|---|---|---|
| | Donaldson Farm | Luling Farm | Baker Farm | Fleming Farm | Ejems Farm | Price Farm | Patman Farm |
| 0-3 | 10 | 13 | 10 | 13 | 35 | 35 | 24 |
| 3-6 | 7 | 10 | 6 | 8 | 13 | 11 | 7 |
| 6-9 | 5 | 5 | 2 | 1 | 4 | 4 | 2 |
| 9-12 | 2 | 2 | 2 | 1 | 4 | 3 | 2 |
| 12-18 | 3 | 1 | 2 | 1 | 4 | 2 | 1 |
| 18-24 | 3 | 0 | 0 | 0 | 3 | 2 | 1 |

of correlation between the rate of P fertilizer recommended for corn fields and the grain yield responses obtained from the addition of P. Crop producers and others have been concerned that P fertilizer recommendations made by the soil testing laboratories are too conservative. Many producers believe that they have observed a crop response to annual applications of P, even when their soil test reports have recommended that none (or very low rates) be added.

## Phosphorus Levels by Depth

Soil cores were collected from the top 2 ft. of the profile at multiple locations across each of seven fields. Each core was sub-divided into six portions as follows: 0 to 3 in., 3 to 6 in., 6 to 9 in., 9 to 12 in., 12 to 18 in., and 18 to 24 in. The composite of the respective depth segments from each field were ground and dried, then analyzed using the following three extractants: Acidified Ammonium Acetate run by Texas A&M University; Weak Bray run by Kansas State University; and Mehlich 3 run by Oklahoma State University.

The P concentrations in the surface samples are significantly higher than those present in the lower soil segments (**Tables 1-3**). At all locations, the soil P concentrations decreased markedly below the top 3 to 6 in. segment. In some cases, the decrease occurred below the 0 to 3 in. segment. Using the values from the acidified ammonium acetate procedure (**Table 1**), the comparative P concentration in the top two segments (i.e., the 0 to 3 in. and the 3 to 6 in.) decreased by 61, 69, and 48 percent for the fields on the Ejems, Price, and Patman farms, respectively. The P concentration decreased from the 3 to 6 in. segment to the 6 to 9 in. segment by 39, 38, 45, and 56 percent for the fields from the Donaldson, Luling, Baker, and Fleming farms, respectively.

The test value of 44 parts per million (ppm) P was considered the "critical" level, above which P fertilizer was not recommended. Thus, using the average of the top two 3 in. soil segments, no P fertilizer

**TABLE 3.** Phosphorus concentrations of soil samples collected from seven farms analyzed using the "Mehlich 3" procedure at Oklahoma State University.

| Soil depth, inches | Phosphorus concentrations of soil samples, ppm | | | | | | |
|---|---|---|---|---|---|---|---|
| | Donaldson Farm | Luling Farm | Baker Farm | Fleming Farm | Ejems Farm | Price Farm | Patman Farm |
| 0-3 | 27 | 11 | 9 | 10 | 31 | 26 | 33 |
| 3-6 | 25 | 8 | 5 | 6 | 14 | 7 | 10 |
| 6-9 | 13 | 5 | 2 | 2 | 4 | 2 | 3 |
| 9-12 | 8 | 3 | 2 | 2 | 3 | 2 | 3 |
| 12-18 | 7 | 2 | 1 | 2 | 3 | 1 | 2 |
| 18-24 | 6 | 2 | 1 | 1 | 2 | 1 | 2 |

was recommended for six of the seven fields. However, the soil test P values from the 6 to 12 in. segments ranged from very low to medium, and suggest a grain yield response from P fertilizer applications.

Since P is relatively immobile in the soil, and with sampling of the soil being predominately from the top 6 in. of the profile for fertilizer recommendations, several questions arise: 1) "Should one rely on the 0 to 6 in. segment of the soil profile for fertilizer recommendations?" (Or, should the top 2 or 3 in. of each soil core be removed before compositing the samples for analysis?) 2) "Should P fertilizer be injected into the soil?" 3) "Will continued use of conservation tillage practices intensify the stratification of P in the surface soil layers?" 4) "How do extremely "dry" or "wet" growing conditions affect the absorption of P by crop roots, and the crop's yield response to additional P applications?" and 5) "How will the recommendations of other plant nutrients be affected if a different soil segment is used than the traditional 0 to 6 in. soil core?"

Certainly, the awareness of the P stratification in Texas soils has necessitated additional field studies to answer some of these questions.

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Research Notes

## *Alberta: Canola Root Rot and Yield Response to Liming and Tillage*

In this research, the effects of aglime were studied on conventional tillage and no-till systems. The aglime increased soil pH and nitrate-nitrogen ($NO_3$-N) in the top 8 inches of soil, but did not alter pH below 8 inches and had no effect on extractable phosphorus (P), exchangeable aluminum (Al), soil water, and ammonium-N ($NH_4$-N). Liming did suppress weed growth and reduced the severity of brown girdling root rot (BGRR). It also increased grain yield and dry matter production of canola.

Liming was effective in each tillage system, but was more effective with no-till. Tillage reduced both soil water and growth of canola. Reduced soil water...and increased weed populations...appeared to be responsible for reduced crop growth in the conventional tillage system.

*Source: Arshad, M.A., K.S. Gill, T.K. Turkington, and D.L. Woods. 1997. Agron. J. 89:17-22.*