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Phosphorus Rate Affects Phosphorus Movement

Nebraska researchers look at effects of different application rates and different soils on phosphorus diffusion as well as phosphorus longevity.

Summary: *Diffusion distances and apparent diffusion coefficients increased in a linear manner as P application rate increased. Longevity of banded P was shortest for the Sharpsburg soil with the highest P absorption capacity, and longest for the Coly soil with the lowest P-adsorption capacity. While most of the P movement occurs in the first few weeks after application, calculations indicate that bands may remain available for plant phosphate uptake from 2.6 to 6.5 years, depending on the soil and applied phosphate rate.*

Applied phosphate in the soil typically moves only a short distance. This movement is primarily by a diffusion process. Rate of phosphate diffusion is influenced by 1) amount of applied P, 2) soil water content/bulk density, and 3) chemical reaction of P with the soil. Studies indicate that deep-placed phosphate is better distributed for crop uptake than surface-applied phosphate because the latter tends to accumulate in surface soils.

Phosphate diffusion and movement also influence residual P effect, P longevity, and the probability that P-affected soil will be collected during soil sampling. The availability of residual-P bands is especially important with present-day emphasis on controlling soil erosion with surface residues and reduced tillage.

While banding is well known to increase P efficiency during the year of application, little research is available on the residual nature of P bands, especially when placed below tillage depth or in no-till systems. Studies have shown that P banded below tillage depth has had greater residual value than broadcast P or seed-applied P.

Objectives of this experiment were to determine 1) diffusion coefficients, 2) P movement, and 3) longevity of banded P in different soils.

Rate effect

Yield. It appears that greater yield responses due to higher phosphate rates may not be because of phosphate fertilizer exhaustion at lower phosphate rates. Instead, the cause may be the larger volume of P-affected soil associated with higher phosphate application rates.

Diffusion. In our studies, diffusion distance increased in a linear manner as phosphate application rate increased, with no significant differences observed between the three soils studied (Figure 1).

Longevity of banded phosphate also increased in a linear manner as phosphate application rate increased (Figure 2).

Soil effect

Adsorption. Amount of P adsorbed was highest for Sharpsburg soil and lowest for Coly soil. The P-adsorption coefficient for Sharpsburg soil was about two and five times higher than for Nora and Coly soils, respectively.

Diffusion. After 94 days, banded phosphate moved only a few inches from the center of applied P bands. Maximum movement was about 1.6 inches at 123 lbs/A of phosphate in the Nora soil (Figure1). Volume of soil being affected to a depth of 12 inches after 94 days ranged from 1.1 percent (Coly and Sharpsburg) to 5.2 percent (Nora). However, probability of contacting any part of the band at soil sampling ranged from 11.7 percent (Sharpsburg) to 25.9 percent (Nora). Research has shown that the surface area of P-affected soil influences plant uptake of added P since it affects the probability of root/P contact.

Longevity. Band longevity averaged across the phosphate rates was lower for Sharpsburg and Nora soils than for Coly soil (Figure 2). The Sharpsburg soil had the shortest longevity, averaging only 3.3 years across P rates, compared with 5.6 and 4.1 for Coly and Nora, respectively. It seems that the greater P-adsorption capacity of the Sharpsburg soil reduced the longevity of added phosphate. As shown in Figure 2, P longevity ranged from 2.6 years (Sharpsburg) to 7.4 years (Coly). Longevity was highest in the soil with the lowest P-adsorption capacity (Coly) and lowest for the soil with the highest P-adsorption capacity (Sharpsburg).

Sampling important

Because of the residual nature of these phosphate bands, it is important to

assess their availability with soil tests. The probability of contacting bands with standard soil sample procedures depends on the amount of soil affected by applied P.

While results do not allow accurate calculations of hand size for times other than 94 days, the probability of contacting these bands with standard soil-sampling procedures is quite high. Not only is the probability of contacting these P bands at soil sampling great, but the residual nature of these bands for plant uptake also could be substantial. Further research is needed to evaluate the residual nature of these bands and how soil sampling and soil test calibration can he altered to account for the residual effects of banding.

Fluids used

Fertilizer and rate. A 4-inch long band of APP (10-34-0) was injected into the soil at a depth of 2 inches. Application rates were 30, 46, 61, 77, 92, and 123 lbs/A of P_2O_5 with a band spacing of 12 inches. P was allowed to diffuse under field conditions on bare soil during the summer of 1986. Precipitation during the 94 days was 13.8 inches.

Soils. The top 6 inches of Coly silt loam and Nora silt loam were collected from small patches of fields in Sherman and Boone Counties in Nebraska, respectively. The top 12 inches of a Sharpsburg silty clay loam soil was removed at the Agricultural Research and Development Center at Mead, Nebraska.

Open boxes 12 inches deep were placed in the removed area and filled with Coly and Nora soils. Sharpsburg soil was used alongside of the boxes.

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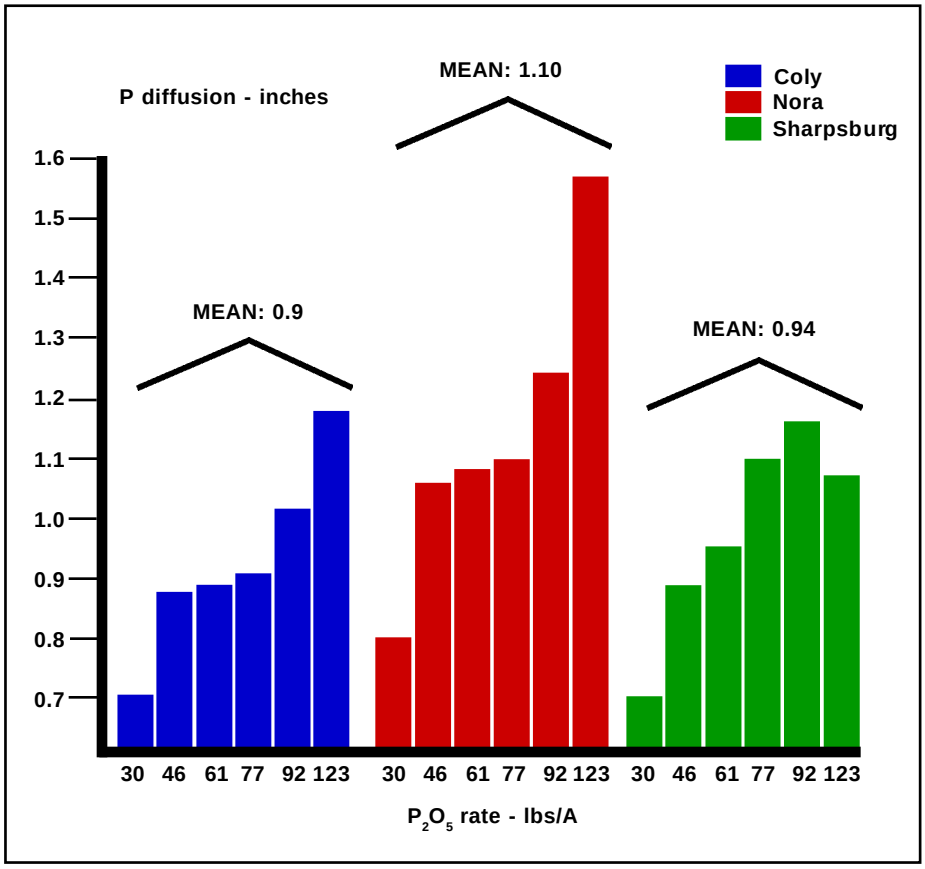

Figure 1. Apparent diffusion distances of banded P at different P rates in three soils, Eghball, et al., University of Nebraska, 1986.

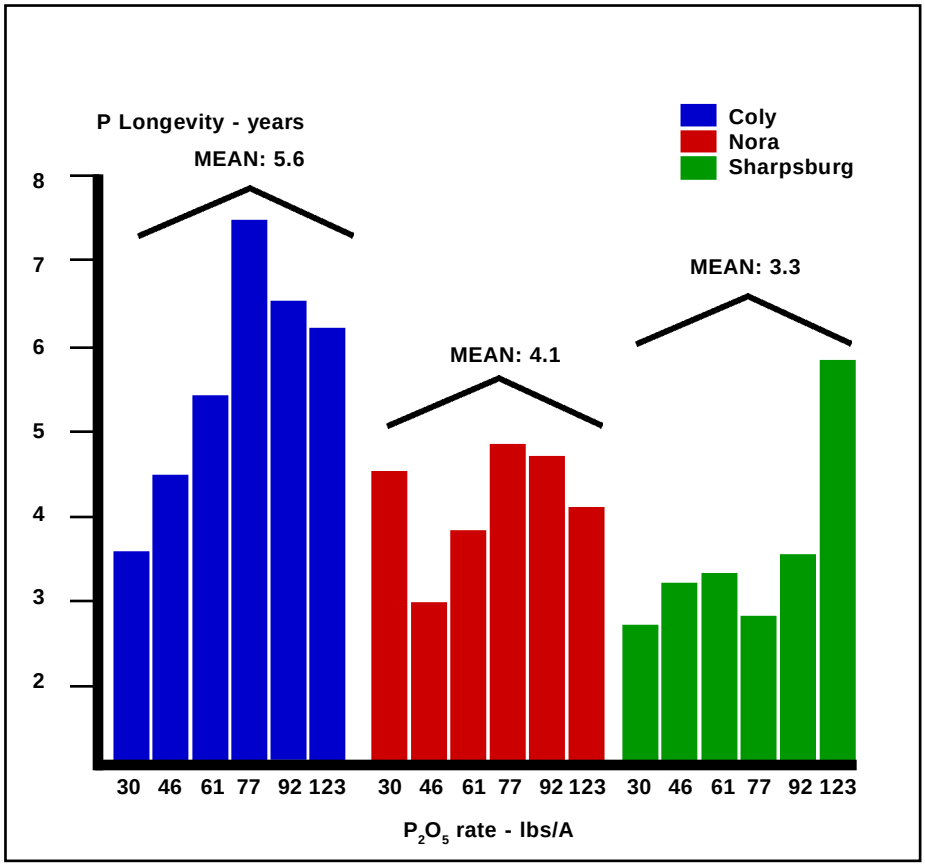

Figure 2. Apparent longevity of banded P at different P rate in three soils, Eghball, et al., University of Nebraska, 1986.