INFLUENCE OF TILLAGE AND PLACEMENT ON THE LOCATION OF PHOSPHORUS IN THE ROOT ZONE[1/]

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In recent years, the ridge-till planting operation and the use of the chisel plow have developed into the most widely accepted planting systems for conservation tillage in Minnesota. While there is opportunity to incorporate plant nutrients in the chisel plow system, previous studies have shown that this incorporation is shallow when compared to the moldboard plow system. The ridge-till system, on the other hand, offers only limited possibilities for fertilizer incorporation. Typical broadcast applications of immobile nutrients can lead to a high concentration near the soil surface. This stratification has been of concern to some. Yet, there has not been a documented incident where nutrient stratification has been harmful to crop growth.

Nutrients concentrated near the soil surface are also susceptible to loss when erosion occurs. Phosphorus and potassium remain attached to the soil particle and reach surface waters when rainfall and/or snow melt is sufficient to cause erosion.

Concerns which focus on nutrient stratification and environmental quality have stimulated efforts to look at alternatives to the traditional broadcast or starter applications of phosphorus and potassium in conservation tillage systems. This report describes the effect of tillage system and placement on the location of phosphorus in the upper portion of the root zone.

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Procedure

This study was initiated in the fall of 1983 at the Southern, Southwest, and West-Central Experiment Stations of the University of Minnesota. The objective was to measure the effect of rate and placement (broadcast, surface band, subsurface band) of a fertilizer supplying both P and K on corn and soybean production in both ridge-till and fall chisel tillage systems in situations where soil test levels for P and K were low and high. Treatments were repeated each year through the fall of 1986. The study was terminated at the end of the 1987 growing season.

Soil samples were collected from selected treatments at the Southern Experiment Station, Waseca in the fall of 1987. Except for the control and a treatment which had received a single large application of P_2O_5 and K_2O (440 and 870 lb./acre respectively) at a depth of 9 to 10 inches in the fall of 1983, all treatments had received 4 annual applications of 66 lb. P_2O_5 and 131 lb. K_2O per acre. Treatments selected represented 3 methods of placement (broadcast, surface band, subsurface band) in 2 tillage systems (ridge-till, fall chisel). The low fertility site was sampled.

Soil samples were taken from the depths of 0-3, 3-6, 6-9, 9-12 and 12-18 inches at 0, 3, 6, 9, 12, and 15 inches from the row, after harvest. This grid sampling procedure was repeated 6 times in each plot. The six samples from each depth at each distance from the row were combined, mixed and a subsample was taken for analysis. The Bray and Kurtz No. 1 procedure was used to measure P. A Golden Graphics (1983) computer program was used to draw the contour lines shown in Figures 1-5.

Phosphorus Distribution

The distribution of P in the upper portion of the root zone, after four years of repeated fertilizer application, was affected by both the tillage system used and the placement of the phosphate fertilizer. The amount of P in the control treatment extracted by the Bray and Kurtz procedure illustrates the influence of tillage (Figure 1). In the fall chisel system, the soil test P values were relatively uniform from the row to the mid point of the row. This would be expected in a fall chisel situation. In the ridge-till system, lower soil test P values were found closer to the soil surface near the ridge. This would indicate a high concentration of roots in the ridge which were active in the absorption of P. With the exception of the ridge, soil test values for P were higher than 10 ppm at a depth of 0-3 inches and lower than 10 ppm at all other depths.

As would be expected, soil test values for P increased substantially after 4 annual broadcast applications of 66 lb. P_2O_5 per acre (Figure 2). Compared to the control, the use of the fall chisel operation increased the soil test P values in the 3 to 6 inch depth. Soil test P values also increased near the soil surface. These values were relatively uniform from the row to the mid-point between two 30 inch rows. The P distribution was different for the ridge-till planting system in two ways. First, there was a substantial increase in soil test P to a depth of only 3 inches. Secondly, higher soil test P values were measured near the soil surface in the area of 6 to 15 inches from the row. This would indicate the accumulation of broadcast phosphate fertilizer in the middle of the row between the ridges. This broadcast phosphate is apparently was not moved to the row in the cultivation operation used to build the ridge. Cultivation, however, was apparently responsible for movement of broadcast phosphate fertilizer to a depth of 3 inches.

For the surface band placement, the phosphate fertilizer was applied on the surface in the middle of two 30 inch rows for both tillage systems. The fall chisel operation was completed after fertilizer application. Although not identical, the P distribution patterns were similar when the phosphate fertilizer was applied in a surface band for both tillage systems (Figure 3). The horizontal movement of P in the fall chisel system was less than expected. Yet, there was an increase in soil test P in the 3 to 6 in. depth with both tillage systems. Again, the highest values were near the soil surface. An increase in soil test P values would be expected in the fall chisel system. Cultivation probably contributed to the increase in P values at 3-6 inches in the ridge-till system.

The location of the subsurface band is shown in Figure 4. The goal was to apply this fertilizer at a depth of 5 to 6 inches in the middle of the row each year. In both tillage systems, the highest soil test

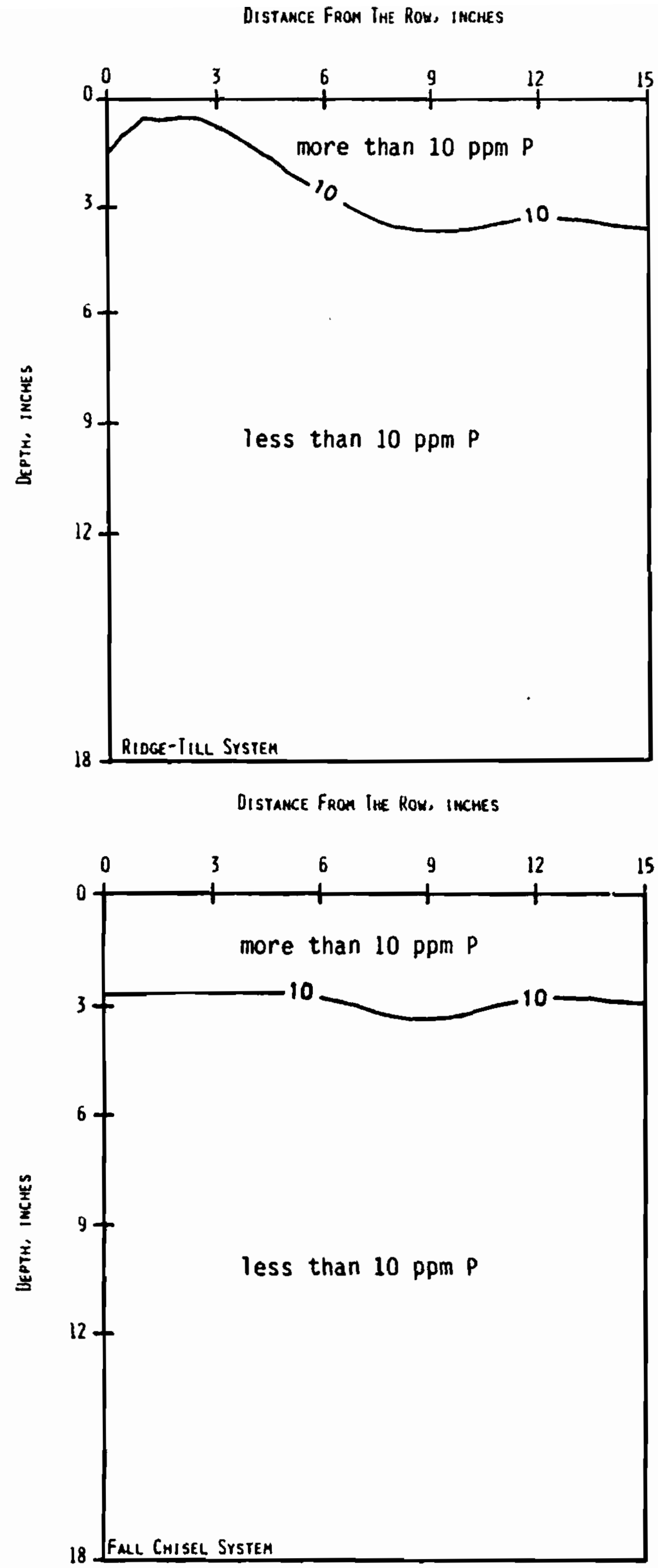


Figure 1. Soil test level for phosphorus in the control treatment as affected by tillage system. The numbered line separates the area where soil test values are higher than 10 ppm from the area where soil test values are less than 10 ppm.

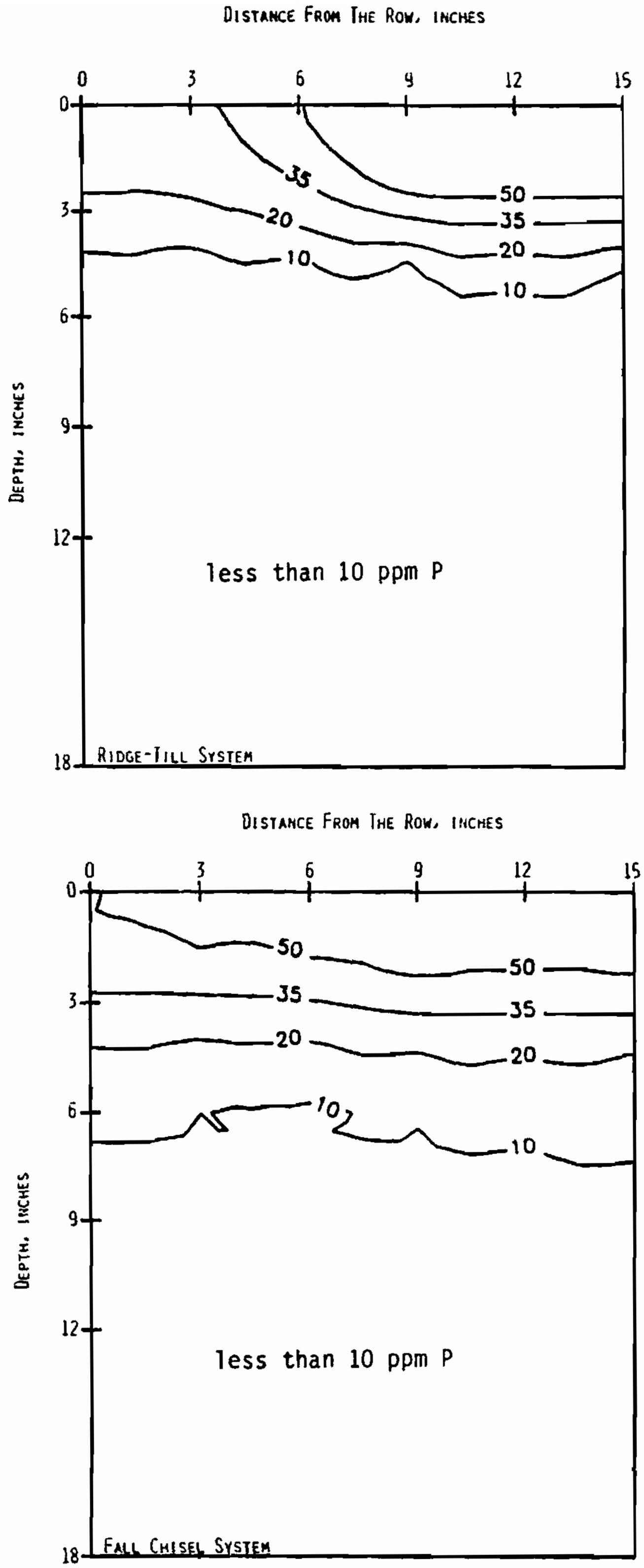


Figure 2. Soil test values for P after repeated broadcast applications in two tillage systems. The numbered lines represent soil test values for P.

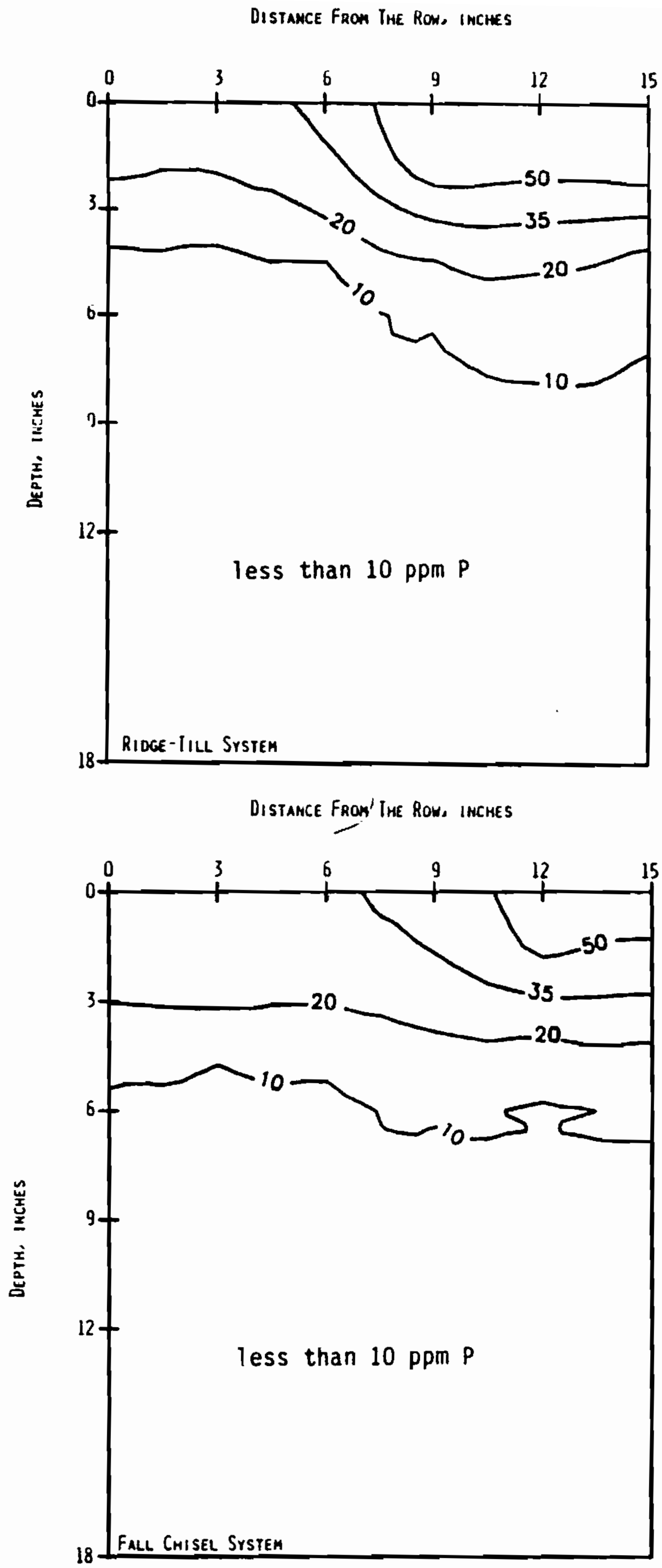
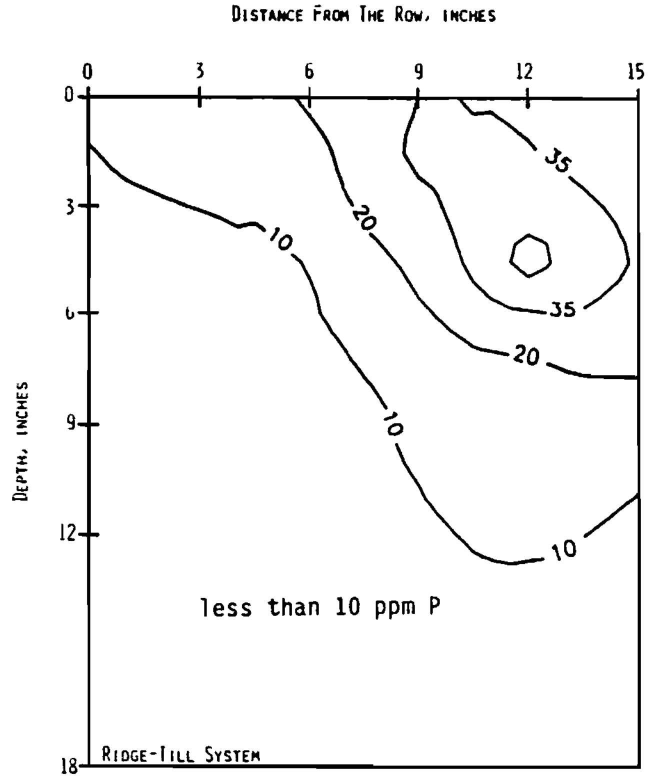


Figure 3. Soil test values for P after a repeated application of phosphate fertilizer in a surface band. The numbered lines represent soil test values for P.



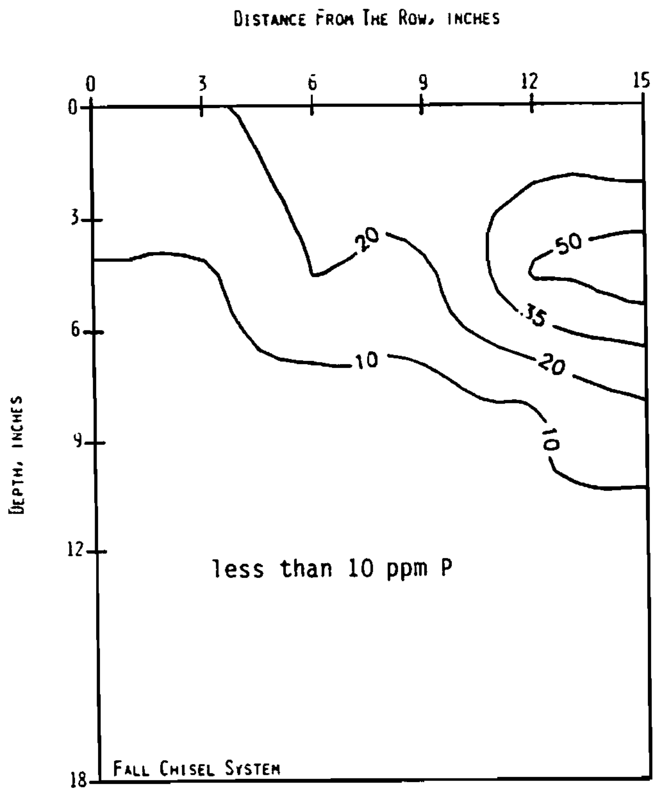


Figure 4. Soil test values for P after repeated application of phosphate fertilizer in a subsurface band. The numbered lines represent soil test values for P.

values for P are at approximately 5 inches. The fall chisel operation apparently did not disrupt the subsurface band. The relatively high soil test P values at 3 to 6 inch depth indicate that the subsurface band would be an accessible source of P for crop growth. The increase in soil test values to 9 inches indicates that there was probably some diffusion of P from the band.

Figure 5 shows the location of the band which was planned to be placed at a depth of 9-12 inches. This placement of 440 lb. P_2O_5 per acre was intended to provide a readily available source of P for several years. It appears that the center of the band is at a depth of approximately 8 inches. The analysis of the soil samples also shows that this band was not placed in the middle of two rows. The P in this band should be readily available to growing plants.

It is also apparent that this band was not disturbed by the fall chisel tillage operation. With the application of a high rate of P_2O_5 at one point, some downward movement of P would be expected. There was, apparently, some movement to 12 inches in both tillage systems.

The results of this study show that the tillage system has the most notable effect on broadcast applications of P. When both surface and subsurface bands are used for repeated application of fertilizer P, there is some movement of P. As would be expected, there are relatively high levels of soil test P in localized areas when these two placement methods are used.

The results of this study also indicate that some changes in recommendations for collection of soil samples might be needed if P fertilizers are repeatedly applied in both surface and subsurface bands in the ridge-till planting system. Much more research is needed, however, before these recommendations can be finalized.

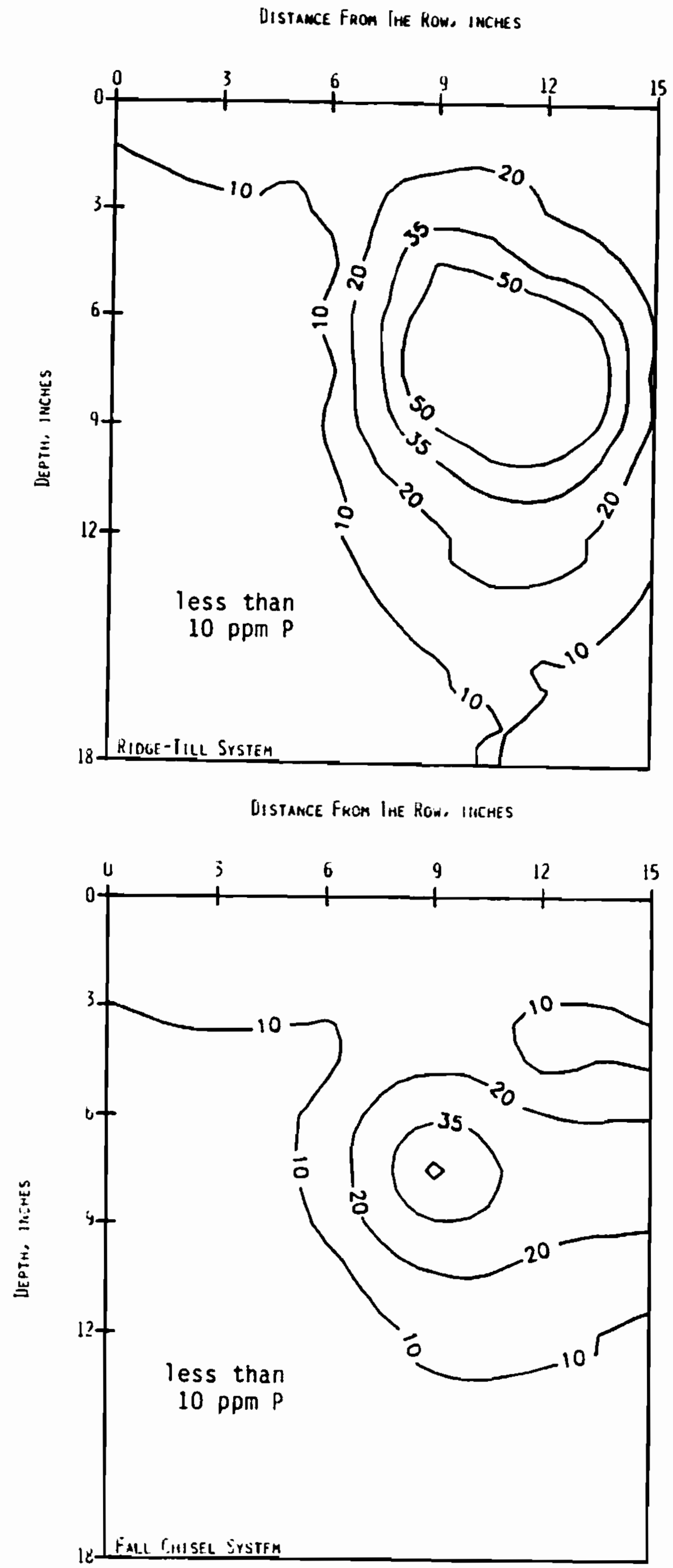


Figure 5. Soil test values for P resulting from a single application of 440 lb. P_2O_5/acre in a subsurface band in the fall of 1983. The numbered lines represent soil test values for P.

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CREDITS

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