FERTILIZER PLACEMENT IN TILLAGE SYSTEMS

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Stimulated by concerns for farm profitability, there has been an increasing interest in efficiency of fertilizer use in recent years. Consequently, there have been several questions which relate to the effect of placement on the efficient use of fertilizers.

Until recently, growers had 2 choices for applying phosphate and potash. They could either broadcast and incorporate sometime before planting or place the fertilizer in a band near the seed at planting (starter fertilizer). Recent developments and improvements in equipment now allow a grower to apply fertilizer in bands either on or below the soil service. These innovations now give the grower several options for placement of phosphate and potash.

The emphasis on conservation tillage production systems has also created an interest in fertilizer placement. This is especially true for the ridge-till and no-till situations. With no major soil disturbance in these systems, it is questionable, for example, if broadcast applications can be as effective as the application of nutrients in a band somewhere in the upper portion of the root zone.

Factors Affecting Placement Choice

It is doubtful if there is one method of fertilizer placement that is ideal for everyone. There are several factors that affect placement choices. Some of the most important are:

- nutrient mobility
- tillage system
- soil test levels
- crop grown
- soil moisture
- equipment availability

One or more of these factors may affect decisions about placement. The impact of most of these factors on fertilizer placement will be discussed in the paragraphs that follow.

The mobility of a specific nutrient in soils is a major consideration in placement decisions. Regardless of tillage system, nitrogen, moving with soil water, is mobile throughout the root zone. Therefore, initial placement should have little or no effect on efficient use. Placement can affect loss in tillage systems which leave relatively high amounts of residue on the soil surface. For these situations, the injection of liquid N sources and incorporation of broadcast urea are suggested management practices.

This discussion will be limited to the placement of phosphate and potash in tillage systems that are used for corn and soybean production.

Phosphate and Potash Placement in Two Tillage Systems

Studies were initiated in the fall of 1983 in Minnesota to measure the impact of various methods of fertilizer placement on corn and soybean production. Two tillage systems (ridge-till, fall chisel) were compared at 3 sites (Waseca, Lamberton, Morris). Sites were selected so as to provide a wide range in soil test values for P and K.

A suspension fertilizer (4-12-24) was 1) broadcast on the soil surface, 2) applied in a band on the soil surface, 3) applied in a band below the soil surface for each tillage system. Corn was grown in 1984 and 1985 and soybeans were grown in 1986. Treatments were reapplied each year. The rate of 4-12-24 used was held constant to supply 44 lb. P_2O_5/acre and 87 lb. K_2O per acre each year regardless of placement. Starter application was held constant at 100 lb. of 7-21-7 per acre each year.

The impact of placement on corn yield in a ridge-till system where soil test values for P and K were in the low range is summarized in Table 1. In both 1984 and 1985, use of starter at the rate selected only, was not adequate for optimum yield. Highest yields were produced by the use of the subsurface band in combination with a starter fertilizer.

As might be expected, broadcast application of phosphate and potash produced the lowest yield when the three methods of placement are compared. Except for cultivation, there is very little soil disturbance in the ridge-till planting system. Since both phosphate and potash are not mobile in soils, these nutrients, if broadcast, are not incorporated into the root zone in the ridge-till planting system. Consequently, uptake is reduced and yields are lower.

Table 1. Influence of placement of phosphate and potash on corn yield in a ridge-till planting system when soil test levels for P and K are in the low range

	Year			
	1984		1985	
Placement	With Starter	No Starter	With Starter	No Starter
	bu./acre			
	82	75	93	84
Broadcast	88	83	118	117
Surface Band	98	99	127	119
Subsurface Band 1	09	106	138	128

Bray #1 P = 7 ppm; Soil Test K = 95 ppm; pH = 6.1

With the fall chisel system and low soil test values for P and K, highest yield in 1985 was produced by the use of the subsurface band in combination with a starter fertilizer (Table 2). Again, use of a starter only was not adequate for optimum yield. The effects of placement, however, were not consistent in the fall chisel system. In 1984, the surface and subsurface bands produced equal yields. Both were better than a broadcast application.

In this study, fertilizer was applied before the fall chisel operation. Therefore, some of the phosphate and potash applied in both the broadcast and surface band placements would have been incorporated into the upper portion of the root zone. Soil moisture differences varied the depth of chiseling each year. This could help to explain the inconsistent effects of placement.

Table 2. Influence of placement of phosphate and potash on corn yields in a fall chisel tillage system when soil test levels for P and K are in the low range.

	Year			
	1984		1985	
Placement	With Starter	No Starter	With Starter	No Starter
	bu./acre			
	82	74	87	79
Broadcast	99	99	123	117
Surface Band	107	100	109	111
Subsurface Band	105	109	133	123

Bray #1 P = 7 ppm; Soil Test K = 95 ppm; pH = 6.1

After evaluating yield data from all sites, it appears that the use of the subsurface band is best suited for ridge-till planting systems where soil test values for P and/or K are low or very low. It is also apparent that the subsurface band should be combined with a starter fertili
zer.

Corn yields were not affected by fertilizer placement when soil test levels for P and K were in the high or very high range (Table 3). Although data from 1984 are shown, this conclusion was reached in both years of the study. So, the knowledge of soil test levels is important in reaching a placement decision.

Table 3. The influence of fertilizer placement on corn yields in 1984 for both ridge-till and fall chisel planting systems when soil test levels for P and K are in the high or very high range.

	Tillage System			
	Ridge-till		Fall Chisel	
Placement	With Starter	No Starter	With Starter	No Starter
	bu./acre			
	154	150	157	151
Broadcast	153	153	154	153
Surface Band	151	151	158	153
Subsurface Band	153	155	157	56

Bray #1 P = 24 ppm; Soil Test K = 217 ppm; pH = 6.6

Changes In Soil Test Values

Placement of phosphate and potash fertilizers can affect both crop yield and the distribution of nutrients in the root zone. This distribution is also related to the tillage system that is used.

Soil samples were collected in the fall of 1987 from a trial at Waseca, Minnesota where phosphate and potash at rates of 66 lb. P_2O_5 per acre and 131 lb. K_2O per acre were applied each year for 4 years. The soil test values for P are shown in Figures 1 and 2.

After 4 years of a repeated broadcast application in a ridge-till system, the highest concentration of P was found at a distance of 6 to 15 inches from the row (Figure 1). The soil test values for P also decreased in the ridge itself. This would indicate that there is a substantial volume of roots in the ridge hat are capable of absorbing needed nutrients. In the fall chisel planting system, soil test values for P were nearly uniform from the row to a point 15 inches from the row (Figure 1) when phosphate and potash were broadcast each year. As would be expected, the highest values for P occurred near the soil surface.

The effect of repeated applications of phosphate and potash in a subsurface band is shown in Figure 2. The fertilizer band was placed at a depth of 4-6 inches each year. With no soil disturbance in a ridge-till system, a higher concentration of P would be expected near the center of the row at a depth of 4-6 inches. This is shown in Figure 2.

The location of the band may have been altered somewhat by the fall chisel operation. Yet, highest concentrations of P were also found at a depth of 4-6 inches with this tillage system. The soil test values for P shown in Figure 2 indicate that

the repeated application of phosphate and potash fertilizers in subsurface bands could create problems for the collection of soil samples.

It is possible to predict the location of bands with some accuracy in a ridge-till system. Sampling schemes can then be planned to either miss the band in sample collection or to sample a portion of the band. Since the location of the fertilizer band cannot be identified in a fall chisel planting system, more variable results in soil test values can be expected for soil samples collected from fields where phosphate and potash are applied in subsurface bands.

Soil Test Level Affects Placement Choice

The data presented in Tables 1 and 2 show that banded applications of phosphate and potash can be very effective for corn production when soil test levels for P and K are in the low range. As soils test levels rise, however, the effect of placement on crop yield decreases. Research trials have demonstrated that broadcast and banded applications of phosphate are equally effective when soil test values are in the medium range. This appears to be true for several tillage systems.

A Special Case

For most field situations, placement would not be expected to have an impact on production when soil test levels are in the high or very high range. Recently, however, a special situation has developed in Minnesota where the application of potash in a band in the center of the ridge has increased yields even though the soil test values for K were considered to be high. In both 1987 and 1988, there were several complaints of potassium deficiency symptoms in corn planted in a ridge-till system. These symptoms appeared even though soil test values for K were in the high range.

As a follow-up to these complaints, three rates of K_2O (40, 80, 160 lb./acre) were injected into the center of established ridges. Three corn hybrids (Pioneer 3902, 3732, and 3737) were planted in the spring of 1989. The effect of injected K_2O on corn yield is summarized in Table 4. The yield of all hybrids was improved by the use of the banded application of K_2O. The 40 lb./acre rate was adequate for optimum yield of the 3902 and 3737 varieties. An application of 80 lb. K_2O per acre was necessary to maximize the yield of Pioneer 3732. There is no apparent explanation for the positive benefit of this banded K_2O in this planting situation. Certainly, more research is needed before this positive response can be explained. The stimulating effect of K_2O has not been observed in fall chisel planting systems at this soil test level for K.

Table 4. Influence of a banded application of K_2O in the center of the ridge in a ridge-till planting system on corn yield in 1989.

Hybrid	K_2O Rate lb./acre	Yield bu./acre
Pioneer 3902	0	144
	40	152
	80	153
	160	152
Pioneer 3732	0	143
	0	159
	80	165
	160	162
Pioneer 3737	0	165
	40	175
	80	175
	160	175

Soil Test K = 145 ppm

Phosphate Placement for Soybeans

The preceeding discussion has been limited to effects of fertilizer placement on corn production. Soybean yields have also been influenced by placement. As with corn, the impact of placement is most evident at low or very low soil test values. Recent trials have been completed to compare the effect of broadcast, starter, and subsurface band application of phosphate on soybean production. Several rates of phosphate were applied. The yields in Table 5 are averages of these rates.

Table 5. Influence of placement of phosphate fertilizer on yield of soybeans in 1987 and 1988.

	Location and Year			
Placement	1987 Waseca	1988 Waseca	1987 Lamberton	1988 Lamberton
		bu./acre		
Control	39.2	20.3	31.4	19.3
Broadcast	43.7	24.7	36.0	20.7
Starter	44.1	27.2	34.8	23.5
Subsurface Band	43.7	23.4	33.4	21.7

Bray #1 P = 5 ppm at Waseca, 1.5 ppm at Lamberton

In 1987, placement had no effect on yield at Waseca, but broadcast phosphate produced the highest yield at Lamberton. Other studies have shown broadcast phosphate to be superior to phosphate applied in a starter.

In 1988, highest yields were produced by the use of a subsurface band at both locations. With the very dry soil conditions and limited rainfall, the subsurface band of phosphate fertilizer was apparently placed with some moisture. This combination increased phosphorus uptake and subsequent yield.

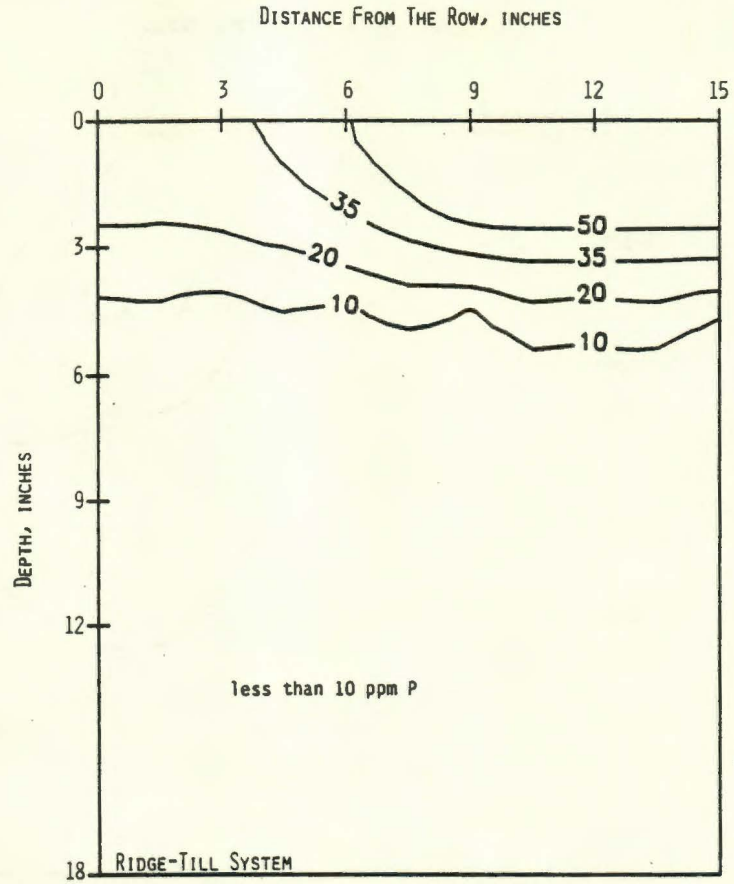
The effect of placement of potash fertilizer on soybean production has been the focus of limited studies. At this time, there is no general agreement on the impact of potash placement on soybean production.

SUMMARY

The information that has been presented in this report is only a small part of the total amount of research that has focused on the placement of phosphate and potash fertilizers. There are some common conclusions that can be reached.

Some of these are:

- Efficiency of use of phosphate and potash increases when these nutrients are applied in a band instead of broadcast and incorporated. PThis is true for all tillage systems.
- Increased efficiency allows for a reduction in recommended rates. The amount of reduction for a banded application when compared to broadcast usage varies from 33% to 50%.
- With banded application, there is reduced contact between soil and fertilizer thereby reducing the potential for fixation of one or both nutrients.
- Placement has more of an impact on yield when soil test values are in the low or very low range. Placement has very little effect on yield as soil test levels increase.
- The total effect of the location of a band of fertilizer in relation to the seed is not completely known or understood. This is a question that deserves much more research.
- At the present time, there does not appear to be a need to change recommendations as the location of the band in relation to the seed changes.
- Fertilizer placement decisions are affected by the moisture status of the soil. Subsurface bands appear to be superior when moisture is limiting. With subsurface bands, the fertilizer is placed in or closer to moisture when topsoils are dry. This improves nutrient uptake and, possibly, yields.
- Placement decisions should be affected by the crop to be grown. Broadcast applications of phosphate have been superior for soybean production. Corn and small grains seem to respond more favorably to banded applications of phosphate and/or potash.
- Surface bands and subsurface bands appear to be well suited for the ridge-till planting system. Many of the tillage practices used in the more conventional planting systems can disrupt or destroy the band. Therefore, these bands may not be the best for moldboard plow and chiselplow situations.



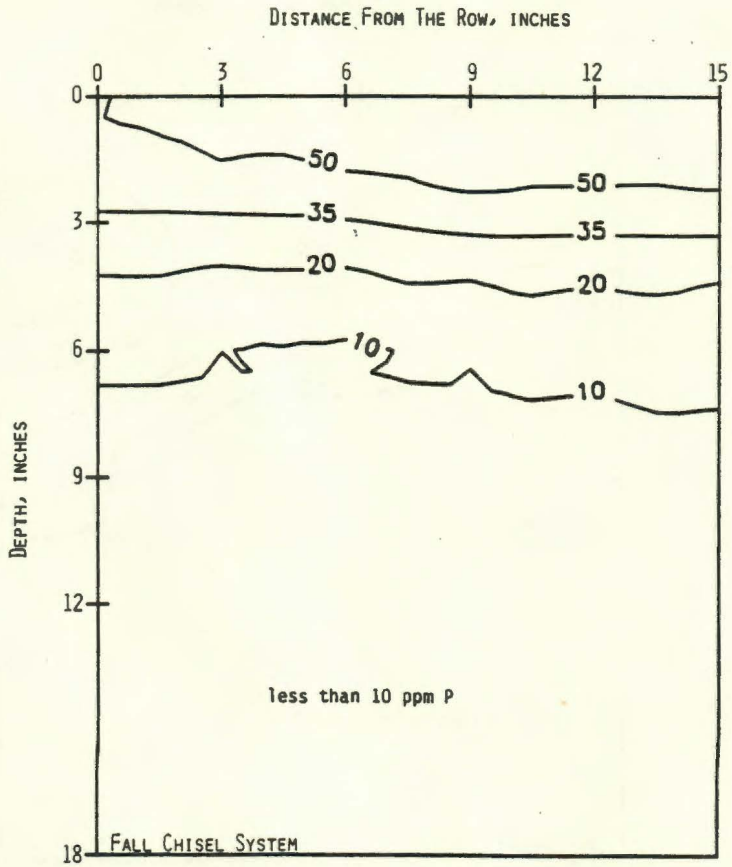
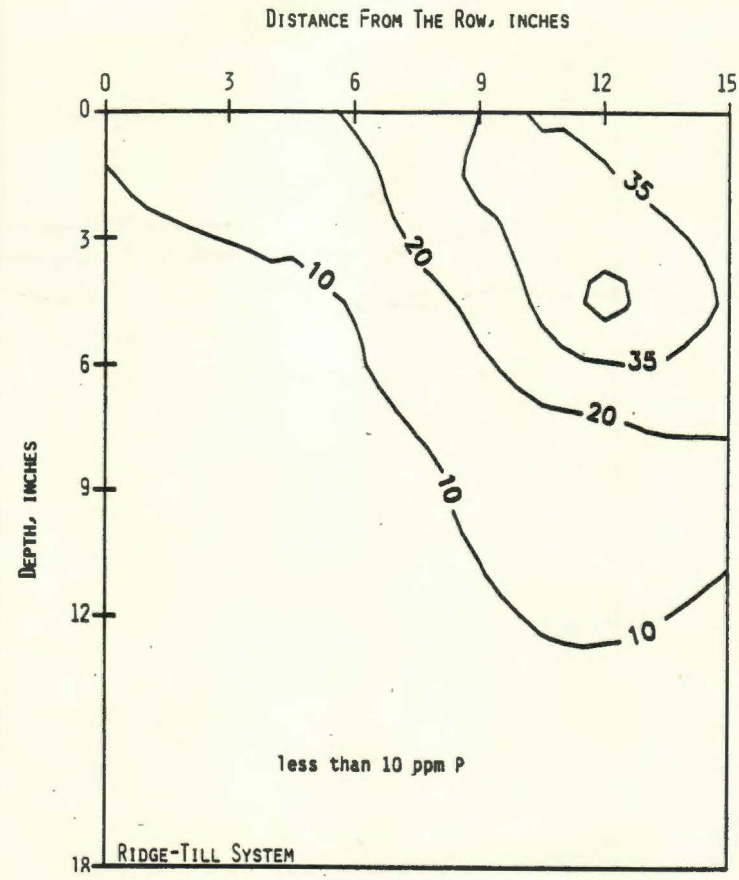


Figure 1. Soil test values for P after repeated broadcast applications in two tillage systems. The numbered lines represent soil test values for P.



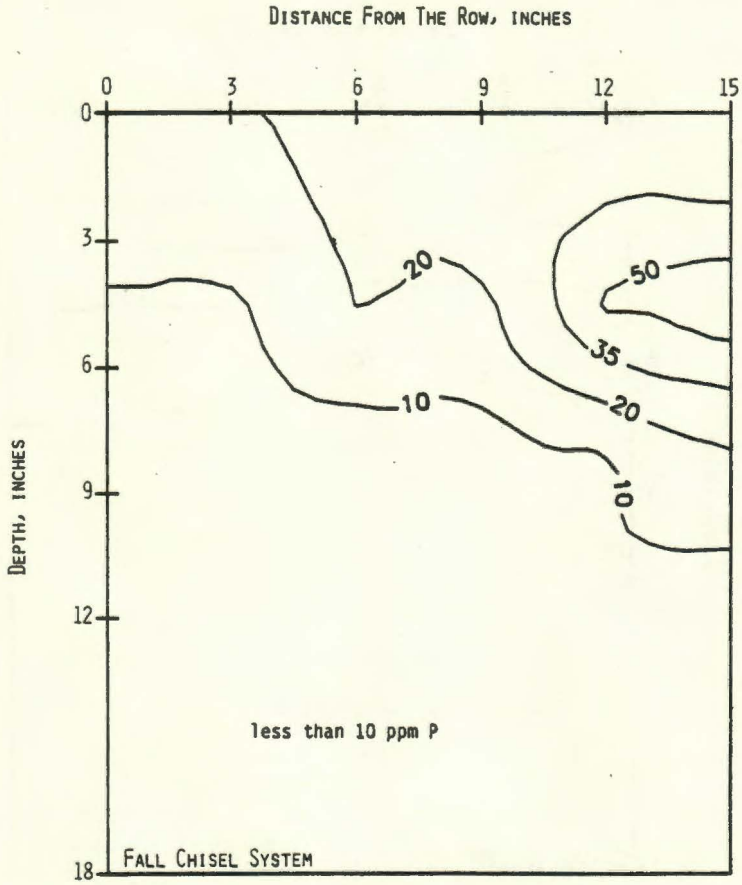


Figure 2. Soil test values for P after repeated application of phosphate fertilizer in a subsurface band in two tillage systems. The numbered lines represent soil test values for P.