



## THE VALUE OF CROP REMOVAL INFORMATION

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There are various approaches used to arrive at phosphate and potash fertilizer suggestions for crop production. Use of printed values for amounts of P and K removed in the harvested crop is a common practice for adjusting suggested rates of phosphate and/or potash fertilizer. The concept is not complicated. Expected removal is calculated by multiplying anticipated yield by some value removed by each bushel (corn, for example). The calculated value is used as the amount applied or fertilizer suggestions are adjusted for the calculated value.

To many, this seems like or appears to be a logical approach. The phosphate and/or potash used is adjusted for the amount of phosphorus and/or potassium removed in the harvested crop. Although logical, is this the correct and most cost effective approach to phosphate and/or potash suggestions?

To answer this question, trials were initiated in 1999 at the Southwest Research and Outreach Center, Lamberton and 1998 at the Southern Research and Outreach Center, Waseca. The corn-soybean rotation was used at both locations. Each crop was planted each year and the study was terminated in 2003. Soils at these two centers are typical of soils across southern Minnesota.

For the study, rates of phosphate applied were based on either crop removal or University of Minnesota guidelines. The University of Minnesota guidelines do not consider crop removal. Since many growers would prefer to apply fertilizer for the total rotation, a single application for both crops was applied in one application was included as one of the treatments for situations where rates were based on crop removal.

To calculate crop removal, anticipated or expected corn yields chosen were 150 bu. per acre at the Southwest Regional Center and 170 bu. per acre at the Southern

Center. This report will deal with corn production only. Phosphorus removed in a bushel of corn was the same at both locations (0.15 lb. P per bushel = 0.35 lb. P<sub>2</sub>O<sub>5</sub> per bushel). The various rates of phosphate along with adequate rates of N and K<sub>2</sub>O were broadcast and incorporated before planting. Since both broadcast and banded suggestions were compared when University of Minnesota guidelines were used, the banded rate was applied in a band to the side of and below the seed at planting.

Soil samples (0 to 6 inches) were collected prior to the initiation of the study; then each year following harvest. Measured corn yields were corrected to 15.5% moisture. For the Southwest Research and Outreach Center, the initial phosphorus soil test was 8.8 ppm (Bray test) and the pH was 6.0. With a pH of 6.1, the phosphorus soil test at the Southern research and Outreach Center site was 13.0 ppm (Bray test).

Corn yields were measured for six years at the Southwest Center site and are reported in Table 1. In 2000 and 2001, yields were limited by moisture stress at one or more times during the growing season.

The phosphate rate used for treatment #2 was calculated from expected yield and crop removal values. The phosphate rate in treatment #3 was calculated from removal values and expected yield for both corn and soybeans (40 bu. per acre). This two year total was broadcast and incorporated before planting the corn crop for this treatment. The phosphate rates used in treatments #4 and #5 are University of Minnesota guidelines for a Bray P test of 9 ppm, an expected yield of 150 bu. corn per acre and broadcast or banded placements respectively.

There were differences among grain yield associated with each treatment each year. The differences can be a

**Table 1. Corn yield as affected by rate of phosphate applied to math either crop removal calculations or University of Minnesota suggestions. Southwest Research and Outreach Center.**

Treatment #	Phosphate Rate Applied	Method of Application	Year						
			1998	1999	2000	2001	2002	2003	
	lb. P <sub>2</sub> O <sub>5</sub> /acre		-	-	-	-	-	-	-
1. Check	0	-	139.3 d	165.6 a	132.0 b	114.3 b	155.2 a	171.4 a	
2. CRA	53	broadcast	169.3 b	174.5 a	137.7 b	125.1 b	162.1 a	167.2 a	
3. CRB	89	broadcast	158.7 bc	178.3 a	135.1 b	143.2 a	175.8 a	159.3 a	
4. UMB	59	broadcast	156.1 c	171.8 a	153.0 a	135.1 a	157.1 a	165.0 a	
5. UM	35	band at planting	189.0 a	175.5 a	159.8 a	136.5 a	155.7 a	141.3 b	

**CRA is crop removal applied annually, CRB is crop removal applied biennially, UMB is University of Minnesota Broadcast, UM is University of Minnesota banded.**

consequence of natural variability in yields or the rate of phosphate applied (treatment). A mathematical procedure called statistical analysis is used to determine if the treatment or variability caused the difference. The results of the statistical analysis are summarized by the letters that follow the yields. For any year, measured yields followed by the same letter are not significantly different at the 0.05 confidence level. In other words, there is a chance of 5% or less that the conclusion supported by statistical analysis is wrong.

Using 1998, for example, treatment caused the difference in yield when the control treatment is compared to all others. On the other hand, treatment did not affect the yields measured in 1999. The differences in measured yields were due to yield variability in the research area.

The effect of treatment on yield was not consistent over the six years of the study. Since the effect of treatment varied with year, it is not appropriate to base decisions on the average yields for the six years.

With a Bray P soil test of 8.8 ppm and an expected yield of 150 bu. per acre, there was not much difference between rates of phosphate applied when treatment #2 is compared to treatment #4. Yet there were significant differences due to treatment in 1998, 2000, and 2001 with higher yield associated with the greater rate in two of the three years. In these two years, use of crop removal as a basis for determining the rate of phosphate to apply produced a rate suggestion that was less than adequate for optimum yield.

With University of Minnesota guidelines, lower rates of phosphate are suggested if the phosphate fertilizer is applied in a band at planting. Comparing treatment #4 with treatment #5, there was no significant difference in grain yield in four of the six years. Contrasting significant effects of treatment were measured in 1998 and 2003 for which there is no apparent explanation. Nevertheless, these results show that, in most years, use of a lower rate of phosphate in a band at planting does not have a negative effect on corn yield when the Bray soil test for P is in the low range (8.8 ppm).

A Bray P soil test of 8.8 ppm is defined as being low. With a soil test in this range, it's reasonable to ask if a higher rate of phosphate would have improved yields. This question can be answered by comparing yields from treatment #2 to treatment #3 or treatment #3 to treatment #4. In one year (2001), the application of 89 lb. P<sub>2</sub>O<sub>5</sub> per acre produced a higher yield than 53 lb. P<sub>2</sub>O<sub>5</sub> per acre, but not higher than 59 lb. P<sub>2</sub>O<sub>5</sub> per acre.

Over six years, yields ranged from the 120 to 140 bu. per acre range to the 175 bu. per acre range. The rate of phosphate needed for optimum yield did not change with yield level.

Corn yields from the same trial conducted at the Southern Research and Outreach Center, Waseca are summarized in Table 2. The approach to determine the rates of phosphate applied was the same. However, the Bray P soil test was higher (13.0 ppm) and the expected

**Table 2. Corn yield as affected by rate of phosphate applied to match either crop removal calculations or University of Minnesota suggestions. Southern Research and Outreach Center.**

Treatment #	Phosphate Rate Applied	Method of Application	Year					Ave.
			1999	2000	2001	2002	2003	
lb. P <sub>2</sub> O <sub>5</sub> /acre			-	-	-	-	-	-
1. Check	0	-	178.6 a	150.7 a	161.0 a	187.7 a	158.9 a	165.3
2. CRA	60	broadcast	179.9 a	150.8 a	164.4 a	192.0 a	166.5 a	170.7
3. CRB	105	broadcast	186.7 a	145.8 a	152.9 a	188.0 a	160.4 a	166.8
4. UMB	40	broadcast	174.1 a	144.1 a	163.1 a	191.4 a	164.8 a	167.5
5. UM	30	band at planting	172.5 a	144.8 a	163.1 a	191.5 a	161.1 a	164.7

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yield was higher (170 bu./A). In addition, yields were measured from 1999 through 2003.

In all years, corn yields were not significantly affected by treatment. Therefore, it's appropriate to look at average yields for the five year period. With a Bray soil P test of 13.0 ppm at the beginning of the study (a medium value), a response to broadcast phosphate would not be expected. None was measured. The banded phosphate at planting also had no effect on yield. With a medium soil test for P, response to banded phosphate might be more likely in cold, wet springs or when corn follows corn.

Consistent with the results from the Southwest Research and Outreach Center, phosphate requirements did not increase as the yield level increased. This observation was consistent for soil with either a low or medium soil test for P (Bray test).

The effect of phosphate application on soil test P (Bray test) was measured at both sites (Table 3). Samples 0 to 6 inches were collected prior to corn planting in 2003.

As might be expected, phosphate application increased soil test P at both sites. Considering the broadcast application, there was a general increase in soil test P as the rate of applied phosphate increased.

**Table 3. Bray soil test for P as affected by phosphate application.**

Treatment #	Phosphate Rate		Method of Application	Location	
	Waseca	Lamberton		Waseca	Lamberton
lb. P <sub>2</sub> O <sub>5</sub> /acre			- - - ppm P - - -		
1. Check	0	0	-	12.0	7.0
2. CRA	60	53	broadcast	26.3	15.5
3. CRB	105	89	broadcast	25.0	17.2
4. UMB	40	59	broadcast	16.0	10.7
5. UM	30	35	band at planting	12.0	11.3

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There are also some observations worth noting. First, even though relatively high yields were measured over a period of five or six years, there was no major change in soil test P. The change from the beginning to the end of the study was about 1.0 ppm P at both locations (Table 3). Some are concerned that there may be substantial reductions in soil test P if phosphate applications are reduced or eliminated. That was not the situation in this study.

At the Waseca location, soil test P was higher in 2003 when phosphate applications were based on anticipated crop removal. The change or increase was less when phosphate applications were based on University of Minnesota guidelines (broadcast application). There was, however, no difference in yield. The additional phosphate used when applications were based on crop removal obviously was an added cost without an economic return. This is a rather weak justification for using anticipated crop removal as a basis for phosphate fertilizer recommendations.

The corn yields and soil test values for P (Bray test) measured in this study show that using crop removal to predict phosphate fertilization can be a wrong decision. At Lamberton, (Southwest Research and Outreach Center) with soil test P in the low range, this approach produced a phosphate application that could be less than optimum. At Waseca (Southern Research and Outreach Center) this approach resulted in higher applications of phosphate without additional yield. In both situations, the approach was not the most cost effective.

Reflecting on the crop removal concept, use of this approach is based on assumptions that are not valid. Some explanation of this statement is needed and is provided in the paragraphs that follow.

Emphasis on use of crop removal as a basis for fertilizer recommendations suggests that a user of crop removal has no confidence in the use of soil testing as a predictive tool for fertilizer recommendations. This

lack of confidence is not justified. Faculty at Land Grant universities across the United States have worked for many years to improve the use of soil testing as a basis for recommendations. This management tool has improved and will continue to improve.

Use of the crop removal concept assumes that the soil does not supply any of the nutrients needed for crop production. If this were true, we might expect to see soil test values for P, K, Zinc or other nutrients approach 0 if fertilizer was not applied for an extended period of time. This, of course, does not happen and the results of this study show little change with production of relatively high yielding corn and soybeans over a period of five or six years.

By using the crop removal concept as a guide, there is an implied assumption that rate of phosphate fertilizer applied should change with the relative level of corn yield. The yield data from the trial at the Southwest Research and Outreach Center do not support this assumption. The rate of phosphate fertilizer needed to achieve optimum yield did not change with yield level.

Use of the crop removal concept assumes that all of the nutrients applied in a fertilizer program are used by the growing crop. This, however, is not what happens when nutrients are applied to soil. Depending on the nutrient and the chemistry of the soil, utilization or uptake from various sources has ranged from 20% to 65% of that applied. Research has shown that instances are rare when nearly 100% of an applied nutrient is used by a growing crop.

Although the concept appears to be logical, research has shown that phosphate fertilizer applications based on crop removal are not cost effective. This concept is also not supported by fundamental principles of soil fertility and soil chemistry.