by Drs. W.M. Stewart, K.A. Janssen, and K. Polizotto

What About P Loss?

Researchers have and are developing strategies for keeping phosphorus in place. Management is the key.

Summary: *Phosphorus lost in runoff from farmland and pastures may contribute to the eutrophication of lakes, ponds, streams, and other bodies of water. Loss of P is most likely where excessive amounts of P have been applied over long periods, or where P applications have been poorly managed.*

The EPA has identified agriculture as the leading source of water quality impairment in U.S. streams and lakes. Significant losses of P are most often the result of mismanagement of manure P, although mismanagement of fertilizer P may also contribute. The eutrophication of P sensitive surface waters can be accelerated by P in runoff water from agricultural land. The problem is often aggravated by proximity of streams and lakes to potential P sources.

Phosphorus is lost from agricultural land in particulate and dissolved forms (Figure 1). The loss of P in dissolved forms may occur through surface runoff water or, in special cases, through leaching. The concentration of soluble P in water moving through the soil profile is usually low due to sorption of P by P -deficient subsoils. However, leaching losses may occur in soils with unusually high soil P levels resulting from excessive manure or fertilizer application, organic soils, or deep sandy soils with little sorption capacity.

Corrective strategies

Reducing dissolved P loss from leaching involves implementing practices that maximize crop P uptake and minimize input in excess of crop needs, reducing leaching by disrupting macropore continuity through tillage, or removing P from surface ditches after field discharge has occurred.

Loss of P in particulate forms is usually associated with the erosion of soil mineral or organic particles. Particulate loss from erosion accounts for about 60 to 90 percent of P loss from cultivated land. We'll look at some proven strategies to reduce such P loss on cultivated lands.

Table 1. Effect of grass filter strips on runoff volume, sediment, soluble P, and nitrate loss, Patty, et al., 1997.

	Site 1				Site 2				Site 3			
Strip width (m)	0	6	12	18	0	6	12	18	0	6	12	18
Runoff vol. (liter)	480	275	220	30	457	73	12	.3	535	71	39	80
Sediment (mg)	20	3	0	0	493	5	4	.4	309	29	8	5
Soluble P (mg)	28	17	22	3	49	69	26	8	264	56	28	29
Nitrate (mg)	2958	1562	924	33	2460	377	62	.03	2577	365	139	88

Vegetative buffer strips are an effective means of reducing surface runoff volume, trapping sediment and restricting the transfer of nutrients and pesticides to lakes and streams. Buffer strips tend to increase infiltration of water and dissolved constituents within the strip. Filter strips may also increase retention of sediment and associated adsorbed compounds by filtration and sedimentation, as well as retention of soluble constituents by sorption onto organic matter and vegetation.

In a recent field study that used ryegrass filter strips of various widths, runoff water volume was reduced as much as 99.9 percent when compared to a control. The grass strips also reduced sediment and soluble P surface runoff by as much as 100 and 89 percent, respectively (Table 1). In another study, sediment retention from bromegrass strips ranged from 40 to 100 percent. Effectiveness of filter strips is usually reduced as runoff velocity increases.

Reducing P solubility from manure applied to agricultural land may result in reduced dissolved P losses in runoff, and through leaching. Research in Arkansas has shown that treating poultry litter with amendments such as alum ($A1_2[SO_4]_3$) or slaked lime ($Ca[OH]_2$) can reduce P solubility and ammonia volatilization by several orders of magnitude. Several compounds were tested for their ability to reduce soluble P levels in poultry litter. About 10 percent of P from this litter was water soluble. Water soluble P levels were reduced from greater than

2,000 ppm to less than 1 ppm with the addition of alum, quick lime, slaked lime and several iron compounds.

By reducing soluble P levels, transport of dissolved P from litter-treated fields may be decreased. In addition, decreased ammonia volatilization increases the N content and nutritive value of litter, and provides a material with an N:P ratio that more closely approaches crop requirements.

Tillage practices affect erosion, runoff, and the loss of P from cultivated land. Increasing vegetative cover through conservation tillage may reduce P loss by reducing erosion and runoff. Figure 2 illustrates the effect tillage has on loss of various P fractions from runoff in the Southern Plains. Soil loss, particulate P, and total P losses were all reduced in no-till when compared to conventional tillage. In another study, conservation tillage reduced total P loss by controlling erosion. When compared to conventional tillage, no-till, chisel plow, and till-plant treatments reduced total P losses by an average of 81, 70, and 59 percent, respectively.

Though reduced tillage may decrease runoff and erosion by increasing residue cover, an accumulation of residue and added P at the soil surface could also result in greater dissolved and bioavailable P losses via runoff.

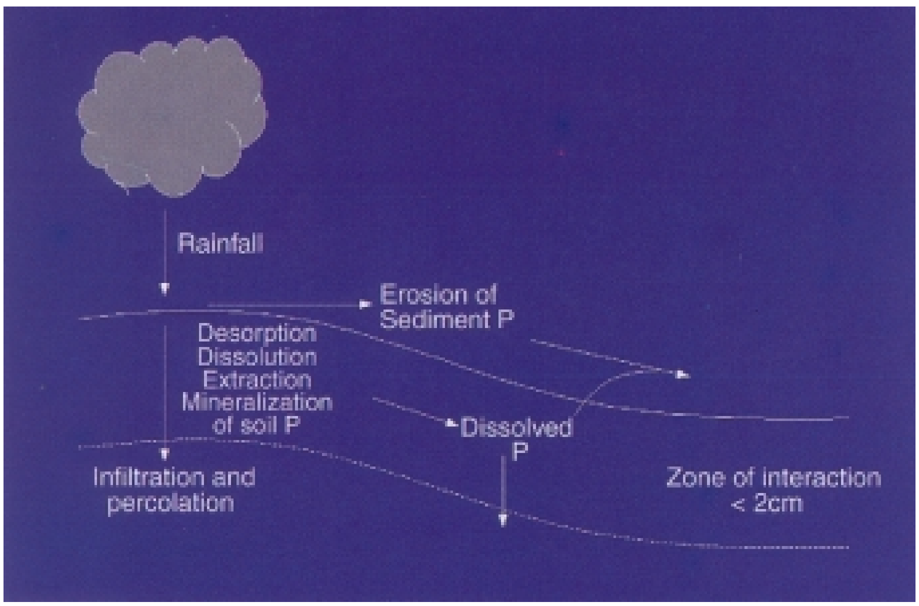

Figure 1. Processes involved in the loss of soluble and sediment P, Daniel, et al., 1994.

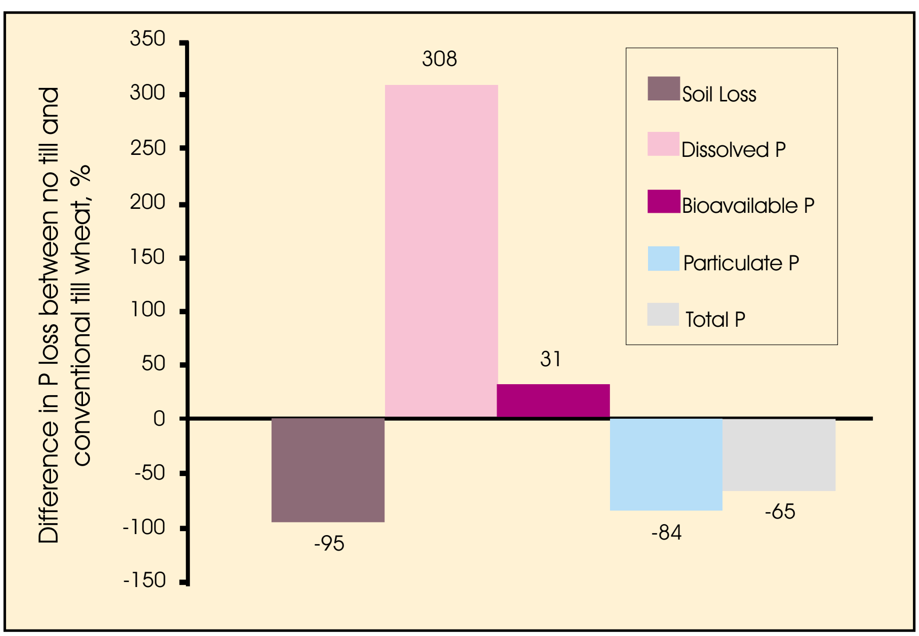

Figure 2. Percent difference in soil and P loss in runoff from no-till and conventional-till wheat in Southern Plains, Sharpley, et at., 1994.

Field study

A recent field study on grain sorghum and soybeans at the east central Kansas Experiment field near Ottawa evaluated the influence of different tillage systems (ridge-till, no-till, chisel-disk) and fertilization practices on P losses in runoff water over a three-year period.

Total runoff varied with rainfall, tillage systems, and years. Runoff, on average, was highest in ridge-till and no-till, and lowest in chisel-disk. Tillage in the chisel-disk system increased infiltration and reduced runoff by drying and loosening the soil. Amount of rainfall that ran off was 18 percent for chisel-disk, 32 percent for ridge-till, and 30 percent for no-till. The higher runoff for conservation tillage contrasts with other reports of *reduced* runoff on soils with better drainage. On average, soil losses were 0.8 ton/A for chisel-disk, 0.6 ton/A for ridge-till, and 0.3 ton/A for no-till. Compared to chisel-disk, ridge-till lowered soil losses by 25 percent, and no-till by 60 percent.

Losses of P in the runoff water also varied with rainfall, tillage system, fertilizer practices, and years. Average total P loss was highest with chisel-disk and ridge-till, and lowest for no-till (Figure 3). These differences generally parallel soil losses, since most of the total P loss was sediment-associated. Only about 5 percent of the sediment-associated P was bioavailable.

Soluble P losses were highest for no-till, intermediate for ridge-till, and least for chisel-disk (Figure 4). Loss of soluble P in chisel-disk was least because of the incorporation of broadcast P. In ridge-till, where fertilizer P was only partially covered by shaving of the ridge at planting, soluble P losses were moderate. In no-till, where broadcast P remained exposed on the soil surface, soluble P losses were nearly six times greater than in the control. In contrast, deep-banded P increased soluble P losses only slightly over the control in all of the tillage systems. Placement of P below the critical zone of mixing between surface soil and runoff water significantly reduced soluble P loss. Bioavailable P loss followed the same general pattern as soluble P, since nearly all of the bioavailable P was associated with the soluble P fraction. Nearly all of the soluble P loss occurred during the first couple of runoffs after P fertilizer was applied, and diminished significantly with subsequent runoff events.

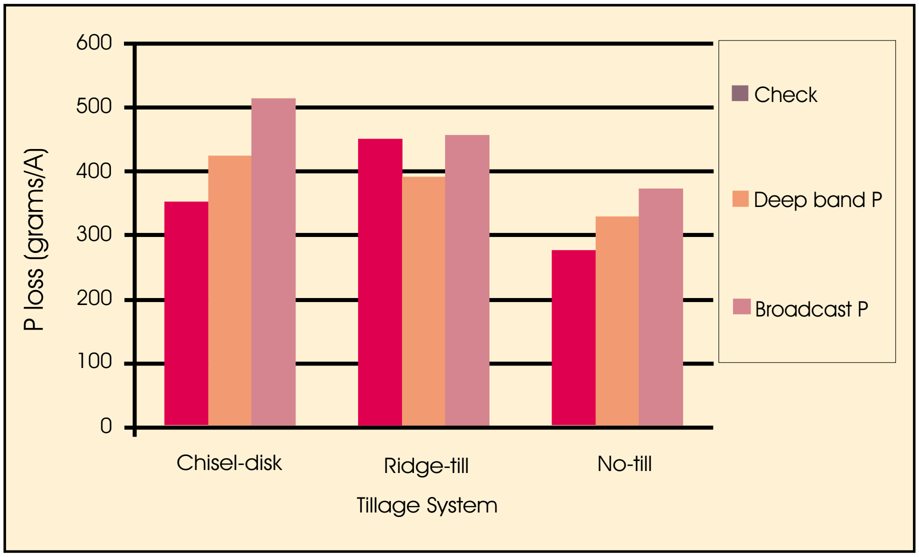

Figure 3. Total P losses as influenced by tillage and P placement (3-year average), Kansas.

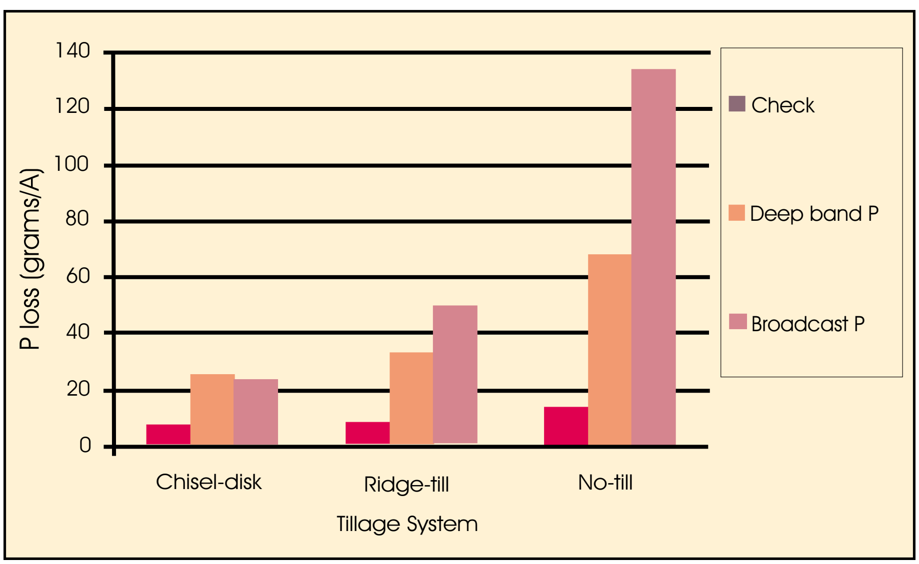

Figure 4. Soluble P losses as influenced by tillage and P placement (3-year average), Kansas.

The results of this study emphasize the importance of subsurface placement or fertilizer r in conservation tillage systems to minimize total and soluble P losses. In tilled systems, fertilizer P should be subsurface applied or incorporated before first runoff occurs.

Following are several practices and tools that can help keep fertilizer and manure P in place:

- subsurface apply or incorporate prior to first runoff
- avoid buildup of soil test P to extremes
- periodically invert P-stratified soils
- use buffer strips, terracing, contour tillage, cover crops, conservation tillage, and impoundment where appropriate.

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Editor's note: This article shows how improved fertilizer-use efficiency and high yields go hand in hand with minimal environmental impact. Continued support of FFF research and education programs provides additional data on the importance of fertilizers in food and fiber production and the compatibility of that production with environmental quality.