RUNOFF PHOSPHORUS LOSS SHORTLY AFTER APPLYING FERTILIZER AND ANIMAL MANURE WITHOUT INCORPORATION INTO THE SOIL

Antonio P. Mallarino, Professor, Department of Agronomy, Iowa State University
Mazhar U. Haq, Assistant Scientist, Department of Agronomy, Iowa State University

Fertilizer and manure are needed to supply crop phosphorus (P) requirements when soils are deficient or to maintain an optimal soil-test P level. Recent research on the value of animal manure nutrients resulted in updated guidelines for manure nutrient management. Soil-test P interpretations and P application guidelines are available in Iowa State University Extension publications PM 1688 and PMR 1003 (see complete references below). However, too high P application rates and/or inappropriate application methods can contribute to surface water quality impairment when runoff occurs. Recent research has been investigating P loss with surface runoff as affected by P source and time elapsing between P application and a runoff event. Phosphorus loss from fields is affected by many source and transport factors, most of which are considered in P Indices like the Iowa P Index. The Iowa P Index and some others developed in the Corn Belt region do not account for potential differences between P sources and the probability of a runoff event after P application. These factors might influence P loss, especially during the first few weeks after P is applied to the soil surface without being incorporated into the soil.

This article summarizes results of three on-farm projects in Iowa that investigated effects of the P source and the time between P application and runoff on P loss with surface runoff. Other research projects not summarized here have been showing that the incorporation of fertilizer or manure P into the soil reduces P loss with surface runoff as long as the increased soil erosion rate caused by the incorporation is small. Elevated soil erosion rates sometimes can offset the beneficial effect of a reduced P concentration at the soil surface.

In one study, conducted during two years at 21 fields, the P sources were broadcast at 100 lb P_2O_5/acre without incorporation into the soil. Sources were no P (control), diammonium-phosphate fertilizer (DAP), solid beef feedlot manure, liquid swine manure from below-building pits, and poultry manure (from egg layers, broilers, or turkeys depending on the field). Simulated rainfall was applied once within 24 hours of applying the P sources. In a second study, conducted during two years at 17 fields, P sources also were broadcast at 100 lb P_2O_5/acre without incorporation into the soil but the P sources applied at all fields were no P (control), DAP, and solid poultry manure from broilers, egg layers, and turkeys. Simulated rainfall also was applied once within 24 hour of applying the P sources. In a third study, conducted in two different fields each of three years, P sources were broadcast in the fall at 100 lb P_2O_5/acre without being incorporated into the soil. The P sources were no P (control), DAP fertilizer, liquid swine manure from below-building pits, and egg-layer manure. Runoff was measured at four timings after P application. Simulated rainfall was applied within 24 hours of P application and after 10 days with or without light rainfall prior to the simulated rainfall runoff, and runoff from natural

snowmelt plus early spring runoff from simulated rainfall. All rainfall simulations were conducted on fields with corn or soybean residue, rainfall was applied at an intensity of 3 inches/hour, and the field areas had 3 to 10 % slope. The runoff samples were analyzed for dissolved reactive P and total P. Ranges across for soil pH, Bray-1 P, and total soil P for the top 6-inch layer of the soils before P application were 5.5-7.9, 5-212 ppm, and 147-1316 ppm across all fields.

Figure 1 summarizes results for the study that measured runoff P within 24 hours of applying fertilizer and manure from beef, poultry, or swine. We show only runoff P concentrations because trends for amounts of P loss per unit area (P load) were similar. The runoff losses of dissolved and total P were much higher following fertilizer application than manure application. Among the manure applications, P loss was highest for swine, intermediate for poultry, and lowest for beef. In fact, the runoff P loss from beef manure and control plots seldom differed in most individual fields. Figure 2 shows little or no variation between different poultry manure sources related to runoff P loss, and that the P concentrations were one-fourth or less than with fertilizer application. Differences between P sources in these two studies are partly explained by the proportion of soluble P (highest for fertilizer and lowest for beef manure) and the physical properties of the sources (differences between fertilizer and manure and between manure sources).

Figure 3 summarizes results for the study that evaluated runoff P loss as affected by P source and the length of time to a runoff event. Runoff P concentration was greatly reduced with increasing time between application and runoff. Runoff P was highest for runoff within 24 hours of application, intermediate after 10 days, and lowest (often not different from the control) for combined snowmelt and early spring rainfall. Light rain before the 10-day runoff event significantly reduced runoff P loss. The differences between P sources varied depending on the time to a runoff event. For the fall season (1 to 10 days after P application), the P loss clearly was largest for fertilizer, much lower for swine manure, and lowest for egg-layer manure. However, differences between sources were small or nonexistent for the combined snowmelt and early spring rainfall events, which happened two to three months after the P application in the fall. In fact, for these late runoff events there was no statistically significant difference between the three P sources and P loss did not differ from the control receiving no P. Reactions of applied P with the surface soil that developed over time greatly reduced the risk of P loss.

The results of these studies confirmed that surface runoff shortly after P application without incorporation into the soil can result in significant P loss. The results also provided support for processes that have been long suspected but not proven in Iowa. A runoff event delay reduces runoff P loss for all sources. Even a short 10-day delay significantly reduces runoff P loss, while a longer delay over the winter further reduces P loss to levels that sometimes are as low as when no P is applied. The P loss is much less for animal manure than for fertilizer (especially for poultry and beef manure) for runoff occurring within a few days after the P application, but differences between sources are much less or nonexistent when the runoff event is delayed for two to three months. The results demonstrate that the risk of P loss shortly after P application without incorporation into the soil is larger for fertilizer than for manure and that the probability

of a runoff event has a major role in determining the magnitude of the P loss from surface P applications.

The implications of the results for P management and water quality are important. In Iowa there is a lower probability of runoff in the fall and early winter compared with late winter and spring. This fact and reactions of surface-applied P that reduce P loss with delayed runoff events suggest that the risk of large P loss from fall-applied fertilizer and manure P is much less than previously assumed, even with significant runoff from snowmelt or rainfall in late winter or early spring. The risk of significant P loss is very high, however, when P is applied without incorporation during periods with a high probability of high-intensity rainfall and runoff.

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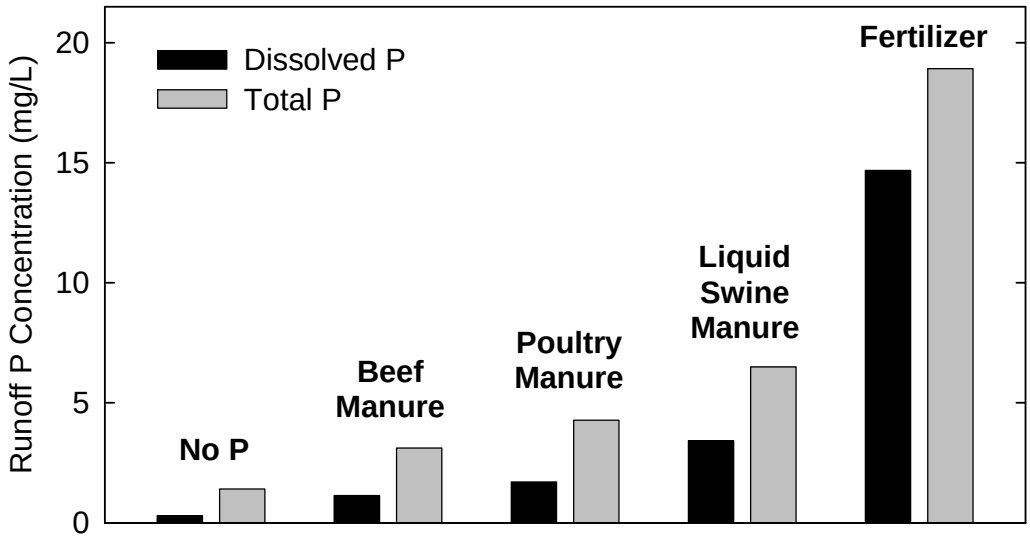

Fig. 1. Runoff P concentration within 24 hours of applying 100 lb P_2O_5/acre using fertilizer (DAP), beef, poultry, or swine manure without incorporation into the soil (averages across 21 Iowa fields).

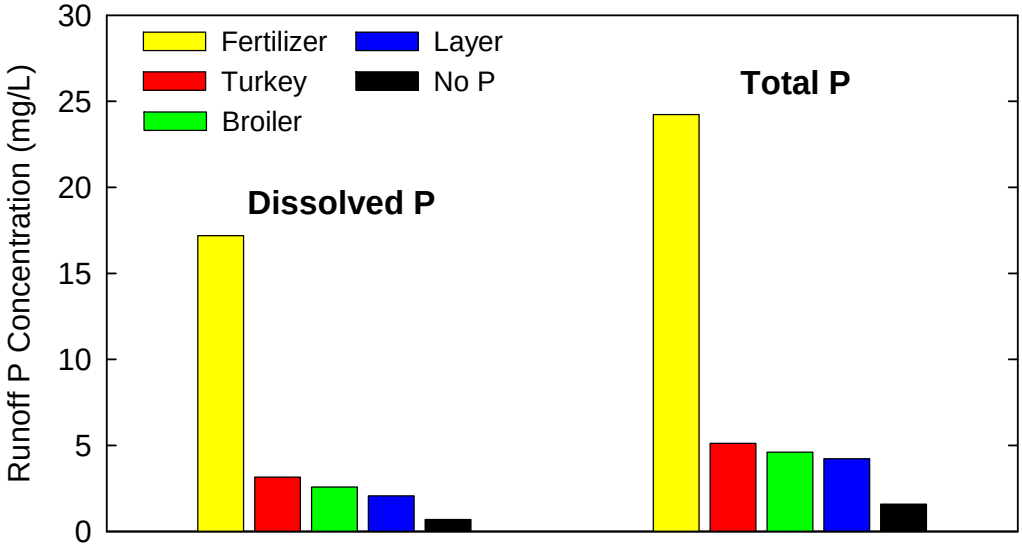

Fig. 2. Runoff P concentration within 24 hours of applying 100 lb P_2O_5/acre using fertilizer (DAP) and manure from broilers, egg layers, and turkeys without incorporation into the soil (averages across 17 Iowa fields).

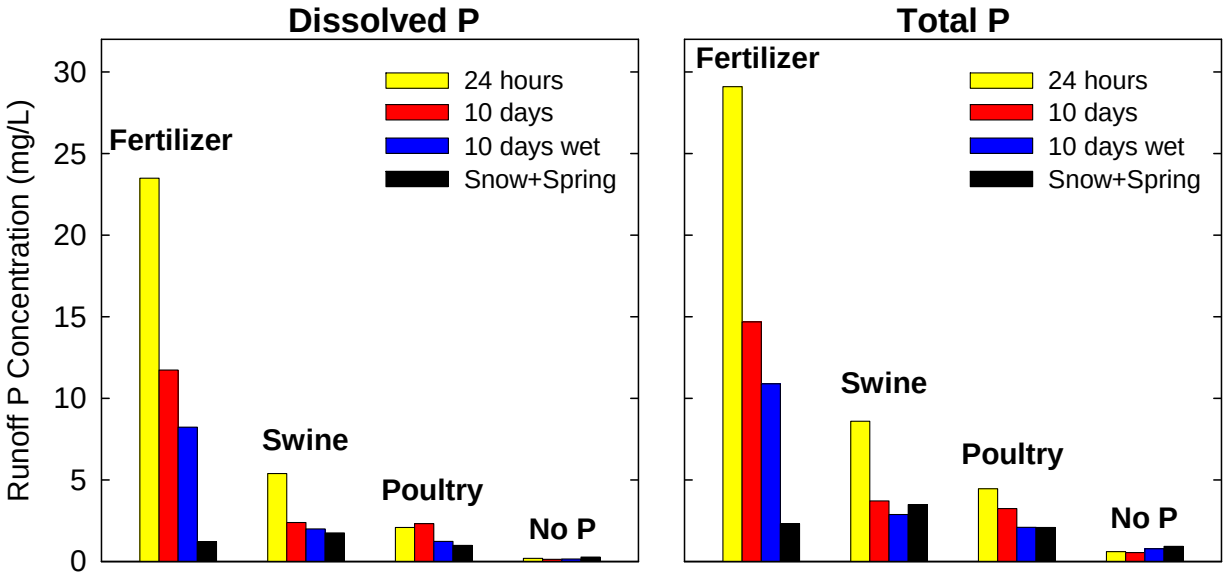

Fig. 3. Runoff P concentration as affected by the P source and the time to runoff after applying 100 lb P_2O_5/acre using fertilizer (DAP), poultry, or swine manure without incorporation into the soil (averages across six Iowa fields). The legend "10 days wet" indicates that light rain occurred between the application and the runoff event. The legend "Snow+Spring" indicates combined results for runoff events caused by late winter snowmelt and early spring rainfall.