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Cover Crops for Protecting Water Quality

Cover crops are a valuable soil-improvement and conservation tool that can also improve water quality. However, the system-specific benefits of cover crops should be weighed against the potential trade-offs to determine if a cover crop can effectively meet water quality goals. Cover crops reliably reduce sediment loss and nitrogen leaching. Cover crops can reduce total phosphorus loss in years with high erosion potential; but cover crops can increase total phosphorus losses in years with lower risk of sediment loss. Therefore, cover crops need to be paired with a fertilizer best-management plan to fully address water-quality concerns.

Choosing to use a cover crop and selecting the cover crop or mix depends on system-specific goals. Cover crops minimize erosion, increase soil organic matter, support soil health, improve nutrient cycling, aid in weed suppression, and provide opportunities for livestock grazing. However, the potential drawbacks of cover crops should be considered, including yield reduction of the subsequent cash crop, additional costs, and unintended effects on water quality.

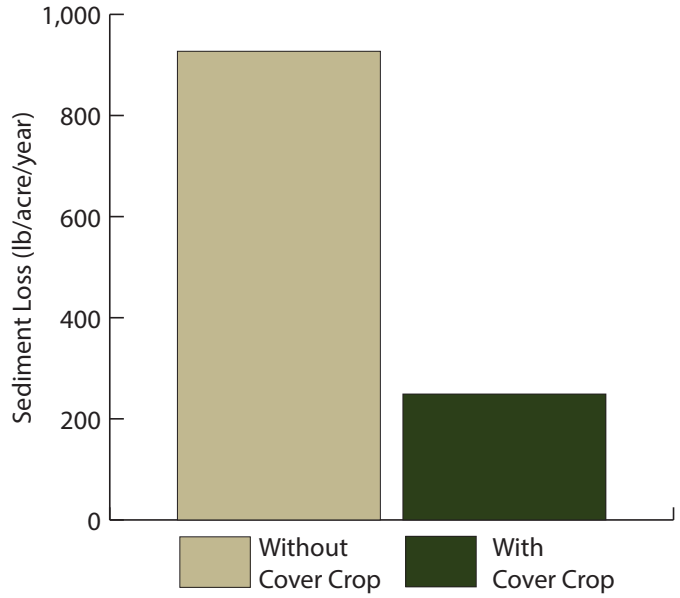

Figure 1. Annual sediment loss with and without a cover crop over 10 years of a no-till, corn-soybean rotation near Manhattan, Kansas.

Cover Crops and Water Quality

Cover crops can be an effective conservation tool to improve water quality by reducing soil loss, particulate phosphorus loss, and nitrate leaching.

Soil Loss

Soil loss in runoff is a concern for long-term agricultural productivity and the downstream water quality of lakes and reservoirs. Sediment in surface water bodies degrades ecosystem quality for wildlife and reduces water storage. Cover crops consistently reduce soil loss during runoff events (Figure 1). This is true under tilled and no-till conditions, even with minimal cover crop growth. Cover crops reduce soil loss through the combined effects of reducing raindrop impact on the detachment of soil particles, as well as by the roots helping to hold soil particles in place (Figure 2).

Phosphorus Loss

Phosphorus carried off fields with runoff water is a substantial environmental concern. This runoff contributes to excessive nutrient levels in surface water in a process known as eutrophication. It also contributes to harmful algal blooms in surface water bodies. Phosphorus is lost as both particulate phosphorus, which is bound to soil particles carried off-field during erosion, and as dissolved phosphorus that is carried off-field in the runoff water solution (Figure 3). In other regions, where tile drainage is common, subsurface phosphorus loss could also be of environmental concern; however, surface runoff is the main transport pathway for phosphorus loss from Kansas agricultural fields.

Figure 2. A May 2017 runoff event from a non-cover-crop plot (left) and a cover-crop plot (right) in a corn production year. Runoff water from the cover-crop plot is clearer than the no-cover-crop plot, visually indicating reduced sediment loss with the cover crop.

Particulate phosphorus loss is reliably controlled by conservation strategies that reduce soil erosion, including cover cropping. On the other hand, the effect of cover crops on dissolved phosphorus losses is inconsistent. Typically, cover crops shift the balance between particulate and dissolved phosphorus loss. Particulate phosphorus loss is dominant from soils without cover crops, and dissolved phosphorus loss is dominant from soils with cover crops (Figure 4). Cover crop effects on total phosphorus loss (dissolved plus particulate phosphorus loss) are highly variable and depend on the amount of erosion. Cover crops are more effective at reducing total phosphorus loss in situations with a high erosion risk.

The decreased particulate phosphorus loss can outweigh the potential increase in dissolved phosphorus loss when soil erosion and particulate P losses are high. Cover crop effectiveness for controlling phosphorus loss increases when additional conservation practices to reduce dissolved phosphorus loss are also used, such as the right rate, right timing, and right placement of P fertilizers.

Nitrate Leaching

Nitrate leaching through the soil profile into groundwater is a form of nitrogen loss that presents a challenge for Kansans. Nitrate leaching is a particular concern in the following situations: irrigated sandier textured soils,

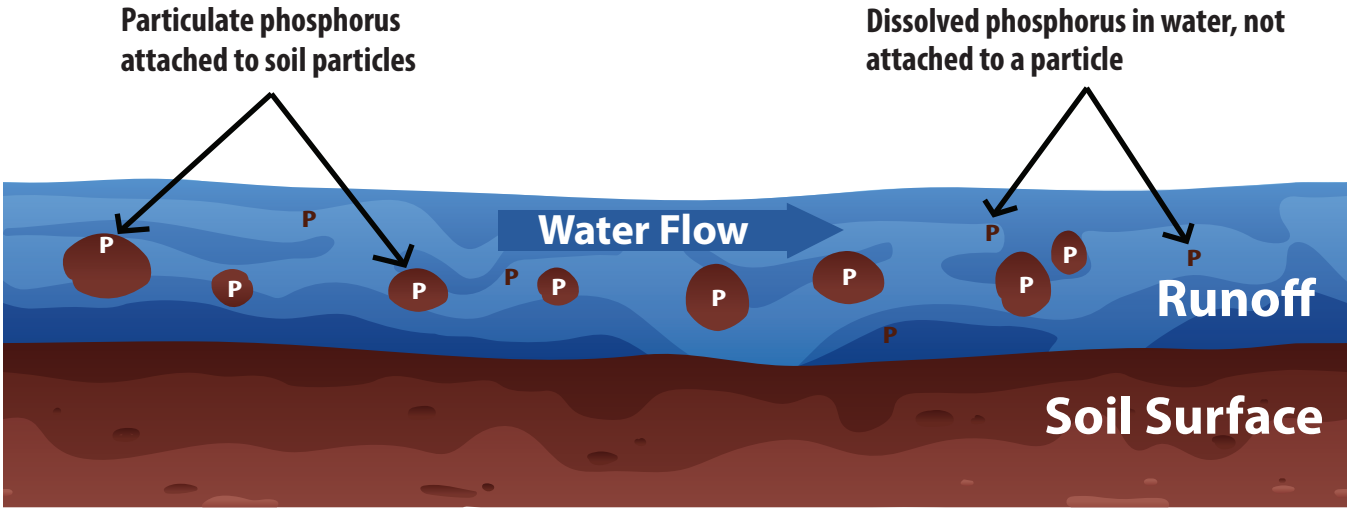

Figure 3. Particulate and solution phosphorus in runoff.

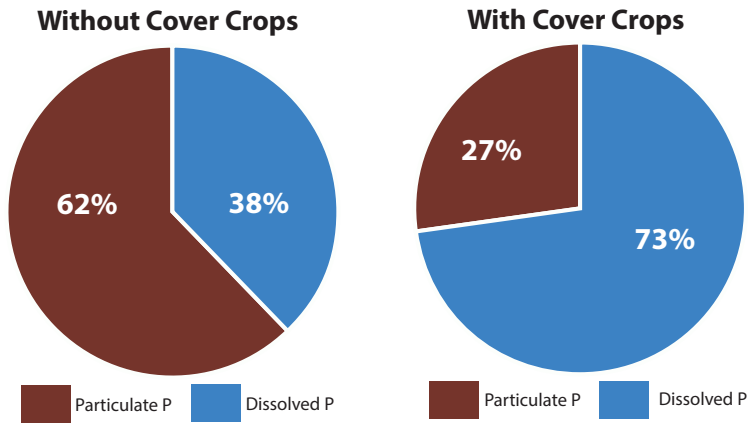

Figure 4. The proportions of phosphorus lost as particulate and dissolved phosphorus differ with and without a cover crop. Although both particulate and dissolved phosphorus can cause problems downstream, dissolved phosphorus is immediately available to contribute to eutrophication and algal bloom development. This data is from 10 years of runoff samples at a no-tilled, corn-soybean rotation near Manhattan, Kansas, for plots receiving spring-injected ammonium polyphosphate without a cover crop (left) and with a cover crop (right)

fields having shallower depth to groundwater, fields with manure, poultry litter, or biosolid application, and instances of crop failure or poor crop growth when an abundance of nitrogen is often left in the soil after harvest.

Cover crops are an effective tool to scavenge nitrate from the soil profile, reducing the amount of nitrate susceptible to leaching into groundwater. This nitrate is then recycled back to the soil as cover crop residue decomposes following cover crop termination and/or tillage. Cover crops typically reduce nitrate leaching by 50% to 70%. The efficacy can range from 0% to 80% reduction depending on the cover crop species, soil texture, cropping system, and climate. Cover crops with robust rooting systems, such as warm and cool-season grasses, are the most efficient.

Figure 5. Situations leading to sediment, nitrate, and phosphorus losses and ways a cover crop reduces risk of loss.

Will a cover crop improve water quality?

Do I have high sediment loss risk?	Do I have high nitrate leaching risk?	Do I have high phosphorus loss risk?
Contributing factors • Intense early precipitation • Hilly or sloped land • Silty or sandy soil • Close to surface water, stream, or drainage ditches • Conventional tillage • Low ground cover cropping system	**Contributing factors** • High soil test nitrate • Poor yield/ crop failure • Anticipating wet fall/winter • Sandy or coarse textured soil • Shallow soil profile, close depth to ground water	**Contributing factors** • For particulate phosphorus loss, see sediment loss risk factors • High soil test phosphorus • History of broadcast applications of phosphorus • Recent surface phosphorus application to highly stratified soil test phosphorus (e.g., under long-term no-till)
A cover crop... • Reduces sediment loss • Reduces sediment-bound/particulate phosphorus loss	**A cover crop...** • Uses nitrogen, reducing nitrate susceptible to leaching loss • Protects ground water quality	**A cover crop...** • Reduces particulate phosphorus • Increases disolved phosphorus • Should include right rate, right time, and right placement of phosphorus fertilizer

For More Information

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