Cover Crops

IF-02

Figure 1. Cover crops can improve soil health and provide other water management and agronomic benefits.

What can cover crops accomplish?

The objectives of establishing a late season cover crop on tile-drained land are ***Conserving Water, Improving Water Quality*** and ***Improving Soil Health***. Cover crops have the potential to conserve water by taking up excess water and by contributing to improved infiltration and soil water holding by building soil organic matter and improving soil structure. They can improve water quality primarily by taking up water and nutrients later in the growing season after harvest. Cover crops can improve soil health by reducing soil erosion, building soil organic matter, enhancing biodiversity, alleviating soil compaction and managing soil salinity.

Overview of cover crops

Cover crops can be seeded at various times during the growing season. They can be under-seeded with the main crop, inter-seeded into the main crop, or planted after harvest (Figure 2). The benefits of cover crops stem primarily from their activity following senescence or harvest of the main crop.

Cover crops use water after the main crop has been harvested, especially when the cover crop is established in-season (under-seeded or inter-seeded) or in conjunction with an early harvest. By growing in late summer and fall, cover crops may reduce excess moisture the following spring (Figure 3) and enable earlier access (improved trafficability) for seeding and other field operations. Conversely, if water retention is an objective, a cover crop and/or associated residue may encourage snow capture during the winter and promote infiltration of snowmelt the subsequent spring. In addition, the growth of cover crops can improve soil structure and increase organic matter content over the long-term, which can, in turn, increase a soil's water holding capacity.

Cover crops continue to take up nutrients, particularly nitrate, after the main crop has been harvested and, as such, have been referred to as "catch crops." These nutrients may come from the soil, as well as shallow groundwater held

Figure 2. Cover crops can be seeded with or into the main crop, or planted following harvest of the main crop, such as this emerging cereal cover crop planted following bean crop harvest (Source: Jason Johnson, USDA-NRCS).

Figure 3. Fall rye inter-seeded into standing corn is evident following corn harvest. Fall cover crops take up water following harvest of the main crop and can provide other benefits such as reduced excess moisture in the spring and improved trafficability (Source: Dr. Abbey Wick, NDSU).

back by controlled tile drainage. This uptake recycles nutrients back into the crop production system, reducing the amount of nutrients available for loss through tile discharge. Growing cover crops is a soil conservation practice that protects erosion-prone soils after a low-residue crop has been harvested. Cover crops also benefit soil health by increasing organic matter, which in turn can help improve soil structure, as well as water and nutrient holding capacity.

Applicability of cover crops in Manitoba

Cover crops have historically been encouraged in Manitoba largely to reduce soil erosion, by wind or water, following the growth of low-residue crops (e.g. beans, potatoes). Cover crops have the potential to provide additional soil and agronomic benefits, and certain water quality benefits; however, the benefits of a cover crop in reducing nutrient losses from tile-drained fields have not been quantified under Manitoba conditions.

Cover crops may increase the risk of dissolved phosphorus loss to surface water during the snowmelt and spring runoff period, which is of primary concern to surface water quality in Manitoba. This is because cover crops generate additional vegetative material above the soil surface which, following decay during freeze-thaw cycles, becomes a source of dissolved phosphorus that may be transported to surface water in runoff (Figure 4). However, losses of particulate phosphorus, or phosphorus bound to soil particles, may be reduced by cover crops as a result of reduced soil erosion losses. The trade-off between potentially higher dissolved phosphorus losses from decaying vegetation and potentially lower particulate phosphorus losses from reduced soil erosion needs to be better understood. Capture and retention of runoff may provide a complementary beneficial practice to reduce the loss of phosphorus from fields.

Figure 4. Cover crops may increase the risk of loss of dissolved phosphorus from decaying vegetation via runoff from fields following snowmelt (Source: Dr. David Franzen, NDSU).

In cold climates the risk of nitrate loss during the winter is low because soils are frozen and tile water does not run. In Manitoba, the majority of tile flow occurs in late spring after snowmelt and spring runoff period when the ground is no longer frozen. Therefore, in order to minimize nitrate loss via tile, over-wintering cover crops should be well-established by late fall so that early spring growth takes up residual soil nitrate before tile flow begins. Earlier seeding also lengthens the time in autumn during which cover crops can absorb nitrate from the soil before winter.

Figure 5. Producers must consider how to integrate cover crops into their individual cropping systems and operational capabilities (Source: Dr. Yvonne Lawley, U of M).

To make informed decisions about how cover crops can be integrated into their rotations, producers must carefully apply knowledge acquired elsewhere within the context of their individual cropping systems and operational capabilities (Figure 5), as well as local climate, landscape and soil factors.

Current research findings

Research in Manitoba to specifically evaluate the water use and nutrient recovery by cover crops on tile-drained fields is lacking. However, one study of an untiled field by Kahimba et al. (2008) where a clover cover crop was under-seeded with an oat crop, found the following benefits from cover crops:

- a reduction in soil moisture compared to oats alone;
- a shallower frozen soil layer by the spring, earlier thawing and enhanced early soil warming;
- deeper infiltration of spring snowmelt.

A 2011 field study conducted in Manitoba (Lawley, 2016) following spring flooding conditions demonstrated that a full season cover crop treatment can reduce soil moisture in the shallow rooting zone (30 cm) in the late summer to fall period when compared to no cover crop (Figure 6). In addition, soil moisture close to the soil surface (5 cm) was consistently drier in the no cover crop treatment (Figure 7). This demonstrates an additional benefit of reduction in evaporative loss from the soil surface, which in turn would result in a reduction in salt accumulation at the soil surface.

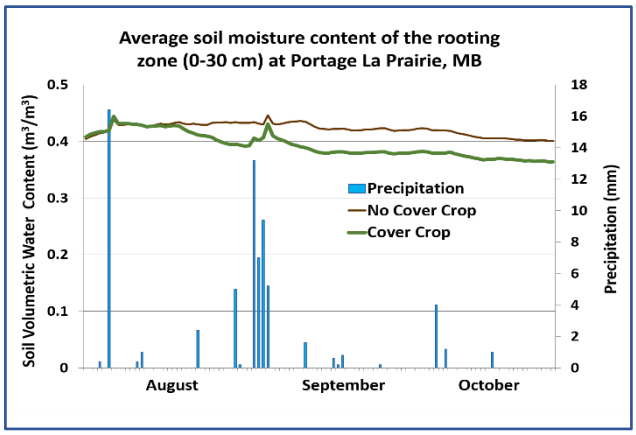

Figure 6. Cover crops can reduce soil moisture in the rooting zone following the main crop harvest (Source: Lawley 2016).

Research elsewhere indicates that cover crops hold some promise for reducing nitrate movement to tiles. In southwestern Minnesota, Strock et al. (2004) found a 13% reduction in nitrate load and an 11% decline in drainage discharge due to a fall rye cover crop added to a corn-soybean rotation. In southern Ontario, Drury et al. (2014) reported that controlled drainage in combination with a winter wheat cover crop reduced nitrate concentrations in tile water by 47% over a simple corn-soybean rotation.

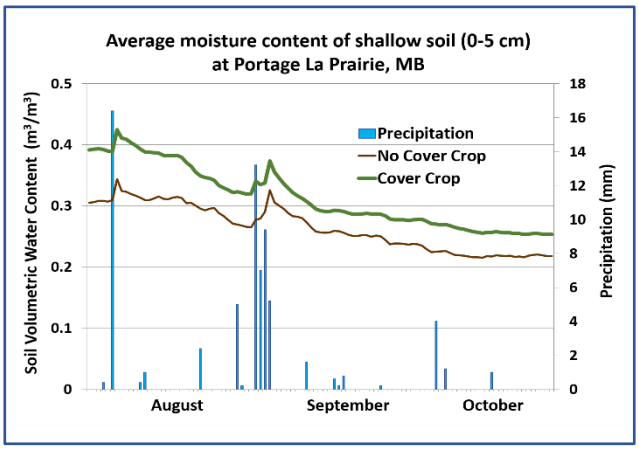

Figure 7. Cover crops can maintain moisture near the soil surface by reducing evaporative loss, potentially reducing salt accumulation (Source: Lawley 2016).

There is little available information about the effect of cover crops on phosphorus loss from tile drains. A study in Indiana (Trentman et al., 2017) found that cover crops did not influence the export of dissolved phosphorus via tile flow in two watersheds. However, this study did not measure phosphorus losses via surface runoff. Following one or more freeze-thaw cycles, cover crops and associated crop residues constitute a source of dissolved phosphorus prone to loss via surface runoff (Liu et al., 2019). Consequently, while cover crops offer some potential environmental and agronomic benefits, their presence may result in a higher loss of dissolved phosphorus. The trade-off between the benefits cover crops provide and the potential for higher dissolved phosphorus and total phosphorus loss must be better understood in order to determine the net environmental impact.

Caution must be used when applying results from other jurisdictions with warmer and wetter climates, as they may not be directly applicable to Manitoba's shorter growing season and colder winters. For example, cover crops are more likely to be effective in reducing nutrient losses through tile discharge in regions with longer growing seasons and reliably adequate moisture for establishment. In such places, the absence of cold winters presents better opportunity for reduction of nutrient losses by the growing of cover crops. More work must be done to better understand the nutrient reduction and water management benefits of cover crops in Manitoba.

Outstanding questions and future research needs

There are numerous outstanding questions and research needs regarding cover crops as a BMP on tile-drained land in Manitoba including:

- What is the impact of cover crops on spring soil moisture content, water infiltration, spring snowmelt and surface runoff, and surface runoff following early spring rainfalls before planting?
- Which cover crop types have the best potential for removing nitrate from the soil to reduce the potential for leaching and loss through tile flow?
- Do cover crops increase the risk of dissolved phosphorus loss during spring snowmelt?
- Can certain cover crop scenarios offer a net benefit in the nutrient (nitrogen and phosphorus) balance of tile-drained fields (i.e. capture and ultimate removal through harvest)?
- Can the trade-offs between environmental costs (i.e. increased water quality risk from dissolved phosphorus in surface runoff) and environmental benefits (i.e. improved soil health, reduced nitrogen export in tile outflow) of cover crop growth on tile-drained land be understood and reconciled?

Complementary practices

Cover crops are well suited to work in a complementary fashion to other BMPs that reduce nutrient loss via tile outflow and make fuller use of water:

IF-01 – Nutrient Management;

IF-04 – Controlled Drainage.

Guidelines for Cover Crops

NRCS, 2016. Conservation practice standard, cover crop. Natural Resources Conservation Service, Iowa. Code 340.

Additional BMP resources

Christianson, L.E., J. Frankenberger, C. Hay, M. J. Helmers and G. Sands, 2016. Ten ways to reduce nitrogen loads from drained cropland in the Midwest. Pub. C1400. University of Illinois Extension.

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Strock, J.S., P. M. Porter and M.P. Russelle, 2004. Cover cropping to reduce nitrate loss through subsurface drainage in the Northern U.S. Corn Belt. J. Environ. Qual.: 33, 1010–1016.

Thiessen Martens, J.R., M.H. Entz and M.D. Wonneck, 2015. Review: Redesigning Canadian prairie cropping systems for profitability, sustainability, and resilience. Can. J. Plant Sci.: 95:1049-1072.

Trentman, M.T., J.L. Tank, T.V. Royer, B.R. Hanrahan, U.H. Mahl, K. Prior and S.L. Speir, 2017. The impact of winter cover crops on the export of phosphorus from tile drains in the agricultural Midwest. Poster presentation, Watersmart Innovations Conference 2017.