Nutrient Management

IF-01

Figure 1. Soil sampling for lab analysis.

What does nutrient management accomplish?

Agricultural nutrients that enter surface and groundwater pose concerns for ecological and human health. The objective of nutrient management is to fertilize the crop in a manner that minimizes nutrient losses to the environment and ***Improving Water Quality***. Nutrient management strategies are used to retain nutrients within the root zone for crop use and reduce nutrient loss from the field via tile flow.

Keeping nutrients in the field and available for crop use also makes good agronomic and economic sense!

Nutrient management requires the implementation of practices that optimize fertilizer use – matching supply with crop requirements to minimize nutrient losses from fields.

Source: modified from www.nutrientstewardship.com

Overview of nutrient management

Nutrient management principles should be followed when fertilizing any agricultural field. For tile drained lands, special consideration should be given to the change in hydrology that the practice achieves.

4R Nutrient Stewardship is an internationally recognized framework that includes all of the components of comprehensive nutrient management. Applying fertilizers according to the principles of Right Source, Right Rate, Right Time and Right Place (the 4Rs; Figure 2) minimizes greenhouse gas emissions and losses of nutrients to surface and ground waters. The installation of tile drainage may require adjustment of any or all of the 4Rs.

Figure 2. *4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place ®).*

Applicability

Nutrient management is key to sustainable agriculture and is an important complementary practice when adopting tile drainage. While nutrient management is broadly applicable in Manitoba, individual practices should be customized to fit each farm's unique combination of climate, soil and landscape features, crop rotation, equipment and overall management system.

Nitrogen issues and management

Nitrogen (N) is one of the most intensively-managed crop nutrients. Once applied to soil, some N is converted to nitrate (NO_3^-), which is highly soluble in water and very prone to leaching (downward movement through the soil profile) (Figure 3). Once below the root zone, nitrate can enter tile drains and discharge to surface water. Numerous studies in the U.S. and Canada link subsurface drainage and increased nitrate movement from fields to surface waters (Christianson et al., 2016). Each of the 4Rs is important to reduce N in tile outflow.

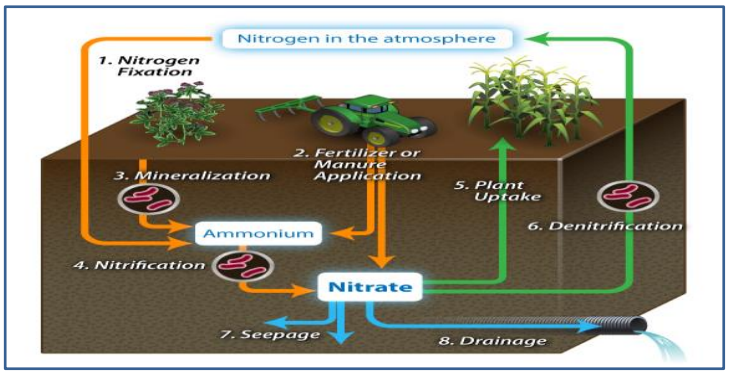

Figure 3. Nitrogen (N) cycle and tile drainage (Christianson et al., 2016).

Right Source. Sources include N fertilizers and animal manures. While there are many types of commercial N fertilizers, Enhanced Efficiency Fertilizers that contain controlled release or inhibitor technology have a particular fit in imperfectly and poorly drained soils. Their use should be reassessed when tile drainage is adopted.

Right Rate. Determining the correct application rate is an essential component of nutrient management. As tile drainage increases productive capacity of the field, a higher rate of N may be appropriate. Producers should soil test every field annually to determine appropriate fertilization rates that consider residual soil nutrients and crop requirements.

Variable rate application technology can be used to reduce application on areas requiring little or no additional N or on sensitive areas if in-field variability is adequately understood (Dinnes et al., 2002).

Right Time. The risk of nitrate leaching to the tiles is higher if soil nitrate levels are elevated when water is moving through the profile. This risk is minimized when N is applied as close as possible to when the crop needs it.

Fall application of ammonium fertilizers is a common practice in Manitoba. Late fall application reduces the risk of nitrate accumulation in the soil because the conversion of ammonium to nitrate slows in cold temperatures. Spring application presents less risk of nitrate leaching during spring snowmelt and early rainfall events, however, spring application is not always feasible.

Perennial forage crops and some annuals receive split applications of N rather than supplying the full N requirement of the crop in a single application. Split applications can also reduce the risk of nitrate leaching. Fertigation, the application of nutrients in irrigation water, is a recognized practice for high-input crops under irrigation management (e.g. potatoes). This practice meters out smaller amounts of N as the crop is growing and reduces the potential for high soil nitrate levels that could be at risk of nitrate leaching.

Within the chosen season, weather conditions and the forecast should be taken into account when timing N applications to avoid excess water moving through the root zone and taking nitrate with it.

Right Place. Applying N in concentrated bands beneath the surface of the soil is more efficient than broadcasting N onto the soil surface. This allows the producer to reduce the overall N application rate to achieve the same yield potential and also reduces the risk of elevated N levels in the soil that could be leached to the tiles.

Phosphorus issues and management

Phosphorus (P) is naturally deficient in Manitoba soils and must be supplied to sustain commercial crop production. In soil, P is less soluble than nitrate and is not particularly susceptible to leaching. It can, however, reach drainage tiles via preferential flow through macropores, such as soil cracks, earthworm holes and root channels (Figure 4).

The main concern associated with P loss from agricultural fields is the accelerated eutrophication of surface water. Phosphorus is primarily transported to surface water via runoff, especially during spring snowmelt. Tile drainage partially shifts the hydrology from surface to subsurface drainage and results in trade-offs between P losses in overland flow versus tile flow.

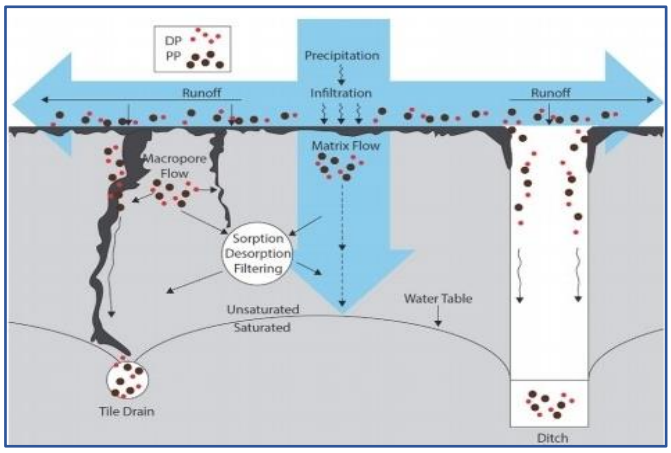

Figure 4. Representation of processes controlling P losses, DP, dissolved phosphorus; PP, particulate phosphorus (Kleinman et al., 2015).

4R Nutrient Stewardship should be followed for P management. The Right Source, Right Rate, Right Time and Right Place should be considered for P application to each field. In addition, incorporating P via tillage should reduce the risk of loss via surface runoff and disrupt macropore networks connecting the field surface to the tiles.

What about manure application on tile drained lands?

The water and nutrient content of manure varies greatly, making it more challenging and costly to manage than synthetic fertilizer. Nutrients from synthetic fertilizers and livestock manure are both susceptible to loss through tile drainage. The 4Rs of nutrient management should be followed when applying manure to tile drained land.

Right Source. Unlike synthetic fertilizer, manure is not a balanced nutrient source. As well, not all of the nutrients in manure are immediately available for crop uptake. Supplying the nutrient needs of the crop requires estimation of the fertilizer value of the manure. Due to its ability to flow, liquid manure is inherently more likely than solid manure to reach tile drains if macropores are present.

Right Rate. Manure is most often applied based on the N requirement of the crop. This often results in over application of P and buildup of soil test P, which increases the risk of P loss via leaching or runoff. At low soil test P levels, accumulation of P is beneficial, but must be well managed by establishing sustainable manure application rates based on soil testing and crop requirements.

Figure 5. Example of manure injection technology.

Right Time. In Manitoba, manure is most commonly applied in the fall to ensure sufficient over-winter manure storage capacity and because favourable conditions for application in the fall generally last longer than in the spring. Application timing should always consider soil moisture levels and the weather forecast. Manure cannot be applied in the winter when ground is frozen, and should not be applied when soil is saturated, tile water is running, or just prior to a rain event.

Right Place. Manure should be placed beneath the soil surface, as much as possible, to maximize nutrient use efficiency and minimize the risk of surface runoff losses. The optimal placement practice includes injection or immediate incorporation of manure that involves disturbance of macropore networks concurrent with application. This is of particular importance for application of liquid manures to reduce the potential for losses via preferential flow (Cooley et al., 2013).

Outstanding questions and potential future improvements

Tillage disrupts the macropore network and the hydrologic connectivity between the soil surface and tile drains. Tillage prior to manure application can reduce preferential flow of nutrients to tiles through cracks and other macropores. More research is required to determine the most effective tillage practices and quantify impacts on tile water quality.

Complementary practices

Nutrient management is complementary with other BMPs that can reduce the volume of tile outflow and drainage intensity, in turn reducing nutrient export from the field:

- *IF-04 – Controlled Tile Drainage;*
- *IF-05 – Site-Specific Tile Drainage Design.*

Similarly, reduction in nutrient loading using nutrient management will lead to improved performance of other nutrient reduction BMPs:

- *EF-01 – Bioreactors;*
- *EF-02 – Saturated Buffers;*
- *WS-01 – Tile Water Recycling;*
- *WS-02 – Constructed Wetlands.*

General nutrient management resources

Manitoba Agriculture, 2007, Manitoba Soil Fertility Guide

Additional BMP resources

Christinson, 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.

Cooley, E.T., Ruark, M.D., and Panuska, J.C. 2013. Managing Tile-Drained Landscape to Prevent Nutrient Losses, University of Wisconsin Discovery Farms, Fact Sheet No. 3 GWQ064- Madison, Wisconsin.

Manure management on tile drained land

Manure management on tile drained lands in Manitoba – literature reviews by Stantec Consulting Ltd./PBS Water Engineering Ltd. and University of Manitoba.

References

Dinnes, D., D. Karlen, D. Jaynes, T. Kaspar and J. Hatfield, 2002. Nitrogen management strategies to reduce nitrate leaching in tile-drained midwestern soils. Agronomy Journal 94:153-171.

Harrigan, T. and B. Northcott, 2007. Keeping Land-Applied Manure in the Root Zone, Part 2: Tile-drained Land. Michigan State University Extension. Extension Bulletin WO-1037.

Kleinman, P., D. Smith, C. Bolster, and Z. Easton, 2015. Phosphorus Fate, Management, and Modeling in Artificially Drained Systems. Journal of Environmental Quality 44:460-466.