Fertilizer Considerations in a Wet Spring - Challenges and Opportunities

Following last year's drought, much of Manitoba badly needed a recharge of soil moisture reserves. The unusually large amounts of rain and snow received this winter and spring will now delay spring seeding and may force some farmers into alternative options for spring nitrogen (N) application.

Advances in fertilizer sources and application methods provide many options to help farmers deal with these challenges. Another challenge is the uncertain supply of fertilizer due to current supply chain disruptions, so options may be limited on fertilizer availability and source.

Usually spring soil test nitrate-N concentrations are higher in spring than in fall. However, this spring, some low areas of fields, where soil test nitrate-N was high last fall, may have less nitrate-N at planting. Although last fall was relatively dry, the large amounts of snow and snowmelt have created patches of overland flooding in low areas of many fields. These patches of submerged soil may lose N due to denitrification and/or leaching if soil temperatures are above freezing. Refer to the factsheet **"**Impact of Spring Flooding on Soil Fertility in Manitoba**"** for more details on potential soil N losses.

Wet soils also reduce N efficiency through greater losses, particularly for broadcast fertilizers. Surface applied nutrients (e.g., broadcast fertilizer) are vulnerable to overland **runoff** loss if applied to soils so saturated that additional moisture is moving as run-off rather than infiltrating into the soil. Furthermore, broadcast N converts quicker to nitrate than banded N, increasing the risk of **leaching** on coarse-textured (sandy) soils and **denitrification** on poorly drained, fine-textured (clay) soils. For more information about these processes, see the **Supplemental Information** section at the end of this factsheet.

Traditional N Fertilization Practices in Manitoba

Recent surveys show that Manitoba farmers traditionally use many options for applying nitrogen and phosphorus fertilizers. Fall application of nitrogen (N) is usually the primary practice for 45% of wheat acres, 34% of canola acres and 32% of corn acres (Table 1). Many farmers took advantage of this opportunity last fall, but may now be wondering about the integrity of that N.

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Manitoba

Table 1. Nitrogen fertilizer placement and timing typically used by Manitoba farmers for spring wheat, canola, soybeans and corn (based on % of acres or volume applied).

Practice	**Wheat**	**Canola**	**Soybeans**	**Grain corn**
% of acres or volume applied				
TIMING				
Fall	45	34	1	32
Spring, preplant	11	13	0	48
At seeding	43	51	4	23
Post seeding, in crop	2	2	1	22
PLACEMENT				
Broadcast , no incorporation	**0**	2	0	11
Broadcast and incorporated	4	13	0	35
Preplant banded	52	40	0	39
Sidebanded	12	12	2	13
Mid row banded	17	19	1	3
Seed placed	13	11	1	2
In crop applied	2	2	1	22

Spring and Summer Options for Applying N Fertilizer

Since early seeding is important for optimizing crop yield, producers will be looking for ways to apply their N fertilizer efficiently without delaying the seeding operation.

This may be especially important for farmers who have not secured their N fertilizer, yet, due to problems with the supply chain.

In order to achieve these objectives for a spring fertilization program, the fertilizer source, placement and timing must be managed carefully to minimize losses of fertilizer N to the environment and optimize crop access to the fertilizer. For more information about these losses of N, see the **Supplemental Information** section at the end of this factsheet.

Fortunately, there are numerous timing and placement options, other than fall broadcast or banded N, to meet N needs of the crop, as shown in Table 1. Combinations of new sources and new application equipment also give farmers more options than ever for spring and midseason applications of N, such as:

- fertilizer application equipment, such as high clearance sprayers and floaters can apply 28-0-0 in dribble or directed bands immediately after planting or in established crops.
- fertilizer additives, such as urease inhibitors, that can be mixed with conventional fertilizers or purchased as enhanced efficiency fertilizers (e.g., SuperU); these additives delay the conversion of urea to ammonia and reduce the risk of gaseous losses due to volatilization of surface applied urea or UAN solutions.
- controlled release fertilizers (e.g., ESN fertilizer, which has a polymer coating) can reduce the toxicity of seed-row placed urea applied at planting so higher rates of N can be applied safely in the seed-row

Spring and summer options for timing and placement include the following:

1) Pre-Plant Banding – Banding N in below the soil surface tends to be the most efficient form of application under western Canadian conditions. Placing the fertilizer below the soil surface protects the ammonia portion from gaseous losses by volatilization. Placing the fertilizer in a band limits the contact between the fertilizer and the soil microorganisms, reducing immobilization of both ammonium and nitrate. Banding also slows the conversion of urea to ammonium and ammonium to nitrate, which can reduce losses by denitrification and leaching. Ideally, bands should not be disturbed by pre-seeding tillage or seeding operations.

In Manitoba, all forms of N fertilizer usually perform well when applied as a spring pre-plant band, provided that the fertilizer is at least 2 inches away from the seed. Anhydrous ammonia (NH_3) should be placed at least 4 inches below the soil surface and, if possible, seeding should be done perpendicular to NH_3 bands. Urea should be banded as deep as possible for seed safety (e.g.,at least 2 inches deeper than the seed) and at an angle to seed rows. There is no need to delay seeding after application if NH_3 or urea is placed at recommended depths, especially on moist clay soils. However, pre-plant banding may potentially delay seeding and dry or disrupt the seedbed, especially in clay soils. This was especially apparent in the spring of 2020, when initially wet soil conditions became dry after preplant banding, resulting in very cloddy seedbeds and substantially reduced crop stands.

Many farmers have low disturbance disk drill seeders that could be used to band granular fertilizer before seeding without bringing up clods.

2) Surface Applications Immediately Before or After Seeding – Broadcasting is a very quick method of applying fertilizers, with applicators being able to cover as much as 1,000 acres per day. However, urea or UAN solution sources of N can be lost by volatilization unless, or until, they are incorporated into the soil with tillage or moved into the soil with precipitation. Tillage during conventional seeding operations is generally sufficient to incorporate urea or UAN solution to reduce volatilization. However, harrowing, shallow vertical tillage, and low-disturbance seeding may not eliminate volatilization loss of urea or UAN.

If either ammonium or nitrate sources are in close contact with crop residues, they may also be subject to immobilization as the residues decompose, since microorganisms will consume N from the soil or fertilizer as they decompose crop residues that may be low in N (e.g., cereal residues). In addition, surface stranding of broadcast fertilizer in dry soil above the active portion of the crop's root system may be a problem in some weather conditions. Also, high rates of broadcast urea-N applied without incorporation on drill-seeded fields may concentrate pellets in the seed-furrow and cause seedling damage to sensitive crops, such as canola.

Shallow incorporation through harrowing, seeder operation, or vertical tillage of broadcast urea or UAN are often insufficient to prevent volatilization losses. Incorporation depths of 2-3 inches may be required should drying conditions persist after application.

Because of the high potential for volatilization and immobilization losses, surface applications of N tend to be less efficient than in-soil banded applications. Efficiency of surface applications tends to improve in higher rainfall areas, since precipitation is more likely to move the fertilizer into the soil, reducing the risk of loss and/or stranding at the soil surface. Efficiency is also lower on high pH soil, since high pH encourages the production of ammonia gas.

While often less efficient than in-soil banded or incorporated fertilizers, surface N applications without incorporation may be appropriate for fertilization of forages, winter cereals and for post-emergent N delivery. However, lack of N fertilizer incorporation will increase the risk of volatilization losses. As a result, if dribble banded to reduce contact with crop residues and soil, UAN will generally be a better choice than broadcast urea for surface applications. Volatilization losses with dribble banded UAN will be lower than with urea, both because the UAN provides a portion of the N as nitrate and because UAN does not increase initial pH at the application site to the same extent as urea.

Both of these factors reduce the proportion of N present as ammonia, thus reducing volatilization. Use of a dribble-band, rather than a spray application, also limits contact between the fertilizer and crop residue, reducing immobilization. As a result, in several field studies in Manitoba, surface dribble-banded applications of UAN were nearly as effective as in-soil banded applications.

Another option to reduce the risk of volatilization loss from broadcast fertilizer is to use a urease inhibitor, in the form of an additive, such as Agrotain, with urea or UAN, or a fertilizer product, such as SuperU. Urease inhibitors slow the conversion of urea to ammonium, allowing more time for the urea to move into the soil before being converted into ammonium and ammonia. Also, the slower conversion reduces the concentration of ammonia at the soil surface, reducing the rate of volatilization.

The economic benefit of urease inhibitors will depend on the relative risk of volatilization loss and the cost of both the fertilizer and the inhibitor. As volatilization losses from UAN are generally lower than from urea, the benefit of using the urease inhibitor is likely to be lower with UAN than with urea. The option of applying a higher rate of fertilizer to account for broadcast N losses, is not a wise option considering current N costs and supply and the environmental impact. Use of urease inhibitors should be used instead of higher "insurance rates of N."

Recent evaluations of spring fertilizer placement and timing have been conducted at Indian Head Agricultural Research Foundation [1,2,3.]

Table 2. Influence of spring N application method on canola and wheat yields.

	Canola 2017	Wheat 2017		Wheat 2019	
	Yield bu/ac	Yield bu/ac	Protein%	Yield bu/ac	Protein%
No N	19	37	9.7	38	11.5
Sideband urea	52	63	13.6	53	14.8
Pre seed, surface applied N					
Broadcast urea	47	61	11.6	52	14.4
Dribble UAN	45	61	11.8	-	-
Broadcast urea 7 Agrotain	44	63	11.8	50	14.4
Broadcast SuperU	47	64	12.1	52	14.3
Split N: ½ sideband, ½ in-season					
Broadcast urea	47	64	12.4		
Dribble UAN	46	65	11.8		
Broadcast urea & Agrotain	48	62	12.4		
Broadcast SuperU	48	65	12.1		

Top yields were generally achieved with side-banded urea, particularly for canola. With wheat, surface applied N generally had less yield and protein than the split sideband in-crop application and the sidebanded N.The split application had similar yield but slightly lower protein than when all N was sidebanded at seeding. These in-crop split applications were made at early bolting of canola and stem elongation of wheat.

3) Placement in the Seed-Row – Placement of fertilizer in the seed-row is an attractive option for situations where N fertilizer can't be applied in a side-band or mid-row band at planting, since it eliminates an extra pass for fertilizer application. If the fertilizer is placed directly with the seed, it eliminates the extra expense, draft requirements and soil disturbance required to side-band or mid-row band the N fertilizer requirements.

Seed-row placement is also a form of banding, so it is efficient in terms of reducing N losses. Applying excess nitrogen with the seed, however, can lead to seedling damage due to a combination of salt and ammonia toxicity. Such damage often reduces crop yields, limits crop response to nitrogen fertilizer and reduces nitrogen use efficiency. In addition, seedling toxicity may delay crop emergence and reduce crop vigour (increasing potential losses from weed competition), delay crop maturity (increasing risk of damage from fall frosts), and lower crop quality. In all cases, the eventual impact of seedling toxicity on crop yield and quality at harvest is highly dependent on the type of growing season.

The amount of seed-placed fertilizer that can be safely applied depends on a number of factors including environmental conditions, crop grown, soil type, width of the seed/fertilizer band, row spacing and fertilizer source. Small seeded crops, such as flax or canola, are more sensitive to seedling damage compared to crops, such as wheat or barley.

With cereal crops, urea tends to be more damaging than ammonium nitrate (34-0-0, which is no longer available), while UAN tends to be intermediate, since it is a blend of urea and ammonium nitrate. Canola is equally sensitive to urea and UAN. Regardless of crop, the rate applied with the seed must be decreased in situations with coarse textured soils (e.g., loam or sand), soils that have low soil organic matter, cool growing conditions, low soil moisture, soils with salts or free lime, or with the use of wide row spacing and/or narrow openers.

The use of air seeders with wide sweeps allows for increased rates of seed-placed fertilizer, since the concentration of fertilizer in contact with the seed is reduced as the seed and fertilizer are spread over a wider area. For more detail about determining safe rates of N fertilizer that can be applied with cereals and canola, please refer to Table 7 of the Manitoba Soil Fertility Guide www.gov.mb.ca/agriculture/crops/soil-fertility/soil-fertility-guide

The risk of damage from seed-placed fertilizer varies greatly from year to year, depending on conditions at seeding, so a rate that caused no problems one year may cause significant damage the next. A reasonable compromise may be to apply a portion of the fertilizer with the seed and broadcast or dribble-band the remainder.

The use of a controlled release fertilizer, such as polymer-coated ESN, can increase the rate of N that can safely be applied with the seed. The amount of safety is difficult to predict since the polymer coating may be fractured during handling, transport and air-seeder delivery, affecting the rate of N release. The suggested safe rate limits are based on the provincial guideline (Table 7 in the Manitoba Soil Fertility

Guide) and the proportion of “well cared for” ESN in the blend with seed-placed urea. At 100%, ESN can be used at three times the safe urea-N rate, and a 50% ESN:50% urea blend can be used at 1.5 times the safe urea-N rate.

4) Side-Banding or Mid-Row Banding at Seeding – Banding of N to the side and below the seed will decrease the risk of ammonia or salt toxicity, compared to seed-placing. Many commercial and home-manufactured openers have been designed for one-pass seeding and fertilizing. These include simple systems where fluid N is dispensed through a tube on the seed-opener and mixed with the soil as it falls back over the seed, combined seed and fertilizer boots which place the N in a band separated from the seed, and systems with separate openers for side-band or mid-row placement.

Often the entire N needs of the crop can be met through sideband placement, but Manitoba research has shown that placement 1 inch to the side and 1 inch below may NOT be sufficient separation for crop safety, especially for sensitive crops, such as canola (Grant et al. Agron. J. 102:875). Therefore, if the entire N needs are to be applied, the side band should be at least 2 inches from the seed row for solution or dry fertilizer and at least 2-3 inches from the seed-row for anhydrous ammonia.

Mid-row banding N fertilizer between every second seed-row at seeding maintains the greatest degree of seed safety. Less soil disturbance, and hence more moisture retention, would be achieved with a disk type mid-row bander unit compared to a shank-type.

Fluid sources are particularly convenient for one-pass systems, as application equipment for fluids is often easier to work with and cheaper to modify than equipment for granular or ammonia application. NH3 is a relatively low-cost N source, but concerns exist as to its seed safety for application in a one-pass system.

Nevertheless, NH3 can be safely applied using side-band or mid-row band equipment, as long as the seed-fertilizer separation is at least 2-3 inches. Good opener wearability, good soil tilth, good moisture conditions, and reasonable speed of operations are also important to ensure that seed and fertilizer separation are maintained. Wing-tip injection of NH_3 on sweep openers has performed well for cereals on heavier soils. However, at the shallower seeding depths required for canola or flax, there may not be sufficient soil coverage to prevent ammonia escape to the surface.

Many of the commercial seeders do a very good job of side-banding or mid-row placement, but the cost of the equipment can be high. Draft requirement and seedbed disturbance may also increase and trash clearance may become a problem. However, the benefits of combining seeding and fertilization into one operation can be significant and may pay long-term dividends.

Recently there have been concerns over shallow placement of urea or UAN in the soil and volatilization potential. Field studies in eastern Manitoba have shown urea placement at ½ to 1 inch depth had slightly more volatilization than at 1.5 to 4 inch placement, but yields were unaffected. Proper coverage and packing help to minimize any potential loss.

5) Banding Nitrogen Immediately After Seeding – A small amount of research and practice indicates that banding NH3 immediately after seeding may have some advantages over top dressing in terms of cost and efficiency. This research was conducted many years ago on heavy clay soils previously seeded with diskers or air seeders. If such a strategy is attempted, ensure that NH_3 is placed perpendicular to the direction of seeding, using a narrow knife or low disturbance opener to minimize destruction of the seedbed. Also, ensure that NH_3 is injected at the recommended depth to minimize the potential for seedling damage and to prevent ammonia escape from the trench.

More recently disk seeders have been observed to successfully place urea into previously planted cereals or canola. Applied at an angle or perpendicular to seeding, crop stands were reduced only over the slot and measured volatilization losses were minimal. Crop stands were superior to preplant banded N which produced cloddy seedbeds.

With very precise guidance (e.g., RTK), some farmers have successfully fertilized between seeded rows after seeding to band apply fertilizer N, but this is only practical in 10 inch or wider row spacing and with low disturbance application equipment that can band fertilizer into the soil with minimal stand disruption or injury.

6) Post Emergence or Midseason Applications – In some situations, producers may want or need to delay applying a portion of their nitrogen fertilizer until they have better estimate of their crop's yield potential or because of constraints on the amount of N fertilizer they can apply before or during seeding.

Historically in Manitoba, midseason applications of all or part of a crop's nitrogen fertilizer has not produced higher yields than pre-plant or one-pass seeding and fertilizing application. However, new fertilizer products and practices have improved the efficiency of post-planting applications as a complement to applications at or near planting. For example, recent research on split N application with urease-treated urea produced highest spring wheat yield when 25-50% of the N was split applied at stem elongation – when more than 5mm of rain was received within 5 days of application.[4]

Top-dressing (broadcasting N after crop emergence) can be a reasonably efficient method of applying N fertilizer if rain falls soon after application, which is common in the spring in much of Manitoba. However, post-seeding surface applications will be subject to the same considerations as surface applications prior to seeding. UAN is well-adapted to use for post-seeding N applications if it is dribble-banded, or injected using coulter applicators after crop emergence. Conversely, applying UAN in a full-coverage spray may result in leaf burning and significant losses of N. Ideally, post-emergent N should be applied to cereals no later than heading and to canola prior to bolting.

Long season, wide row crops like corn or sunflowers have numerous opportunities for in-season N, including top dressing (discussed previously) as well as side dressing (banding N in soil, between rows) and surface banding (e.g., y-drop application of UAN).

Regardless of which source and placement is used for midseason applications, the crop's early season N requirements must also be met. Therefore, a substantial amount of N should also be applied at or near planting in situations where soil N supplies are low and/or to deal with the risk of adverse weather that could delay post-seeding applications.

Volatilization losses will be higher on high pH soils, especially if an urease inhibitor is not used. There may also be an enhanced risk of stranding of N at the soil surface with prolonged dry weather, regardless of whether a urease inhibitor is used. Therefore, the likelihood of a benefit from post-seeding applications increases with the chance of significant in-season precipitation. This is because the crop is more likely to be able to gain access to the applied N and, because if yield is primarily limited by available moisture, in-season rainfall increases yield potential and response to applied N. In addition, early season denitrification and leaching losses of N already present in the soil will be greater under wet conditions.

One More Consideration: Making Sure Your P and K Fertilizer is "In Place"
Another fertilization issue to consider is the logistical challenge of getting P and K fertilizers to retailers and farmers for this coming spring season, when the transport and warehousing system will be severely stressed to handle the extraordinarily large quantities of N fertilizer. Although there are agronomically efficient options for applying N fertilizers after crops are planted, there are no equivalent timing and placement options for applying P and K efficiently after planting. That is why the same surveys summarized in Table 1 show that over 90% of wheat and canola fields in Manitoba are fertilized with phosphorus (P) at seeding, for example. Therefore, given the importance of banding P and K at time of planting, farmers should ensure that they have their bulk requirements for P and K fertilizers "in place,"preferably on their farms, well ahead of seeding time.

Supplemental Information

Minimizing Nitrogen Fertilizer Losses to the Environment
Fertilizer use efficiency will be greatest when a source, placement and timing combination is used that minimizes N losses by the following mechanisms:

1) **Volatilization** is the loss of N to the atmosphere as ammonia gas. Ammonium and ammonium-producing sources, such as urea or UAN solution, may be lost by volatilization when left on the soil surface, while nitrate sources are not susceptible to this loss. The ammonia dissolves and travels in soil moisture, so volatilization losses increase with factors that increase evaporation, such as warm air and soil temperatures and wind. Applying ammonium-based fertilizer when temperatures are cool, winds are light and rainfall is imminent helps to reduce volatilization losses.

Table 1. Conditions that Affect Volatilization Losses of N Fertilizer

High Loss Potential	Low Loss Potential
moist conditions, followed by rapid drying	dry conditions, followed by rainfall
high wind velocity	low wind velocity
warm soil temperatures	cool soil temperatures
high soil pH (> pH 7.5)	low soil pH (>7.5)
high lime content in surface soil	no lime at soil surface
coarse soil texture (sandy)	fine textured soil (clay)
low organic matter content	high organic matter content
high amount of surface residue (Zero Till)	low amounts of residue (intensive tillage)

2) **Immobilization** refers to the "tie-up" of N in the soil microorganisms as they decompose crop residues and use plant available N, such as ammonium and nitrate, for their own growth and reproduction. This is a temporary loss, since the N will become plant available when the microorganisms die and decompose, but it restricts N availability in the year of application. Immobilization losses are greatest for crop residues that have a low concentration of N or a high ratio of C to N (e.g., cereal crop residues) and when straw volumes are high (e.g., corn and wheat straw versus canola or soybean residue).

3) **Denitrification** is mainly a microbial process that converts nitrate-N to gaseous forms of N, which can be lost to the atmosphere. Denitrification occurs when available oxygen in the soil is limited, such as very wet or flooded conditions or when the soil is very compacted. Losses are higher on fine-textured soils (e.g., clay) and in depressional areas of the landscape where water ponds. Even when the soil is not completely flooded, there will be microsites in the soil where oxygen availability is limited and denitrification can occur. The rate of denitrification will be faster when soil temperatures are warm, because the activity of the microorganisms that cause denitrification increases with increasing soil temperature.

4) **Leaching** is the movement of N in the soil water down through the soil profile. When the N moves below the rooting depth, the plants can no longer reach the N, so it is lost for crop use and poses a threat to groundwater quality. Ammonium-N is normally bound to soil particles and is protected from leaching losses. Therefore, N in the nitrate form is much more susceptible to leaching losses than the ammonium form. Leaching will increase with increasing precipitation and is greater on coarsely textured (sandy) soils with lower water holding capacity.

5) **Runoff and Erosion** is not generally a serious problem where fertilizer N is banded or incorporated. However, if fertilizer is applied onto snow or frozen soils, or if surface application is followed by heavy rainfall, losses may be substantial. The potential for N loss from these pathways will depend on soil type and environmental conditions. Therefore, when selecting a fertilizer management program, the soil and environmental conditions should be evaluated to assess the relative risk of losses by volatilization, immobilization, denitrification, leaching and runoff or erosion.

Additional resources and references:

Details on risks of N losses and spring N options are summarized by Dr. Cynthia Grant (retired AAFC research scientist) and posted at:
www.umanitoba.ca/faculties/afs/MAC_proceedings/proceedings/2004/grant_spring_options.pdf

IHARF Reports on 4R Nitrogen management are available at:
[1] www.iharf.ca/wp-content/uploads/2018/04/4R-N-Management-in-Canola.pdf
[2] www.iharf.ca/wp-content/uploads/2020/05/4R-Nitrogen-Management-Principles-in-Spring-Wheat.pdf
[3] www.iharf.ca/wp-content/uploads/2018/04/4R-N-Management-in-Wheat.pdf

[4] N fertilization options, including midseason applications, for high yielding spring wheat:
www.mbwheatandbarley.ca/wp-content/uploads/2019/03/Mangin-Flaten-N-mgmt-for-HY-wheat-project-revised-technical-report-2018-03-31.pdf

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