The National Centre for Livestock and the Environment
environmental stewardship
farm productivity & viability
food quality & safety
animal health & welfare
efficient energy & water use
University of Manitoba

BENEFICIAL MANAGEMENT PRACTICE (BMP) FOR GREENHOUSE GAS MITIGATION

SELECTING THE *RIGHT PLACEMENT* OF FERTILIZER N IN MANITOBA

"N fertilizer placements are dependent on fertilizer, crop and soil type, equipment availability, and farm economics"

BACKGROUND

- There are a variety of N fertilizer placements that are dependent on fertilizer, crop and soil type, equipment availability, and farm economics. Typical N placements in Manitoba are (Figure 1):
    1. **Surface Broadcast** – synthetic fertilizer or manure applied onto the surface of the soil, either before seeding or after crop establishment. Both liquid and granular fertilizer, as well as liquid or solid manure can be broadcast-applied. "Broadcast topdressing" usually refers to applying fertilizer or manure on the surface of established fields (e.g. established annual crops or forages)
    2. **Broadcast Incorporated** – synthetic fertilizer surface broadcast and then incorporated into the soil with cultivation or seeding equipment. Both liquid or granular fertilizer and liquid or solid manure can be applied this way
    3. **Banding or Injection** – synthetic fertilizer or manure applied in bands of about 2.5-3.8 cm by the side or below the soil surface to provide a concentrated zone of nutrients. Granular fertilizer, liquid manure and anhydrous ammonia can be applied this way. Options:
        - ***Pre-plant Banding or Injection*** – both terms refer to placing N in a band underneath the soil surface prior to planting. "Injection" usually refers to banding gas or liquid forms of nutrients
        - ***Side-band*** – fertilizer is placed to the side and below every seed row in a band during one-pass seeding and fertilizing operations
        - ***Mid-row Band*** – fertilizer is placed between every second seed row, or between paired seed rows in one-pass seeding and fertilizing operations or two-pass systems (e.g. fall N application and spring seeding)
        - ***Top Dressing*** – fertilizer is banded, dribbled or streamed on surface of soil between or near base of rows of young plants
        - ***Side-dressing*** – fertilizer is applied in subsurface bands between rows of young plants, typically corn when plants are 30–60 cm tall or potato after emergence and at hilling, to provide N near the time of maximum plant uptake

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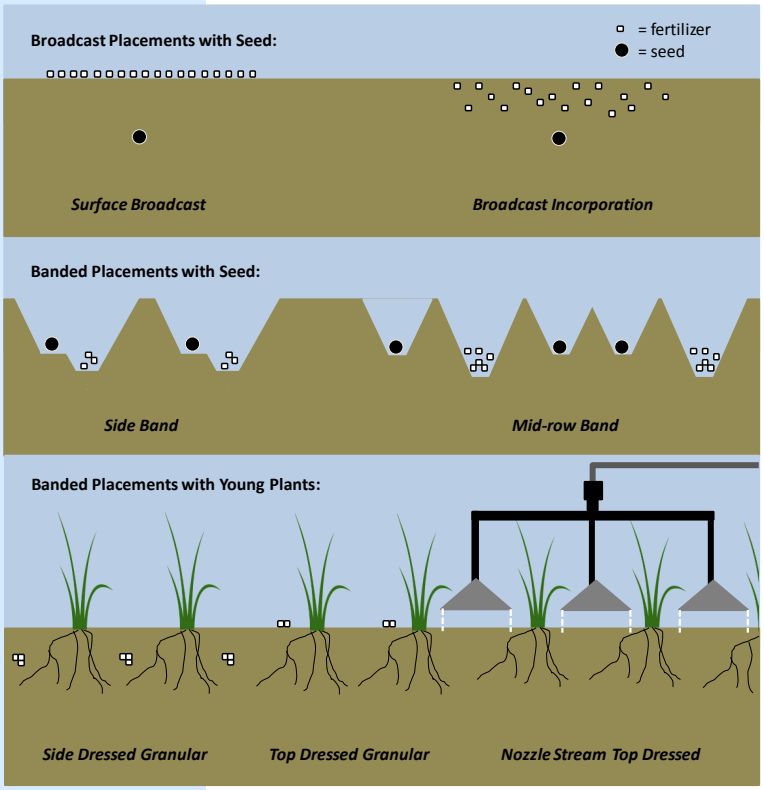
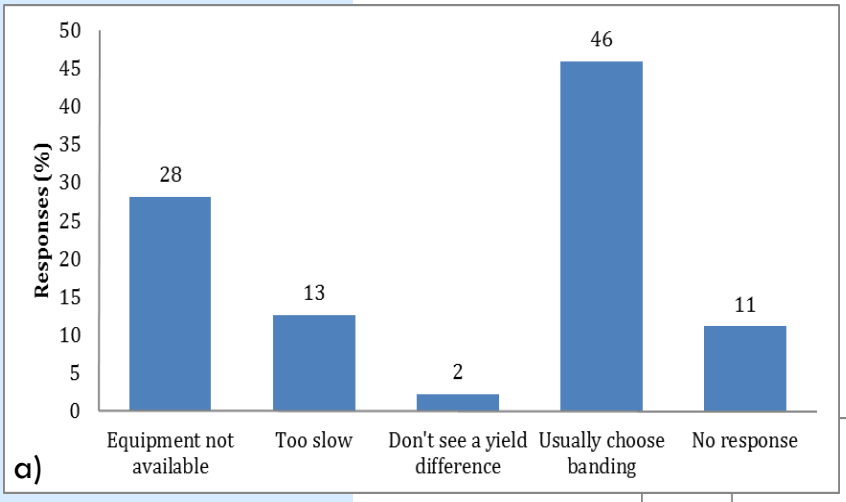


Figure 1: N fertilizer placements broadcast and banded with seed, and banded with young plants.

4. ***Seed Placed*** – a small to moderate amount of fertilizer placed with the seed at planting in conjunction with banding or side-dressing. Both liquid and granular fertilizer can be used. Seed safety is a concern limiting the amount of fertilizers that can be placed this way. The amounts depend on fertilizer timing and the overall N fertilizer rate required for a particular crop. Other factors such as soil pH, salt content and potential NH_3 toxicity issue also need considerations
5. ***Fertigation*** – smaller amounts of water soluble granular fertilizers (e.g. urea) or liquid fertilizers (e.g. UAN) are incorporated with the irrigation water and distributed onto fields through an irrigation system multiple times throughout the growing season



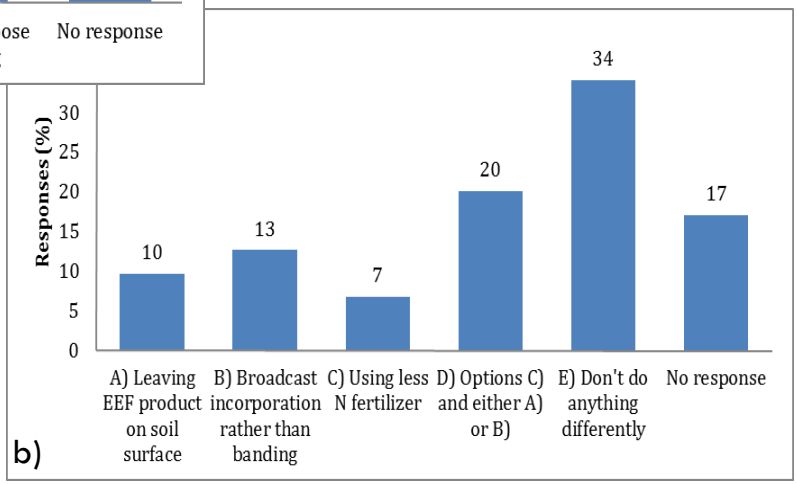


Figure 2: Manitoba Agronomists Conference 2015 survey results (135 participants):

a) "Why do you not choose / recommend banding when it is the BMP for your crop?"

b) "I intend or currently use / recommend enhanced efficiency fertilizers (EEF) differently than non-EEF sources by: "

(Source: Amiro et al 2015)

- Results from a recent survey conducted at the Manitoba Agronomists' Conference in December 2015 indicate that there are economical and informational barriers to adopting best management practices for N fertilizer placement in order to reduce N fertilizer losses through ammonia volatilization, nitrate leaching and nitrous oxide emissions (Figures 2a and 2b)

WHAT SHOULD WE DO?

- Consider your field's specific soil texture, pH, time of crop N requirements and potential N loss paths when selecting N fertilizer type
- Tailor your placement to the selected N source, rate and timing of application
- Consider subsurface banding conventional and enhanced efficiency fertilizers to reduce losses of N through ammonia volatilization, nitrate leaching and nitrous oxide emissions
- Consider fertigation for horticulture (typically potato and processing tomato) or annual crops that require regular irrigations
- Where surface placement is the only option, consider using fertilizer with a urease inhibitor or incorporating to reduce ammonia volatilization losses

WHY SHOULD WE DO IT?

- Subsurface banding of conventional ammonia-based N fertilizers can reduce immobilization of N by soil microbes compared to broadcast incorporation. The heightened concentration of ammonia within the band is toxic to microbial communities. Only fertilizer along the periphery of the band can be converted to plant-useable forms, allowing for an extended period of nutrient availability
- Surface broadcast and surface banding of conventional ammonia-based fertilizers increase the risk of N losses through ammonia volatilization
- It is essential that Controlled-Release enhanced efficiency fertilizers (EEFs) such as ESN be subsurface banded rather than left on the soil surface because the coated granules need complete contact with soil to release N at specific thresholds of soil temperature and moisture
- Fertigation allows N fertilizer to be supplied directly to the root zone during the growing season to match the crop's N needs, improve fertilizer efficiency, and thus allow farmers to use less N fertilizer than conventional ways
- Fertigation reduces tractor operation, resulting in minimal crop damage, less fuel use, wear and labour

HOW SHOULD WE DO IT?

- Surface broadcasting conventional fertilizers, Controlled-Release or stabilized EEFs; will increase N losses through ammonia volatilization, therefore incorporation is recommended
- When applying N in fall, it is best to subsurface band into late fall, but prior to soil freeze-up. Consider using double inhibitor Stabilized EEFs with urea, nitrification inhibitor addition to anhydrous ammonia, or Controlled-Release EEFs
- For long season crops such as corn and potato, when using conventional fertilizers alone, perform split applications to match crop demand e.g. side-dressing N for corn, fertigation for potato
- With fertigation, in order for nutrients to effectively reach the roots of the established crop and not be lost through ammonia volatilization, approximately 2 cm of water–nutrient solution (typically with UAN) should be applied to the soil surface

"It is essential that Controlled-Release EEFs such as ESN be subsurface placed rather than left on the soil surface because the coated granules need complete contact with soil to release N "

WHERE SHOULD WE DO IT?

- Conventional synthetic fertilizers, manure and EEFs are recommended to be subsurface banded or injected whenever possible for most efficient use of nutrients
- On heavy clay soils such as those in the Red River Valley, it is recommended that subsurface banding be used in either late fall or early spring, rather than spring surface broadcast. It can be problematic to move surface granular urea or UAN into soil if dry conditions prevail
- On medium to coarse textured soils such as those around the Assiniboine Delta, either subsurface banding or broadcast incorporation are recommended
- Fertigation is a good option for high cash horticulture crops like potato that are grown on coarse textured soil and already require irrigation to maximize yield potential

"Subsurface banding provides higher N use efficiency and has the potential to reduce fertilizer rates compared to broadcasting"

POTENTIAL ADVANTAGES:

- Subsurface banding has the potential to reduce fertilizer rates, N losses and operation costs compared to broadcasting
- Injection of anhydrous ammonia can be cost effective because of the lower retail cost and greater market availability over time than other sources
- For horticulture crops such as potato, fertigation can reduce equipment costs by allowing producers to use the same equipment to apply irrigation water as well as fertilizer at critical stages throughout the growing season

POTENTIAL DISADVANTAGES AND UNCERTAINTY:

- Surface broadcast has high N losses by volatilization, denitrification, and run-off erosion compared with subsurface placement or fertigation
- Banding equipment is costlier than broadcast spreaders
- Banding can cause "salt effect" that reduces water uptake by young seedlings if too much fertilizer is placed with or too close to the seed
- While banding generally reduces N losses, its benefit on yield improvement is not consistently significant
- Fertigation increases costs and its effectiveness heavily relies on the overall irrigation infrastructure design
- Fertigation has potential issues with weather, i.e. rainy weather can delay the need for irrigation and thus delaying N application, and/or uneven application of fertilizer on a windy day using sprinkler systems

HOW DO WE KNOW THIS?

Several research projects have been undertaken by the University of Manitoba and Agriculture and Agri-Food Canada on heavy clay soils of the Red River Valley as well as sandy loam and clay loam soils in southwestern Manitoba to study the effectiveness of N fertilizer placement on crop yields, N uptake and losses (see Research Highlights section for more detail). These local studies aim to compare N_2O emissions and N use efficiency of a variety of different fertilizer placement strategies typically used by producers in Manitoba (e.g. surface broadcast, broadcast incorporated, side band, mid-row band, shallow and deep banding).

To measure N loss to the atmosphere as N_2O, enclosed chambers are strategically placed on the soil surface over the zone of N fertilizer application. Gas samples are extracted from the chamber at regular intervals over a given period of time. Increasing concentrations of N_2O in the chamber over time indicate N loss from the soil to the atmosphere, and decreasing concentrations indicate the uptake of N_2O to microbial denitrification.

N fertilizer use efficiency can be expressed as an Emission Factor; an indicator which calculates the percent of fertilizer N that is lost to the atmosphere as N_2O emissions, after having accounted for native soil N losses.

Nitrogen use efficiency for crops is determined using a yield-based emission intensity indicator which represents how many kg of N was lost as N_2O emissions over the growing season per tonne of grain produced.

Local studies have found:

- At sites near Winnipeg (heavy clay soil), subsurface banding in fall and spring is more effective at reducing N losses than spring surface broadcast
- At a site near Brandon (clay loam soil), greatest N losses were always from fall banded treatments, and there was little difference between spring subsurface banded and broadcast treatments
- No significant differences in yield were found from different urea placement strategies (broadcast incorporated, single side-banded, double mid-row banded) at research sites near Carman and Oak Bluff
- Side band of urea or EEF sources tended to reduce N_2O emissions than broadcast-incorporation from spring wheat grown at two locations in the Red River Valley, based on either fertilizer percentage or yield production
- Banding of urea or ESN delays N_2O emission peaks and tended to reduce emissions more than broadcast for irrigated potato on sandy loam soils in southwestern Manitoba

"At sites near Winnipeg (heavy clay soil), subsurface banding in fall and spring is more effective at reducing N_2O losses than spring surface broadcast"

RESEARCH HIGHLIGHTS

Burton D.L., Li X. and Grant C.A. (2008) *Influence of fertilizer nitrogen source and management practice on N_2O emissions from two Black Chernozemic soils*. Can. J. Soil Sci. 88: 219–227.

This 3-year study examined the influence of nitrogen source, time and method of application (spring surface broadcast, spring subsurface banded, fall subsurface banded) on N_2O emissions from 2 sites near Winnipeg (heavy clay soil) and Brandon (clay loam soil) growing hard red spring wheat. At the Winnipeg site subsurface banding in fall and spring were more effective at reducing N losses than spring surface broadcast. At Brandon, the greatest N losses came from fall banded treatments while there was little difference between spring subsurface banded and surface broadcast treatments.

Gao X., Asgedom H., Tenuta M. and Flaten D.M. (2015) *Enhanced efficiency urea sources and placement effects on nitrous oxide emissions*. Agron. J. 107: 265–277.

This paper reported a 2-year field study investigating the effects of urea fertilizer placement (broadcast incorporated, single side-banded, double mid-row banded) on N_2O emissions at two locations growing spring wheat within the Red River Valley (Carman and Oak Bluff). At both sites, yield was unaffected by urea placement however yield-based emission intensity (kg N lost as N_2O per Mg of grain) was significantly higher for broadcast incorporated compared to single side-banded urea.

Baron K. and Tenuta M. (2014) *Developing best management practices to mitigate greenhouse gas emissions from irrigated potato production in Manitoba*. Final Report AAFC#:3000528623.

This report synthesized results of recently completed greenhouse gas emission studies implementing 4R strategies in potato production systems in Manitoba and other temperate regions. One particular 2-year study at Carberry, MB (clay loam soil) looked at placement (in-hill subsurface banding versus broadcast incorporation) effects on N_2O emissions from urea and Controlled-Release EEF (ESN) at rates of 100 or 200 kg N/ha. It was found that banding of urea or ESN at 100 or 200 kg N/ha reduced N_2O emissions compared to broadcast incorporation.

Maharjan B. and Venterea R.T. (2013) *Nitrite intensity explains N management effects on N_2O emissions in maize*. Soil Biol. Biochem. 66: 229–238.

This paper reported a 2-year study investigating the effects of N fertilizer source and placement method (mid-row banding and broadcast incorporation) on N_2O emissions and soil N dynamics from corn fields near St. Paul, Minnesota. Compared with broadcast incorporation, mid-row banding of urea reduced soil nitrite accumulation and N_2O emissions by 50%. When Stabilized EEFs were used, placement of fertilizer had little effect on N_2O emissions and soil nitrite accumulation. Results imply that management practices that reduce nitrite accumulation can reduce N_2O emissions.

Funding for production of this factsheet was provided by the Government of Canada through the Agricultural Greenhouse Gases Program of Agriculture and Agri-Food Canada.