Chapter 5.1

Getting the Most Out of Commercial Fertilizer Applications

learning objectives

- List five fertilizer placement methods and their impact on fertilizer effectiveness.
- List advantages and disadvantages of applying fertilizer in the fall, spring, and after crop emergence.

Important Terms

Table 5.1.1 Key words and Definitions

Term	Definition
Ammonia Toxicity	This occurs when the free ammonia ion (NH_3^+) is released when urea-N fertilizer converts to the ammonium form (NH_4^+). A high concentration of the free ammonia ion causes germination and seedling damage. Highly calcareous soils are more susceptible to ammonia toxicity than non-calcareous soils.
Banding	Any application method where the fertilizer is applied in concentrated strips, either on the surface or sub-surface.
Broadcast Application	Fertilizer applied on the soil surface.
Dribble Banding	Surface banding of liquid fertilizer.
Fertigation	Applying fertilizer using irrigation water and equipment.
Foliar Application	Applying liquid fertilizer to the leaf surface.
Knifing or "Knifing in"	Band application below the soil surface.
Broadcast and Incorporation	Incorporation of broadcast fertilizer using conventional tillage equipment.
Seed-Placed (in row)	Fertilizer placed in the same furrow as the seed.
Pre-Plant Application	Fertilizer application prior to seeding of the crop.
Salt Effect	The osmotic pressure or "pull" that fertilizers have on soil water. This osmotic pressure will prevent soil moisture, which is near the seed, from being accessed by the germinating seed and young seedling. This can be a major cause of germination and seedling damage. Salt effects are most severe when soil moisture is limited.
Seedbed Utilization (SBU)	The width of fertilizer and seed spread, relative to the row spacing, reflects the relative concentration of fertilizer in the seedrow. The higher the SBU, the more fertilizer that can safely be applied with the seed. For example a 7.5 cm spread with a 15 cm row spacing is 50% SBU (7.5/15 x 100 = 50%).
Side Banding	Fertilizer placed in a row near the seed during the one-pass seeding operation.
Side-Dressing	Fertilizer application in a row adjacent to the crop row.
Split Application	Fertilizer application is split into two or more applications.
Starter Fertilizer	Fertilizer applied when planting, usually in or near the seed row.

The balance of nutrients in manure does not match the nutrient requirements of crops. Strategic use of commercial fertilizers can address this imbalance by helping to optimize the use of manure nutrients and minimize the accumulation of nutrients (e.g., P) in soils that can occur with long–term, repeated applications of manure. As such, the judicious and efficient use of commercial fertilizer is an environmentally responsible management practice.

This chapter will introduce important terms and concepts related to optimizing commercial fertilizer application including: fertilization, product placement methods, and the timing of commercial fertilizer applications.

Fertilizer Placement

The primary difference among fertilizer application techniques is where fertilizer is placed relative to the developing crop and its roots (Figure 5.1.1). This has implications for how effective the crop will be able to utilize certain nutrients.

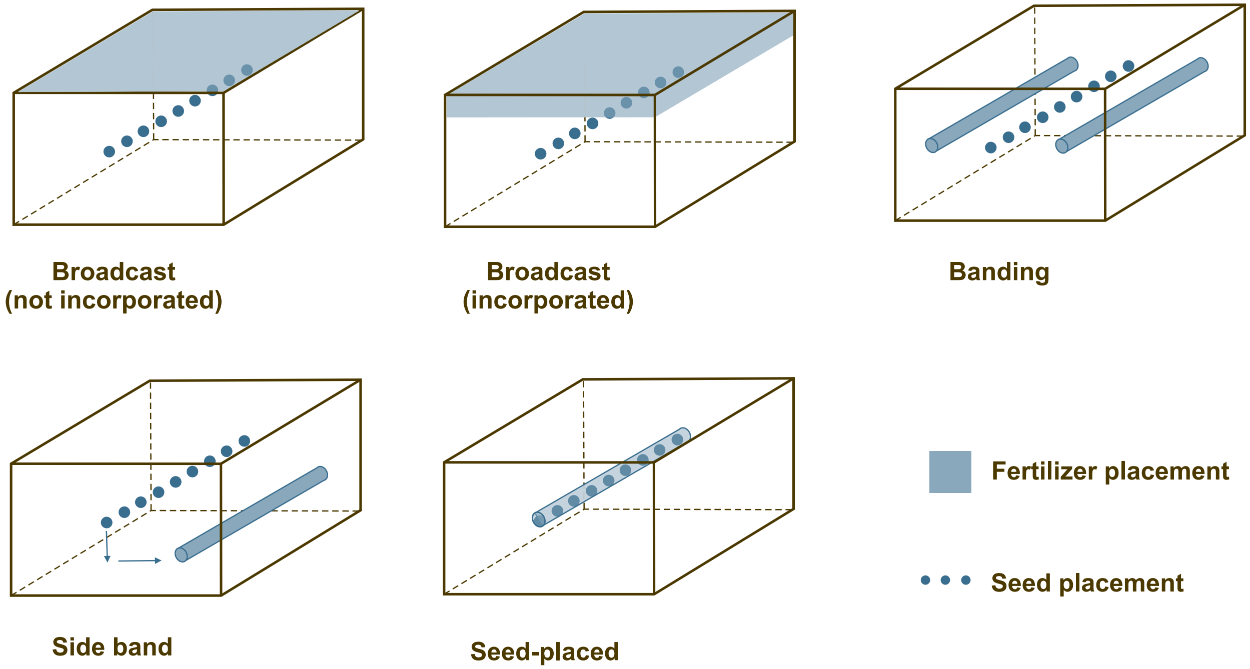

Figure 5.1.1 Placement of Fertilizer Using Different Application Techniques

Broadcast and Broadcast and Incorporation

Broadcasting spreads fertilizer across the soil surface. Broadcast fertilizer can be left on the soil surface or incorporated by a tillage operation after application. With incorporation, these nutrients are mixed into the surface layer of the soil where root interception is more likely to occur.

Broadcasting is generally the fastest and least costly fertilizer application method. On established crops it is usually the only practical way to apply fertilizer without damaging the crop. Elemental sulphur is particularly suited to broadcast applications because the granules are left on the soil surface and exposed to weathering processes, which oxidizes the sulphur to plant available forms.

Broadcast fertilization has some limitations. Without adequate incorporation a portion of broadcast nitrogen fertilizers may volatilize and be lost to the atmosphere. Immobile nutrients (e.g., P, K, Cu) broadcast on the soil surface could be stranded above plant roots. These nutrients are inaccessible for root uptake or crop production and susceptible to loss through wind and water erosion, possibly ending up in environmentally

sensitive areas. Broadcasting, even with incorporation, mixes fertilizer with crop residue. As a result, microorganisms immobilize nutrients (primarily N) for weeks or months while they decompose the residue. Because of these limitations broadcasting is usually considered the least efficient way to apply most crop nutrients.

Seed-Placed

Seed-placed fertilizer refers to fertilizer placed within the seed row. It can be an effective placement method because the added nutrients are in close proximity to developing roots making them readily accessible to plants. This is especially important for immobile nutrients such as P and Cu.

There is no common nutrient loss process (e.g., volatilization or run-off) for seed-placed fertilizer. The problem with this method, however, is that fertilizer in the seed row can be harmful to seed, delaying or severely reducing crop emergence. This damage is due to ammonia toxicity or a salt effect from the fertilizer. The maximum fertilizer rate that can be safely placed in the seed row depends on the fertilizer used, crop type, soil moisture, and the width of spread of seed and fertilizer in the seed row (SBU). Urea (46-0-0) is the most damaging seed-placed fertilizer due to ammonia toxicity. Potash (KCl) and ammonium sulphate (20-0-0-24) are also problematic since these products induce a salt effect. Usually this is not as damaging as ammonia toxicity.

Band or Side Band

Banding is the application of fertilizer in a narrow row at seeding depth or slightly deeper. Banding can be done weeks or months prior to seeding, or during seeding depending on equipment. Side-banding refers to the placement of fertilizer in a narrow row slightly to the side and below the seed row during the seeding operation. Banded and side-banded fertilizer applications have similar characteristics, and are both considered “banded” fertilizer. Mid-row banding places a row of fertilizer midway between two rows of seed, during the seeding operation. Side-banding and mid-row banding maintains a consistent distance between fertilizer and the seed, while fall banding or banding in a separate operation creates varying distances between fertilizer granules and the seed row.

Band placement is efficient for most fertilizers since the band is below the seed and roots will grow toward the fertilizer source. Banding creates a greater distance between seed and fertilizer, and this allows the opportunity to apply higher rates of fertilizer during seeding without a risk of ammonia toxicity and salt effect. For N, the narrow band of fertilizer is below crop residues so immobilization is not a factor. For P and K, the band has minimal soil contact and consequently little sorption occurs. There is no common nutrient loss process (e.g., volatilization or run-off) with spring banding.

Banding fertilizer may require an additional field operation and cost more because of additional energy requirements (e.g., fuel). Banding is not an effective placement for elemental sulphur because weathering and redistribution is limited.

Dribble banding refers to the application of liquid fertilizer in narrow strips on the soil surface before or after seeding. The effectiveness of dribble banding is more comparable to broadcasting than to banding fertilizer. Nutrient loss processes common to dribble banding and broadcasting include N volatilization and immobilization and P, K, and Cu stratification.

Getting the Best Results from Banding P Fertilizers

Here are some additional tips on successfully banding P fertilizers:

- Keep the spacing between bands narrow (less than 30 cm or 12 in), so P uptake is not delayed during early growth due to distance between bands and seedlings. On very low P soils stripping can occur. This is caused by poorer growth of plants midway between phosphate bands when the bands are too widely spaced.
- Band P fertilizer deep enough to avoid disrupting the bands during subsequent tillage and seeding operations.
- Avoid banding P and N fertilizers together if N is being applied at rates higher than 70 to 80 kg/ha (63 to 72 lb/ac). The high rate of N will reduce the efficiency of P fertilizers because plant roots cannot penetrate the concentrated N band and are less effective at taking up P.

Foliar

In foliar fertilization, nutrients are sprayed onto leaves, stems, and soil surfaces with conventional spraying equipment. Foliar applications are not effective for most nutrients (N, P, K, and S) because leaves cannot absorb enough nutrients for plant growth. Without rainfall or irrigation after application, foliar fertilizers are ineffective, and will only damage plants through fertilizer burn. Some forms of micronutrients are effective when foliar applied (Table 5.1.2).

Fertigation

Fertigation is the application of nutrients through irrigation water. It allows nutrients to be supplied throughout the growing season to meet crop demand. To be effective, nutrients should be delivered with a minimum of 1.5 to 2.0 cm of water to move the nutrients into the soil. Unlike foliar applications, fertilizer burn is not a problem with fertigation because of the amount of water that is applied.

If inadequate water is applied the fertilizer nutrients can be lost through volatilization or stranded at the soil surface out of reach of plant roots. Depending on the quality (hardness) of the water, precipitates (such as calcium phosphates) can form from the combination of fertilizer and cations in the irrigation water.

Table 5.1.2 General Micronutrient Application Guidelines

Nutrient	Fertilizer Form	Timing	Recommended Rate[1], kg/ha (lb/ac)			
			Broadcast and Incorporate	Banded	Seed-placed	Foliar
Copper (Cu)	Sulphate Oxysulphate	Spring or fall	3.9 to 5.6 kg/ha (3.5 to 5.0 lb/ac)	NR	NR	NR
	Oxysulphate	Fall	5.6 kg/ha (5.0 lb/ac)	NR	NR	NR
	Chelated	Spring	0.6 kg/ha (0.5 lb/ac)	NR	0.3 to 0.6 kg/ha (0.25 to 0.5 lb/ac)	0.2 to 0.3 kg/ha (0.2 to 0.25 lb/ac)
Zinc (Zn)	Sulphate Oxysulphate	Spring or fall	3.9 to 5.6 kg/ha (3.5 to 5.0 lb/ac)	NR	NR	NR
	Oxysulphate	Fall	5.6 to 11.2 kg/ha (5.0 to 10 lb/ac)	NR	NR	NR
	Chelated	Spring	1.1 kg/ha (1.0 lb/ac)	NR	NV	0.3 to 0.4 kg/ha (0.3 to 0.4 lb/ac)
Manganese (Mn)	Sulphate	Spring	56 to 90 kg/ha (50 to 80 lb/ac)	NR	4.5 to 22.4 kg/ha (4.0 to 20 lb/ac)	NR
	Chelated	Spring	NR	NR	NR	0.6 to 1.1 kg/ha (0.5 to 1.0 lb/ac)
Boron (B)	Sodium Borate	Spring	0.6 to 1.7 kg/ha (0.5 to 1.5 lb/ac)	NV	NR	0.3 to 0.6 kg/ha (0.3 to 0.5 lb/ac)

[1] Rates are in kg (or lb) of elemental Cu, Zn, Mn, and B per ha (or ac). NR = not recommended, NV = not verified.

Adapted from Barker, 2006

Timing of Application

The goal of applying fertilizer is to deliver nutrients to plants before or just as they are needed. In western Canada, fertilizers may be applied in the fall, in the spring prior to seeding, during seeding, or after seeding; either before or after the crop has emerged.

Fall Applications

The main advantage of fall application is the length of time available to fertilize. This can relieve time pressures in the spring relating to fertilizer handling and application.

Banding of N fertilizer is the most common fall application practice because N prices are often lower in the fall than in the spring. It is most effective when soil temperatures have cooled to less than 10°C, because soil microbial processes involving N are minimized. The greatest risk faced when considering fall application of N is the potential for denitrification N losses in the spring when soils can be saturated after spring snowmelt.

Losses from fall banded P and K are very rare. Research suggests that the timing of P fertilizer banding (fall versus spring) appears to have little effect on fertilizer efficiency. Broadcasting elemental sulphur fertilizer in the fall allows more time for weathering and conversion to crop available forms.

Soil sampling should always occur prior to nutrient application, however, soil analysis results may not be available to plan fall fertilizer applications. A common practice is to split fertilizer application between fall and spring. A base rate is applied in the fall, followed in the spring by an application based on moisture conditions and soil test recommendations from fall sampling. Fall fertilizer application also means an extra field operation. This can add to production costs, reduce snow-trapping capability, and increase a field's erosion potential.

Since snowmelt is responsible for the bulk of runoff in Alberta, unincorporated fall broadcast nutrients are at risk of being lost. Wet conditions in early spring that occur on fine textured and poorly drained soils in central and northern Alberta can cause significant losses of fall applied nitrogen through denitrification. Fall broadcast applications of N are most subject to loss. Table 5.1.3 shows the relative efficiency of fall and spring broadcast and banded applications under various conditions.

Table 5.1.3 Relative Effectiveness of Different Methods and Timing of Nitrogen Application (yield improvement compared to spring broadcast and incorporation = 100)

Application Method	Soil Climate Categories			
	Dry[1]	Medium[2]	Wet[3]	Irrigated[4]
Spring Broadcast and Incorporation	100	100	100	100
Spring Banded	120	110	105	110
Fall Broadcast and Incorporation	90	75	65	95
Fall Banded	120	110	85	110

[1] Well drained soils that are seldom saturated during spring thaw. Although spring and fall banded nitrogen were equally effective in research trials, fall banding may be more practical under farm conditions. The extra tillage associated with spring banding may dry the seedbed and reduce yields.

[2] Well to moderately drained soils that are occasionally saturated during spring thaw for short periods.

[3] Poorly to moderately drained soils that are saturated for extended periods during spring thaw. In research trials conducted in the higher rainfall areas, spring broadcast nitrogen was well incorporated and seeding and packing completed within a short period of time. Under farm conditions, shallow incorporation or loss of seedbed moisture resulting from deeper incorporation may cause spring broadcasting to be somewhat less effective than shown here.

[4] Well drained soils in southern Alberta that are seldom saturated during spring thaw.

From Kryzanowski, L., 2004

tip

Late summer applications of fertilizer are recommended for forage seed production to maximize yield, as forages are setting their yield potential in the fall.

tip

Research in Alberta suggests that, based on moisture conditions, fertilizing winter cereals at seeding to meet requirements is an efficient way of fertilizing fall-sown crops.

Spring Applications

Spring application in this discussion refers to fertilization prior to or at seeding. The idea is to provide immediately available nutrients to the growing crop. There are several advantages of spring versus fall application including:

- During spring application nutrients are applied close to when the crop requires them.
- Nutrients are not stored over the winter in the soil so they are not susceptible to early spring losses (e.g., runoff, denitrification). An exception is elemental S fertilizer, which has less opportunity to convert to crop available forms when applied in the fall.
- Spring application allows for more precise nutrient applications, since spring moisture conditions can be considered.
- Soil analysis results and changes in expected crop prices can be incorporated into planning.
- By applying fertilizer in the spring, high disturbance field operations can be avoided in the fall, leaving more standing crop residue to trap snow and enhance moisture retention.
- Applying in the spring may allow the possibility of combining the seeding and fertilizer operations into one-pass, reducing field operations.

Some of the disadvantages of spring application include:

- The soil disturbance associated with spring application can dry out the seedbed thereby reducing germination and yield potential.
- The time required to complete seeding and related field operations may increase.
- Regional weather conditions in the spring can have a large impact on demand for fertilizer, which can impact availability and cost.

Some producers purchase fertilizer in the fall and store it until spring. This requires suitable storage facilities, which can be a substantial cost. Storing fertilizer also has an environmental risk, since inappropriate storage can result in nutrient release to the environment.

Post-Emergent Applications

Post-emergent fertilizer application refers to an application after crop emergence including: fertigation, broadcast, banded, and foliar applications. The major advantage of post emergent fertilizer application is that it permits adaptation to dramatic changes in growing conditions after seeding (e.g., moisture conditions or nutrient deficiencies). When moisture conditions are better than expected, additional fertilizer can help to take advantage of the increased yield potential. Alternatively, excessive precipitation can lead to conditions that promote nutrient loss and additional fertilizer could be applied to compensate for losses.

In some instances, post-emergent nutrient applications can result in crop damage. This is influenced by crop type and stage of development, as well as environmental conditions at the time of application. For each nutrient, there are limits on the form and amount that can be safely foliar-applied to the crop.

A major challenge with post emergent applications is that to be effective nutrients must be taken up by the plant before productivity is limited by deficiencies. There is a very narrow window of opportunity for this to happen successfully. In addition, multiple applications represent additional costs.

summary

- Fertilizer can be applied in several ways including broadcast (with or without incorporation), seed-placed, banded, foliar, or fertigation.
- Broadcast applications, especially without incorporation, carry the greatest risk of nutrient loss. Broadcast application is recommended when using fertilizers containing elemental sulphur to promote weathering.
- Seed-placed and side-band applications are generally the most effective because nutrients are placed in close proximity to the seed.
- Foliar applications are not effective for most nutrients (N, P, K, and S) because leaves cannot absorb enough nutrients for plant growth.
- Fertigation allows nutrients to be supplied throughout the growing season using irrigation systems. If inadequate water is applied, fertilizer nutrients can be lost through volatilization or stranded at the soil surface out of reach of plant roots.
- The main advantages of fall application are lower fertilizer prices and greater time availability. Excessively wet conditions in early spring can cause significant losses of fall applied N through denitrification.
- Some advantages of spring application include nutrients are applied close to when the crop requires them and are not susceptible to early spring losses. A disadvantage of spring application is the extra time required for field operations.
- Post emergent fertilizer application permits adaptation to dramatic changes in growing conditions after seeding.