
FERTILIZER PLACEMENT STRATEGIES TO MAXIMIZE EFFICIENCY

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Background

Fertilizer placement technology has undergone much evolution since the early days of direct seeding in the 1970's and 1980's. At that time, placement of fertilizer in the seed-row was usually the only option for in-soil placement in a single pass, limiting the amount of fertilizer that could be applied in order to avoid potential seed and seedling injury. For higher rates of fertilizer to be applied, broadcasting was the alternative and it was soon recognized that broadcasting had many limitations, not the least of which is the relatively greater potential for losses and lower crop recovery of nutrient as compared to in-soil placement.



The development of air delivery systems and seeding tools to pass through heavy crop residues, along with new opener configurations and on-row packing systems has made the task of single pass seeding and in-soil fertilizer placement much easier and more efficient. From the standpoint of fertilizer placement, the ability to “double shoot” and thereby place fertilizer in bands separate from the seed-row has been the most significant development and has opened up a myriad of fertilizer placement possibilities.

To a producer today, the large number of fertilizer product, delivery and placement options can seem overwhelming, especially when combined with the diverse array of crops that are grown in most farming operations. Many factors influence what will be the “best” fertilizer placement system for a producer. Important considerations are system capital cost, draft requirements, maintenance time and costs, and agronomic performance. This paper focuses on how to predict the agronomic performance of fertilizer placement configurations by understanding basic concepts about nutrient loss mechanisms, mobility of nutrients in the soil, and plant rooting habits. These concepts are key in getting as much of the applied fertilizer nutrient as possible into the crop plant, termed “nutrient use efficiency”. Maximizing nutrient use efficiency through optimum fertilizer placement will give best yield and economic response to applied fertilizer and minimize potential losses of fertilizer nutrient to the environment.

Reducing Nutrient Losses Through Placement

The common nitrogen fertilizer forms in use on the prairies today: anhydrous ammonia (82-0-0), urea (46-0-0) and urea-ammonium nitrate (UAN) solutions (28-0-0) are all susceptible to varying degrees of volatile ammonia losses when placed on, or close to, the soil surface.

Anhydrous ammonia: $\text{NH}_3(\text{gas}) \cdot \text{NH}_4^+$ (available ammonium)

Granular urea: urea $\cdot \text{NH}_3(\text{gas}) \cdot \text{NH}_4^+$ (available ammonium)

UAN Solutions: urea, NH_4^+ , NO_3^- (available nitrate)

To minimize volatile ammonia loss during application, it is essential that anhydrous ammonia be placed at a depth sufficient to give the ammonia gas opportunity to react with water and convert to the ammonium form, which is retained in the soil and therefore is available for plant uptake. Closure and sealing of the injection channel is essential to retain the ammonia gas in the soil and allow conversion of the gas to ammonium. Granular urea should also be placed below the soil surface and covered with a layer of soil to reduce volatile ammonia loss, since the first reaction that urea undergoes in the soil is conversion to ammonia gas (hydrolysis), induced by the enzyme urease. If enzymatic hydrolysis takes place on the surface of the soil, the potential for ammonia loss is high. Urease inhibitors (e.g. Agrotain™) are now available. The inhibitor can be applied to urea fertilizer and will stop the conversion of urea to ammonia gas for a period of about two weeks. This gives an opportunity for surface applied urea to be leached into the soil before the hydrolysis occurs.

Solution (liquid) nitrogen forms like 28-0-0 are comprised of urea, ammonium and nitrate dissolved in water. The urea component is susceptible to volatile ammonia loss, but the ammonium is much less susceptible. For this reason, surface dribble banding or shallow placement of 28-0-0 is of less concern as far as ammonia volatilization losses are concerned. Some recent work with surface dribble banding of 28-0-0 has shown yield responses and N recovery in annual crops and forage grasses similar to in-soil banding, provided that rainfall is received shortly after application to move the nitrogen into the soil.

Placement of fertilizer nitrogen, phosphorus and potassium in a concentrated band tends to reduce losses of nutrient and increase plant uptake as compared to spreading the fertilizer throughout the soil volume. Placement of urea in a concentrated band will slow down the conversion of ammonium to nitrate, which is



beneficial for reducing losses of nitrogen by nitrate leaching or conversion of nitrate to nitrogen gases under saturated or partially saturated conditions. Having phosphorus and potassium fertilizer in a concentrated band will increase availability since there is less opportunity for the fertilizer to contact with the soil and become fixed. The only instance where broadcast application is likely to benefit availability over banding is with elemental sulfur fertilizer. Broadcasting of elemental S will tend to enhance oxidation of the elemental sulfur to the plant available sulfate form as opposed to a band where oxidation rates are reduced.

In low disturbance direct seeding it is especially desirable to place the fertilizer band below the surface thatch or duff layer that builds up after several years of no-till. By placing fertilizer in mineral soil beneath the thatch layer, the fertilizer is physically isolated from potential temporary nutrient tie-up by microorganisms decomposing the surface residues. Deeper placement can also help reduce access to the fertilizer by surface germinating weeds such as millet and kochia. Depth of placement of a fertilizer band can also influence depth of crop root proliferation, as when roots encounter a nutrient rich zone they will tend to proliferate in that area. Placement of the fertilizer band should be deep enough that the fertilizer is placed into moisture, which can enhance the rooting environment for the crop as well as the solubility and availability of the fertilizer nutrient.

Ensuring Positional Availability Through Placement

An important concept to keep in mind is that a plant nutrient in the soil is not “available” unless it can move to a root surface where it can be taken up. The roots of a crop actually come into direct contact with only a small proportion (perhaps only 10% at most) of the total available nutrient in a soil volume. The remainder of the nutrient has to move to the root surface, either with the soil water moving to the roots, or through the soil water to the root surface. Key to optimizing fertilizer placement for different plant nutrients is knowledge of the distances various nutrients can move from where they are placed. Nitrogen and sulfur are considered “mobile” nutrients in our prairie soils: nitrate and sulfate dissolved in the soil water are carried with the water moving to the roots over long distances (potentially upwards of a meter or more). Phosphorus and potassium, on the other hand, are considered “immobile” nutrients, because they tend to become readily sorbed or “stuck” to the soil particles. Phosphorus and potassium therefore can only move a few millimeters from where they are placed to the root surface by diffusing through water films in the soil. Some micro-nutrient fertilizers like copper and zinc also tend to be of low mobility in prairie soils, especially if they are applied as salts like copper sulfate and zinc sulfate.

The spring-seeded annual grain crops in Saskatchewan (cereals, oilseeds, pulses) take up much of the nitrogen, phosphorus and potassium needed to complete their entire life cycle in the first few weeks following germination. Ensuring early season access of the crop to these nutrients is therefore important in maximizing yield response to fertilizer applied. The placement of the fertilizer in relation to the seed-row and where the roots of the germinating seed and seedling will be can have a profound effect on nutrient utilization and crop response, depending on the nutrient and the crop. Three common approaches to fertilizer placement at the time of seeding are depicted in Fig. 1.

Placement of fertilizer in the same furrow as the seed can be advantageous for a “starter” effect, particularly for phosphorus and potassium with cereals. Placement of P and K in the seed-row ensures that these immobile nutrients are accessible early on when the plant needs them and can provide an advantage in enhancing early crop vigor and development. Cereals tend to be more tolerant of fertilizer placed in the seed-row than oilseeds (i.e. canola and flax) and pulse crops (i.e. peas and lentils), but guidelines for maximum safe rate of nutrient placed in the seed-row should be consulted for all crops when making seed-placed rate decisions. One should not risk crop establishment problems related to too much fertilizer placed with the seed, especially with the sensitive crops.



Fig. 1. Common Fertilizer Placement Options

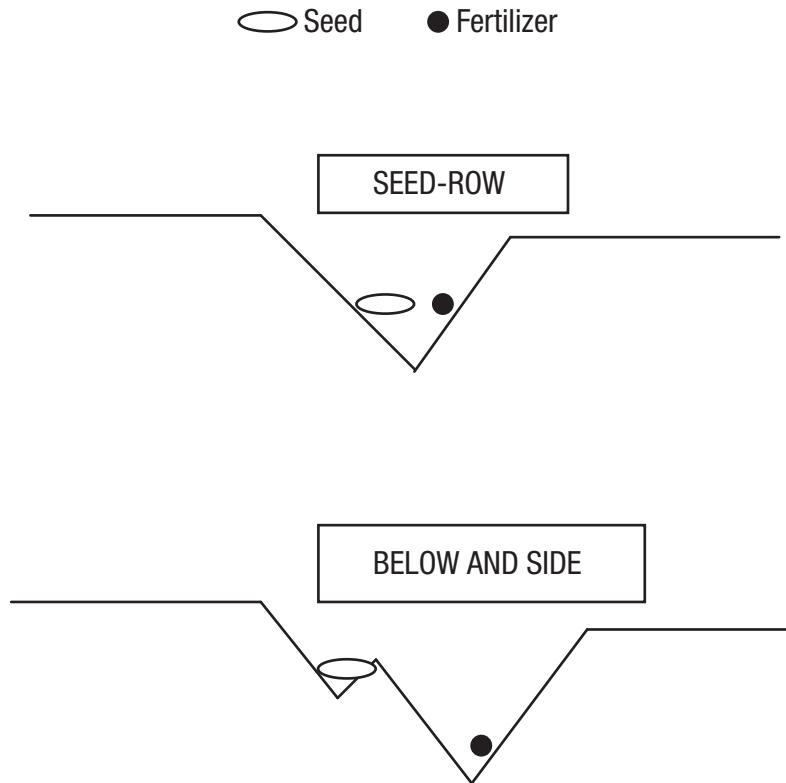


Fig. 1. Common Fertilizer Placement Options

Placement of fertilizer to the side of the seed-row or below and to the side can be achieved with double shoot openers that create a separate furrow and barrier of soil between the seed-row and the fertilizer band. Separation may also be achieved using the “squirt” concept with liquid fertilizer, in which the liquid is directed to a location beside the seed-row through a tube. A placement configuration in which all fertilizer N,P,K is placed below and to the side, such as one inch below and one inch to the side of the seed-row represents a good all-around placement for a variety of crops and nutrients. For crops with fibrous rooting systems such as cereals and pulses, and for crops with tap plus fibrous roots such as canola, placement below and to the side represents a good compromise. Adequate safety can be achieved through good separation of seed and fertilizer bands and the nutrient is still positioned close to where the roots of the young plant will be, important for early access to phosphorus and potassium. Still, it is important to check that separation is being achieved when high rates of nitrogen are being side-banded close to the seed-row. Recent research has shown that both urea and anhydrous ammonia can be side-banded successfully with wheat, canola and flax at low and high rates with good equipment, but caution should be exercised when using high rates with sensitive crops, particularly on dry soils.

Mid-row placement of fertilizer typically involves a separate set of openers that places the fertilizer in a band located mid-way between every second seed-row. Placement of fertilizer nitrogen in a separate furrow located between the seed-rows provides maximum separation distance and minimizes worry about fertilizer damage to germinating seeds or seedlings from a salt or ammonia toxicity effect. With a mid-row placement configuration, the placement of some starter fertilizer phosphorus and potassium in the seed-row is desirable, since these



immobile elements will only be accessed at advanced crop growth stages if placed in the mid-row band. The amount that can be safely placed with the seed will depend on the opener configuration used, and may be a consideration in selection of opener, as openers with narrower spreads such as knives will limit seed bed utilization (opener spread/row spacing) and the amount of starter nutrient that can safely be placed.

In a recent Master of Science project in the College of Agriculture, University of Saskatchewan (Thavarajah et al. 2003 Journal of Plant Nutrition 26: pp 683-690), the effect of placement of urea nitrogen in relation to the seed-row was investigated in a field trial near Melfort, SK. Plant Root Simulator Probes (PRSTM) were used to assess the supply of ammonium and nitrate nitrogen to the seed-row of canola from seeding to germination as affected by placement of urea one inch below and one inch to the side of the seed-row, versus mid-way between the seed-row with a horizontal separation distance of about four inches. As expected, available nitrogen supplies to the seed-row from seeding to germination were greater for the side-row banded urea than the mid-row banded urea due to the closer proximity of the side-row band to the seed row. Based on the yield responses observed, higher early nitrogen supplies to the seed-row may be a disadvantage at high rates with sensitive crops under dry conditions, but the earlier fluxes of N into the seed-row with side-row banding may be of advantage at lower N rates in highly nitrogen deficient soils. The general lack of large differences in agronomic response to nitrogen fertilizer band placement in relation to the seed-row in this study is consistent with the high mobility of nitrogen in the soil as compared to phosphorus and potassium.

Conclusion

Fertilizer placement as it influences nutrient loss, accessibility of the nutrient to the crop, and risk of crop injury is an important consideration when making fertility management decisions on a farm. A placement system should be selected with an eye towards placing the nutrients with minimum loss and maximum root uptake potential and crop safety.