Starter Fertilizer in Corn Production

Starter fertilizer in corn production has traditionally been recommended for fields with low phosphorus (P) levels or cool soil temperatures due to early planting, high residue cover or northern location. In those conditions, starter fertilizer placed near the developing seed provides easily accessible nutrients until soil conditions improve and a larger root system is established. However, some growers seeking to exploit current grain price opportunities are evaluating whether starter can play a more prominent role in increasing corn yields.

Starter Fertilizer Defined

Starter fertilizer is defined as small amounts of plant nutrients – nitrogen (N), phosphorus (P) and potassium (K) – placed in close proximity to the seed, usually at planting (Hergert and Wortmann, 2006). To be considered starter, nutrients must be strategically positioned to enhance early seedling vigor and development – directly below the seed, to the side or both.

Starter fertilizer placed in contact with the seed (“pop-up” fertilizer) is another option, but its use requires a great deal of caution to avoid possible germination and seedling injury. The amount of pop-up that can safely be applied is limited, and depends on the fertilizer used and soil properties. For example, starter fertilizer containing ammonium thiosulfate should not be placed in contact with the seed (Hergert and Wortmann, 2006).

A starter fertilizer is usually composed of two or more nutrients. Under most situations, a combination of nitrogen and phosphorus constitutes an effective starter material. Liquid 10-34-0 and dry 18-46-0 are common starter fertilizer materials. Liquid 7-21-7 and dry 8-32-16 are also commonly used. Addition of zinc and/or sulfur may be warranted in sandy, low organic matter soils, and other materials may also be used.

Early Corn Root Development

After corn seeds imbibe enough water for germination, the first root structure to emerge is the radical, which is soon followed by the lateral seminal roots (Figure 1).

The seminal root system does not take up substantial quantities of nutrients; instead, the young seedling relies primarily on the stored nutrient reserves of the seed at this stage of development. Soon after emergence (VE) the young corn seedling will begin to develop its nodal root system, the primary roots for water and nutrient uptake of the plant.

Stresses May Impede Nodal Roots

Stresses that impede nodal root development may be continuous in the field, or may occur sporadically (variably) in micro-environments throughout the field. Sporadic stresses include: uneven residue distribution, dry or cloddy soils, wet spots, diagonal anhydrous ammonia bands, fertilizer salt injury, wheel traffic compaction, seed furrow (sidewall) compaction, insect or herbicide damage to roots, and soilborne diseases.

Sporadic stresses can have their fair share of detrimental consequences to grain yield. This is because individually affected plants are likely to fall behind if conditions remain unfavorable. Once a plant falls behind by two or more physiological growth stages, it will be shaded and outcompeted by its neighbors and will likely not catch up, resulting in uneven stands (Figure 3).

Research on Corn Yield Response to Starter

Starter fertilizer applications to corn have been well researched and documented. The scientific literature shows numerous cases where starter has produced positive, meager and no corn grain yield increases. This array of results means that positive grain yield responses are likely related to both environmental and cultural interactions. Starter research...
across geographies has generally shown that areas of the northern Corn Belt more consistently and positively respond to starter fertilizer. In the central Corn Belt, fields managed with no-till or reduced tillage, poorly drained fields, or those testing low in P were more likely to respond.

Consistent grain yield responses to starter fertilizers may also be expected on soils that have low soil organic matter or soils that have coarse (sandy) soil surface textures. Many soils formed from Mississippi River alluvium that stretch from portions of central Minnesota to the Gulf of Mexico fit this description. Average grain yield responses of 12.5 bu/acre were documented in some studies on these soils (Mascagni et al., 2007). In these studies (Figure 4), the largest and most consistent yield responses were on the sandiest soils, and grain yield responses were more likely from the P in the starter.

**Hybrid Responses to Starter Fertilizer**

A Kansas State study with five hybrids in a no-till system found that starter fertilizer (N and P) significantly increased early season growth, N and P uptake at V6, and N and P concentration in the ear leaf (Gordon, et al., 1997). All hybrids responded similarly to the starter application. The study also found that all hybrids required less growing degree units (GDUs) to pollination when starter was used, with an average of 80 less GDUs required. This is a key finding for dryland corn production in Kansas, where yield is often limited by late season drought stress.

**Banded Applications More Efficient**

Application of P as a starter fertilizer is usually more efficient than broadcast applications, especially when inherent soil P levels are very low or for calcareous high pH soils above 7.5 (Shapiro et al, 2003). For example, recommended P rates can be reduced by 1/2 when applied as a banded starter fertilizer compared to broadcast application (Table 1). This is because banded starter applications result in less soil immobilization and more crop available P than broadcast applications, especially for high pH soils with low P levels. Use of a band-applied P starter is an especially appealing alternative to broadcast application when P based fertilizers are extremely expensive.

**Avoiding Salt Injury from Starter Fertilizers**

The rate at which a starter fertilizer can be applied depends on the salt content or index of the fertilizer, proximity of starter to the seed, and soil texture (Hergert and Wortmann, 2006). Salt index is a function of the sum of the N, P and S content in the fertilizer (Table 2, Mortvedt, J.J. “Calculating Salt Index”).

**Table 1. P fertilizer recommendations (Shapiro, et al, 2003).**

<table>
<thead>
<tr>
<th>Soil P Level (ppm P)</th>
<th>Relative Level</th>
<th>Amount of P to Apply (P₂O₅)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Bicarbonate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 3</td>
<td>Very Low</td>
<td>Broadcast 110, Band 40</td>
</tr>
<tr>
<td>4 - 10</td>
<td>Low</td>
<td>(100-50)</td>
</tr>
<tr>
<td>11 - 16</td>
<td>Medium</td>
<td>N/A</td>
</tr>
</tbody>
</table>

¹ Data supplied by Ontario Agronomy Guide for Field Crops – Pub 811

**Table 2. Salt index comparisons for commonly used starters, expressed as pounds of salt effect/gal and relative to 10-34-0.**

<table>
<thead>
<tr>
<th>Product</th>
<th>Analysis</th>
<th>Salt Index, lb/gal</th>
<th>Value Relative to 10-34-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium polyphosphate</td>
<td>10-34-0</td>
<td>2.28</td>
<td>1</td>
</tr>
<tr>
<td>7-21-7</td>
<td>7-21-7</td>
<td>3.04</td>
<td>1.33</td>
</tr>
<tr>
<td>Urea ammonium nitrate</td>
<td>28-0-0</td>
<td>6.75</td>
<td>2.96</td>
</tr>
<tr>
<td>Urea ammonium nitrate</td>
<td>32-0-0</td>
<td>7.78</td>
<td>3.41</td>
</tr>
<tr>
<td>Ammonium thiosulfate</td>
<td>12-0-0-26</td>
<td>30.9</td>
<td>13.55</td>
</tr>
</tbody>
</table>

The limits for application rates of 10-34-0 to help avoid salt injury as a function of fertilizer placement and soil texture are shown in Table 3.

**Table 3. Gallons of 10-34-0 that can be safely applied for corn in 30-inch rows as influenced by distance from the seed and soil texture (Hergert and Wortmann, 2006).**

<table>
<thead>
<tr>
<th>Placement</th>
<th>Sandy Soils</th>
<th>Non-Sandy Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-34-0 (gal/acre)¹</td>
<td></td>
</tr>
<tr>
<td>With the seed (pop-up)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>1/4 to 1/2 inch from the seed</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>1 inch from the seed</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>2 inches or more from seed</td>
<td>20+</td>
<td>40+</td>
</tr>
</tbody>
</table>

¹ Determine safe application rates for other fertilizers by dividing the value in Table 3 by the “Value Relative to 10-34-0” in Table 2.
² The safe application rate for soybeans is 1/2 of these values.
³ For row-widths narrower than 30 inches, the application rate may be increased. Multiply values by 1.5 for 20-inch rows, 1.36 for 22-inch rows, and 2.0 for 15-inch rows.
Salt damage is most pronounced when soil moisture is low, so adequate soil moisture at planting or rainfall soon after help minimize salt injury. To diminish the probability of salt injury, avoid over-applying nitrogen, potassium or sulfur fertilizers close to the seed.

**Conclusions**

**Corn grain yield increases from starter fertilizer applications are most likely:**

- In northern portions of the Corn Belt, regardless of tillage practices
- When cultural practices such as no-till or minimum tillage are utilized
- On coarse textured and or low organic matter soils
- On poorly drained or cold soils
- On low testing P and K soils
- When nodal root systems are severally impeded by stresses
- When soils pH is unusually high or low
- When substantial drought stress is likely

Higher corn prices and changes in farming practices (e.g., earlier planting) may create new roles for starter fertilizers beyond their traditional applications. One such role may be as insurance against prolonged, unfavorable weather conditions occurring soon after planting. Growers and agronomists are encouraged to continue testing starter fertilizer in a variety of field situations to further determine when and where these treatments may be most responsive.

**References**