



Starter Fertilizer

STARTER FERTILIZER BENEFITS

- Starter fertilizers are most beneficial when crops are planted into cold, wet soils in early spring or late fall, regardless of soil fertility. Using a starter is especially important in conservation tillage systems. Crops planted in late spring or early fall generally do not require a starter fertilizer unless soil fertility levels are low.
- Starter fertilizers are a small amount of fertilizer applied near the seed to meet the demands of the seedling for readily available nutrients until the plant's root system develops. They also enhance the development of the emerging seedling.
- Nitrogen (N) and phosphorus (P) are the key nutrient components in a starter fertilizer. Phosphorus is nonmobile in the soil, thus, undeveloped seedling roots have difficulty obtaining the necessary amounts for proper growth. Also, phosphorus promotes vigorous root growth.
- Corn is the most responsive crop to starter fertilizer use. The response of forage crops to starter fertilizers has not been as consistent as with corn. Sorghum usually does not require a starter fertilizer. Small grains will respond to starter fertilizer especially on marginal fertility soils and when crops are planted in late fall. In general, using a starter fertilizer when planting soybeans is not recommended.

MATERIALS

- Generally, any high-quality, complete fertilizer that contains at least nitrogen and phosphorus will work as a starter. For optimum effectiveness, the phosphate should be combined with ammonium nitrogen.
- On high phosphorus soils an N only starter will usually provide similar starter response without adding extra P to an already high P soil.

- Many different fertilizer analyses can be used as starters. For a starter effect alone, the analysis is not critical as long as it meets the criteria described above. Where P or K is recommended on the soil test, choose an analysis that best matches the recommendations.
- For N only starters, ammonium sulfate (21-0-0-24S) and ammonium nitrate (34-0-0) are good choices.
- Solid and fluid forms of starter fertilizer, applied at similar rates and placement, provide the same results.
- Monoammonium phosphate (MAP; 11-52-0) and ammonium polyphosphate (10-34-0) based fertilizers make excellent starter fertilizer materials.
- Use caution with starter fertilizers that contain diammonium phosphate (18-46-0) and especially urea (46-0-0) because both of these materials can cause seedling injury. Keep the rate low and do not place directly with the seed.
- If micronutrients are required, they can usually be applied in the starter fertilizer.

RATES

- For corn, if the fertility level is good, a small amount of fertilizer (about 100 pounds of starter per acre) will provide an adequate starter response. Do not apply more than 70 pounds of N + K₂O per acre if the fertilizer is placed approximately 2 inches away from the seed. Reduce the rate if starter is placed closer than 2 inches from the seed.
- Larger amounts of N can be applied in the starter but do not exceed the limits above for total N + K₂O.
- For forage crops, the rate should not exceed 60 pounds of N + K₂O per acre.
- For oats, do not apply more than 20 pounds of N or 45 pounds of N + K₂O per acre in the seed row.
- For winter wheat and barley, do not apply more than 15 pounds N or 30 pounds N + K₂O per acre in seed row.

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PLACEMENT

- The recommended placement of the starter for corn or sorghum is 2 inches beside and 2 inches below the seed. Do not use a starter if sorghum is drilled.
- Starter can also be applied directly with corn seed as a pop-up, however, avoid urea and DAP, and keep the rate low.
- Starter for forage crops should be banded 1 inch directly below the seeds.
- For small grains, the starter is usually drilled directly with the seed.

WHAT IS STARTER FERTILIZER?

Starter fertilizer is a small quantity of fertilizer nutrients applied in close proximity to the seed at planting. Starter fertilizers enhance the development of emerging seedlings by supplying essential nutrients in accessible locations near the roots. Rapid crop establishment is desirable since plant development and yield can be influenced during early growth stages. Also, fast-growing young plants generally are more resistant to insect and disease attacks and can compete with weeds more effectively. Readily available nutrients near young plants help ensure rapid early growth and the formation of large leaves, which are necessary for photosynthesis, subsequent growth processes, and earlier crop maturity.

WHEN TO USE A STARTER FERTILIZER

A starter fertilizer is most beneficial when the crop is planted into cold, wet soils, regardless of the total fertility status of the soil. Cold, wet soils cause reduced root growth rate, nutrient mobility, and nutrient mineralization (i.e., the breakdown of nutrients into plant usable forms). Cold, wet soils generally are most prevalent in early spring and late fall. However, soils in reduced tillage systems usually are colder and wetter than those in conventional tillage systems because of the insulating effect of the surface mulch. Thus, starter fertilizer is as important, if not more important, in conservation tillage systems as it is in other tillage systems. Conditions such as those mentioned above are most common in the northern crop producing regions of the United States. Crops planted late in the spring generally will not have the same response to a starter as will crops planted earlier, because the warmer conditions already allow adequate plant growth and nutrient mobility. Therefore, it is not as critical to use a starter in this situation, except on low testing soils. However, it is acceptable to include a fertilizer during planting to provide for recommended maintenance fertilizer needs.

HOW STARTER FERTILIZER AFFECTS PLANT GROWTH

The use of starter fertilizer enhances crop growth primarily because it places a readily available supply of plant nutrients (especially phosphorus) in a position where they are easily accessible to the limited root system of a seedling. Even though a soil may have high fertility, a seedling's root system may not be able to obtain the necessary nutrients due to lack of size and density within the soil (see Figure 1). Once a plant's root system is established, it will be able to extract nutrients from the bulk of the soil (Figure 2). At this point, the soil serves as the primary source of plant nutrients. Since the plant now has a well-developed and extensive root system, it has more surface area to intercept nutrients and moisture throughout the soil.

Figure 1. A seedling root system cannot acquire needed nutrients from the bulk soil.

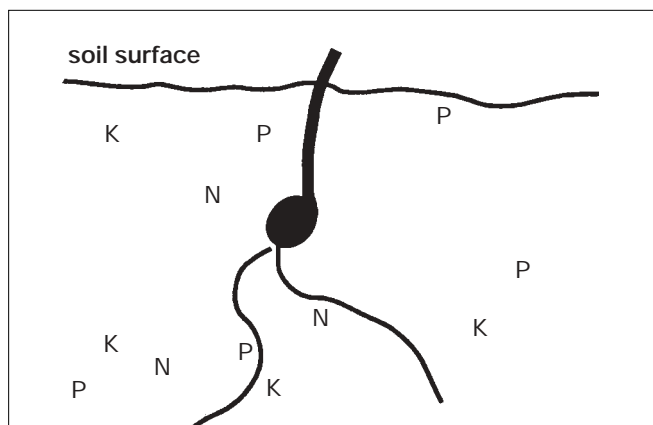
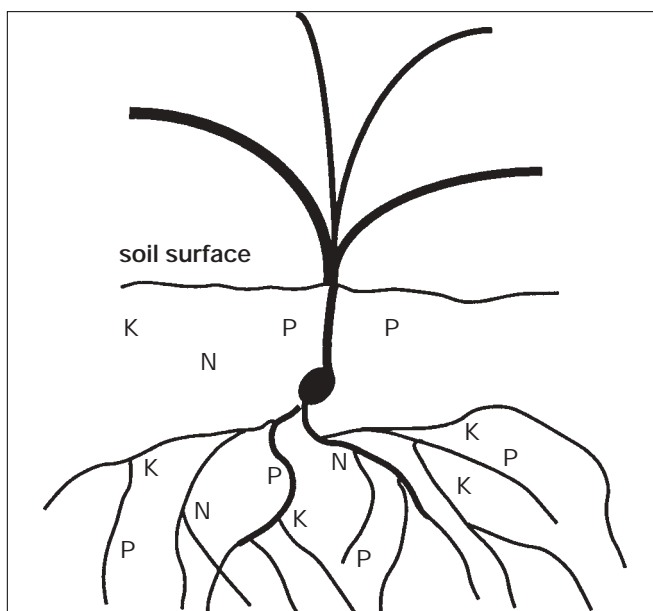


Figure 2. A well-developed root system can more effectively obtain nutrients from the soil.



Starter fertilizer composed of nitrogen and phosphorus (P or P_2O_5) provides the most favorable crop response. Unlike other nutrients, such as nitrogen, which are mobile and have a greater chance of contacting roots to be absorbed, phosphorus compounds are bound and do not readily move within the soil. To be absorbed by the plant, the roots must approach very close to the phosphate to be taken in. Thus, a small amount of strategically placed phosphorus-containing fertilizer will be readily accessible to the seedling roots. Phosphorus is important for promoting vigorous root growth, resulting in healthier, dark-green plants. The lack of phosphorus results in stunted, purple-colored plants. (However, other factors besides lack of fertility may cause purple-corn syndrome, such as soil compaction, environmental stress, herbicide injury, or various crop varieties.) While P may be the most critical nutrient in starter fertilizer, N in the starter may also help plants overcome early season N deficiency due to the slow release of nitrogen from organic matter during cold, springtime conditions. Also, it has been shown that some N in the ammonium form common in starter fertilizers will enhance P uptake from the starter and from the soil. Potassium (K or K_2O), also referred to as "potash," is not as critical as N or P in a starter, but some response is likely when soil K levels are marginal, especially under cold, wet conditions. Starter fertilizer response is frequently manifested as increased early season growth, slightly lower grain moisture at harvest, and higher grain yields. The rapid growth and earlier maturity are important in areas where medium and short-season corn varieties are grown. Overall, the use of a starter fertilizer increases fertilizer efficiency and thus reduces fertilizer costs.

In Pennsylvania, especially on farms with livestock or poultry, having high and sometimes very high P soil test levels is becoming more common. The use of P containing starter fertilizers on these high testing soils has been questioned both regarding the necessity of P in the starter and the potential environmental impact of adding P to soils that are already high in P. Recent research has shown that in some instances there is a benefit to adding starter fertilizer for corn even on high testing soils. However, this benefit is seen only about 20 percent of the time and the size of the response, while significant, is usually relatively small. Thus, it is probably not necessary to use a starter at all on these high P soils unless conditions are very adverse and the soil test levels are only marginally high. This research has also shown that if starter is used on these high P soils there are several management alternatives that should be considered. Using a very low rate of starter fertilizer placed directly with the seed (see discussion of pop-up placement later in this fact sheet) usually gives as good or better response than a traditional starter rate and placement while only adding a very small amount of P to the soil. Another alternative is to use an N-only starter fertilizer such as ammonium sulfate or ammonium nitrate. On high P soils, research has shown that these N-only starters performed as well as traditional starters.

Recently there has been a trend toward adding secondary and micronutrients into starter fertilizers. Micronutrients are key players in many of the processes important for plant growth. However, in Pennsylvania there are very few micronutrient problems, because (1) the heavier, loamy texture of our soils helps to maintain adequate levels of micronutrients (sandy-textured soils, by contrast, often show micronutrient deficiencies); (2) the slightly acidic nature of our soils helps to maintain micronutrient solubility; and (3) Pennsylvania agriculture is largely animal based, so much of our cropland gets periodic applications of manure, a good source of micronutrients. Unless there is a specifically identified need for a secondary or micronutrient and thus a high probability of a response, there will be no economic benefit to routinely applying secondary or micronutrients. If a need for micronutrients has been identified, adding micronutrients to starter fertilizers is usually an excellent method of supplying the small amount of these nutrients that might be recommended based on a soil test or plant tissue analysis. Several exceptions should be noted. It is well established that high P levels can reduce zinc (Zn) availability and high K levels can reduce magnesium (Mg) availability. Therefore, adding Zn or Mg to a starter containing normally high levels of P and K may not be very effective. Recent research has indicated that periodic broadcast applications of Zn fertilizer and Mg containing dolomitic limestone are more effective than starter applications of these nutrients when a need for them has been determined. Also, boron (B) should *not* be added in a starter fertilizer.

Use of Starter Fertilizers in Agronomic Crop Production

It is well established that the use of starter fertilizer is a beneficial and economic practice in Pennsylvania and surrounding states, especially for corn production. Using starter fertilizer on other agronomic crops such as soybeans, small grains, and sorghum is not as common. However, it may occur in certain situations. Before applying any fertilizer, it is recommended that the soil be tested to determine the fertility status of the field. A starter fertilizer can be used to supply a portion of the crop's nutrient needs, with additional fertilizer applications made before or throughout the season to meet the remaining crop requirements. In certain situations, a starter can meet the P and K needs of the crop and eliminate a second trip over the field later in the season. The use of a starter fertilizer can slow the rate of crop planting due to the necessity of refilling fertilizer boxes. However, most would agree that the benefits of using a starter greatly outweigh this disadvantage.

Corn

A properly managed corn starter-fertilizer program can be a positive step toward improving yields and profitability. There are several important management considerations for starter fertilizer use in corn, including materials, rates, and placement. These starter fertilizer management considerations apply to corn grown for grain or silage.

Materials

Any high-quality, complete fertilizer that contains at least nitrogen and phosphorus will work as a starter fertilizer. Generally, it should contain a high phosphate (P_2O_5) ratio (e.g., 1-2-1, 1-3-1, 1-4-2, or 1-5-0) and the phosphate in starter fertilizers should be highly water soluble. For optimum effectiveness, the phosphate should be combined with ammonium nitrogen. There are many different analyses of fertilizers that can be used, including but not limited to 10-10-10, 10-20-10, 8-32-16, 8-28-12, 7-21-7, 9-18-9, 11-52-0, and 10-34-0. For the starter effect alone on higher testing soils, the actual analysis is not critical as long as it meets the criteria outlined above. Choose the most economical, good quality fertilizer available. When soil tests are low enough that P and or K are recommended, choose an analysis that best matches the recommendations. As discussed earlier, N-only starters may be a better approach for corn on high P soils. Ammonium sulfate (21-0-0-25S) and ammonium nitrate (34-0-0) are the best materials for N-only starters.

There is an important precaution associated with certain fertilizer materials. Diammonium phosphate (DAP; 18-46-0) and especially urea (46-0-0) containing materials should be used with *caution*, since some injury may occur if the rate is too high or if it is placed too close to the seed. Both of these materials react in the soil to produce free ammonia (NH_3), which can harm germinating seeds and seedlings by burning tissues and inhibiting root growth. At lower rates and with appropriate placement, these materials can be used in starter fertilizer.

The fertilizer does not have to be labeled as a “starter” to be used for this purpose. The physical form of the fertilizer does not make a difference in starter performance. High-quality blends, granulated complete fertilizers, and fluid fertilizers will all provide good results. Although liquid fertilizers can be applied at lower quantities than dry forms, the effect of the nutrients when they are applied at the same rate per acre is the same. In most cases, liquid forms are more expensive than dry materials. However, if the metering device and plumbing on the planter units are accurate, liquid forms can be applied at lower quantities, provide a good starter effect, and be cost-effective. Generally, monoammonium phosphate (MAP; 11-52-0) based materials are excellent as starter fertilizers. Similarly, ammonium polyphosphate (10-34-0) is an excellent liquid starter material. A starter can be a straight material, such as MAP, or it can be a blend of various materials to obtain a desired fertilizer grade.

Rates

In general, only a small amount of fertilizer is required to get a starter response if the soil fertility levels test within the optimum or higher range. Under these conditions, 100 pounds of starter per acre or the lowest corn planter setting is more than adequate. At low soil fertility levels, the rate can be increased to meet a large portion of the P_2O_5 and sometimes K_2O needs of the crop. Phosphorus is usually the only nutrient that can be applied totally in the starter band (i.e., up

to 90 pounds). Banded phosphorus is about as twice as effective as broadcasted phosphorus in the short term, but the long-term effects are similar. Less phosphorus fertilizer is required when it is placed in the band.

Higher starter rates of nitrogen and potash can cause salt injury to the seedling crop. The maximum rate should not exceed a total of 70 pounds of nitrogen (N) plus potash (K_2O) per acre. For example, if 200 pounds per acre of a fertilizer with an analysis of 8-32-16 is applied, then:

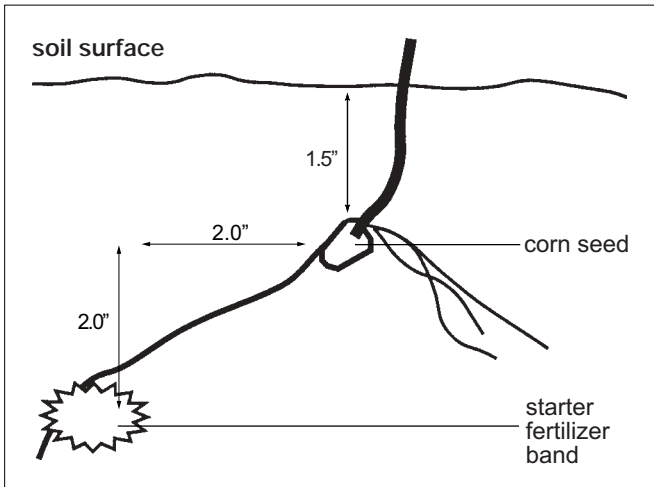
$$\begin{array}{r} 200 \times 0.08 = 16 \text{ lb N/acre} \\ 200 \times 0.16 = 32 \text{ lb } K_2O/\text{acre} \\ \hline \text{Total} \quad \quad 48 \text{ lb N} + K_2O/\text{acre} \end{array}$$

However, the 70 pound maximum applies only if the fertilizer placement is 2 inches from the seed. For closer placement, the total amount should be reduced. If the fertilizer is placed directly with the seed (i.e., “pop-up,” see Placement section for more information), no more than 10 pounds of N + K_2O should be applied per acre. For placements that are between “2 by 2” and pop-up, adjust the rate according to the distance from the seed (i.e., greater than 10 pounds but less than 70 pounds per acre). These rate limits are especially critical for no-till situations because of less accurate starter fertilizer placement.

Nitrogen can be applied at a higher rate as a starter fertilizer without causing seedling injury and can help growers avoid early season N deficiency until sidedressing. This is especially important where manure or legume N is not commonly used in the cropping system. Since urea should not be used as a starter, lower N analysis materials such as ammonium nitrate (34 percent N) or ammonium sulfate (21 percent N) should be used, resulting in large amounts of material to be handled. For example, it would require 500 to 600 pounds per acre of total fertilizer material to apply 50 or 60 pounds per acre of nitrogen with these lower analysis materials. In general, the major drawbacks of this system would be the need to continuously refill the planter fertilizer boxes, which greatly slows the planting process. Also, care must be taken not to exceed the 70 pounds/acre N + K_2O maximum rate. A more common approach to accomplish this for corn is dual placement. A small amount of starter is applied with the planter along with a simultaneous injected or dribbled application of N usually 4 inches or more from the seed row. All of the N requirement of a corn crop can be applied this way if sidedressing some of the N is not practical.

In general, the typical range for starter fertilizer rates is between 100 and 300 pounds per acre. For a starter effect alone, the lowest rate that can be accurately applied with the planter is usually adequate. Usually, there is more concern with too much starter than with too little.

Figure 3. Diagram of most effective starter fertilizer placement for corn. Seed should be planted about 1.5 inches below the soil surface. The fertilizer band should be placed 2 inches beside and 2 inches below the seed so that developing roots can easily obtain necessary nutrients, but not cause injury to seedling.



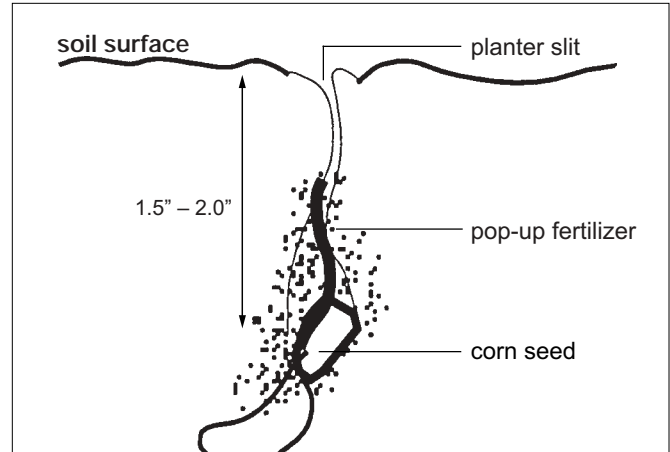
Placement

The tillage system has very little effect on materials and rates used for starter fertilizers, however the type of tillage system may significantly influence placement. Placement is important since seedling plants must have access to the nutrients. The standard starter placement is 2 inches beside and 2 inches below the seed (see Figure 3).

This practice allows developing roots to easily access the fertilizer and also protects roots from fertilizer burn. However, in no-till situations, positioning the seed to an adequate depth may be difficult enough, let alone placing the fertilizer 2 inches below the seed. A few alternative placements have been proposed. These include 1) placing a starter band two inches beside and at the same depth as the seed; or 2) dribbling the fertilizer over the seed row, often in front of the no-till coulters. These methods can provide some benefit and are better than having no starter fertilizer at planting. However, they may cause application difficulties and may not be effective as the “2 by 2” method or the third alternative, “pop-up.” The pop-up method places the fertilizer directly with the seed and can provide excellent results (see Figure 4). With pop-up placement there is no need for a separate fertilizer opener on the planter, which can be a major benefit in no-till systems where planter penetration is a problem. Also, pop-up placement enables growers to use lower rates of starter fertilizer which may lower costs, reduce the amount of P applied on soils already high in P and reduce the quantity of fertilizer that has to be handled during planting, e.g., fewer planter fill-ups. Pop-up placement has also been incorporated into seed firmers, which are being used on more and more planters. These applicators allow very precise placement of the pop-up fertilizer either on or close to the seed depending on the style of seed firmer used.

There are some potential problems with pop-up starter placement. The most important is the potential for injury to

Figure 4. Pop-up fertilizer placement in relationship to a germinating corn seed.



the seedling by the fertilizer. Injury caused by pop-up placement can seriously reduce stands, especially under dry conditions on light or sandy textured soils. Consequently, there are two very important rules that must be followed for pop-up placement: 1) the rate must be kept below 10 pounds of N + K₂O per acre; and 2) the fertilizer must not contain any urea or DAP. While the use of pop-up placement eliminates the need for a separate fertilizer opener, it does create some other challenges, especially with dry fertilizer systems. It is often difficult on most planters to reduce a dry starter rate low enough for safety. For a common 10-20-10 starter for example, the pop-up rate would have to be less than 50 pounds of fertilizer per acre. Also, the starter delivery system would have to be redirected back to the seed units, which can be difficult on some planters. While there is no agronomic difference between fluid and solid starter fertilizers, this may be one situation where the fluid fertilizers have a practical advantage. It usually is easier to regulate lower rates with a fluid fertilizer and it also is easier to plumb the fluid lines back to the seed units. As long as the equipment can be adequately set up for pop up placement, and the rules mentioned above are followed, pop-up placement of starter fertilizer can be an attractive option.

Forages

The response of forage crops to starter fertilizer has not been as consistent as with corn. If there is good soil fertility (i.e., soil tests within the optimum to above optimum range) a starter is not recommended. In addition, forage species are planted at high seeding rates, thus various seedlings have a greater chance of obtaining nutrients throughout the soil to establish the stand. Also, many modern drills do not have a combination fertilizer unit to allow the application of fertilizers. However, using a starter when possible can be beneficial, especially to meet small amounts of nutrient requirements recommended by a soil test; and/or if there are adverse soil conditions such as low fertility and cold-wet weather at planting.

Materials

As with corn, fertilizers with high-phosphorus contents, such as 10-20-10, 10-10-10, 8-32-16, and 10-34-0, can serve as a starter fertilizer. A dry or fluid fertilizer formulation can be used. Use caution with fertilizers which contain urea as a starter.

Rate and placement

The rate should be kept below about 60 pounds of N + K₂O in the starter to prevent salt damage to the seedlings. The starter should be banded 1 inch directly below the seed. This practice is especially important for legume seedlings. If a starter fertilizer cannot be banded and the soil test indicates optimum to above optimum fertility levels, no fertilizer should be applied. The broadcast method is less effective than band placement because it will only give a beneficial response under very adverse environmental conditions (when soil fertility level is low). Generally, four times the amount of broadcasted phosphorus is required to provide the same response as banded phosphorus for legume establishment. Routinely *broadcasting* a small amount of fertilizer as a starter is *not* recommended under most conditions.

If a soil test taken just prior to establishment indicates the need for additional or large amounts of fertilizer, it is best to split the fertilizer application with the bulk of the nutrient needs met with broadcast fertilizer or manure, as opposed to meeting all the nutrient needs with a starter. In this situation, a small amount of the total fertilizer requirement, such as 20-40-40 per acre, should be banded at planting or applied to the surface to meet the immediate needs of the crop as it is established.

Small Grains

Applying a starter fertilizer with small grains is not as critical to the success of the crop as it is with corn production. However, the addition of a starter can be very important for winter grains grown on soils with marginal soil test levels or if the crop is planted late, when soils are cold and wet. Depending on the fertilizer requirements indicated by the soil test, all the fertilizer may be broadcast prior to planting or a portion may be applied with the drill and the remainder broadcast. However, fertilizer injury to the seedling may occur if too much starter is applied with the seed. The following are some guidelines for using a starter with small grains. Use a high-phosphorus, non-urea-containing fertilizer material as a starter. For spring oats, do not apply more than 20 pounds N or 45 pounds N + K₂O per acre in the row with the seed. For winter barley and winter wheat, do not apply more than 15 pounds N or 30 pounds N + K₂O per acre in the seed row.

Sorghum

In general, using a starter fertilizer is not as common when growing grain or forage sorghum. Starter fertilizers and rates similar to those used for corn can be used with sorghum when planted with a row planter (see section entitled Corn for additional information), but if the crop is drilled, starter fertilizers in the row should be avoided to prevent injury.

Soybeans

Soybeans, like other crops, require sound fertility programs. However, since soybean seedlings are extremely sensitive to fertilizer injury, it generally is not recommended that a starter fertilizer be used at planting. Also, since soybean planting usually occurs when the soils are warmer, plant growth and nutrient mobility and uptake from the bulk soil are generally not a problem. If the soil test recommends adding nutrients, it is best to apply the needed fertilizer before seeding. However, growers using a row planter could place a band of starter at least 2 inches to the side of the seed. Starter fertilizer placed any closer than 2 inches can severely injure the seedling. Under all conditions, *do not drill fertilizer with the seed or use "pop-up" fertilizer with soybeans.*

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