Fertilizer Placement

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Fertilizer placement is an integral part of efficient crop management. Correct placement often improves the efficiency by which plants take up nutrients and consequently encourages maximum yields of intensively managed agronomic crops. Correct fertilizer placement is especially critical for maximum crop yields under reduced tillage operations.

Correct fertilizer placement can protect both surface and groundwater quality. Subsurface banding of nitrogen (N) and phosphorus (P) fertilizers is a best management practice (BMP) designed to protect surface water quality by reducing potential erosional losses. Subsurface banding in many cases would also be a BMP for protecting groundwater quality because plant N and P use efficiency increases. High crop-use efficiency leaves less N in the soil to leach into groundwater.

Application methods

Broadcast—Broadcast fertilizer application refers to a uniform distribution of material on the soil surface. When applied after planting, a broadcast application is often referred to as a *topdress application*. When a broadcast application is incorporated into the soil, it is referred to as *broadcast-incorporated* (figure 1). The advantages and disadvantages of each type are as follows:

Broadcast topdress—*Advantages*

- Easy to apply.
- Results in relatively uniform fertilizer distribution.
- Requires inexpensive application equipment.

Broadcast topdress—*Disadvantages*

- Leaves more fertilizer available to weeds.
- Enhances N losses by volatilization, denitrification, and erosion compared with placement in the soil.
- Requires rainfall or irrigation to move N into the plant root zone.
- Leaves nonmobile nutrients (P, K, and some micronutrients) almost totally on the soil surface, making them unavailable to the plant root system.

Broadcast incorporated (plow-moldboard)—*Advantages*

- Places a major portion of the fertilizer in the soil zone where moisture is most apt to be available for plant uptake.
- Leaves fertilizer less available for weeds.
- Reduces the chance of salt injury to seedlings.
- Increases the overall fertility of the soil.
- Decreases N fertilizer losses by volatilization and erosion.

Broadcast incorporated (plow-moldboard)—*Disadvantages*

- Distributes the majority of the fertilizer possibly too deeply for the roots of young seedlings.
- Increases the potentials for leaching losses of N and sulfur (S) in wet years.
- Requires more fertilizer than other broadcast treatments for equivalent plant yields.
- Enhances the opportunity for nutrient tie-up (especially P) compared with banding and shallower placement.
- Requires more energy to incorporate the fertilizer.

Broadcast incorporated (plow-chisel)—*Advantages*

- Places large amounts of fertilizer in the seedling root zone.
- Promotes rapid nitrification of NH_4^+ to NO_3^-.
- Leaves crop residues on the soil surface for erosion protection.
- Reduces volatilization losses of N fertilizers.

Broadcast incorporated (plow-chisel)—*Disadvantages*

- Mixes fertilizer only 2 to 3 inches into the soil surface.
- Allows weed seedlings more access to fertilizer.
- Leaves nutrients inaccessible to roots as the surface soil dries out.
- Increases opportunities for nutrient tie-up compared with banding.

Broadcast incorporated (disk)—*Advantages*

- Positions some fertilizer near seedling root zones.
- Promotes rapid nitrification of NH_4^+ to NO_3^-.

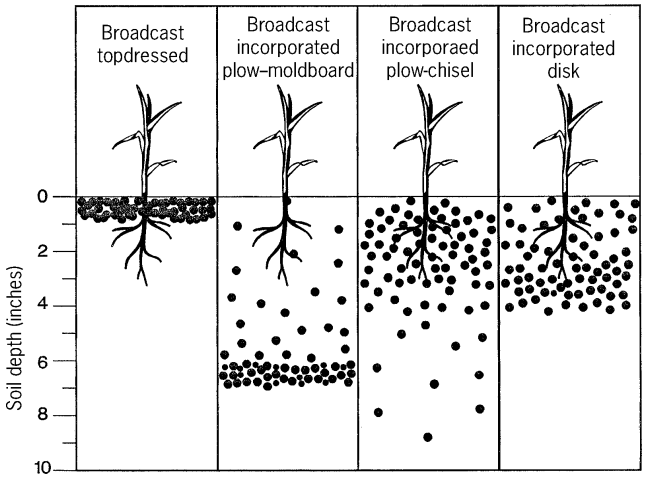

Figure 1. Early season fertilizer distribution using four methods of broadcasting fertilizers. Note that corn plants are used in this example.

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- Uses organic residues efficiently.
- Distributes fertilizer in the upper 3 to 4 inches of the soil profile.
- Reduces losses from volatilization and erosion compared with surface placement.

Broadcast incorporated (disk)—*Disadvantages*

- Allows for P and K fixation.
- Stimulates some weed growth.
- Results in potentially higher N and S leaching losses than with surface placement.
- Stores little fertilizer deep in the profile for later season plant nutrition.

Banding—Banding refers to placing nutrients below, above, on one side, or on both sides of the seed or seedlings at planting (figure 2). A surface or subsurface banding treatment after the crop is planted is referred to as a *sidedress application*. All plant nutrients except boron (B) can be successfully banded. Fertilizer bands should be placed at least 2 inches away from the seed to prevent salt damage and ammonia toxicity.

Banding—*Advantages*

- Places fertilizer where seedling root systems can more readily use the nutrients.
- Provides crops additional nutrients if sidedressed during the growing season.
- Improves nutrient use efficiency.
- Requires less fertilizer per acre than broadcasting.
- Positions fertilizers so that they are more available to the crops than to the weeds.
- Improves crop tolerance of root diseases.
- Permits application in one operation with planting or in separate operations.
- Retains nutrients during soil erosion.
- Releases tied-up nutrients and reduces nutrient tie-up.
- Promotes rapid early plant growth by increasing P availability.
- Promotes winter hardiness through improved P and K nutrition.
- Lessens P and K fixation by limiting surface area contact with the soil.

Banding—*Disadvantages*

- Increases N and S leaching losses compared with surface placement.
- Slows planting if applied with a drill.
- Requires more costly equipment or equipment modification.

Pop-up—Pop-up, or starter, fertilizer applications refer to placing small amounts of nutrients in direct seed contact (figure 3). Nitrogen and P are usually pop-up fertilizer components. The high salt contents of N, K, and S fertilizers limit the amount that can be applied in a pop-up application.

Pop-up—*Advantages*

- Places fertilizer where root systems of seedlings can more readily use nutrients as long as the seed zone remains moist.
- Positions fertilizer so it is more available to the crops than to the weeds.
- Decreases loss of nutrients by erosion compared with surface placement.
- Increases rapid early plant growth because P promotes plant vigor.
- Restricts zone of soil contact, thereby reducing P and K fixation.
- Boosts seedlings under wet, cold soil conditions.

Pop-up—*Disadvantages*

- Increases potentials for N and S leaching losses.
- Requires more than one application to meet the crop's fertilizer requirement.
- Threatens seeds with salt injury if the fertilizer is too concentrated.
- Results in ammonia toxicity to seeds if the N is too concentrated.

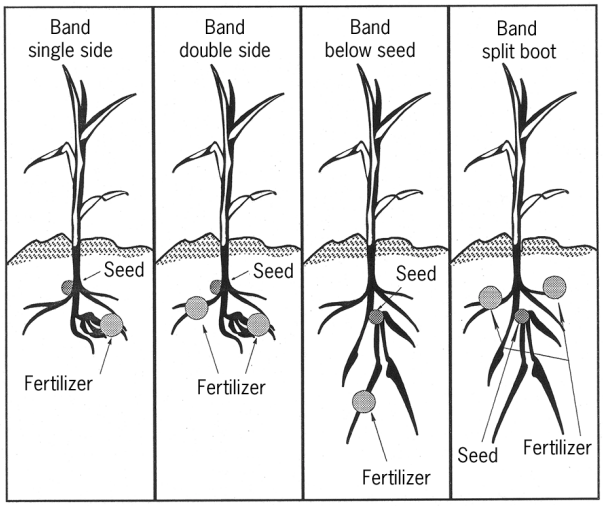

Figure 2. Methods of banding fertilizers. Note that corn plants are used in this example.

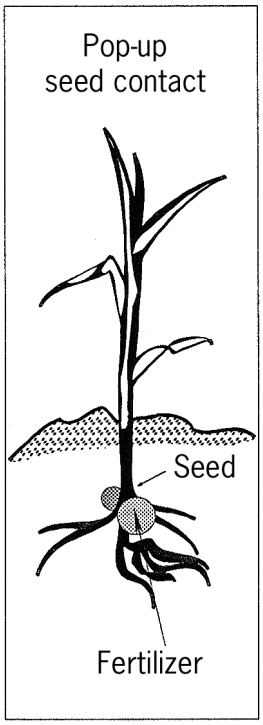

Figure 3. Pop-up application of fertilizers. Note that a corn plant is used in this example.

Solid fertilizers used in pop-up applications should have several of the following characteristics:

- N and P content with a high P content.
- High water solubility.
- Low salt index.
- High nutrient content (analysis or grade).
- Minimal content of N materials that liberate ammonia such as urea and diammonium phosphate (DAP).

Because pop-up fertilizer placement can cause seedling damage, limit the rates of fertilizer materials. Observe the following guidelines when placing solid fertilizers with the seed at planting:

Wet soils (spring-seeded crops)—Apply a maximum of 30 pounds per acre (0.7 pounds per 1,000 square feet) of N + K + S. Unlimited P can be applied.

Dry soils (fall-seeded crops)—Apply a maximum of 15 to 20 pounds per acre (0.3 to 0.5 pounds per 1,000 square feet) of N + K + S. Unlimited P can be applied.

For liquid fertilizers, the rates of N + K + S can be increased by up to 50 percent.

Placement of specific nutrients

There are 17 essential elements for plant growth. Fourteen are provided to plants by soils and/or fertilizers. This list includes six macronutrients, which plants require in relatively large quantities: nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg). Plants also require eight micronutrients in relatively small amounts: boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn). The other three essential elements, carbon (C), hydrogen (H), and oxygen (O), are supplied by air, water, or both.

It is uncommon for soils to be lacking in more than four essential plant nutrients at any one time. Nickel and chlorine have never been shown to be deficient in Idaho soils. Calcium and magnesium are generally applied to soils only as liming materials to raise soil pH.

The following are general guidelines for fertilizer placement:

Nutrients that are generally broadcast

- Nitrogen
- Sulfur
- Calcium (as a liming material)
- Magnesium (as a liming material)
- Boron
- Copper (but banding is more efficient)
- Manganese (but banding is more efficient)
- Zinc (but banding is more efficient)

Nutrient that is generally banded

- Phosphorus (broadcast only when you have moderate to high P levels already in the soil, at soil pH values of 5.5 to 6.5)

Potassium, a special case

K can be broadcast or banded. Ninety percent of the time broadcast and band applications are equivalent. Broadcasting is preferred in sandy soils that have a low CEC (less than 3 meq/100g). Banding is preferred in soils containing a lot of vermiculite and/or illite, where K fixation occurs.

Nutrients that are generally not broadcast

- Iron (generally applied as a foliar spray)
- Molybdenum (generally applied as a seed treatment)
- Chlorine (not needed)
- Nickel (not needed)

Factors affecting nutrient availability

The major function of correct fertilizer placement is to enhance nutrient availability and plant uptake. Factors that affect fertilizer nutrient availability to plants include positional availability, soil temperature, soil moisture, root disease, soil compaction, and weed competition.

Positional availability—Nutrients concentrated in the root zone stimulate root growth and plant vigor. Placing fertilizer near the seed and in the root zone improves the chances for the roots to intercept nutrients early in the growing season. The nature of the plant root system influences fertilizer placement depth because the fertilizer must be easily accessible. The relative salt tolerance of the plant dictates the upper limit of pop-up, or starter, fertilizer that can be used.

In conservation tillage, placing the fertilizer below crop residue for early root access improves fertilizer use efficiency.

Phosphorus availability for crop plants is usually greater in soils where fertilizer is banded than where fertilizer is broadcast. Banding reduces the contact of P fertilizer with soil, resulting in less P fixation.

Temperature—Plant nutrient absorption, soil chemical reactions, and nutrient movement to plant roots are much slower at lower soil temperatures. Either pop-up or band applications of N and P improve plant uptake at lower temperatures. This is especially important for early seeded, spring crops in cool, wet springs because of slow root growth. Since soil temperatures are often lower with conservation tillage, placing fertilizer near the seedling roots is more important in reduced tillage operations.

Soil moisture—Plant roots extract nutrients for growth from the soil water. Consequently, moisture is important for nutrient availability. If possible, fertilizer should be placed in moist soil zones.

Root disease—Decreased root health and restricted root growth can severely limit water and nutrient uptake. Where root diseases are a problem, banding fertilizer below seed depth and below or near seed rows for early root access may improve crop growth and yield potential. Fertilizer placement is most important for reducing the effects of root disease when planting cereals in succession under no-till or minimum tillage. Conversely, fertilizer placement is less important where the potential for root diseases is minimized by longer crop rotations, early control of volunteers and weeds, and other production practices.

Soil compaction—Untilled soils usually have higher bulk densities (more compaction) than conventionally tilled soils. Soil compaction reduces root growth and nutrient availability. Band and pop-up fertilizer applications tend to counteract the detrimental effects of soil compaction on root growth and nutrient uptake. Shanking fertilizer below seeding depth can also help fracture compacted soil and improve root growth.

Weed competition—Surface broadcast and broadcast incorporated fertilizer applications make the fertilizer available for weeds. On the other hand, placing fertilizer in the soil near the seed or concentrated in the root zone positionally favors the crops and limits the supply to weeds. Weeds close to banded fertilizer must be controlled because competition is more intense where nutrients are concentrated.

Surface accumulations of nutrients

Less mobile nutrients such as P and K accumulate on the soil surface where fertilizers have been surface broadcast and not incorporated. More mobile nutrients, such as nitrate-nitrogen (NO_3-N) and sulfate-sulfur (SO_4-S), require water to move into the plant root development zone. When the soil surface dries out, these nutrients become positionally unavailable. In nonirrigated areas, a dry soil surface logically calls for placing commercial fertilizers deeper, to reach favorable root zone moisture.

When nutrients, particularly N, are allowed to accumulate on the soil surface or are placed there, soil acidity often increases. Nitrogen applied as ammonium-nitrogen (NH_4-N) near the soil surface will acidify the soil as it is converted to NO_3-N by soil microorganisms. Where N fertilizer is routinely broadcast, the pH of the upper few inches of the soil profile is often 0.5 or more pH units lower than the soil below. This intense acidification lowers the availability of N, P, S, and Mo in the surface soil.

Acidification from fertilizer application often reduces nodulation on legumes, such as peas, lentils, and alfalfa. Intense soil-surface acidification from broadcast fertilizer applications may decrease the persistence of chloro-S-triazine and sulfonylurea herbicides but increase the persistence of imidazolinones.

Soil and environmental factors that influence nutrient placement

Nitrogen—Nitrogen fertilizer can be lost from soils by several mechanisms: volatilization, leaching, surface runoff, and erosion. Nitrogen can also be tied up in plant residues. Banding N fertilizer deep below plant residue often reduces losses attributed to these factors; however, losses due to leaching may also increase.

Ammonia volatilization losses may occur when ammonium-based N fertilizers (ammonium nitrate, ammonium sulfate, urea) are surface broadcast on soils with a pH more than 6.5. Volatilization losses can be reduced by broadcast incorporating N fertilizers or by banding them below the soil surface. Volatilization losses of surface N are insignificant on soils with pH values less than 6.2.

Fertilizer placement can partially reduce leaching losses of N. Fertilizing with ammonium-nitrogen (NH_4-N) rather than nitrate-nitrogen (NO_3-N) can further reduce losses, as will correct irrigation scheduling. Deep placement of N will often reduce denitrification.

Nitrogen losses can be minimized by placing N fertilizer away from decaying organic matter. In most cases, pop-up or band applications place N away from the straw residue layer in the soil. Crop residues do not break down if N is not available. Limited soil N for residue decomposition can be more critical under conservation tillage management.

Phosphorus—Low soil temperatures and extremes in soil pH reduce P availability in soils. Cool temperatures and high rainfall during the spring are known to reduce plant P uptake. However, placing P with or near the seed increases the concentration of available P sufficiently to partially compensate for the lowered uptake rate. Research data suggest a definite yield advantage with pop-up and band P applications under cold, wet soil conditions.

Sulfur—Available SO_4-S behaves like nitrate in soils: Because it is mobile, it is subject to leaching. Fertilizer placement is not critical because surface-applied material can easily move into root zones with modest amounts of rainfall or irrigation.

Boron—Boron acts similarly to NO_3^- and SO_4^{2-} in soils but moves at a slower rate. High concentrations of B in soils are toxic to plants. Consequently, apply B as a broadcast treatment, never in a pop-up or band treatment.

Fertilizer placement and crop yield

Research shows that N and P broadcast applications produce yields equal to banded applications only under optimal conditions. Often, banding both N and P increases yields when compared with broadcast treatments. Placing N and P below the seed in a band generally produces the best results. It is more critical to band P and N than other nutrients. Benefits from banding S have not been widely observed.

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