University of Idaho
College of Agriculture

Cooperative Extension Service
Agricultural Experiment Station

Current Information Series No. 757

Fertilizer Placement

R. L. Mahler and R. E. McDole

Placement of fertilizers is an integral part of efficient crop management. Correct placement of fertilizer often improves the efficiency by which nutrients are taken up by plants and consequently encourages maximum yields of intensively managed agronomic crops. It is also apparent that correct fertilizer placement is more critical for maximum crop yields under reduced tillage operations than with conventional tillage management.

Terminology

Solid and liquid fertilizers can be applied to crops by several methods. The three basic methods include broadcast, band and pop-up.

Broadcast — Broadcast fertilizer applications refer to a uniform distribution of material on the soil surface. When surface applied after planting, broadcast is often referred to as topdressing. When material is uniformly applied to the soil surface and then incorporated into the soils, it is referred to as broadcast-incorporated. Four different types of broadcast fertilizer applications are shown in Fig. 1.

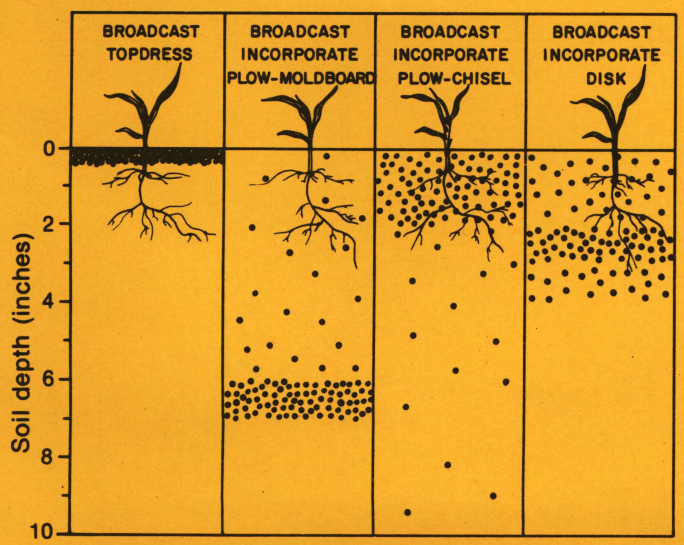

Fig. 1. Methods of broadcasting fertilizers.

Broadcast Topdress — *Advantages*

- Easy to apply.
- N will move into soil with rainfall or irrigation.
- Uniform fertilizer distribution.
- Less expensive equipment.

Broadcast Topdress — *Disadvantages*

- Fertilizer is more available to weeds.
- N losses by volatilization, denitrification and erosion.
- Nonmobile nutrients (P, K and some micronutrients) remain almost totally on the soil surface. This leaves these nutrients positionally unavailable to the plant root system.

Broadcast Incorporate (Plow-Moldboard) — *Advantages*

- Puts major portion of fertilizer in soil zone where moisture most apt to be available.
- Less available for weeds.
- No salt injury to seedlings.
- Increases fertility of overall soil.
- Decreases volatilization and erosion losses.

Broadcast Incorporate (Plow-Moldboard) — *Disadvantages*

- Fertilizer too deep in soil for roots of young seedling.
- More potential for leaching problems (N, S) in wet years.
- Requires more fertilizer than other broadcast treatments.
- More opportunity for nutrient tie-up.

Broadcast Incorporate (Plow-Chisel) — *Advantages*

- Puts large amounts of fertilizer in root zone of seedling.
- Rapid nitrification of NH_4^+ to NO_3^-.
- Leaves residues on surface for erosion protection.
- Reduces volatilization losses.

Broadcast Incorporate (Plow-Chisel) — *Disadvantages*

- Only mixes fertilizer into surface 2 to 3 inches.

- Fertilizer is more available to weed seedlings.
- As the surface of topsoil dries out, roots cannot obtain nutrients.
- More opportunity for nutrient tie-up.

Broadcast Incorporate (Disk) — *Advantages*

- Some fertilizer in proximity to root zone of seedlings.
- Rapid nitrification of NH_4^+ to NO_3^-.
- Organic residues efficiently utilized.
- Fertilizer distribution in upper 3 to 4 inches of soil profile.
- Reduces volatilization and erosion losses.

Broadcast Incorporate (Disk) — *Disadvantages*

- Potential for P and K fixation.
- Some weed stimulation by fertilizers.
- Higher potential N and S leaching losses.
- Little fertilizer deep in profile for older plant roots.

Band — Banding refers to the placement of nutrients below, above, on one side of and/or on both sides of the seed or seedlings. A surface or subsurface banding treatment after the crop is planted is referred to as sidedressing. Several types of band applications are illustrated in Fig. 2.

Banding — *Advantages*

- Fertilizer placed where limited root systems of seedlings can more readily utilize the nutrients.
- Sidedressing during the growing season can add more nutrients as needed by the crops.
- Amount of fertilizer needed per acre is lower than with broadcasting.
- Fertilizer is positionally more available to crops than to weeds.
- One operation with planting.
- Less erosion losses of nutrients.
- Acidity of concentrated band releases tied-up nutrients.

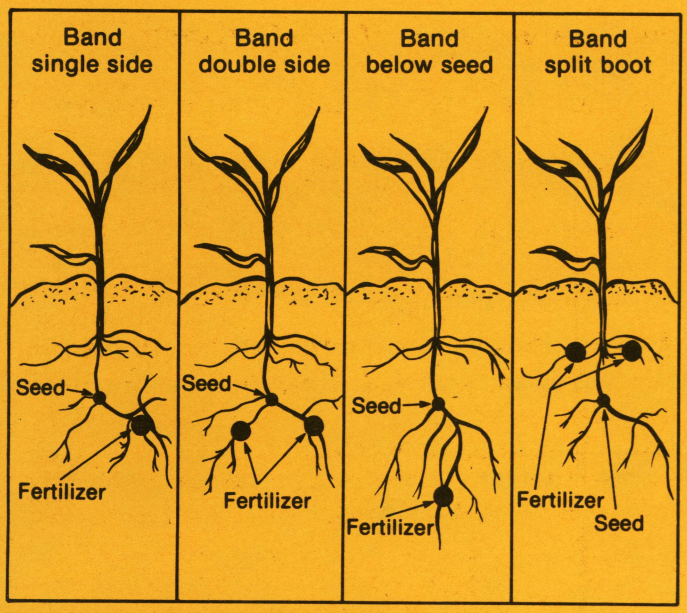

Fig. 2. Methods of banding fertilizers.

- More rapid early plant growth because seedlings get promotion of plant vigor (P) and winter hardiness (K).
- Restricted zone of soil contact lessens P and K fixation.

Banding — *Disadvantages*

- Leaching losses of N and S may be increased.
- More costly to apply (energy) than planting or fertilizing only.
- Poor utilization of organic residues of previous crop.
- Slower planting.
- Requires more costly equipment.

Pop-up — Pop-up (starter) fertilizer applications refer to placement of small amounts of nutrients in direct seed contact. Nitrogen and phosphorus (P) are usually components of pop-up fertilizers. An illustration of pop-up is shown in Fig. 3.

Pop-up — *Advantages*

- Same as those listed for banding.
- May give an extra boost to seedlings under wet, cold soil conditions.

Pop-up — *Disadvantages*

- Same as those listed for banding.
- Too high of a fertilizer concentration with seeds may result in salt injury.

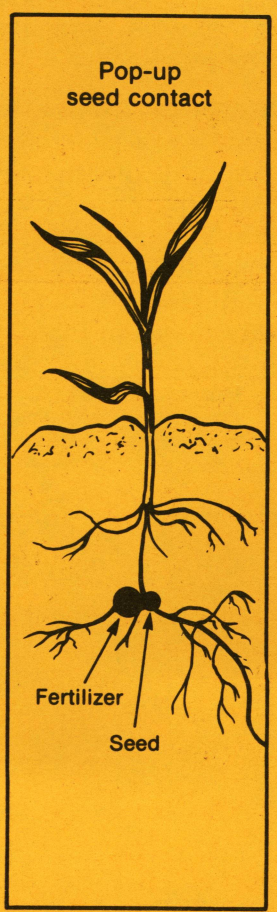

Fig. 3. Pop-up application of fertilizers.

Nutrient Availability

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

Positional Availability — Plants have been shown to be stimulated by high nutrient concentrations in the root zone. Placement of fertilizer near the seed and in the root zone enhances the chances of root interception of nutrient early in the growing season. The nature of the plant root system influences the depth of fertilizer placement because the fertilizer must be located where it is most easily accessible to plants. The relative salt tolerance of the plant dictates the upper limit of pop-up or starter fertilizer that can be used.

Phosphorus availability for crop plants is usually greater in soils where fertilizer is banded than when fertilizer is broadcast. The banded fertilizer reduces the contact of fertilizer P with the soil, and as a result, less P fixation occurs.

Temperature — Nutrient absorption by plants, chemical reactions in the soil and the movement of nutrients to plant roots are much slower at lower soil temperatures. Either pop-up or band applications of N and P improve plant uptake under lower temperatures. This is especially important for early seeded spring crops in cool, wet springs because of slow root growth. Since research has shown that soil temperatures are often lower with conservation tillage, fertilizer placement near the roots of the seedlings 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.

Soil Compaction — Untilled soils usually have higher bulk densities (more compaction) than conventionally tilled soils. Soil compaction has an adverse effect on nutrient availability. Band and pop-up fertilizer placement applications tend to counteract the detrimental effects of soil compaction on nutrient uptake.

Weed Competition — Surface broadcast and broadcast incorporated fertilizer applications put the fertilizer in an available position for all weeds. On the other hand, placement of fertilizer in the soil near the seed or concentrated in the root zone positionally favors the crops and limits the supply to weeds.

Surface Accumulation of Nutrients

Less mobile nutrients, such as P and K, remain where they are applied. Thus, these nutrients accumulate on the surface of soils where fertilizers have been surface broadcast and not incorporated. On the other hand, more mobile nutrients such as nitrate-nitrogen (NO_3–N) and sulfate-sulfure (SO_4–S) require water to be moved deeper in the soil profile to the zone of plant root development. When the surface of the soil dries out, nutrients become positionally unavailable because roots near the surface of the soil cannot take up nutrients without soil water. In nonirrigated agricultural areas, the drying out of the soil surface would logically call for deep placement of commercial fertilizers because of the greater likelihood of favorable root zone moisture.

When nutrients, particularly nitrogen, are allowed to accumulate or are placed on the soil's surface, an increase in soil acidity often occurs. 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 nitrogen fertilizer is routinely broadcast on the surface of agricultural soils, the pH of the upper few inches of the soil profile is often 0.5 pH or more units lower than the soil below. This intense acidification lowers the availability of N, P, S and Mo in the surface soil.

Nodulation on legumes, such as peas, lentils and alfalfa, is often reduced because of acidification caused by fertilizer placement. Intense acidification of the soil surface because of broadcast fertilizer applications may also result in diminished effectiveness of some herbicides.

Factors That Determine Nutrient Placement

Several soil and environmental factors determine optimum placement, rates and timing of fertilizer applications. The nature of the fertilizer nutrients also affects methods of application.

Nitrogen — There are several mechanisms through which N fertilizer can be lost from soils. These include volatilization, leaching, denitrification and erosion. Nitrogen can also be tied-up in plant residues. Deep banding of nitrogen fertilizer below plant residue can often reduce losses attributed to the above factors.

Ammonia volatilization losses may occur when ammonium-based N fertilizers (ammonium nitrate, ammonium sulfate, urea) are surface broadcast on soils with a pH above 6.5. Losses because of volatilization can be reduced by incorporating broadcast N fertilizers or by banding fertilizer below the soil surface. Volatilization losses of surface nitrogen are not significant on soils with pHs less than 6.2.

Leaching losses of N can be partially reduced by fertilizer placement. Losses can be further reduced, however, by fertilization with ammonium-nitrogen (NH_4^+–N) rather than nitrate-nitrogen (NO_3^-–N). Deep placement of N will often reduce denitrification.

Loss of available N because of tie up in plant residues can be minimized by placing N fertilizer away from decaying organic matter. In most cases, pop-up

or band applications place the N below the straw-residue layer in the soil. Crop residues do not break down if N is not available. This practice is most critical under conservation tillage management.

Phosphorus — Phosphorus availability in soils is reduced with low soil temperatures and extremes in soil pH. Cool, wet springs are known to cause a reduction in P uptake by plants. Placement of P with or near the seed increases the concentration of available P sufficiently that it partially compensates for the lowered uptake rate that occurs in cold soil such as in the early spring. Research data indicate a definite yield advantage with pop-up and/or band P applications under cold, wet soil conditions. When soil pH is below pH 5.8, iron and aluminum tie-up phosphorus. When soil pH is above 6.6, calcium ties-up phosphorus.

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

Boron — Boron (B) acts similarly to nitrate and sulfate in soils but moves at a slower rate. High concentrations of B in soils are toxic to plants. Consequently, B should always be applied as a broadcast treatment and never used in a pop-up or band treatment.

Fertilizer Materials

Research has shown that at best broadcast applications of N and P will produce yields equal to banded applications. Often banding both N and P results in increased yields when compared to broadcast treatments. Placement of N and P below the seed in a band generally produces the best results. It is more critical to band P and N. Benefits from banding S have not been widely observed.

High salt content of nitrogen and potassium fertilizers limits the amount that can be applied as a pop-up treatment. Phosphorus does not contribute to a salt hazard when placed with the seed at planting.

Available research information indicates that correct fertilizer placement is a more critical factor to be considered under conservation tillage than conventional tillage. Placing the fertilizer below crop residue improves fertilizer use efficiency.

The Authors — Robert L. Mahler is a research soil scientist, and Rober E. McDole is an Extension soil specialist, both in the University of Idaho Department of Plant, Soil and Entomological Sciences at Moscow.

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