# Phosphorus Fertilizer Placement

Phosphorus added to soil quickly becomes fixed in less available forms as the P reacts with other soil components. Fertilizer placement helps overcome fixation. However, P moves very little in most soils so application close to where root development occurs is often desirable.

Specific recommendations for phosphorus (P) placement are difficult. There is no one best method of application. Soil and growing conditions influence placement choices. Application method can offset the effects of P fixation by soils and increase P efficiency.

## Phosphorus Placement Options

Phosphorus placement can be broken into two general application methods: broadcast or band.

**Broadcast.** Application of fertilizer to the soil surface, with or without subsequent incorporation. Broadcast is the simplest application method and is best suited for high-speed operations and heavy application rates. When plowed or disked in, broadcasting produces the most uniform P distribution within the root zone and provides more root contact with P. However, it also maximizes contact between the soil and fertilizer so the opportunity for fixation is higher.

**Band.** Applications that concentrate the fertilizer in narrow zones or bands that are kept intact to provide a concentrated source of nutrients. Banding is advantageous where soil test levels are low, where early season stress from cool or wet conditions is likely to limit root growth and nutrient uptake, and for soils that have a high tendency to fix P in unavailable forms.

Phosphorus may be banded prior to, during, or after planting. Banding options include:

**Deep band.** Applications 2 to 6 inches below the soil surface. Knifing a narrow concentrated band of fertilizer below the soil surface as a preplant or side-banding fertilizer to the side and/or below the seedrow are forms of deep banding. Also included is dual banding, or double shooting, which is placement of two fertilizers, usually nitrogen (N) and P, together in the band.

**Surface band or surface strip.** Application of solid or fluid fertilizer in narrow strips on the soil surface prior to planting (may be incorporated) or over the row after planting.

**Point injection.** Use of a spoked wheel to inject fluid fertilizer into the rooting zone 4 to 6 inches deep at 8-inch intervals.

**Starter or seed placement.** Applying small amounts of fertilizer in direct contact or close to the seed (i.e. 1 to 2 inches below and to the side) at planting. Starter P is especially helpful in promoting early plant growth and enhancing seedling vigor. This early stimulation of crop growth is often termed "pop-up effect". However, starter fertilizer must be used cautiously because many crops are sensitive to seed placed fertilizer and can only tolerate low rates near the seed.

**TABLE 1.** Dual banding N and P increases winter wheat yields and P efficiency (Kansas).

| Method | | Wheat yield, | Plant P, |
|---|---|---|---|
| N | P | bu/A | % |
| 0 | 0 | 46 | 0.22 |
| Band | 0 | 51 | 0.21 |
| Broadcast | 0 | 44 | 0.23 |
| Band | Band | 64 | 0.27 |
| Band | Broadcast | 53 | 0.22 |
| Broadcast | Band | 56 | 0.23 |
| Broadcast | Broadcast | 53 | 0.23 |

## Crop Response to Placement

**Small grains and canola.** Band applied P is generally superior to broadcast P in small grains, especially on low P soils or on soil with high fixing capacity. A "pop-up" effect from starter P is commonly observed in the Northern Great Plains, regardless of the soil P level because of cool soil conditions early in the spring.

Dual banding N and P in the fall or spring prior to seeding has increased P efficiency and yields (**Table 1**). When placed together in a band, the ammonium-N keeps fertilizer P available longer by delaying the effects of normal soil reactions that fix P.

Recent developments in reduced tillage seeding equipment and openers have permitted high rates N and P to be placed together in close proximity to the seed during planting. This equipment increases the separation between seed and fertilizer and allows all the nutrient requirements to be safely applied in a one-pass seeding and fertilizer operation. Good seed/fertilizer separation and precision placement of P are crucial for small seeded crops such as canola because oilseeds are highly susceptible to seedling damage from any fertilizer placed in direct contact with the seed.

**Sunflower.** Germinating sunflower seed is very sensitive to soluble salt in the soil and fertilizer applied in the row at seeding. Phosphorus requirements are similar to wheat, but P placement below and to the side of the seed is apparently beneficial.

**Corn and grain sorghum.** Broadcasting P before primary tillage operations is the most common application method for conventional corn. Building P fertility to high level throughout the root zone optimizes yields. However, broadcast application in conservation tillage systems leads to high concentrations of P near the soil surface. This works well where soils are warm, soil test levels are high, and adequate moisture throughout the growing season ensures root proliferation near the surface. But if soil test levels are low and growing conditions do not encourage rooting activity near the soil surface, band application is recommended.

Courtesy of Flexi-Coil.

**Optimum P** fertilizer placement offers greater efficiency and higher yield potential.

The effectiveness of application method in conventional and reduced tillage systems is demonstrated in the data in **Table 2**. The difference between application methods disappears when soil fertility is high.

Starter P is very effective in increasing corn and sorghum yields, but especially so in conservation tillage systems which often have cooler and wetter soils early in the spring. It can also have significant effects on grain moisture. Advanced maturity and higher yields combine to produce lower grain moisture at harvest and reduced drying costs.

**Alfalfa and perennial grasses.** Banding starter P directly below the seed at planting will ensure good root development and seedling establishment. Banding has also shown advantages on acidic, high-fixing soils. On low-fixing soils, broadcasting and incorporating large P applications before planting can supply P needs for several years.

**TABLE 2.** Phosphorus placement and soil fertility influence corn yield in conventional and reduced tillage systems (Minnesota).

| | Low fertility | | High fertility | |
|---|---|---|---|---|
| Placement | Fall chisel | Ridge-till | Fall chisel | Ridge-till |
| | Two-year average, bu/A | | | |
| Control | 84 | 87 | 156 | 150 |
| Broadcast | 110 | 102 | 151 | 151 |
| Surface band | 108 | 112 | 152 | 152 |
| Deep band | 118 | 123 | 153 | 153 |

Broadcast application works well on established forages. Although P movement is restricted, perennial crops have greater root density and higher nutrient removal near the soil surface compared to annual crops. Banding P into established forage has shown little advantage over broadcasting, largely due to stand damage during the banding operation. However, recent studies have shown banding can be effective if the opener causes minimal disruption of roots and the stand.

**Vegetables and potatoes.** High concentrations of P in the vicinity of vegetable plant roots help avoid early season stress. Banded P has been found to be important for early season, direct-seeded tomatoes on cold, high pH soils. Starter P placed one to three inches below onion seed produced best seedling vigor, uniformity, and plant development. Researchers concluded that placement had a larger effect on onions than did rate. When N, P, and potassium (K) are banded together, potato yields may be better than broadcast application due to the complimentary effect of ammonium-N on P uptake.

**Soybeans and field beans.** Soybeans generally prefer broadcast placement. They respond best to an overall high P fertility in the root zone which is usually best accomplished by incorporating broadcast P. However, under drier conditions and low P soils, some Canadian researchers have found banding P below the seed will produce better yields than broadcasting. Field beans (dry beans) are sensitive to direct seed placement of fertilizers. Recommended placement is either below and to the side of the seed or broadcast.

**Cotton.** Broadcast and incorporation or shallow banding (2 to 4 inches) are the recommended placement methods for cotton. On medium and high P soils, there appears to be little difference between methods. However, subsoil can be very low in available P and K. Research in Mississippi has shown that when these nutrients are deficient in the subsoil, banding 6 to 15 inches deep produces better yields than broadcasting. Cotton also responds well to starter fertilizer regardless of the main method of application.

**TABLE 3.** Starter P increases corn yields at very high soil test levels (Wisconsin).

| Soil test P, ppm[1] | Starter $P_2O_5$, lb/A | | |
|---|---|---|---|
| | 0 | 20 | 40 |
| | Corn yield, bu/A | | |
| 35 | 103 | 137 | 134 |
| 56 | 122 | 142 | 148 |

[1]ppm = parts per million

## Summary

Band-applied P normally outperforms broadcast P at low soil test levels and modest P rates. But the differences between methods usually decrease with increasing application rates or increasing soil test levels. However, even at high soil test levels, response to starter P often occurs. For example, **Table 3** shows how starter P at rates as low as 20 lb $P_2O_5$/A dramatically increased corn yields even though soil test levels were very high. Similar responses have been reported for wheat, barley, potatoes, and other crops.

Cold soil conditions are usually a factor when high P soils respond to starter P, but the possibility of response on high P soils is good when any condition imposes stress early in the growing season or other production factors are optimized.

There is no one best P application method. Field conditions, soil test level, soil P buffering capacity, crop, time of application, equipment, and other management factors all influence application choice. However, some general considerations follow:

- Placement of P for small grains may be more critical than for row crops and forages. Limited root systems, shorter growing seasons, and cooler temperatures enhance the response to banded P over broadcast.
- Placement of ammonium-N with P improves P uptake and slows fixation.
- On high P soils, maintenance P applications may be effective regardless of placement method.
- Reduced tillage crops, row crops, and spring-seeded small grains may require P placement close to the seed, regardless of P soil test.
- Limited root systems in some specialty

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**TABLE 3.** Generalized interpretation of the Phosphorus Index.

| Phosphorus Index | Generalized interpretation |
|---|---|
| **less than 5** | **LOW** potential for P loss. If current farming practices are maintained, there is a low probability of adverse impacts on surface waters. |
| **5-8** | **MEDIUM** potential for P loss. The chance for adverse impacts on surface waters exists, and some remediation should be taken to minimize the probability of P loss. |
| **9-22** | **HIGH** potential for P loss and adverse impacts on surface waters. Soil and water conservation measures and a P management plan are needed to minimize the probability of P loss. |
| **more than 22** | **VERY HIGH** potential for P loss and adverse impacts on surface waters. All necessary soil and water conservation measures and a P management plan must be implemented to minimize the P loss. |

manure and fertilizers. However, in areas of the country with concentrated animal production, local P surpluses can be large.

## The Phosphorus Index

Soil test levels are not adequate indicators of risk of P loss. An index must consider both source (soil test P and applied P) and transport factors. Erosion and runoff are the primary transport pathways. These depend on soil and landscape properties such as slope, soil cover, distance to watercourse, and infiltration properties. Placement of applied P is important, as these transport pathways are most active at the soil surface.

The Phosphorus Index is being developed as a screening tool to rank sites for potential loss of P. The site characteristics used in the index are shown in **Table 2**. Weighting of the factors and the method of calculating the index vary in different versions. **Table 3** shows how the index can be interpreted.

Several watershed studies have shown that 90 percent of the P lost to surface water arises from 10 percent or less of the land area. Such areas occur where both the source and transport factors are high. Use of the Phosphorus Index will allow greater flexibility in placement of manure and fertilizer to build soil fertility in areas where the benefit to crop production will be the greatest and the risk of harm to the environment will be at a minimum. Management efforts for high yield cropping systems, focused on areas unlikely to harm the environment, will produce more food on less land, relieving pressure to use marginal, erodible land for crops. BC

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and vegetable crops make P placement an important management practice.

- Where P fixation is an overriding factor, banding all the P is probably advisable. High P concentrations in bands help delay fixation reactions.
- High yielding row crops, especially corn, may require relatively high P levels throughout the rooting zone for maximum yields. On low to medium P soils, banding at least some of the P may provide a yield advantage.
- Where P use has been minimal in the past and resources are limited, banding moderate amounts of P on more acres will likely optimize returns. BC