4 nutrient stewardship

DECISION-MAKING GUIDE PHOSPHORUS

The 4R Nutrient Stewardship Framework provides a comprehensive approach of managing plant nutrients to increase food production while improving the ecological integrity of farms. When correct decisions are made regarding the 4R's (using the right nutrient source, at the right rate, at the right time, and in the right place) there are many benefits, including better crop growth, decreased nutrient leakage to the environment, and the protection of natural areas and wildlife.

Implementing 4R principles is challenging because there is no single set of correct practices that can be universally adopted. Each farmer and crop adviser makes decisions best suited to local conditions and crops—adjusting practices for each field and soil, production targets, weather conditions, economic objectives, environmental concerns, and regulations—to meet the overall goals. Because local conditions determine the appropriate 4R practices, nutrient management decisions are best made at a local level, rather than with centralized regulations.

Phosphorus (P) is an essential plant nutrient in limited supply in many soils. Insufficient P in the soil limits the early growth of seedlings, reduces crop yield, and delays maturity. With P deficiency, plant growth is stunted. In some species, leaves turn dark green; in others, leaves turn red or purple as anthocyanin pigments accumulate.

Phosphorus fertilizer is retained by the soil and is less easily lost than nitrogen. Added P is adsorbed to soil minerals or precipitated as sparingly soluble compounds of calcium, magnesium, iron, and aluminum. The amount of soluble phosphate available for plant uptake is generally highest between soil pH levels of 5.5 and 7.5. Plants take up soluble P as orthophosphate ($H_2PO_4^-$ or HPO_4^{2-}).

Small amounts of P loss from soils can impact water quality by stimulating algal blooms. Practices that control soil erosion limit the losses of particulate forms of P. Applying the right P sources at the right rate, time, and place limits losses of soluble P in runoff.

The principles of 4R Nutrient Stewardship provide a scientific basis for a farmer to make fertilizer decisions to achieve production goals in an environmentally acceptable manner that meet social objectives.

Provide a balance of essential plant nutrients, considering the use of all available nutrient sources. *Plant roots only take up nutrients in a soluble form and they must be present when the plant needs them. Phosphorus fertilizer sources should be selected based on plant availability, chemical properties, and need for other nutrients.*

Examples of Right Source

- Where available, manures and biosolids contain P and can improve soil fertility. They are not as easily applied as fertilizers, and their value as a P source for plants may vary.
- Depending on the soil need for additional nutrients, P fertilizers containing nitrogen, potassium, calcium, sulfur, or zinc can be selected.
- Granular P fertilizers include mono- and di-ammonium phosphate, and single or triple superphosphate. The choice of granular versus fluid fertilizers depends on application equipment, amounts needed, and relative pricing.
- Fluid fertilizers containing polyphosphates can temporarily keep some micronutrients like manganese and zinc more available by chelating them. Poly-phosphates convert rapidly to orthophosphates in soil.
- Rock phosphate has limited solubility, but can be an effective P source when finely ground and applied in large quantities to acidic soils.

IPNI International Plant Nutrition Institute
3500 Parkway Lane, Suite 550
Peachtree Corners, GA 30092-2844
USA | www.ipni.net | Ref # 16023

Apply P based on soil nutrient supply and plant demand. *Have the soil tested to determine the risk of P deficiency, and whether replenishment of removal is needed. Realistic predictions of crop performance and yield can be used to estimate crop nutrient removal.*

Examples of Right Rate

- Crops remove less P than nitrogen and potassium, but the amounts are highest in seeds and grains. The P in fertilizer is expressed as P_2O_5, while some analyses of plants or manures may report P. Convert P to P_2O_5 by multiplying by 2.29.
- Soils should be analyzed for P at least once every 3 to 4 years. Different soil testing methods report very different amounts of the soil's available P, so be sure to identify the appropriate level for the soil test method and the crop.
- When available P in the soil is at an optimum level, apply as much as crop harvest removes. When it is higher than optimum, apply less. When it is below, apply more.
- Plant tissue testing is useful for monitoring adequate P nutrition. The tissue of some crops, like potatoes, is often sampled several times through the growing season.

Decisions on the time of P application should account for the dynamics of crop nutrient demand, soil nutrient supply, potential losses, and the logistics of field operations. *In general, it is preferable to add fertilizer as close to the time of plant uptake as possible. In many situations, crop response to applied P does not vary much with timing of application. Risk of water contamination can be much higher when P is applied during periods of higher likelihood of surface runoff and active tile drain flow.*

Examples of Right Time

- The early growth stages of annual crops are most susceptible to P deficiency. Applying P at planting in a band near the seed ensures maximum access by the young seedlings. Plan well ahead to ensure that P application does not interfere with timeliness of planting.
- Plants take up P until maturity. The more extensive root proliferation later in the growing season usually is enough to prevent further deficiencies as long as the available soil P level is in the optimum range.
- When sources containing soluble P are left on the soil surface, the P remains soluble until it interacts with the soil. A rainfall event generating runoff or tile flow soon after P application can elevate dissolved P in drainage water to concentrations of concern for water quality, even when only a few percent of the applied P is lost. Do not apply onto frozen or snow-covered soils.

Consider where plant roots are growing, and how soil is reacting with applied P sources. *Apply with minimal disturbance of the crop residue protecting the soil. Manage variability within the field. In consistently low-yielding areas, it may be useful to reduce fertilizer applications to match crop needs, avoiding the risks of inefficiency and economic loss.*

Examples of Right Place

- Placing P fertilizer in bands near where the crop roots are expected to grow makes it most available to the crop and protects it from runoff losses. Strip-till banding may be a good option where conservation tillage is practiced.
- Broadcasting is often the most economical way to apply large amounts. To limit increased loss of P in runoff, incorporate P without increasing soil erosion, or apply at a time of the season when runoff risk is low.
- While P fertilizers have lower salt index than nitrogen or potassium, excess amounts in contact with the seed can delay germination and reduce seedling emergence.
- Zones within a field requiring different rates of application should be identified based not only on soil tests, but also on crop yields, landscape, and field history.