Phosphorus In Mississippi Soils

Phosphorus (P) is a nutrient essential for plant growth. It stimulates root and shoot growth, promoting vigorous seedling growth and advancing maturity. It is integral to the conversion of solar energy to the chemical energy that plants need to synthesize sugars, starches, and proteins.

Phosphorus management and nutrition have both economic and environmental implications. This publication examines P in soils, plant uptake, soil fertility and testing, and management of P fertilizers.

Phosphorus in Soils

Phosphorus exists in soils in organic and inorganic forms. Organic forms of P are found in humus and other organic materials.

Phosphorus in organic materials is released by a process involving soil organisms. The activity of these microbes is highly influenced by soil moisture and temperature. The process is most rapid in warm, well-drained soils. Mississippi research shows that only 1 percent of the total soil organic P is mineralized per year in cotton and soybean production systems. Since initial soil P levels are low and plant uptake is only one possible fate of the mineralized P, the contribution by mineralization to plant available P is small.

Inorganic P is negatively charged in most soils. Because of its particular chemistry, P reacts readily with positively charged iron (Fe), aluminum (Al), and calcium (Ca) ions to form relatively insoluble substances. When this occurs, this process fixes P in an unavailable form. In this regard, P does not behave like nitrate -N (NO_3-), which also has a negative charge but does not form insoluble complexes.

The solubility of the various inorganic P compounds directly affects the availability of P for plant growth. This is influenced by the soil pH with optimal availability at pH values between 6 and 7. When pH is less than 6, plant available P is increasingly tied up in aluminum phosphates. As soils become even more acidic (pH below 5), P is fixed as iron phosphate.

Some soils in Mississippi have pH values greater than 7. When pH values exceed 7.3, P is increasingly made unavailable by fixation in calcium phosphates.

Rice is grown on Mississippi Delta soils that historically have medium to high soil test levels of P. Phosphorus becomes more available as rice fields are flooded but is rapidly converted to unavailable forms as the soil dries out.

This fixation is more extensive and less reversible under alternating flooding-draining regimens, such as crop rotation systems, than in continuously flooded or continuously moist situations. Supplemental phosphate may be needed for subsequent crops grown in rotation with rice because of this fixation. This phenomenon is often seen in other flooded soils.

Because most Mississippi soils are acidic, P fixation is dominated by Al and Fe compounds. Producers should follow a regular soil testing schedule and liming program to allow greatest availability of both native- and fertilizer-applied P. The efficiency of phosphate fertilizers is greater if you apply lime to neutralize soil acidity in fields before P fertilization.

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Phosphorus Uptake by Plants

Plant roots take up most P as either of two ions. Because most Mississippi soils are neutral to acidic, uptake is almost totally as the $H_2PO_4^-$ ion. On soils with higher pH, there will be some absorption of the HPO_4^{2-} ion. Plants do not absorb organic forms of P.

The absolute quantity of these ions present in the soil and available for uptake at any one time is very small. The amount that is dissolved and accessible in the soil solution is in equilibrium with solid phase P. The solid phase consists of both the organic and inorganic forms in the soil.

Crops generally need more P than is normally dissolved in the soil solution for optimal growth; therefore, this P "pool" must be replenished many times during the growing season. The soil's ability to do this is key to the soil's plant-available P status.

Soil Testing for Phosphorus

If the soil P level is not adequate for optimal crop growth, supplemental fertilization may be necessary to ensure adequate amounts are available.

You should base the need for supplemental P on soil test recommendations. Information on soil testing in Mississippi is available for farmers and homeowners. Soil testing measures the ability of a soil to provide P to the soil solution for plant use but does not measure the total quantity of available P. In other words, the soil tests provide an index of P in soils that is related to the phosphate fertilizer needs of the crop. The relationship between the P index determined by a soil test and phosphate fertilizer requirements is developed through research. Plant P uptake and yield are related to measured quantities of P in soil.

Different soil testing laboratories use different solutions in extracting P from a soil sample. These different techniques can result in very different numeric values reported by different laboratories. This increases the importance of the index concept. Direct comparison of P levels between laboratories is very difficult unless they use the same procedures, solutions, techniques, and indices. However, it is hoped each laboratory can determine roughly equivalent indices.

Indices commonly used to report soil test P levels are very high, high, medium, low, or very low. Each category should reflect the probability of response to phosphate fertilizer application. Crops grown on soils with a very high P index normally should not respond to phosphate fertilizer application, but crops on very low P soils should usually respond.

Table 1: MSU Extension Service Soil Testing Laboratory soil testing indices for phosphorus for all crops.

Soil Test Levels (pounds per acre)	MSU-ES Soil Test Index (based on Mississippi Soil Test Extractant)
0-18	very low
19-36	low
37-72	medium
73-144	high
greater than 144	very high

Phosphate Fertilization

In general, no fertilizer P is recommended for soils testing in the high or very high indices using the MSU-ES procedures. Several fertilizer options are available if a soil test recommends phosphate be added to maximize plant growth. Nitrogen is also a major ingredient of some materials.

P needs of plants are most critical in the earliest growth stages. If the pH is between 6 and 7 and the soil has a low risk of erosion, you can apply P in the fall for cotton or grain production. However, fall-applied P to soils that are later flooded for duck habitat may be unavailable to crops the following year.

P usually does not move much within in the environment if there is no erosion. Because of this, corn and grain sorghum may benefit from P fertilization in a band near planted seed. Roots do not grow to fertilizer, but when a root system meets localized P (or nitrogen) fertilizer, the roots will proliferate in that area. Placing fertilizer bands below and near the seed enhances the possibility of roots finding the fertilizer. Increased rooting because of the fertilizer-induced proliferation improves early plant vigor by more efficiently using all nutrients in the rooting zone.

Research with soybeans has not indicated a similar response to fertilizer placement. This is probably because of the different root systems of soybeans and grain crops.

Most forage crops develop many small roots close to the soil surface. These crops can efficiently use annual broadcast fertilizer applications to established stands. The preferred management before seeding forages is to broadcast and incorporate P fertilizer at the recommended rate. After establishment, you can apply P fertilizer annually at rates required to meet crop needs and to minimize environmental impact.

Because P does not readily move within soils, placement of phosphate fertilizers is a major management decision in crop production systems. There is no ideal placement for all crops. Decisions about phosphate fertilizer placement depend on the intended crop, soil test P level, and environmental considerations.

Animal manures and bedding materials contain significant amounts of P in organic forms. After microbes convert P from the organic forms, it is subject to the same fates as inorganic fertilizer P when applied to soils.

Detailed information on commercial fertilizer recommendations, options, and management is provided in Extension Publication 2647 *Nutrient Management Guidelines for Agronomic Crops Growin in Mississippi* and Publication 2500 *Inorganic Fertilizers for Crop Production*.

Table 2: Common phosphorus-containing fertilizers.

	N	P_2O_5	K_2O
Ammonium polyphosphate	10	34	0 (liquid)
Ammonium polyphosphate	16	62	0 (dry)
Diammonium phosphate	18	46	0
Monoammonium phosphate	11	48	0
Ordinary superphosphate	0	20	0
Triple superphosphate	0	46	0

Environmental Concerns

Phosphorus movement off agricultural land to surface waters may speed algal growth in water bodies. These algae ultimately die and decay in the water. This process may reduce oxygen levels and ultimately reduce higher-order aquatic populations.

Research has shown 50 to 95 percent of P movement within a landscape is attached to moving sediment. Since P is closely attached to solid soil materials, erosion control limits P movement to surface waters. Best management practices (BMPs) are simple, low cost, common sense ways to minimize P movement.

Information on BMPs for fertilizer applications is available in Extension Publication 2647 *Nutrient Management Guidelines for Agronomic Crops Grown in Mississippi*. Use the best combination of these for your situation.

Some situations may require more extensive nutrient management planning, such as animal feeding operations. This may include the Mississippi Phosphorus Index Risk Assessment Tool to evaluate the potential for P to move in the landscape. Avoid confusion: note that this is not the same index illustrated in Table 1.

The risk assessment tool incorporates site-specific soil conditions and applied management practices in the evaluation. Soil test phosphorus levels, soil permeability, field slopes, animal byproduct application rates, distance to surface water, and other factors are used to determine the probability of nutrient movement in the landscape. Evaluations are done on a field-by-field basis, usually by county Natural Resource Conservation Service offices and private technical service providers.

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