IMPORTANCE OF PHOSPHORUS AND POTASSIUM IN CORN DEVELOPMENT

Introduction

Phosphorus (P) and potassium (K) are two of the twelve essential nutrients for plant growth. Both P and K are absorbed in large quantities by corn plants. Phosphorus is important for stimulating root and shoot growth and promoting vigorous seedling growth. Potassium is important for corn growth because it helps increase disease resistance and water stress tolerance. Adequate K increases the ability of corn plants to efficiently uptake other nutrients. Soil test results and determining crop removal rates of P and K help guide fertility management decisions.

Phosphorus Availability

Phosphorus in the soil is an "immobile nutrient", which has a relatively short range of movement in the soil over time. Effectiveness of P uptake is enhanced by the availability of soil moisture and temperature. Dry soil conditions can negatively impact uptake by the root system. Phosphorus is present in the soil in both organic and inorganic forms. Most P in the soil is tied up chemically in a form that is unavailable to a crop in a single growing season. The amount of P available for plant uptake is very low compared to the total amount of P present in soil. For example, total soil phosphorus may exceed 800 to 1,000 pounds per acre, but the plant available P in soil solution might only be 0.04 to 0.13 pounds per acre. As a crop removes the available P, the soil releases more plant available P into the soil solution. When the plant requires more P than the soil can release, the plant can become deficient. Soil tests do not report total P in the soil but are developed to predict if the soil will be able to release enough available P during the growing season to keep up with the projected yield goal. Fertilizer recommendations are made when the test levels indicate that a yield response would be expected. Manure is an excellent source of P, mostly in the organic form. The amount of P available to plants in manure can vary depending on several important factors.

- Diet of the animal
- Animal species
- Handling and storage of manure
- Type and amount of bedding material

Manure is a source of slow-release P that must be broken down by soil microbes into plant-available forms.

Role of Phosphorus in Plant Development

Plants require P for growth throughout their life cycle, especially during the early stages of growth and development. Phosphorus is integral to the conversion of solar energy to chemical energy that plants need to synthesize sugars, starches, and proteins. It is essential for the transfer of energy, produced through photosynthesis, to be used for growth and reproduction.[1] Adequate P levels during early season growth are required to enhance shoot and root growth and used for crop establishment. Adequate P increases water use efficiency and yield potential. When P levels are inadequate, corn cannot grow, produce, or tolerate stresses.

Cold Temperature Induced Phosphorus Deficiency Symptoms

Early season P deficiency symptoms can occur in cool soils with adequate P. Cool soils limit root growth and nutrient uptake, resulting in a temporary P deficiency and plants that may be stunted or purple in color (Figure 1). Occasionally, the purple coloration is not a symptom of P deficiency but related to air temperatures and bright sunny days. The purple coloration is caused by the accumulation of reddish purple pigments. It has been hypothesized that a combination of bright, sunny days and cool nights (40's to 50's F) during the V3 to V6 stages results in the accumulation of the pigments as a result of high photosynthetic activity during the day and little metabolism of them during the night.[2] This condition will not impact yield, unlike if the symptom is the result of a P deficiency. Symptoms diminish as the soil warms up.[3]

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Some corn products during early development can mimic these cold temperature P deficiencies. These corn families have a natural genetic purple seedling color that can be mistaken for cold weather induced P deficiency. This purple coloration can be observed on some corn products during all stages of plant development.

Phosphorus Uptake During Critical Growth Stages

Corn plants increase P uptake rapidly after the V6 growth stage (six visible leaf collars), which is about four to six weeks after planting. Phosphorus uptake continues until near maturity. Mid- to late-season P uptake will be directed toward reproduction. Symptoms of P deficiency on older corn include stunted plants and yellowing of the leaf margins of older leaves. In addition, stalks may be thin and short, and maturity can be delayed. Soil testing or tissue testing for P levels may confirm deficiency.

Figure 1. Phosphorus deficiency symptom in corn, older leaves turn purple in color.

Important Potassium Soil Characteristics

Like P, most of the potassium (K) in the soil is not readily available for plant growth and development. The total amount of K in soil ranges from 5 to 25 tons per acre.[4] Almost all K is tied up in the soil as structural mineral component. The amount of K supplied by soils varies during the growing season and can determine if a K deficiency will be observed in a corn crop. Fields with compacted soil or with conservation tillage practices where no subsurface band of K is applied, may show K deficiency. Dry soil conditions can also negatively affect soil K uptake by plant roots. Very light or sandy soils often are more likely to have lower K soil test levels which can result in higher K fertilizer applications.

Figure 2. Potassium deficiency symptoms in corn on outer leaf margins, appearing on older leaves first.

Role of Potassium in Plant Development

Potassium is associated with movement of water, nutrients, and carbohydrates within the plant. These functions stimulate early growth, increase protein production, and improve the efficiency of water use and resistance to diseases and insects. Plants with insufficient K have difficulty absorbing water and N from the soil, which might increase drought stress.

Corn plants conserve water and reduce moisture stress by closing leaf stomata (openings on the undersides of leaves) mechanism, which is regulated by K. Plants with inadequate K may be slower at closing their stomata, which reduces protection from drought stress. Additionally, deficient plants may have reduced energy making capacity via photosynthesis.

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Role of Potassium in Stalk Rot Disease

Stalk rots are among the most common and damaging of the corn diseases. Yield losses can result from premature plant death and lodging. The severity of stalk rot loss can be minimized with an optimum balance between K and nitrogen (N) levels in plant tissue. Excessive N that is out of balance with K, can cause a rapid flush of growth which may cause the plant to have insufficient structural composition to guard against fungal pathogens that cause stalk rot. Potassium has been associated with improvement of stalk strength. When corn plants take up enough K, stalk dry down is moderated after maturity and the risk of lodging may be reduced.

Potassium Uptake During Critical Growth Stages

Potassium uptake by corn increases rapidly around the V6 growth stage, approximately four to six weeks after planting. Potassium uptake is completed soon after silking (R1 stage). When K demand becomes large and there is not enough available K, deficiency symptoms may become visible. Potassium deficiency symptoms in corn first appear on the lower leaves because K is easily moved within the plant from older to younger leaves. Leaf symptoms are a yellowing to necrosis (tissue death) of the outer leaf margins (Figure 2). These symptoms begin at the leaf tip and progress down the margin toward the leaf base. Leaves often die especially during hot, dry, and windy conditions when K deficiency is severe.[5] Plants lacking K may have shortened internodes, weak stalks, excessive lodging, and increased leaf and stalk disease; they may also have a lighter green color when viewed from a distance.

Managing Phosphorus and Potassium

Understanding both crop nutrient uptake and removal can help producers better match plant nutritional needs to reach a target yield goal. The soil fertility levels for P and K are greatly impacted by their availability in the soil and previous crop removal. Each bushel of corn harvested per acre removes approximately 0.35 pounds per acre of P_2O_5 and 0.20 pounds per acre of K_2O. Corn harvested for silage or if the stalks are removed after harvest remove significantly more, each ton removes approximately 2.54 pounds per acre of P_2O_5 and 8.2 pounds per acre of K_2O.

Soil fertility tests should be conducted at least every other year to verify that appropriate fertility levels are maintained. If there is concern about fertility, especially due to very high or very low yields, yearly soil tests can aid with fertility decisions. It is important to apply fertilizers based on the values of the soil test. When soil test levels are in the high range, recommendations for P and K fertilizer application may not be needed. When test levels are in the optimum range an application rate equal to the amount of nutrients removed at harvest is recommended. Always consider residual fertility from previous crops and manure applications when determining application amounts. It is very difficult to raise soil test levels if soil test levels are very low. Only if nutrient application rates exceed the crop removal rate can soil test levels be increased. In general, 20 pounds of P_2O_5 and 6 to 10 pounds of K_2O above crop removal are required to raise the soil test levels one part per million for P and K, respectively.[6] The actual amount of each nutrient needed depends on the initial soil test level, yield level, soil texture, clay minerals, and organic matter levels.

Sources

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