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Role of Phosphorus in Pulses Crop Production

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Introduction

Legume crops play a valuable role in sustainable agriculture through their ability to increase fertility level and soil health. Legumes, which are in positive symbiotic relations with some bacteria in the soil, can increase the amount of nitrogen (N) in the

soil through biological nitrogen fixation (BNF). However, in order to maximize such functionalities, legumes require more phosphorus (P), which is essential for energy transformation in nodules. Furthermore, phosphorus (P) is important for root formation, nutrient uptake, and legume crop growth. However, most agricultural soils lack sufficient phosphorus (P) to support efficient biological nitrogen fixation (BNF) because it occurs in stable chemical compounds that are not readily available to plants. Phosphorus (P) shortage reduces production significantly in leguminous crops. From 2010 to 2016, production was in the range of 16 -19 Million Metric Tons (MMT), but it has increased dramatically in the last two years to 25-27 MMT. Pulse production increased by almost 48 percent from 18.24 MMT in 2010-11 to a record level of 26.96 MMT in 2021-22. Out of 17 essential elements, pulses specially need adequate amount of N, P, Ca, Mg, S and Mo. The inbuilt mechanism of biological N_2 fixation enable pulse crops to meet 80-90 per cent of their nitrogen requirements, hence a small dose of 15-25 kg Nitrogen ha^{-1} is sufficient to meet out the requirement of most of the pulse crops. Phosphorus is the second most critical plant nutrient overall, but for pulses it assumes primary importance owing to its important role in root proliferation and thereby atmospheric nitrogen assimilation. Phosphorus is involved in metabolic and enzymatic reaction and is a constituent of ATP and ADP. Response to applied P to the tune of 17-26 kg P ha^{-1} has been observed in most of the pulse crops on low to medium available Phosphorus soils.

Phosphorus is required for many physiological processes in legumes, including photosynthesis, respiration, and energy transfer. It is also essential for the formation of DNA and cell membranes, as well as for the development of roots and nodules. Legumes have a unique ability to form a symbiotic relationship with soil bacteria called rhizobia. These bacteria colonize the roots of legumes and form nodules, where they convert atmospheric nitrogen into a form that the plant can use for growth. This process, called nitrogen fixation, requires large amounts of energy, and phosphorus is critical for providing that energy. In addition to its role in nitrogen fixation, phosphorus is also important for the overall growth and development of legumes. Phosphorus-deficient plants often exhibit stunted growth, reduced yield, and poor-quality crops. In fact, phosphorus deficiency is one of the most common nutrient deficiencies in legume crops and can limit their productivity in many parts of the world.

Effect of Phosphorus on Root Nodulation

Leguminous plants, such as green gram, black gram, chick pea soybeans, peas, and clover, have a unique ability to form a symbiotic relationship with nitrogen-fixing bacteria called rhizobia. This symbiosis occurs within the root nodules, where the bacteria convert atmospheric nitrogen into a form that the plant can use for growth and development. Phosphorus plays a critical role in this process in several ways:

1. **Nodule Development:** Phosphorus availability is important for the initiation and development of root nodules. Adequate phosphorus levels in

the soil promote nodule formation, ensuring a sufficient supply of fixed nitrogen for the plant.

2. **Energy Production:** Phosphorus is a key component of ATP (adenosine triphosphate), which is the primary energy currency in cells. During nodulation, energy-intensive processes occur, such as the synthesis of leg-hemoglobin (a protein that carries oxygen within the nodule) and the production of enzymes involved in nitrogen fixation. Sufficient phosphorus levels are necessary to support these energy-demanding activities.
3. **Metabolic Processes:** Phosphorus is involved in various metabolic pathways within the plant, including the synthesis of nucleic acids, proteins, and phospholipids. These processes are essential for cell division, growth, and the production of new nodule tissue.

Phosphorus is necessary for nodule development, energy production, and various metabolic processes involved in nitrogen fixation. However, an appropriate balance is required, as excessive phosphorus can hinder nodulation. It is important for farmers and gardeners to manage phosphorus levels in the soil to optimize nodulation and ensure the successful growth of leguminous plants.

Common Phosphorus Application Methods in Legumes

Effective phosphorus application methods can enhance the growth, yield, and overall performance of legume crops. Here is some common phosphorus application methods used in legume crop cultivation:

1. **Soil Incorporation:** Phosphorus fertilizers, such as di-ammonium phosphate (DAP) or triple superphosphate (TSP), can be applied to the soil before planting or during soil preparation. The fertilizer is spread evenly over the soil surface and then incorporated into the soil using tillage equipment. This method ensures that the phosphorus is in close proximity to the developing roots of the legume plants.
2. **Band Placement:** Instead of broadcasting phosphorus fertilizer over the entire field, it can be applied in bands or rows near the seed or root zone of the legume crop. This method ensures that the nutrients are concentrated in the immediate vicinity of the growing plants, allowing for more efficient uptake. Band placement can be done at planting time or as a side-dressing during the growing season.
3. **Side-Dressing:** Side-dressing involves applying phosphorus fertilizer to the soil surface along the sides of growing legume plants. This method is typically done during the growing season when the crop's nutrient demand increases. Side-dressing allows for targeted application near the root zone, improving nutrient uptake and minimizing nutrient losses.
4. **Seed Coating:** Phosphorus fertilizers can be coated onto the legume seeds before planting. This method is particularly useful when dealing with small-seeded legume crops. The seed coating provides a localized nutrient source for the emerging seedlings,

promoting early root development and phosphorus uptake.

5. **Foliar Application:** In some cases, phosphorus can be applied directly to the foliage of legume crops as a foliar spray. This method is typically used as a corrective measure when phosphorus deficiency symptoms are observed during the growing season. Foliar application of Nano DAP allows for quick absorption and can provide an immediate nutrient boost to the plants.
6. **Starter Fertilizers:** Phosphorus-based starter fertilizers, high in available phosphorus content, can be applied in close proximity to the seed at planting time. This method helps provide a readily available source of phosphorus to the developing seedlings, enabling them to establish strong root systems early in the growth stages.

It's important to note that the specific application method and phosphorus fertilizer rate should be determined based on soil tests, crop nutrient requirements, and local agronomic recommendations. Consulting with agricultural extension services or agronomists can provide tailored advice for phosphorus application in legume crops based on your specific circumstances.

Phosphorus Plays a Crucial Role in the Growth and Development of Legume Crops by:

1. **Seed Germination:** Phosphorus is essential for the early stages of seed germination. It is involved in energy transfer processes and helps in the development of the root system.
2. **Improving Nitrogen Fixation:** Phosphorus is needed to support the enzymes responsible for nitrogen fixation in legume crops. Without adequate phosphorus levels, the symbiotic bacteria in the root nodules may not be able to function properly, leading to reduced nitrogen fixation.
3. **Supporting Root Development:** Phosphorus is essential for root growth and development, and legume crops require strong root systems to fix nitrogen efficiently. Adequate phosphorus levels in the soil help to promote the growth of a healthy root system in legumes.
4. **Photosynthesis:** Phosphorus plays a critical role in the process of photosynthesis, which is how plants produce their food. It helps in the synthesis of ATP, which is used as an energy source for photosynthesis.
5. **Flowering and Fruiting:** Phosphorus is required for the development of flowers and fruits in pulse crops. It is involved in the production of nucleic acids, which are essential for cell division and growth.
6. **Resistance to Stress:** Phosphorus helps in the development of a strong and healthy plant that can resist stress from disease, pests, and environmental factors such as drought and low temperatures.
7. **Enhancing Yield and Quality:** Adequate phosphorus levels in the soil can lead to increased yield and better quality in legume crops. Phosphorus supports the development of seeds, flowers, and fruits, which are essential for crop yield and quality.

The availability of phosphorus in soil is often limited by factors such as pH, organic

matter content, and soil texture. In acidic soils, phosphorus may become bound to aluminum or iron and become unavailable to plants. In addition, soils with low organic matter content or sandy texture may have a low capacity to hold onto phosphorus, making it more prone to leaching or runoff. To address phosphorus deficiency in Indian soil, farmers may use a combination of approaches such as soil testing, fertilizer application, and crop rotation. By applying phosphorus-containing fertilizers such as diammonium phosphate (DAP) or single superphosphate (SSP) at the right time and in the right amount, farmers can help to ensure that pulse crops have access to sufficient phosphorus for optimal growth and yield. Additionally, incorporating organic matter into soil through practices such as composting or green manure can help to improve soil health and increase phosphorus availability.

Conclusion

Phosphorus is a key nutrient in pulses production, influencing various aspects of plant growth, development, and reproduction. Its adequate availability in the soil promotes healthy plant growth, improved yield, and better crop quality. By understanding the role of phosphorus and implementing responsible nutrient management strategies, farmers and agricultural practitioners can optimize pulse production and contribute to sustainable and efficient agriculture.