CHAPTER-I
INTRODUCTION

CHAPTER I

INTRODUCTION

1.1. Phosphorus, an important plant nutrient

Phosphorus is an important plant nutrient, next only to nitrogen and classed along with nitrogen and potassium as a major plant nutrient element. Pierre (1938) referred to it as the" master key" element in crop production. It is associated with several vital functions and is responsible for several characteristics of plant growth such as utilization of starch and sugars, photosynthesis, nucleus formation and cell division, fat and albumin formation, cell organisation and transfer of heredity. Phosphorus is constituent of nucleic acids, phytin and phospholipids. Phosphorus has been reported by some workers to stimulate root growth. An adequate supply of phosphorus in the early stages of plant growth is important for laying down primordia for reproductive parts of the plant. It helps in early maturity of crops, particularly cereals and poor availability of phosphorous markedly reduces their growth. Phosphorus is essential for seed formation and occurs in large quantities in plant seed and fruit. The role of high energy phosphate bonds (ATP, ADP, AMP) in respiratory and photosynthetic processes is well established. Two symptoms of phosphate deficiency are reduced plant size and unusual deep green colour of the leaves.

1.2. Phosphate compounds in soil and manure.

Phosphorus is found in soil, manure, plants and micro-organisms in various organic and inorganic combinations. Thus soil contains both organic and inorganic forms most of which are unavailable to plants. Phosphate in soil solution is generally present in negligible amounts as compared with other forms.

Inorganic forms of phosphorus

Large quantities of phosphorus in inorganic forms occur in minerals as insoluble calcium, iron or aluminium phosphates. The native soil phosphorus probably originated from the dissolution of rock containing mineral apatite. $Ca_{10}(PO4 \cdot CO_3)_6 (FOHCL)_2$. This mineral may be in the form of carbonato-chloro-or hydroxyapatite or in combination of all these as the formula shows. In soil the phosphorus is found as flourapatite, hydroxyapatite, chlorapatite as iron or aluminium phosphate or in combination with the clay fraction.

The calcium phosphates are dominant in neutral to alkaline soils whereas iron and aluminium phosphates occur in acidic soils.

Calcium Phosphates

These exist in various forms, the most important for plant growth is monocalcium phosphate $[Ca(H_2PO_4)_2 \cdot H_2O]$ which is water soluble and the dominant part in superphosphate. Dicalcium phosphate $CaHPO_4 \cdot 2H_2O$ is sparingly soluble in water and is present in many phosphate fertilizers prepared by treating monocalcium phosphate with ammonia or calcium hydroxide. Tricalcium phosphate $Ca_3(PO_4)_2$ is an insoluble form dominant in alkaline soils. Hydroxyaptite $Ca_{10}(PO_4)_6(OH)_2$ is a phosphatic constituent of bones. Bone meal contains 20 to 28 percent P_2O_5 of which about 50 percent is citrate soluble. On alkaline soils it is less effective than superphosphate. Flourapatite $Ca_{10}(PO_4)_6F_2$ is the major constituent of phosphatic rock in North Africa, the USA, USSR and elsewhere and forms the principal raw material for commercial production of phosphatic fertilizers. such as super phosphate. The P_2O_5 content of rock phosphate varies considerably and the water soluble P_2O_5 of rock phosphate is negligible. Rock phosphate may be economically used in acidic soils that are low in available phosphorus. Rock phosphates are generally not recommended in neutral to alkaline soils where acid treated rock phosphates such as superphosphates are used.

Organic Phosphorus.

Vegetation and decaying plant residues entering the soil are the main sources of organic phosphorus compounds. Crop residues contain0.05 to 0.5 precent phosphorus. Organic forms comprise phytins. phospholipids, nucleic acids, phosphorylated sugars and coenzymes.

1 .3. Chemical fixation of phosphorus.

The plants take phosphorus as the primary orthophosphate ion H_2PO_4 or secondary orthophosphate ion H PO_4.In contrast to leaching losses of NO_3. SO_4 Cl anions. H_2 PO_4 and HPO_4 are retained in most soils when added and in many cases this retention is so great that the element becomes largely unavailable to growing plants. In other words. the soluble forms of phosphorus. when applied to soil as phosphatic fertilizers are rendered insoluble. This is known as chemical fixation of phosphorus.

In acidic soil the fixation of phosphorus is due to one or more of the following reasons.

1) Precipitation of insoluble compounds from the soil solution:In many acid soils, added phosphorus is fixed as iron and aluminium orthophosphates.

2) Reaction with hydrated sequioxides: Most soils contain appreciable quantities of hydrous oxides of iron, aluminium and manganese. These colloidal oxides and phosphate ions are attracted to each other and held to the surface particles in the form of basic iron and aluminium phosphate. Soils with a high quantity of these hydrous oxides fix large quantities of phosphorus such as red and yellow podzolic and red brown latosolic and lateritic soils.

3) Reaction with silicate clays: Phosphate ions may combine directly with clays such as montmorillonites (2:1 type) and Kaolinites (1:1 type) by replacing a hydroxyl group in an aluminium compound or by forming a clay -Ca-Phosphate linkage. Phosphorus is retained to a greater extent by 1:1 than by 2:1 type clays .. (Tisdale & Nelson 1958)

In neutral to alkaline soils the formation of diphosphate and triphosphate ions take place and the solubility of calcium orthophosphate decreases in the order mono-di- and triphosphates. In most alkaline soils the activity of calcium is high and thus favours the formation of insoluble di and tricalcium phosphate. A part of tricalcium phosphate may actually revert to hydroxyapatite. In alkaline soils containing free calcium carbonate, phosphate ions coming in contact with solid phase $CaCO_3$ are precipitated on the surface of these particles. Another way of phosphate fixation in alkalinesoil is retention of phosphate by clay saturated with calcium.

1.4 Status of phosphorus in Indian soils.

Total phosphorus in soil depends upon the parent material and management practices. According to Raychaudhari and Datta (1964) the total phosphorus in Indian soils varied from 130 to 1310 ppm. In acidic hill soils of Assam, it varied from 175 to 1220 ppm and in soils of Bengal it varied from 131 to 1120 ppm. But most of the soils contained around 436 ppm. Alluvial soils of Bihar had a range of 175 to 436 ppm total p with a mean value around 350 ppm. Most of the black soils of Maharashtra had around 1000 ppm phosphorus. Semi arid soils of Rajasthan were rather poor in total phosphorus. Alluvial soils of Uttar pradesh on an average containes 350 ppm. phosphorus.

Dhir (1956) reported that Indian soils contained 165 to 1377 ppm. total P with an average value of 474 ppm. The average values for black, alluvial, forests desert and red soils were 419, 415, 1228, 240 and 376 ppm. respectively. With exception of forest and some alluvial soils most of the soils were deficient in available phosphorus. The total phosphorus. in Indian soils varies greatly in relation to parent material, soil group, climatic condition, texture and management practices.

There are substantial rock phosphate deposits in India. The total reserve being around $100x10^{6}$ tonnes (Jhingram and Chaudhari 1977).

About 1/6th of this reserve is of high grade area (more than 30% P_2O_5) while the rest is of medium (15-25% P_2O_5) and poor grade (5-15% P_2O_5) types. High grade phosphate ores are thus not available in India.

1.5 Phosphate Solubilizing microorganisms (PSM)

Only water soluble phosphates present in the soil are absorbed by the plants. But the water soluble form of phosphates is in extremely small quantities. Though water soluble phosphatic fertilizers are applied to the soil, they are converted into insoluble form due to interaction between added soluble phosphate and soil constituents. Phosphates solubilizing micro-organisms play an important role in converting insoluble phosphatic compounds such as rock phosphate, bone meal, basic slag and particularly the chemically fixed soil phosphorus into available form.

Many fungi, bacteria and actinomycetes are potential solubilizers of bound phosphates in soil. They play an important role in soil, by solubilizing phosphorus and making it available to plants.The mostefficient bacterial isolates were identified as *Pseudomonas striata Pseudomonas rathonis*, *Bacillus polymyxa* and fungal isolates such as *Aspergillus awamori*,*Penicilliun digitatum*,*Aspergillus niger* and *Schwanniomyces occidentalis*.

1.6 Mechanism of P Solubilization

There are two schools of thoughts [illegible]

interpreting the mechanism of phosphate solubilisation by micro-oraganisms

a) Solubilizatoin by production of organic acids.

b) Solubilization by action of phosphatase enzyme.

a) The major microbiological means by which insoluble phosphorus compounds are mobilized is by the production of organic acids. The organic acids convert tricalcium phosphates to di or monobasic phosphates with the net result of an enhanced availability of the element to the plants. The organic acids produced by microorganims are lactic acid, citric acid, glycolic acid and succinic acid.

b) The liberation of phosphorus from the organic phosphatic compounds is due to action of enzymes of esterase type by micro-organims.

1.7. Role of P S M. in Crop productivity.

The phosphorus content of most soils is quite low (Chakravarti 1964, Raheja 1966), So the application of phosphatic fertilizers in the available form is essential for better crop yield. It is well known that more than two third of phosphatic fertilizer is rendered unavailable within a very short period of its application due to fixation in the soil complex.[Hemwall (1957) Languth et al (1957) Mandal and Khan (1972].

It has been established that there are specific groups of soil micro-organisms which increase the availability of phosphates to plant, not only by mineralizing organic phosphorus compounds but also rendering inorganic phosphorus compounds more available to them. (Gerretsen 1948, Mischustin and Namova

1962 a & b, Menkina 1963, Sundar Rao 1965, Taha et al 1969 Tardieux Roche and Tardieux 1970, Gaur 1974). Considerable success was earlier claimed, particularly by Russian workers in increasing yield and quality of crops by inoculating seeds with pure and efficient strains at *Bacillus megaterium* var. phosphaticum commonly called phosphobacterin, which mineralizes organophosphate.

Microbial solubilization of inorganic and organic phosphate compounds has been extensively studied under Indian conditions (Sundar Rao et al 1963, Gaur 1972, Gaur and Ostwal 1972, Gaur and Singh 1982). Therefore one of the approaches would be to increase the number and activity of efficient PSM in the root zone of plants by use fo microbial inoculants for increasing phosphorus availability to the plants from the soil as well as added phosphates.

Gerretsen (1948) was the first to demonstrate that plants took up more phosphate from insoluble phosphate fertilizers in the presence of micro-organisms. Since then many workers have got encouraging results with PSM inoculation in increasing the yield of crop plants.

1.8. Importance of phosphorus in groundnut nutrition.

Field grown groundnut plants are reported to have generally good nodulation with naturally occuring rizobium strains.Nair et al. (1971) reported that one of the major facors affecting nodulation in groundnut in soils of Tamilnadu was the inadequacy of available phosphorus in the soils. Despite the fact that phosphorus deficiency reduces symbiotic nitrogen fixation by restricting host plant growth. Some recent evidences suggest that phosphorus requirement for nodulation and maximum nodule activity are much greater than that of the host plant. (De Mooy et al. 1975). The maximum nodule acvtivity required even higher levels of applied P than for maximum nodulation (De Mooy and Reseek 1966). Thus phosphorus is a key element in plant nutrition and nitrogen fixation of groundnut plant.

The present work was conducted to study the effect of PSM on growth and metabolism of *Arachis hypogaea* L which considered the following aspects

1) Effect of PSM on growth of the plant (root and shoot length ; dry wt per plant).
2) Effect of PSM on nodulation and leghaemoglobin content of the plant.
3) Effect of PSM on chlorophyll content of the plant.
4) Effect of PSM on NR activity
5) Effect of PSM on N,P and K uptake of the plant.