STUDIES ON PHOSPHATE DISSOLVING ACTINOMYCETES IN CALCAREOUS SOILS

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CONTENTS

1. INTRODUCTION

Cultivation of more areas becomes a main duty to face the great increasing in human population in Egypt. Most of the newly cultivated lands are sandy and/or calcareous soils. One of the big problems faced culivation of such soils, particularly calcareous one, is that, considerable amounts of the added phosphorus becomes fixed by soil constituents into unavailable forms for plant nutrition. Even after fertilization with superphosphate, the available phosphorus level decreases sharply after a short peroid from application.

Attention had consequently been focused on certain types of microorganisms capable of dissolving di-or tri-calcium phosphate and rendering them available for plant nutrition. Many investigators had been repeatedly give the impression that the inoculation of such soils with phosphate dissolving bacteria helps in providing the growing plants with their requirements of phosphorus.

Although actinomycetes are one of the most important groups in soils, few studies have been underlined regarding their ability to solubilize unavailable phosphate.

The present investigation is concerned with the study of actinomycetes capable of dissolving unavailable phosphates in different calcareous soils; isolation and identification of the most active strains and testing their activities in dissolving various sources of inorganic phosphates (rock phosphate and basic slag) and mineralization of organic phosphorus (phenolphthalein diphosphate and lecithin). The effect of inoculation with the most active strains of phosphate dissolving *Streptomyces* on dry weight, nodule fresh weight and some nutrients uptake by faba bean plants cultivated in calcareous and clay soils in a greenhouse were also studied.

2. REVIEW OF LITERATURE

2.1. Proplem of phosphatic fertilization in calcareous soils:-

Phosphorus (P) as a major nutrient in plant nutrition its main role in soil fertility and plant growth had been repeatedly recognized in agricultural practices.

Phosphorus plays an important role in certain essential steps in the accumulation and release of energy durring cellular metabolism. Phosphates exist in the soils in both inorganic (Tricalcium phosphate, rock phosphate, and mono or dicalcium phosphate....etc) , and organic (Lecithin, phytin and phospholipides....etc), forms. Phosphorus deficiency of higher plants may be resulted from the absence of sufficient amounts of this nutrient in certain soils, as well as it is often due to poor phosphorus availability (Hanafy, 1972; and Saber, 1982).

The big problem confronting phosphate fertilization in highly calcareous soils is the enormous amount of P sorbed by the soil.

Wursten (1949) found that when 100 lb $acre^{-1}$ of a water-soluble phosphate is added to a calcareous soil, its availability reduced within 24 hours to 22-25 lb $acre^{-1}$, after which a relatively contstant level of availability is maintained.

In calcareous soils the soluble mono-calcium phosphate, derived from either microbial breakdown of organic matter or introduced with certain phosphatic fertilizers, is converted to di-or tricalcium phosphate which inturn precipitated with 24 hours (Lewis et al 1950).

Moreover, phosphorus in arid soils such as soils in some parts of Egypt is found in complex precipitated forms of $Ca_3 (Po_4)_2$ or even apatite. In Egypt, the amounts of available phosphorus in calcareous soils varied between 1.0 and 57.3 ppm in the water extract and between 14.7 and 152.9 ppm in $NaHCO_3$ extract (Omar, 1957).

In soils containing between 1 to 4 percent of lime, phosphorus absorption was found to be inversely proportional to the lime content, but when lime exceeds 4% correlation was poor (Millar, 1959).

Kacar (1967) found that fixation of phospate ranged from 8.5 to 95.1% in 89 samples of mainly alkaline calcareous soils investigated. There was a highly significant correlation between phosphate fixation and $CaCO_3$ content. Lewis and Racz (1969) showed that high amounts of calcium in calcareous soils resulted in a rapid precipitation of a large portion of the added phosphorus.

Larsen and Widdowson (1970) showed that although $CaHPO_4$ may initially be formed when soluble phosphate is added to a calcareous soil, it is not stable in the soil and will be converted to less soluble calcium phosphate and ultimately finish up in the least soluble form fluor-apatite.

El-Rashidi et al (1976) found that water soluble phosphorus added to calcareous soil quickly disappears from the liquid phase, but it is a matter of contradiction wheather the mechanism of this reaction is predominately adsorption on the surface of solid particles or a true precipitation of sparingly soluble phosphate.

When super and/or diammonium phosphates were added to the calcareous soils of the Valencia region (Spain),the percentage of fixed P in the soil was greater with diammonium phosphate than with superphosphate and its percentage rose with increasing rates of both fertilizers. After 300 days of application 66-88% of the applied phosphate was fixed (Primo et al, 1976).

Barrow and Shaw (1979) found that the lower the initial concentration of calcium is the faster occurs the desorption of phosphate. Bayoumi and Rahan (1984) found that the desorption of phosphate as percentage of absorbed P increased with decreasing $CaCO_3$.

pH of the calcareous soil is one of the main factors which affect phosphate solubility. Arnon and Johnson (1942) and Arnon et.al, (1942) found that the absorption of phosphorus by plants is at its highest level at pH 7. They also reported that experimental plants (tomato, lettuce and Bermuda) failed to absorb phosphorus at pH 9. They ascribed the failure of plants to absorb phosphorus at this pH value to be due to the ionic form present. Within the range of pH favourable for plant growth, monovalent $H_2PO_4^-$ ion predominates. At pH 9 the dominant ionic forms of phosphate are the divalent ion $HPO_4^=$ and trivalent $PO_4^=$. Thus once, the pH outside the plant roots is relatively high (above 6.5) or in the neighbourhood of pH 8-9, one can expect that the plant suffer from-phosphate inavailability.

Thompson (1957) found that maximum absorption of phosphorus by plants occurs at pH between 6.5 - 7.5.

Joos and Black (1950) found that the availability of rock phosphate was relatively high at pH 4.6 and 5.6 whereas it was low at pH 6.6

plant growth.Sackett et al (1908) were the first to detect that microorganisms are able to convert insoluble phospates to available soluble forms.

Gerreston (1948) observed that plants took up more phosphates from insoluble phosphatic fertilizers in the persence of microorgamisms and those phosphate dissolving bacteria existed in the rhizosphere.

The main role of the soil microorganisms in solubilizing phosphates can be summerized in the following two points:

1- Solubilization of inorganic insoluble phosphates.

2- Mineralization of organic phosphates.

2.2.1.Solubilization of inorganic phosphate :-

Itano and Kan (1957) obtained pure cultures of bacteria isolated from graded chernozem and podzolic soils which showed marked mineralization capacity of insoluble organic and inorganic phosphorus compounds.

Krasil'nikov et al (1957) found that the addition of bacteria isolated from soil and able to decompose $Ca_3(PO_4)_2$ increased phosphorus uptake by barely plants and the contents.of water soluble phosphorus, protein phosphate and lipoid phosphates in the plants.

Muromtsev (1958) stated that Aspergillus niger dissolve Ca phosphates more rapidly than bacteria do. Sperber (1958 a &b) found that the major group of phosphate dissolving bacteria (50 - 60 per cent) was Arthrobacter, while the main genera represented were Brevibacterium, Flavobacterium, and Achromobacter. One or two isolates were found in the genera Sarcina, Serratia and an unidentified yeast.

Bromfield (1959) stated that in aqueous media containing 5% sucrose and other nutrients with ground of rock phosphates (0.1%), various mixed cultures isolated from soil increased phosphate solubility when incubated at 27°C for 70 days.

Mahmoud et al (1973) investigated phosphate dissolving microorganisms in different Egyptian soils. They found that the soils of Egypt support high densities of inorganic phosphate dissolving bacteria. The most predominant groups that accomplish inorganic and organic phosphate mobilization were found to be sporeformers and Streptomyces. This finding is of a particular importance since these groups can withstand drynes and high temperatures to which soils of Egypt are subjected to in summer. Other phosphate dissolving organisms constituted smaller percentages such as Micrococcus, and G^+ ve rods.