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STUDIES ON BEHAVIOUR OF CERTAIN PHOSPHATE SOURCES IN SOIL WITH SPECIAL REFERENCE TO NUTRITION OF PLANTS

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BY

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1. INTRODUCTION

Phosphorus is one of the elements necessary for plant growth and usually taken up by plants as orthophospate ions.

Not all of the phosphate in the soil is in a form which may readily supply the crop with phosphorus. Two main fractions may be thus assumed to be present: The first fraction can be available for plant and the second cannot. Of course,information about the magnitude of reversion between the indicated two fractions under Egyptian soil conditions should be useful in giving advices for the correct use of different phosphate fertilizers.

Recently, considerable efforts are introduced to develop different salts of polyphosphoric acids to be used as nonclassic concentrated phosphatic fertilizers, the disadvantage of their relatively high cost being gradually of less significancy with better technology.

The increasing use of condensed phosphates in fertilization has stimulated the interest in their behaviour within different soils. The widely accepted assumption that hydrolytic degradation to orthophosphate is a prerequisite for the effective utilization of such fertilizers by plants makes this hydrolysis an important area of study. Besides, although efficiency of such materials as

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a source of phosphorus for plants has been evaluated in a number of studies, yet insufficient information are available on agronomic performance in Egyptian soils.

The present investigation has been accomplished to evaluate behaviour of certain common representative condensed phosphates in certain representative Egyptian soils. This has been performed through evaluation of their hydrolysis, availability and suitability as a P source for P uptake by alfalfa crop.

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2. REVIEW OF LITERATURE

The study of condensed phosphates is important not only because such compounds are considered as sources of inorganic phosphorus through transformation into orthophosphate released into soils, but also because condensed phosphates are considered as modified economic fertilizers.

2.1. Behaviour of phosphorus in soil.

Phosphorus occurs in soils as either organic or inorganic form, both being constituents of total form. Each of these forms consists of various fractions with different solubility and ability to be extracted with various extractants.

2.1.1. Occurrence and distribution of total and inorganic soil phosphorus.

2.1.1.1. Total soil phosphorus.

According to Cooke (1970), total soil phosphorus is often a useful parameter of soil-phosphate "capacity"; soils poor in total phosphorus usually have little capacity to supply element to growing plants although sometimes characterized by low retention for added phosphate.

Total soil phosphorus varies widely from one soil to another. Mengel and Kirkly (1978) reported that total content of soil phosphorus is in the range of

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0.02 to 0.15% P. Udo et al. (1984) added that saline soils have generally higher values than those of fresh water hydromorphic ones with figures variable between 352 and 2055 ppm.

According to Miller (1955), variations in total phosphorus content may be attributed to type of parent material, climatic conditions under which the soil is developed, degree of weathering, texture, organic matter content and microbial activity. The author postulated that fine-texture soils generally contain more phosphorus than sandy ones developed under the same climatic conditions. This was confirmed by Kaila (1963) as well as Hoyos and Gracie (1963) who reported that total phosphorus content increases as soil particles size decreases. Later on, Hanley et al. (1965),working on Irish soils, found that content of total phosphorus is about 10% and 60% in sand and clay fractions respectively.This is different from results introduced by Cholitkul and Tyner (1971) who noted no correlation between total phosphorus and clay content.

Upper layers of soil usually contain more total phosphorus than the lower ones, Shawarbi and Moustafa (1959), Kaila (1963) and Bapat et al. (1965). Recently, Adepoju et al (1986)added that surface soil materials from

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the 0- to 15 cm depth of 12 sites are suspected to contain high levels of P, as a result of years of repeated applications of either inorganic or organic P fertilizers.

Under local conditions, references indicate that total phosphorus in Egyptian soils varies considerably, the low values being associated with sandy and calcareous soils and higher values being associated with heavy textured alluvial soils. Amer and Abou El-Roos (1975) found that total P ranges from 870 to 1781 ppm in clay loam soils, about 722 ppm in sandy loam soils and from 337 to 481 ppm in sandy ones. Similar results were obtained by Ibrahim et al. (1980) whose results showed that total P ranges from 1040 to 1400 ppm in alluvial soils and from 110 to 637 in some desert and calcareous ones. More recently, Holah et al. (1985) postulated that total-P ranges from 323 ppm in sandy soils to 1355 ppm in alluvial ones.

2.1.1.2. Inorganic soil phosphorus.

Inorganic soil phosphorus and its fractionation have been the interest of several investigators, status of different fractions being mainly affected with soil texture, pH and activities of dominant cation.

Scheffer et al.(1960) and Chang (1966) emphasized

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the association of Ca-P with coarse fraction of soil, different results being obtained by Halstead (1967) who reported that such fraction is associated with silt fraction. Later on, Amer and Abou El-Roos(1975) found that the proportion of acid extractable Ca-P increases markedly with the increase of fine sand or sand + silt contents of the soil, sulphuric acid extractable P (thought to be mainly apatities) being reported by Tiessen et al. (1983) to be accumulated in soils under cultivation particularly in the coarse silt (50-5 μm) fraction.

Under conditions of calcareous soils, Mashhady and Ramy (1981) and Holah et al.(1985) showed that calcium phosphate is the dominant inorganic phosphorus fraction, the precipitated forms being reported by Al-Khateeb et al.(1986) to be dicalcium phosphate dihydrate, octacalcium phosphate and B -tricalcium phosphate with the latter being the dominant after 3000 hr from P addition.

Iron and Aluminum phosphates were reported by several investigators, such as Yuan et al. (1960) and Singh et al. (1966), to be dominant in acid soils rich in sesquioxides. Verma and Tripathi (1982) added that Fe-P is the most abundant inorganic phosphate fraction contributing to phosphate nutrition of rice, Al-P being the next in abundance. Sah and Mikkelsen (1986) further

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postulated that phosphorus added as Ca $(H_2PO_4)_2.H_2O$ is recovered mainly in the Fe-P and Al-P fractions, recovery of Fe-P being greater in flooded-drained soils but Al-P being greater in unflooded ones.

Sen Gupta and Cornfield (1962) pointed out that inorganic phosphorus fractions, expressed as percentage of their total, decrease in the order of Ca-P>Al-P> Fe-P> easily replaceable P. For alluvial soils, however, Amer and Abou El-Roos (1975) reported the order of Ca-P> Al-P > Reducant soluble-P > Occluded Al & Fe-P > Saloid-P, proportion of occluded phosphate fraction being fairly constant within studied soils probably representing an inherent property of their Nile mud parent material. Recently, Holah et al. (1985) found the order of Ca-P> Al-P> Reducant soluble Fe-P> occluded-P> Fe-P> Saloid-P in the surface (0-30 cm) layer of samples representing the different soil types of Egypt.

2.1.2. Availability of soil phosphorus.

2.1.2.1. Water soluble phosphorus.

Usually, water soluble phosphorus comprises a very small proportion of the total soil phosphorus. Larsen (1967) reported that the concentration of phosphorus in the soil solution ranges from 0.1 to 1 ppm and varies with properties of both solid and liquid phases as well as

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the soil solution ratio. In fact, Hooker et al.(1980) reported that the tie-up of water soluble P is very rapid in calcareous soils. Ibrahim et al. (1980) added that water soluble-P ranges from 0.1 to 1 ppm in alluvial soils and from 0.14 to 0.34 ppm in calcareous ones.

Paauw (1971) postulated that the correlation between the water extractable soil phosphate (Pw value) and the response of plants is high for most Holland soil types. Accordingly, the author suggested that such Pw value provides a reliable estimate for the availability of soil phosphorus to plants under conditions of wide range of soils.

2.1.2.2. Available soil phosphorus.

According to El-Shall (1982), the relatively small amount of phosphorus present in the soil solution is considered to be the immediate source of phosphorus for growing plants. As this is depleted, equilibrium existing between the soil solution and other contributing forms of soil phosphorus should be disturbed and phosphorus will be drawn from these forms to regain equilibrium. The author added that if the time factor is not taken into account, essentially most elements present in the solid phase may eventually move into the soil

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solution through course of weathering processes. A more realistic definition of the available phosphorus was suggested to be the amount of labile phosphate that can contribute to the replenishment of phosphorus in the soil solution during plant growth.

Several authors such as Nelson *et al*. (1953) have developed chemical methods, using different extractants, to evaluate amounts of available phosphorus in soil. Some organic and mineral acids as well as solutions of neutral salts or buffers have been suggested. This reflects the complexity of phosphorus status under the conditions of soils vastly different in nature and properties; it also reflects the non-similarity of P requirement of plants and their ability to take up soil-P.

According to El-Shall (1982), one of the most influencial soil factors determining the choice and efficiency of the test method is soil pH. The author added that soil pH controls the solubilities of soil carbonates and silicates as well as the chemical forms of both species in the soil solution. Therefore, it is not surprising that efficiency of any developed soil test varies to a great extent under the conditions of acid, noncalcareous and calcareous soils.

Hamdi *et al*. (1960) noted that Olsen's method is

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