NUTRIENTS POTENTIALITY OF SANDY SOIL AND ITS RESPONSE TO NPK FERTILIZATION

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I - INTRODUCTION

Special consideration has been given in Egypt to studies and research on the utilization of sandy soils since large area of the potentially irrigable lands belong to this category. The total area reclamed of these soils is 300'000 acre of which 50'000 ac in Upper Egypt and 250'000 ac. in the Delta. With the exception of small scattered areas in the Delta and Nile Valley most of the sandy soils are in the desert which makes up more than 95% of the total area of Egyptian soils of which some parts are under cultivation such as the southern part of Tahrir province. Sandy soils, in Egypt, are considered one of the expanding areas for increasing the cultivated lands. The main constituent of sandy soils is the sand fraction and this does not supply any nutrient to growing plants. Accordingly, the fertility level of sandy soils is controlled by their clay and organic matter content. They are exceptionally poor in the plant nutrients and often are in shortage of potash and phosphate.

Therefore the aim of the current investigation is to evaluate the fertility of some Egyptian sandy soils by estimation of the chemical potential of two macro nutrient ions; potassium and phosphorus, and evaluation of Q/I (Quantity/Intensity) relationship. Moreover, the effect of N, P and K fertilizers on the yield of barley grown in these soils, was also studied.

II- REVIEW OF LITERATURE

The lifetime of a crop is characterised by well-defined growth stages; during each stage the plant has a "work" potential defining its strength to assimilate and use a nutrient from the soil (Addiscott and Talibudeen, 1969). Interactions, positive or negative, between nutrients play their recognised parts in defining the magnitude of this 'work'. 'Nutrient potential' in soil represents the work needed to withdraw the nutrient from the soil. Numerous attemptes have been made, most of them emprical, to correlate "potentials" to nutrient uptake by plants in the field or Laboratory.

Addiscott (1970) stated that whether or not potential is the right term for defining the soil fertility status of a special nutrient, there seems to be three principal factors that are likely to characterize soil fertility:

I- The capacity factor as examplified by the cation and anion exchange capacities together with the total elemental composition of the soil.

II- The intensity factor which describes the strength of the nutrient ion in solution and is commonly expressed as the activity of the ion in solution.

III- The buffering capacity factor which measures the resistance of the soil system to change in intensity and is defined as $\triangle$ quantity/ $\triangle$ intensity.

II-1. The capacity factor:

II.1.1. Potassium capacity:

Available potassium could be divided into two parts, one dissolved in the soil solution, and one associated with the solid-soil phase. The latter is most often in an exchangeable or adsorbed form, but can also be a chemically combined or precipitated form; and it acts as a reservoir that replenishes the soil solution when depleted. This fraction is often refered to as the quantity term, as distingnished from the intensity term which describes the status of the nutrient in solution (Khasawneh, 1971).

Several definitions were given to exchangeable form of potassium. Wiklander (1954) defined the exchangeable potassium as the fraction which is adsorbed on the colloidal material and replaced with neutral salts in relatively short time. Garman (1957) reported that exchangeable potassium is a quantity removed with a definite extractant of specific concentration and dilution ratio, it is not truly a characteristic entity of the soil. It is generally accepted that "exchangeable potassium" is adsorbed on the surface of soil particles. On the other hand, it is agreed upon that all "adsorbed - K" is synonymous with "exchangeable - K". Likewise, "non-exchangeable - k" may include some strongly adsorbed potassium.

Values of exchangeable potassium were found by Wiklander (1958) to vary between 0.1 and 2.0 meq./100g soil and to represent usually not less than 1% of the total potassium in mineral soils.

Abdel-Bar and Ghobrial (1960) reported that the level of exchangeable potassium ranged from 0.06 to 2.82 meq/100g soil representing about 1.25 and 6.90% of the total exchangeable cations in some Egyptian soils. The lower value is for normal coarse texturel soils while the higher is for fine textured and salt-affected soils. With respect to sandy soils, El-Karabawy (1971), Abou El-Roos (1972) and Ali (1974) found exchangeable potassium values varied between 0.32 and 1.16 meq/100g soil. Similar results were reported by Sheta (1977).

Maclean *et al.* (1957), Mathews & Smith (1957), Arnold & Close (1961 a), Schroeder *et al.* (1961), Arnold (1962 a). Maclean et al. (1964), Nuttall et al. (1967), Eagle (1968), Raymundo et al. (1968), Sabet et al. (1969), Herbihy & Moss (1970), Braunschweig & Mengel (1971), El-Kharabawy (1971), Abou El-Roos (1972), Sobulo (1973) and Ali (1974) reported the existence of high correlation between the amount of potassium removed by continous cropping and initial soil exchangeable potassium.

None-exchangeable potassium includes all the forms of potassium except water-soluble and easily or immediately exchangeable potassium. This form of soil potassium occurs in primary minerals such as potash-feldspars (orthoclase and microcline), the feldspathoide (lucite), and in micas (muscovite and biotite). It is also found in certain secondary minerals, specially in micaceous clays; i.e. hydrous mica, which entrap potassium in their lattice structure (Rich, 1972).

Attoe & Truog (1945) and Wiklander (1961) found that non-exchangeable potassium amounts to about 99% of the total potassium content in mineral soils, making up about 1 - 4% of soil on weight basis. Lasheen (1966), Abou El-Roos (1968), Ali

(1969), Abou-El-Roos, (1972) reported that values of non-exchangeable potassium in arable soils of Egypt varied between 4 - 30 meq. K/100g soil; the low level being found in sandy soils and the higest in fine textured and salt affected soils.

Mathews & Smith (1957), Arnold (1962b), Arnold & Close (1961 b), Wiklander (1961), Barber & Mathews (1962), Moss & Coulter (1964), Barrow (1966), Rezk (1968), Sabet et al. (1969), Ahenkorah (1970), El-Damaty et.al. (1972), Fergus et al. (1972) and Abou El-Roos (1972) stated that exchangeable potassium present in a soil is not suffient for a crop and demonstrated that once the pool of exchangeable potassium in a soil has been exchausted, continued potassium uptake depends entirely on the release of non exchangeable potassium.

Haylock (1956) studied the capacity of soils to supply potassium and obtained two forms of potassium by succesive extracting the soil with one normal boiling nitric acid. One of these forms is of a low solubility and comes out in the extracts at a constant rate. The other form is highly soluble and is mostly released in the initial extractions. He refered to these two forms as "constant - rate potassium (CR - K), and step potassium (Step - k), " and he found that only the latter is readily available to plants in the course of 15 month's cropping period. Ali (1974) found that the step-k values of the highly calcareous soil were 1.79 and 6.50 meq/100g soil while ranged between 1.87 and 4.77 in the alluvial one and the sandy soil samples have the lowest step-k values ranging between 1.53 and 1.84 meq/100 soil.

Numerous investigators obtained good correlations between potassium extracted by HNO_3 acid and that uptaken by crops in greenhouse trails, e.g., Rouse & Bertramson (1949), Sabet _et al._, (1969); Oliveria _et al._, (1971); Lind (1972); Abou El-Roos (1972) and Ali (1974).

II.1.2. Phosphate capacity:

Phosphate capacity measurement is an estimate of the amount of P from the solid phase that will enter the soil solution (thus becoming diffusible or available for uptake) for a unit change in P concentration of the soil solution (Olsen, 1973). The capacity factor is important because the P concentration determined at the beginning of the growth period does not give sufficient information on the P supply to plants during that period.

Attempts to use total phosphorus determination fraction for assessing phosphorus status were made, the results have shown that the amount of total phosphorus is extremely variable. This may be due to the type of matrial from which soils were derived, the climatic conditions under which they are developed, the degree of weathering, the organic matter content, and microbial activity. (Amer, 1969).

Total soil phosphorus is often a useful indication of soil-phosphate "capacity" ; thus soils with small per cent total phosphorus usually have little capacity to supply phosphorus from reserves, and sometimes they retain little of phosphate that added. (Cooke, 1970).

On the other hand, Amer (1969) reported that determination of total phosphorus in soils has been overlooked since it is generally believed that it is of little value in assessing the phosphorus status, as a nutrient for plants, in the soil.

In certain Egyptian soils, Abdel Bar (1953) found that total phosphorus varied between 0.11 and 0.18% P. While Amer (1969) found that, the total, phosphorus content for sandy soils was low being in the range of 10.0 - 67.0 mg p/100g. soil. Kaila

(1963) estimated the total phosphorus content in some finnish soils and found it to be 820 ppm in sandy soils, 890 p.p.m. in fine sandy soils, 950 p.p.m. in loamy soils, and 1050 p.p.m. in silty soils. Hanley _et al._ (1965) working on Irish soils, found that the sand fraction contains about 10% and the clay fraction about 60% of the total phosphorus.

Miller (1955) found that fine-textured soils in general contain more phosphorus than sandy soils developed under the same climatic conditions. Thus, total phosphorus content in the soil is a function of parent material, soil texture, degree of weathering and organic matter content. It was reported by Abdel-Bar (1953), Kaila (1963), and Hoyos and Gracia (1963), that total phosphorus content increased as soil particles sizes decreased. On the other hand Gholitkul and Tyner (1971) found no correlation between total phosphorus and clay content of the soil. Gracie & Khalil (1948), Shawarbi & Moustafa (1959), Kaila (1963) and Bapat _et al._, (1965) reported that the upper layers of the soil usually contain more total phosphorus than the lower ones.

The formation of the various discrete chemical forms of phosphate in the soil is apparently related to soil factor such as pH values activities of various cations, solubility products of the various phosphates, degree of chemical weathering, and the fertilizer practice (Chang and Jackson, 1958).

Amer (1969) found that the extractable inorganic phosphorus constitutes the majorty of total extractable phosphorus in some Egyptian sandy soils. Amer and Abou El-Roos (1975) stated that most of the total phosphorus exists in the inorganic form (77 - 96% of total P). They also suggested that the phosphate in both H_2SO_4 extracts originates from aptite, the first and second H_2SO_4 - P is denoted by the expression acid extractable Ca-P and also the porportion of acid extractable Ca-P increases markedly with the increase of fine sand or fine sand + silt contents of the soils. Scheffer _et al._, (1960) and Chang (1966) emphasized the ossciation of Ca-P with coarse fraction of the soil. On the other hand, Halstead (1967) reported that Ca-P is associated with silt fraction of the soil.

El-Rashidi (1972), Amer & Aboul Roos (1975), and El-Shall (1977) reported that the relative abundance of the inorganic phosphorus fractions could be arranged in the order: