Chemistry of Potassium in Highly Calcareous soils

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Thesis

Submitted in Parital Fulfilment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department of Soil Science
Faculty of Agriculture
Ain Shams University

1972

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بسم الله الرحمن الرحيم

A C K N O W L E D G E M E N T

The writer wishes to express his deep thanks and gratefulness to Professor Dr. Mahmoud Ahmed Omar, Head of Soils Department, Azhar University and Dr. Abdel-Alim Metwally, Lecturer of Soil Chemistry in Soil Department, Ain Shams University for suggesting the problem, keen interest, guidance constructive idea, faithful help and precious advice during the study and preparation of this thesis.

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ARABIC SUMMARY.

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I. INTRODUCTION

Early studies have shown that the alluvial soils of Egypt contain ample amount of potassium. This is due to the fact that the Nile deposits contain about 0.5% K_2O and the leaching is limited under the arid climate prevailing. Thus these alluvial soils are rarely fertilized with potassium. This is not the case with the highly calcareous soils of Tahrir province and north west coast of Egypt. It had been reported that these soils may suffer from potassium nutrition problems. In a symposium on the calcareous soils of Egypt held in Alexandria in 1968, reports were presented that claimed little or no response to K-fertilization in these soils. The very limited work that has been done with some of these soils showed that potassium was fixed by some soils of Tahrir province. It has been repeatedly shown that Ca and Mg concentrations can affect the uptake of potassium by plant. Such highly calcareous soils are expected to be Ca-saturated which may have an adverse effect on K-uptake in these soils. At any rate, very little informations are now available concerning potassium status and behaviour in such soils. The present work was carried out to provide such informations through the following studies :

1) Determination of the different forms of potassium
2) Evaluation of the K-supplying power and response to K-fertilization.
3) Evaluation of the K-bonding energy in these soils using Langmuir adsorption isotherms.
4) The fixation and release of potassium by these soils using different techniques.
5) The Ca and Mg concentrations, at activity ratios representing those found in calcareous soils on K-uptake by plant.

A- Potassium Status :

Water soluble potassium :

Anderson *et al.* (3) studying a number of humid area soil samples found, that they contained between 0.002 - 0.02 me. soluble potassium/100 gm. soil. On widening the soil water ratio to 1 : 10, the extracted potassium increased by 3 to 27 fold. The potassium content of the soil solution represented from 0.5 to 7.8 percent of the exchangeable plus soluble-K.

Wiklander (67) reported that the amount of the water soluble potassium depends on factors such as : a) the amount of exchangeable potassium, b) types of primary and secondary minerals, c) water content, d) intensity of leaching, e) kind of other ions and their concentrations present, and f) the season.

Barbir and Treome (5) stated that the potassium concentration of a soil solution depends on two factors quite distinct and independent of each other. The first factor is the degree of potassium saturation of the soil; the second is the overall concentration of the solution, which is entirely independent of the chemical properties of the soil.

Serry and Eid (59) reported that the water soluble potassium in some Egyptian soils varied from 0.02 - 0.12 me.

/100 gm. soil in soil extracts of 1 : 2 soil water ratio.

Kasem (30) found K concentration in these soils to vary from 0.005 to 0.03 me./100 gm. in soil paste making 1% of the exchangeable plus soluble potassium. He reported higher figures of soluble potassium in the saline soils which ranged from 0.01 to 2.8 me./100 gm. soil making 7.75 - 40.6% of exchangeable plus soluble K.

Van Hostitz (41) suggested that the water soluble potassium, even in fertile soils, is inadequate to meet the major requirements of a crop to this macronutrient element.

Exchangeable potassium :

Reitemeier (45) reported that the exchangeable potassium of the soil is difficult to define theoretically and to determine experimentally for at least three reasons :

a) The absence of a sharp distinction between soluble and exchangeable fractions.
b) The existence in some soils of difficultly exchangeable potassium which is not immediately extractable by the usual reagents.
c) The dissolution of mineral potassium by the exchange extractant.

Wiklander (67) defined the exchangeable potassium as the amount which is adsorbed on the colloidal material and replaceable with neutral salts in a relatively short time.

Raitemaier (49) reported that the partition of potassium between soluble and immediately exchangeable forms depends on several factors including : a) the concentration of soluble potassium, b) the nature and concentration of competing cations and c) the nature of the exchangeable material.

Anderson et al. (3) showed that the exchangeable potassium of semi-humid and humid regions of U.S.A. ranged between 0.17 and 0.87 me./100 gm. soil.

Abdel-bar and Ghobrial (1) found that the level of exchangeable potassium varied between 0.06 and 2.82 me./100 gm. soil making about 1.25 and 6.9% of the total exchangeable cations in some soils of Egypt.

Non exchangeable potassium :

The term "nonexchangeable" as defined by Raitemaier et al. (48) includes all soil potassium except the water soluble and immediately exchangeable forms. The term "difficultly exchangeable" is applied to potassium ions more slowly released by the usually exchange extractants or dependent for replacement on particular cation or group of cations, or more or less quickly released by more vigorous extractants. Terms such a "moderately available" "slowly availably" and "unavailable" refer to vegetation system. German (21) gives the element in this form the "structural potassium" and reported that it is not readily replaced by other cations in most extracting solutions.

As suggested by Magistad (34) the plant depends mainly on the nonexchangeable potassium for its nutrition if the supply of potassium from the exchangeable form is inadequate. The response to fertilization may occur not only at this stage but also when exchangeable potassium falls below 0.41 - 0.51 me./100 gm. soil.

Praps (20) test showed that about 58% of total potassium removed by plants comes from the nonexchangeable form. This percentage has been found by DeTurk (16) to vary between 6.7 and 39% of the total amounts taken up by plant. Serry and Mishriki (60) reported that the nonexchangeable potassium utilized by plants ranges from nil to 71% of the total amount absorbed.

General principles of the release of nonexchangeable potassium during cropping were summarized by Reitemeier (49) as follows : a) The capacity of different soils to supply nonexchangeable potassium of native origin to different plants differs greatly.

b) Soils of equal total potassium content differ in their ability to release reserve potassium to growing crops.

c) Fixed potassium is more available to growing plants than nonexchangeable native potassium in the soil.

d) The exchangeable potassium of a particular soil has no correlation with the reserve supplying power of the soil unless it represents the equilibrium level of the soil.

e) Plants absorb more reserve potassium than is liberated to exchangeable form in absence of plant during moist storage at equal periods of time.

Merwin and Michael (39) found that most of the potassium released from nonexchangeable to exchangeable form was derived from the clay fraction which was more active than the silt and the sand.

El-Sokkary (17) reported that the amount of non-exchangeable potassium in some Egyptian soils varies between 1.7 to 11.2 me./100 gm. soil, the lower levels being found in sandy soils and the high levels in the fine textured ones. He also found that the nonexchangeable potassium increased as the total potassium increased.

<u>Fixed potassium</u> :

Reitemeier (49) stated that between the nonexchangeable and exchangeable forms of potassium there exists a category of K ions more tightly bound than the latter, though more available than the former. This form called "Fixed potassium" is firmly bound to some inorganic soil colloids and is not readily replaceable with neutral salts.

Scheffer and Schachtschabel (53) gave the mineral potassium the name nonexchangeable potassium. They stated that if one disregards soils with a low content of silicates, the nonexchangeable potassium comprises by far the largest proportion of the total potassium which mostly lies between 0.2 and 3.3 percent in normal soils and between 2.7 - 6.7 per cent K in alkali soils.

El-Sokkary (17) studied potassium in six soil samples from the western side of the Nile Delta. He reported that the total potassium varied between 1.9 - 13.4 me./100 gm. soil. Abdel-Bar (1) reported that nonexchangeable potassium makes up about 84.4% of the total potassium in some Egyptian soils and that the silt fraction contains considerable amounts of nonexchangeable potassium.

The relationship between the forms of potassium and the rate of different fixation steps has been given by Wiklander (67) as follows :

water soluble K $\underset{\text{very rapid}}{\overset{\text{very rapid}}{\rightleftharpoons}}$ exchangeable K

rapid ↓↑ very slow

Fixed K

El-Sokkary (17) reported that a direct relationship exists between exchangeable and nonexchangeable potassium. He also found that potassium fixation was usually accompanied by a decrease in the exchangeable potassium.

B- Chemical and Biological Methods for Evaluating Available K:

MacLean (33) found that the water soluble potassium was not sufficient alone for assessing potassium supply in soils of varying amounts of nonexchangeable form which contributes to plants uptake.

Hood et al. (25) reported that water soluble potassium, a measure of the potassium in the soil solution, was better correlated with yield than was exchangeable K. He also found that the water soluble potassium gave a better correlation with the potassium absorbed by plant in a short time.

Moreover, Lamb (31) has reported that plant can reduce with difficulty, the amount of exchangeable potassium in soil below 0.64 me./100 gm. soil. Bray (12) concluded that the soils containing 100 lb. of exchangeable potassium gave yield of corn about 70 per cent as high as soil fertilized with potassium. Pratt (46) found a good correlation between exchangeable potassium and corn yield on soils containing less than 100 lb. of exchangeable potassium. Attoe (4) found the linear relationship between the potassium content of tobacco plant expressed as percent K and logarithm of the exchangeable value.

The release of potassium from nonexchangeable form studied by many investigators. Haagsma & Miller (23) found that the release of nonexchangeable potassium from Holdimand clay to H-saturated Dowex 50-W cation exchange resin increased with increasing temperature although the increase was greater for a temperature increase from 50° to 80°C than from 5° to 50°C. Delbert et al. (14) found that heating NH_4-saturated Spencer soil at 500°C gave a maximum K-release after two hours. At 300°C it took about four hours to release one fourth of the amount of K released at 500°C. They also found that the fixed potassium cannot be released in one heating.

Attoe and Truog (4) found that extracting the soil with ammonium acetate removed the readily available fraction of soil potassium whereas leaching with 0.5 N hydrochloric acid after two hours shaking removed what could be considered the moderately available potassium of the soil. McGoerge (37) reported that the citric acid-soluble potassium gave better indications of the probable need for potassium fertilizers than that fraction of potassium extracted by 0.2 N