AVAILABILITY OF SOME MICRONUTRIENTS IN ALLUVIAL AND CALCAREOUS SOILS OF EGYPT

By

SAYED MADANY ARAFAT
B. Sc. Agric. Science (Soil)
Ain Shams University (1976)

THESIS

Submitted in Partial Fulfilment of
the Requirements for the Degree of

MASTER OF SCIENCE
IN
SOIL SCIENCE

Soils Department
Faculty of Agriculture
Ain Shams University

1983

APROVAL SHEET

Name: Sayed Madany Arafat

Title: Availability of Some Micronutrients in Alluvial and Calcareous Soils of Egypt.

Thesis
Submitted for the Degree of
MASTER OF SCIENCE
In
Soil Science

This thesis has been approved by:

Talaat El Gabbia
A.F. El-Sherif
M S Foda

(Committe in charge)

Date: / /1983

بسم الله الرحمن الرحيم

ACKNOWLEDGEMENT

The author wishes to express his appreciation and gratitude to Prof. Dr. S. El-Sherif, Head of Soils Department and Dr. S. Fuda, Associate Professor, Faculty of Agriculture, Ain Shams University for planning this study, supervision and precious advices.

Thanks are also due to Dr. F.A. Mosaad, Associate Professor, Soils and Water Use Laboratory, National Research Centre, for his active supervision, constant guidance, valuable suggestions and deep interest during the excution of this research and preparation of the manuscript.

Thanks are also expressed to all the staff members of Soils and Water Use Laboratory, National Research Centre, for providing facilities throughout this work.

CONTENTS

Page

1. INTRODUCTION

The status of micronutrients in Egyptian soils started to be a subject of discussion in the last few years. Although a considerable data have been published on such subject, yet, it seems that detailed information on the status of some micronutrients is still of interest.

The total amount of micronutrients in a soil provides only limited information, as this can seldom be correlated with availability to plants and does not show how the element is bound in the soil. The average of total micronutrients content may reach 100 times that of available forms. Many factors influence the degree of availability of soil micronutrients to the plant. These include, soil texture, organic matter content, calcium carbonate, pH, soluble salts .... etc. All these factors have direct bearing on the availability of micronutrients in Egyptian soils. Attention is also paid to find correlation, if any, between the four micronutrients cations (in the total and available forms) and the main soil characteristics.

The successful use of a chemical technique for assessing plant-available soil micronutrients depends upon the efficacy of the method in extracting the elements from these compounds in the soil which can be considered to participate in its supply to plants. Several extracta of varying efficiency have been proposed for the assessment of "available" soil micronutrients.

In view of this brief introduction, the current investigation was planned for studying the status of four micronutrient cations and search out the most important factors responsible for their availability in some alluvial and calcareous soils of Egypt. Such goal was performed by a number of laboratory and greenhouse experiments. These experiments dealt with the estimation of available micronutrients either chemically by employing different extractants, or biologically by plant analysis.

2. REVIEW OF LITERATURE

2.1. Status of micronutrients cations in soils:

a) Iron:

Iron constitutes about 5% by weight of the earth's crust and is abundent either as component of various minerals or in the form of amorphous oxides and hydroxides in the soil.

The primary minerals in which Fe is present include the ferromagnesian silicates such as olivine, augite, hornblende and biotite. Primary iron oxides which occur in many soils include hematite (Fe_2O_3), ilmenite ($FeTiO_3$) and magnetite (Fe_3O_4).

Iron may also be present in secondary minerals lattices in soils and it is essential element in a large group of clay minerals, Oades (1963).

Inorganic iron in the soil solution may be hydrolysed to yield Fe^{3+}, $FeOH^{2+}$, $Fe(OH)_2^+$, $Fe(OH)_3$ aq, $Fe(OH)_4^-$. The first three species will predominate in acid media, whereas the latter two species will predominate where pH is greater than 7.0, Lindsay (1972).

The total iron content in different soil types were studied by numerous investigators. Randhawa (1971) reported that the Indian soils, which belong to many soil groups contained 0.4 to 27.5% total iron. Krauskopf (1972) stated that the iron content of soils reflects the composition of the rock from which they are derived. In general, the total content of iron in soils ranged from 0.1 to 6.0%.

Tayel (1964) studied the status and behaviour of iron in some soils of Egypt, and found that the total iron content of the alluvial soils ranged from 1 to 7%. El-Gala and Hendawy, (1972), added that total iron in the Egyptian soils varied from 0.54 to 3.4% with the highest amounts in the alluvial soils and the lowest amounts in the calcareous one. Abdel-Kader and Abu-Ghalwa (1973) in their study on 36 soils samples representing six soil regions of Egypt found that total iron content varied between 1.7 and 12.9%. Lower figures have been recorded by Rabie (1979) when found that total iron content ranged between 1.34 to 1.68%, 0.67% to 1.0% and 0.37% to 0.67% for the heavy alluvial, light alluvial and calcareous soils, respectively. El-Nennah <u>et al</u> (1980) reported that the total iron content ranged between 4.05% to 6.32% and from 1.64% to 3.15% in alluvial salt affected and calcareous soils of Egypt, respectively.

Khasawneh (1971) classified the iron status in soils as; a) water soluble, b) exchangeable and c) non exchangeable. Water soluble iron is immediately available for plant uptake while exchangeable and non exchangeable sources allow for the replacement of the soil solution when it is depleted by iron uptake. Adsorption reactions involving iron would be expected to play a minor role and perhaps at the most represent only an "intermediate" between solution phase and precipitation of insoluble compounds. Page and Whiltig (1961) reported that the adsorption of iron by montmorillonite and Kaotinite occur under acids as well as under reducing conditions. In the same respect, Fordham (1969) found that the adsorption of Fe^{3+} by kaolinite under conditions excluding precipitation was affected by the Fe originally present in the clay. He also stated that the quantity of Fe adsorbed was pH dependent. From pH 2.0 to 2.7 the amount of Fe adsorbed was correlated with the concentration of $FeOH^{2+}$ in solution and from pH 2.7 to 3.6 the amount correlated with the concentration of $Fe(OH)_2^+$.

Takkar (1969), in Indian soils, found that the exchangeable iron forms was about 17.6% of the extractable Fe with 1N NaOAc (pH 2.8). Exchangeable Fe^{2+} forms a major portion (90%) of the total exchangeable iron but extractable Fe^{2+} forms only 49% of the total exchangeable iron. Anter et al (1977) reported that the exchangeable ferrous iron increases gradually with depth, the poorly drained soils have higher concentrations than those of the well drained ones. They also found an exchangeable ferric iron decreases gradually with depth especially in the imperfectly drained soils and at the lower part of the profile it nearly disappears. The ratio between exchangeable ferrous and ferric iron indicates the presence of the reduction conditions in the imperfectly drained soil and in the lower layers of the other soils.

In Bihar Indian calcareous soils, Dubey et al (1970) indicated that available and reducible iron ranged from 2.2 to 107.2 ppm and from 94 to 1212 ppm, respectively. Martinez (1970) studied the content of soluble and extractable iron in 15 Argentinian soils and found that the values for extractable and soluble iron ranged from 2 to 16.8 ppm and from 2.0 to 28 ppm, respectively. Ladha and Baser (1971) reported that the available iron in samples taken from seven soil groups of Rajasthan soils ranged from 0.3 to 15.7 ppm.

In some Egyptian soils, El-Gala and Hendawy (1972) found that the available iron ranged between 6.5 and 16.3 ppm with higher values in the alluvial soil and lower values in calcareous one. Also, Holah (1977) reported that the average values of iron extracted in alluvial, sandy and calcareous soils of Egypt were 7.6 ppm, 4.6 ppm and 5.3 ppm, respectively. While, El-Nennah et al (1980) stated that the available iron in the alluvial salt affected and calcareous soils ranged from 5.1 to 18.9 and from 7.5 to 12.0 ppm, respectively.

b) Manganese:

Manganese occurs in various primary rocks and particularly in ferromagnesian materials. In igneous rocks, for example, ferrohorlonite ferrogabbro contains 1620 ppm Mn, whereas acid gronophyre contains 80 ppm Mn, Mitchell (1964). In sedimentray rocks Mn differs from most heavy metals in that is more abundant in limestone and dolomite than in shale. There are number of minerals that contain Mn in combination with O_2, CO_3 and SiO_4, namely pyrolusite (MnO_2), hausmannite (Mn_3O_4), manganite (MnOOH), rhodochrosite ($MnCO_3$), and rhodonite ($MnSiO_3$), Krauskopf (1972).

In naturally occurring compounds manganese lies in three valences, namely, 2^+, 3^+ and 4^+. The trivalent ion is unstable in solution, and the quadrivalent ion appears only at pH values below those found in nature, Krauskopf (1972).

Total manganese levels may differ considerably between various soils. Mitchell (1955) found that the total manganese in mineral soils varied from 300 to 700 ppm. Purtova, (1969) stated that the amount of total manganese changed according to the soil type and depended on the nature of the soil forming rocks. Soils on basic rocks contained more Mn than those developed on acidic weathered rocks. Piya Dungpatra et al (1979) recorded that total Mn ranged between 640 and 3040 ppm in 15 soils of Kentucky.

With respect to the soils of Egypt, Abdel-Lateif, (1965) found that the total Mn in basin irrigated land was 1298 ppm and decreased after flooding to 949 ppm. El-Sherif et al (1970) reported that the total Mn in fertile alluvial soils of Bahtim ranged from 1000 to 1450 ppm. Ghanem et al (1971) added that the total Mn ranged between 116 and 1300 ppm, the values being higher in the alluvial than those of the calcareous and sandy soils. Mohmoud (1978) found that the total content of manganese ranged from 118.8 to 1626 ppm, from 150 to 1625 ppm, from 650 to 937 ppm and from 312.5 to 500 ppm in Nile alluvial, fluvio-lacustrine, lacustrine and marine calcareous soils, respectively.

Leeper (1935) divided the forms of soil manganese into, a) water soluble Mn^{2+}, b) exchangeable Mn^{2+}, c) easily reducible manganese dioxide (MnO_2) and d) relatively inert manganic oxides. The easily reducible manganese dioxide includes compounds of different proportions of Mn^{2+} and MnO_2. The composition of the manganic compounds is not constant but conventionally considered as the dioxide MnO_2. The form of easily reducible manganese dioxide is considered to be of major importance. The different forms of manganese which are taken into consideration are soluble, exchangeable, easily reducible and their summation or the so-called active form. Vuletio and Mijatovic (1967) found that an exchangeable and easily reducible manganese varied from 12 to 142 ppm and were related to soil pH. Mishra and Taipathi (1972) studied the distribution of manganese in soils of Uttar pradesh and reported that exchangeable form constituted 2.69% of the total Mn and tended to decrease with profile depth.

El-Damaty et al (1971) studied the status of manganese in the alluvial soils of Egypt and found that the majority of soils under investigation had exchangeable Mn up to 50 ppm, easily reducible manganese between 140 and 490 ppm. The active manganese which constitutes the two preceeding forms ranged between 164 and 584 ppm. They also declared that, although there are moderate amounts of Mn in the Egyptian soils, the water soluble manganese is completely absent from these soils. Ghanem et al (1971) determined the various forms of manganese in Egyptian soils and showed that water soluble and exchangeable manganese ranged from 0.2 to 11.0 ppm. The easily reducible and Na_2-EDTA extractable manganese ranged from 3.9 to 436.5 and from 3.1 to 622.4 ppm, respectively. These forms were generally higher in the alluvial than in either calcareous or sandy soils. Metwally et al (1973) reported that the calcareous soils are not only poor in their exchangeable manganese content but also its resevior of easily reducible manganese is still below the sufficient limits to supply the growing plants with their manganese requirements. These soils have an average content of 2 and 25 ppm of exchangeable and reducible Mn respectively. Anter et al (1977) found that water soluble manganese was in higher concentration in the imperfectly drained soils as compared with the other studied soils. Its concentration increases with depth until the layer adjacent to the ground table where an abrupt increase is noticed.