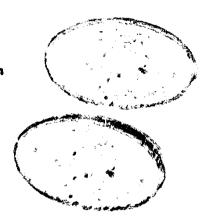# EFFECT OF PROLONGED SYSTEMATIC APPLICATION OF FERTLIZER AND CROP ROTATION ON SOIL IRON INTENSITY AND Fe^{++}/Fe^{+++} IN PLANTS USING RADIOISOTOPIC TECHNIQUE

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1. INTRODUCTION

The population of Egypt is increasing at a much higher rate than that of the cultivated land which is very limited. For this reason, intensive cultivation is extremely needed to face the demands of this increasing number of inhibitants. In this situation, the agricultural vertical expansion need heavy application of macronutrient fertilizers to the soil. In turn, the nutritional balance in the soil is frequently disturbed. The use of micronutrient fertilizers is not so far a common practice in Egypt and therefore, micronutrients are the most affected by the application of macronutrient fertilizers. In Egypt, the fertilization Permanent Experiment in Bahtim was established since 1912 to study the effect of contineous additions of N, NP and NPK under triple crop rotation using cotton as the main crop followed by wheat and maize. Moreover, in 1919 it was modified to use single and double rotation as well as farmyard manure to compare the effect of mineral and organic fertilizers, under different crop rotations, on physical and chemical soil properties as well as the plant growth. Under these conditions, micronutrient studies did not take a considerable attention from scientists. One of these micronutrients is iron. Iron has many important functions in plant metabolism. Although iron is frequently taken up in the ferric state (Fe^{+++}), it is

generally accepted that the ferrous state (F^{++}) is the meta-boilically active form of iron in plant. Therefore, the aim of the current work is to investigate the effect of prolonged systematic application of mineral and organic fertilizers as well as different crop rotation with or without iron treatments on:

1) Native available iron in the different soil samples using carrier-free ^{59}Fe.

2) Fe^{2+}/Fe^{3+} ratios in fresh leaves of soybean plants.

3) Total uptake of Fe, N, P and K by soybean plants.

2. REVIEW OF LITERATURE

2.1. Iron in soil and plant:-

Under Egyptian condition, Elgala and Hendawy (1972) found that total iron ranged from 5400 ppm to 34000 ppm Fe with the lowest amounts in calcareous soils and the highest amounts in the alluvial ones. One the other hand, Abdel-Kader and Abu Ghalwa (1973) found in 36 soil samples from different locations in Egypt that the total iron content varied between 1.7 to 12.9 %. However, Elsikhry (1976) noticed that total content of Fe in different soils of Egypt ranged from 4625.5 to 16187 ppm; the highest values were for the alluvial samples and lowest were for sandy ones, while in calcareous the values were lying in-between. Abdallah (1977) studied the iron availability in different soils of Egypt. He found that available iron extracted by EDDHA ranged between 8 to 123 ppm in calcareous soils, while from 41 to 184 ppm in alluvial ones.

Kasaweneh (1971) classified the iron status in soils as (a) water soluble (b) exchangeable and (c) non exchangeable. Water soluble iron was immediately available for plant uptake, while exchangeable and non exchangeable sources allow for the replacement in the soil solution when the available form was depleted by plant uptake.

Paneque and Olmedo (1971) found that the mean values of Fe_2O_3 in clay, silt, fine sand and coarse sand fractions in Western Andalusia soils were 9.0, 3, 1.6 and 2.7%, respectively.

Lehr (1972) reported that iron entered into a wider range of ractions than any of the other micronutrients in soil. In addition, the occurrence of the Fe^{3+} compounds often depended on an intermediate oxidation reaction of Fe^{2+} to Fe^{3+}.

Loeppert and Clarke (1984) studied the reactions between dissolved iron salts and $CaCO_3$ and the role of these reactions influencing the subsequent availability of Fe to plants in calcareous soils. They found that the reaction between Fe salt and calcite was stoichiometric, i.e., 2 and 3 equivalents of calcite were consumed per mole of Fe^{2+} and Fe^{3+}, respectively.

Dayanand and Sinha (1984) determined the solubility of native forms of iron in calcareous soils by DTPA equilibrium method. They found that soluble hydroxy ions of iron increased the total metal ion activity several fold over Fe^{3+} activity in equilibrium with ferric oxides and hydroxides. They added that first approximation of metal ion activities in soil solution could be predicted from a single measurement of pH of the system.

Gad-Allah, (1984) studied the available iron in some Egyptian soils. He found that the determination of Fe^{2+} in faba bean plants (*Vicia faba*) revealed a high correlation co-efficient between dry matter in plant and Fe^{2+} in soil. Moreover, he found a correlation coefficient between Fe uptake by faba bean (*Vicia faba*) plant and Fe^{2+} in the investigated soils. Furthermore, he concluded that chelated Fe-fertiliz-ers were expected to be more effective than soluble Fe salts in alleviating iron defficiency in such soils.

Concerning iron in plants, Marchner et al (1974) studied the mechanism of iron uptake in different plant species. They found that when Fe availability became low, sunflowers were able to mobilize iron in its form not normally available, for uptake by decreasing the pH of the nutrient solution, via decreased uptake of anions. They added that the decrease in pH did not seem necessary for mobilization of iron by barley plants. However, maize plants were Fe-inefficient and unable to decrease the pH or to release reducing substances under Fe-stress, thus maize developed iron chlorosis.

Brown (1978) studied iron uptake by plants and reported that green plants required a continuous suplly of Fe as they grow because of the immobility of iron.

Balba et al (1979) studied ferrous and ferric ratio in normal and chlorotic bean plants, in loamy sand soil known to be deficient in iron from the nile banks at Gizah. They found

that lower leaves of bean plants contained high amount of Fe^{2+} than upper ones, and Fe^{2+}, Fe^{3+} concentrations in the plant varied according to its age, the plant part, the older of leaves and HCO_3^- treatment. Also, they found the ratio of Fe^{2+}/Fe^{3+} increased in lower leaves and stem than their ratios in the upper leaves and buds. These results indicated a sub-stantial translocation of iron from older to younger leaves and they added that Fe^{3+} must be reduced to Fe^{2+} in lower leaves before its upward movement in both normal and chlorotic bean plants.

Olsen and Brown (1980) studied some factors related to iron uptake by dicotyledonous and monocotyledonous plants. They found that dicotyledonous plants were more effective than monocotyledonous plants in their ability to uptake iron.

Pierson et al (1984) studied the plant genotype differ-ences to ferrous and total iron in emerging leaves in diff-erent plants. The experiments were conducted to determine the differences in Fe^{2+} and total Fe in newly emerging leaves of sorghum and maize genotypes considered to be "Fe-suscepti-ble" and "Fe-tolerant" to low levels of Fe. Treatments con-sisted of growing plants in nutrient solutions with and with-out iron under growth chamber conditions. They found that once Fe deficiency chlorosis symptoms were visually observed in plants grown without iron, leaf samples were collected daily from plants grown in both - Fe and + Fe solutions for

Fe^{2+} and total Fe determinations. Fe^{2+} in the newly emerging leaves of plants grown in - Fe or + Fe solutions remained fairly constant while total Fe changed daily and was dependent on the amount of Fe deficiency stress in sorghum, but not necessarily in maize. Total Fe and Fe^{2+} values were fairly similar in plants with severe Fe deficiency chlorosis symptoms. Sorghum and maize plants regreened after Fe had been added to the growth solutions and total Fe increased in the developing leaves of these plants within two or three days. Total Fe changes were related to the degree of Fe dificiency stress and the active Fe in the leaves of these plants was not related to Fe^{2+} but to total Fe. On the other hand, they found that broad bean and soybean plants showed greater ability to overcome Fe deficiency stresses compared to sorghum and maize.

2.2. Response of plants to iron sources, rates and methods of application:

Wallihan and Garber (1968) studied the effect of iron nutrition on root : top ratios of rice plants grown in culture solution with iron levels of 0.1, 1 and 10 mg iron as $FeSO_4.7H_2O$. They found that root : top ratios varied with level of iron. Also, they added that growth of plant tops was more affected by nutrient supply than the growth of roots.

Ambler and Brown (1974) studied the effect of iron supply on two varieties of soybean seedlings. They found that the

seedling stage of both two varieties was not affected by Fe stress. They concluded that iron was not a limiting factor in establishing a good stand of soybean in the field because of the readily available source of Fe from the seed.

Randall (1975) reported that foliar application of iron was more effective in correcting visible effect of iron chlorosis than soil application.

El-Khattari and Anderson (1979) studied the effect of three sources of Fe (FeEDDHA, $FeSO_4$ and powdered metallic Fe) with five rates on sorghum grown on clay, clay loam and sandy loam soils. They found that the clay and sandy loam soils had exhibited occasional Fe deficiency problems, whereas the clay loam soil caused severe Fe chlorosis. They added that correction of Fe chlorosis in the clay loam soil with FeEDDHA was nil, and required rates > 50 ppm Fe as $FeSO_4$ and 5000 ppm as metallic sources. Also, they found the second crop plant had less iron than the first crop at all Fe levels.

Das et al (1982) studied the effect of micronutrients on rice seedlings grown on calcareous soil. They found that application of 15 Kg of each trace element (Zn, Fe, Mn) or in combination to the nursery bed significantly increased root and shoot dry weight and shoot length. They added that application of trace elements in the nursery bed and at transplanting significantly increased grain yields.

Dahiya and Singh (1982) studied in pot trails the effect of iron soil application on yield of dry matter of oats grown on light soil. They found that application of iron at rate of 20 ppm significantly increased dry matter production, and nutrients uptake.

Hsu and Ashmead (1982) studied the effect of pH of iron solution as foliar application on iron absorption and growth of corn plants grown on soils with different pH. They found that dry matter yield and iron uptake increased when plants were sprayed with 200 ppm Fe as Metalosate. They added that effectiveness of iron was associated with high pH of both iron solution and soil.

Under Egyptian condition, Shata (1982) studied in pot experiment, the relationship between increasing application of available iron as Fe^{2+} and Fe^{3+} on spinach plants grown in sandy and calcareous soils. He found that the Fe^{2+}/Fe^{3+} ratio increased significantly with increasing iron addition. On the other hand, iron uptake and consequently Fe^{2+}/Fe^{3+} ratio in spinach plants grown in calcareous soil were relatively lower than those grown in sandy soil at all rates of iron application. Similar results were also obtained by El - Sherif et al (1984).

Hamze et al (1985) studied the iron treatment of lime - induced chlorosis : implications for chlorophyll, Fe^{2+}, Fe^{3+}