STUDIES ON THE MICRONUTRIENTS IN SOILS

COPPER AND ITS RELATIONSHIPS WITH NITROGEN AND PHOSPHORUS IN THE SOILS OF THE U.A.R.

By

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INTRODUCTION

It is well known that nutrients at optimal levels and proper balance are essential for normal plant growth and production. Copper is one of those micronutrients which are required in traces only for normal plant growth. The essential role of copper in the nutrition of higher plants has been pointed out by numerous investigators.

The availability of copper and its uptake by plants are greatly affected by the mechanical constituents of the soil, pH value, $CaCO_3$ and organic matter content. It is known that the concentration of copper in plants depends on the concentration of the corresponding mobile forms in the soil. The higher content of complexed copper may partly explain the lack of copper deficiency in calcareous soils.

It is of great interest to investigate whether macronutrients have an effect on the behaviour and uptake of micronutrients or vice versa. The use of chemical fertilizers being nearly devoid of micronutrients, and the increase of rates of nitrogen and phosphorus application to crops may lead the investigators to study the readily available forms of micronutrients and its relationship with the other macronutrients. Quantitative information on copper and its relationship with nitrogen and phosphorus is scarcely found in the literature concerning the soils of the U.A.R.

For the aforementioned reasons, it was thought to study the forms of copper in some selected representative soil samples from the U.A.R. Copper relationship with nitrogen and phosphorus was also considered under this investigation.

* * *

2. REVIEW OF LITERATURE

2.1. Historical:

Early in the present century it was suspected that copper might be essential to plants. Lutman (1916) and later Cook (1923) reviewed the various reports of the stimulating effect of copper on plant growth. Sommer (1931) used special purified salts, and water redistilled in Pyrex, and became the first to demonstrate that, without a minute amount of copper, the growth cannot take place. Lipman and Mackinney (1931) established the status of copper as a plant nutrient. Anderssen (1932), Bergman and Trutan (1937) and Okuntsov (1946) reviewed that copper treatment may not only increase the amount of chlorophyll in a plant, but it may also have a protective effect against chlorophyll destruction.

Stout and Arnon (1939) found that the success of early experiments was hindered, not only due to impurities in the nutrient salts used, but also to the traces of copper in water from stills with metal condensers. Gilbert (1948), Berger and Truog (1948), have found that the application of copper to mineral soils increased production even where these soils apparently contained enough copper for normal growth.

Willis et al. (1936) & Swanback(1950) added that copper in addition to its nutritive value, acts as an oxidation catalyst in rendering other elements available. Such results indicate that copper and possibly other trace elements have been considerably more value as soil amendments than is suggested by the slight amount taken up by the plant.

At the McCollen-Pratt Institute held at Johns Hopkins University (1950), copper was chosen the subject of the first symposium because of its essentiality to both plants and animals and because deficiencies of the element are widespread in the soils of the World. The symposium covered many phases of copper nutrition, including its enzymatic functions, the effect of its deficiency on plants and animals, and the interrelationships between copper and other nutritive elements.

2.2. Copper in Plant:

All plants contain copper and the amount of copper in a plant varies depending on species, soil, the amount of fertilizer used, and other factors.

Carles (1917) reported that chiefly with the possible health danger of an excessive amount in food, and [illegible] generally disappeared [illegible]

[illegible] fruit with copper spray residue usually contained less of the element than many food materials which had been consumed for years without ill effects. Lindlow et al. (1929) reviewed that in descending order of copper content, some different classes of plant foods are arranged as follows: nuts, dried legumes, cereals, green legumes, roots, leafy vegetables, fruits and nonleafy vegetables.

Everljem and Hart (1929), Lipman and Mackinney (1931), Colman and Ruprecht (1935) suggested that the amount of copper in a plant may be increased by copper fertilization. Bacon and associates (1950) found that copper was taken up by the leaves of tobacco plants in amounts varying directly with the amounts applied to the soil.

From a physiological point of view, Stotz et al. (1937), Mulder (1950) and Hewitt (1951) suggested that copper is important as a constituent of at least three enzymes: ascorbic acid oxidase, lactase and tyrosinase. The latter may be taken to include monophenol and polyphenol oxidases.

Sommer (1931) reported that copper has some functions in chlorophyll formation, although the chlorophyll

[illegible]

[illegible] (1933) and [illegible] et al. (1934) found also that copper has been found to increase the chlorophyll content of wheat, conberries, citrus and other plants.

Harmer (1945) pointed out that copper is considered to be active in the processes of respiration. There is evidence that copper is associated with protein which serves as a catalyst in various oxidation processes in the plant.

Mulder (1949) found, in studying the tyrosinase activity of potato tubers in relation to enzymatic blackening, that tubers from plants grown on soils poor in copper, although making an entirely normal appearance, had a tyrosinase activity less than one-tenth of that of tubers from plants with a normal copper supply.

Steward (1964) mentioned that copper plays a fundamental role in potential terminal respiratory oxidase systems. He added that copper may be needed for the formation of iron prophyrin precursor of chlorophyll.

2.2.1 Copper content of plants:

Erkam and Jorma (1947) pointed out that copper contents of the leaves of 34 species and varieties of plants ranged from 4.2 to 31.7 mg./kg dry matter.

[illegible], in determining copper removed [illegible] crops, found that cereals, pulses, potatoes, sugar beets, clover and lucerne removed 0.025, 0.03[illegible], 0.047, 0.090, 0.035 and 0.046 kg/ha respectively. Snytko (1964) mentioned that copper accumulated in various plant organs. Jacintho, Catani and Pellegrino (1964) reviewed that copper content in sugar cane varied with age from 7.4 to 62.8 p.p.m. in the canes and 10 to 30 p.p.m. in the leaves. They mentioned that the uptake of copper increased with plant age to a maximum in the 14th month.

Hallsworth et al. (1965) pointed out that the copper content of plants showed a logarithmic relationship to the level of copper in the nutrient solution.

Chen, Wei and Yeh et al. (1967) showed that the corresponding figures for forage crops (maize, sweet potato tops) were 15.3 p.p.m. in a latosol, alluvial and saline soils with an average content of 15.3 p.p.m. of copper.

Glinski (1967) found that copper content of hay was 1.2 to 17.6 p.p.m. depending on the type of soil. Hay from peat soils contained only an average of 4 p.p.m. copper, but hay from muck soils contained 13.7 p.p.m. copper.

[illegible] and [illegible] (1967) [illegible] that [illegible] grown in culture solution contain 7.[illegible] p.p.m. copper in roots and [illegible].2 p.p.m. in nodules. When copper sulphate was added to the solution, copper content raised to 17.2 p.p.m. in roots and 11 p.p.m. in nodules.

Gupta and Mackey (1968) reviewed that copper content of spinach, barely and lucerne ranged from 2.5 to 8.5 and from 6.6 to 13.2 p.p.m. on untreated and copper treated sand loamy soils which were low in exchangeable copper content and treated with 2.5 p.p.m. copper as copper sulphate.

2.2.2. Diagnosis of copper deficiency and toxicity:

A pale yellow coloration of the outer scales of yellow onion bulbs and a die-back of the leaf tips, have been observed by Harmer (1945) and other workers, when the crop was grown on copper-deficient soils. They also reported that a burning of the leaf edges of spinach similar to that caused by potassium deficiency. Addition of copper to soils having a low available supply have not only increased yields of many crops but have resulted in a darker green in spinach and lettuce, an orange yellow rather than pale yellow in carrots, table beets, and sugar beets.

[illegible] the copper content of plants is not an infallible guide in the diagnosis of copper deficiency. When growth is severely stunted, as it usually is under conditions of severe copper deficiency, the copper content of the plant material may not be unduly low.

Steindl (1948) noticed that Droopy Top disease of sugar cane grown in copper deficient sandy soil can be recovered by the use of copper sulfate spray. Castellani and Ettore (1948) reported that leaf black spots on peanut plants can be affected by the use of copper suspensions. Bould and Nicholas et al. (1950) recommended that a dieback of apple tree shoots can be corrected by the application of copper sulfate spray or by injection of the salt in powdered form.

Henkens (1957) reported that the normal black color of Aspergillus spores in copper deficient media, changed through brown and yellow, and in complete absence of copper, no spores are formed and the mold remain white.

Copper deficiency has been observed in the Netherlands in oats and wheat. With oats, symptoms may be expected when copper decreases below 2 mg/kg. In some cases extremes of pH and high humus content contribute to the