The Libyan Journal of Agriculture: volume 4, 1975

A Study on the Extractable Copper as Related to Soil Texture and Lime Content in some Jeffara Soils

T. NAJI, M. ASSEED, M. F. GHONEIM AND A. SASI[1]

ABSTRACT

Experiments were conducted in the laboratory and in the greenhouse to study the status of copper in some Jeffara soils as related to the growth and performance of tomato plants.

Laboratory work included several attempts to relate the status of available Cu to certain soil constituents. These were: organic matter, carbonate, and soil mechanical analysis. Three types of soils: black, red, and alkali soils were used to assess the role of organic matter and carbonate, in copper retention by the soil. Results obtained showed that the majority of available Cu, as indicated by the extractable Cu, is held either with the soil organic matter or combined with calcium carbonate. The relative easiness of converting any of these forms to an available form is, however, variable.

Another attempt was concerned with the relationship between soil mechanical analysis, carbonate, and the level of extractable copper in the soil. Three profiles were dug in the experimental farm of the University of Libya in Sidi El Mesri area. Samples were taken from successive layers in each profile. The copper content was shown to be associated with the soil separates more than to its content of calcium carbonate. This was verified in a third experiment using two different solvents for the extraction of copper.

INTRODUCTION

Copper is recognized as one of the essential micronutrients for higher plants. It is usually present in soils in the form of salts that vary in their solubilities. Sulphate, sulphide, hydroxide, and carbonate are examples of each salt. It also may exist in various organic combinations as a constituent of the soil organic matter.

As reported by Glinski (5), the average contents of 0.1 N HCl extractable copper were as follows: 1.2 ppm in sandy podzolic soils, 1.5 ppm in Rindzinas, 2.8 ppm in muck soils, 2.2 ppm in alluvial soils, 2.7 ppm in black earth soils, and 4.2 ppm in peat soils.

Deficiency of Cu has frequently been reported for crops growing on sandy soils (7,8). This is especially true in arid and semi-arid regions, where the retention of available Cu

[1] *T. Naji, M. Asseed, M. F. Ghoneim and A. Sasi, Department of Soil & Water, Faculty of Agriculture, University of Tripoli.*

by soils is usually low. This is due to the relatively low content of organic matter, high pH, and the high content of carbonate (7,9).

This paper presents some preliminary studies on the copper status in the Jeffara sandy soils.

MATERIALS AND METHODS

The investigation consisted of two separate parts. The first one dealt with the evaluation of Cu status in three different soils. For that purpose, profiles were dug in three locations in the Jeffara area. Samples were taken at various depths in each profile. The collected samples were then prepared appropriately for the subsequent analysis. This included the determination of soil texture, lime content, and extractable copper.

The other part was a greenhouse experiment designed to study the effect of adding copper as CuO to the soil on the growth of tomato plants. Soil material was collected from the Faculty farm, dried, sieved through a 0.5 mm sieve, and then placed into 9 pots. Each pot contained 6 kilograms of soil. Copper oxide was added to each pot and mixed thoroughly with the soil. Three levels of CuO were used. These levels were: 0, 100, and 200 mg of CuO per pot. Each level was replicated three times. Addition of CuO was made prior to planting. Two tomato plants about one month old were planted in each pot. Plants were supplied with all essential nutrients except Cu through the addition of a complete-minus Cu-Hoagland No. 2 nutrient solution. Application of the nutrient solution was made at three intervals during the experimental period. A volume of one litre was added to every pot at each interval.

After about 105 days, the experiment was terminated where tomato plants were cut and kept for the various determinations. These included the measurement of plant length and the fresh and dry weight of plants. At the end of the experiment, the soil in each pot was analyzed for extractable copper.

During the experimental period, several observations were made concerning the general behaviour and condition of the growing plants.

1. Extractable copper was determined in the various soil samples following the cyclohexane colorimetric method (4). Readings were made on a colourimeter using a 600 mu filter within 5–10 minutes from developing the colour.
2. The mechanical analysis of the soils was carried by the pipette method. The treatment of soils with HCl was omitted because of the high carbonate content in such soils.
3. Calcium carbonate was determined volumetrically by means of a calcimeter. A weight of 0.1 gm from each soil was used, and the results were corrected to normal temperature and pressure.

PRELIMINARY WORK

Some preliminary trials were made to verify the effect of organic matter and carbonate on the status of copper in three different: black, red and alkali soils. Samples of those soils were subjected to three different treatments. These included: treatment with H_20_2, treatment with $H_2O_2 + HCl$, and ignition of soil samples. Extraction of Cu in the untreated and the treated soil samples have thus allowed for the estimation of the various forms of Cu retained in the soil tested.

Table 1 Amount of copper extracted from the untreated and the treated soils.[1]

	Amount of Cu-mg/2 gm soil			
Type of soil	Control A	H_2O_2 treatment B	H_2O_2 + HCl treatment C	Ignition D
Black soil	5.5	4.6	2.3	1.5
Red soil	1.0	0.6	0.4	0.2
Alkali soil	7.1	3.4	0.7	0.9

[1]Soil samples were supplied each with 40 ml of $CuSO_4$ solution (containing 9.1 mg Cu) prior to treatments and extraction.

Table 2 Amount and percent of copper held by various soil constituents in three different soils.[1]

	Black soil		Red soil		Alkali soil	
Form of Cu retained in the soil	mg Cu/ 2 gm soil	%	mg Cu/ 2 gm soil	%	mg Cu/ 2 gm soil	%
Cu held with Organic fraction	0.9	16.36	0.4	40.0	3.7	52.11
Cu held by soil carbonate	2.3	41.82	0.2	20.0	2.7	28.03
Cu lost after ignition	4.0	72.27	0.8	80.0	6.2	87.32

[1]Percent of Cu was referred to the amount found in the untreated soil (control).

RESULTS AND DISCUSSION

The retention of copper by organic matter, carbonate and other soil constituents is known to affect to various degrees the availability of the element in the soil (7,9). Table 1 shows the data obtained for the amount of Cu extracted from both the untreated and the treated soils in the preliminary experiment. The difference in the amount of extractable copper between the control and the treated soils is presented in Table 2, expressed as absolute amount and as percentage.

Data in both Tables 1 and 2 indicate that the proportion of copper held by the soil carbonate compared to that of the organic fraction differed according to the type of soil. In the black soil, the carbonate-held copper was much greater than the organic copper. Reverse situations were however, manifested in both the red and the alkali soils. This may be attributed to the difference in carbonate content which was highest in the black soil compared to the other two soils.

In general it seems that the majority of the available copper (as indicated by the extractable Cu) is held in the soil in one or more of the forms just described. The relative easiness of rendering any of those forms available to the plant is however, variable. Several workers (5,7,9) have pointed that the Cu held in the organic fraction is probably the easiest form to be converted to an available form.

Table 3 shows the data obtained from the mechanical analysis, carbonate content, and extractable copper for three different profiles made in the University farm in Sidi

Table 3 Mechanical analysis, carbonate content, and extractable copper in samples collected from three different profiles in the University Farm.

Profile No.	Sampling depth cm	Mechanical Analysis %			Carbonate content (as $CaCO_3$) %	Extractable Copper ppm
		Sand	Silt	Clay		
1	0–30	65	17	18	7.44	0.19
(Valley profile)	30–60	56	22	22	13.05	0.30
	60–90	56	21	23	10.77	0.38
	90–120	59	20	21	9.96	0.43
2	0–30	73	11	16	6.54	0.08
(Hilly profile)	30–60	72	13	15	5.61	0.11
	60–90	75	8	17	6.20	0.11
	90–120	79	6	15	5.01	0.13
3	0–30	76	8	16	8.49	0.22
(Impermeable profile)	30–60	58	17	25	25.01	0.90
	60–90	52	19	29	57.72	0.05
	90–120	—	—	—	—	—

El-Mesri area. Examination of such data indicate that the copper content was in general associated with the texture of the soil. The higher the clay content, the greater was the concentration of extractable copper. This was in turn associated with the depth of layers tested in each profile exhibited lower Cu contents compared to the samples of the other two profiles. This was probably due to surface leaching of Cu from the hilly spots to the adjacent depressions. The fact that profile no. 1 (valley profile) showed higher values for extractable copper than profile 2 (hilly profile) substantiates this explanation. The phenomenon of copper leaching from the soil was also reported by others (7,12).

Based on these results, it seems that the effect of carbonate on copper availability is only partial. In order to verify the role of carbonate in affecting the availability of this element, samples were taken from 4 different soils in the Jeffara area and then extracted for Cu using two different solvents. This was then related to the soil's content of calcium carbonate. Table 4 shows the data obtained from such analysis. These data indicate that there was no direct relationship between the soil's contents of $CaCO_3$ and the amount of Cu extracted from the soil. This was true when either solvent was used for the extraction

Table 4 Concentration of Copper extracted with two types of solvents in 4 different surface soils.

Location of samples tested	Concentration of extractable copper, ppm.		$CaCO_3$ content
	IN HNO_3	0.02 M EDTA	%
University Farm	0.37	0.13	6.54
Garian	0.43	0.19	12.93
Ellasaba	0.65	0.59	5.55
Marij	0.58	0.45	32.78

Table 5 The effect of copper addition on the fresh and dry weights, average length of tomato plants, and on the level of extractable Cu in the soil at the end of the experiment.

Level of copper mg CuO/pot	Fresh weight (g)	Dry weight (g)	Average length (g)	Concentration of Cu in the soil
0 (control)	207	36.2	78.5	0.14
100	239	38.0	81.2	0.45
200	268	43.3	83.3	0.87

of copper. These findings are in partial agreement with what has been found by Alston and McConaby (1). It may, therefore, be stated that the availability of Cu in soils is not directly associated with the amount of carbonate present. Other soil constituents may play more important roles in that respect.

In the greenhouse experiment tomato plants were closely observed during the experimental period. In general, there was a close relationship between copper application to the soil and the time of fruiting. Plants supplied with the highest level of Cu-200 mg CuO/pot started to give fruits 8 days earlier than those growing under other treatments. The idea that copper addition is probably related to enhancing plant maturity is worth of special consideration, and perhaps should be further studied in detail.

The investigation included also a greenhouse experiment. Tomato seedlings were transplanted into pots each containing 6 kg of soil to which CuO was added at three levels. These levels were: 0, 100, and 200 mg of CuO per pot. Observations during the growth period indicated that addition of copper resulted in early fruiting of tomato plants. Growth of plants, as measured by fresh and dry weights as well as length of plants was stimulated by copper application.

At the end of the experimental period, plants were cut at the soil surface, and the fresh and dry weights of both plants in each pot were determined. The average length of plants was also measured. The soil in each pot was sampled and analysed for copper. Table 5 shows the data obtained from those measurements. These data indicate that there were appreciable increases in the fresh weight, dry weight and length of plants upon the addition of CuO to the soil. This was especially true at the highest level applied. This may be used to indicate that copper addition was beneficial to the growth of tomato plants. Several other investigators (2,6,11) have observed similar effects.

The data further show that the concentration of copper in the soil at the end of the experiment was proportional to the amount of CuO added. After a period of about 4 months from copper addition, the status of this element in the soil reflected its levels at the beginning.

LITERATURE CITED

1. Alston, A. M., and S. McConaky. 1965. The E.D.T.A. extractable copper and zinc in Northern Ireland. R.C.S. Ministry of Agriculture Northern Ireland 14: 49–59.
2. Arnon, D. I. 1965. Functional aspects of copper in plants pp 89–110. *In* W. D. McEloy, and H. B. Glass, Editors, Copper Metabolism. John Hopkins Press, Baltimore, Maryland.
3. Bear, F. E., and S. J. Toth. 1948. Influence of calcium on availability of other cations. Soil Sci. 65 :69–75.

4. Fiskell, J. G. A. 1965. Copper determination in soils p. 1078–1089. *In* C. A. Black (ed.) Methods of Soil Analysis, Part II. Monograph 9. American Society of Agronomy, Inc., Publisher, Madison, Wisc. U.S.A.
5. Glinski, J. 1967. Forms of copper in soils of Inja Wladama Lakeland. Soil and Fort. 30 : 39.
6. Hewitt, E. J. 1951. The role of the mineral elements in plant nutrition. Ann. Rev. Plant Physiol. 2 : 52–55.
7. Leeper, G. W. 1952. Factors effecting availability of inorganic nutrients in soils with special reference to micronutrient elements. Ann. Rev. Plant Physiol. 3 : 1–16.
8. Lubinovich, I. S., and G. D. Dubikovski. 1966. The dependence of trace elements on mechanical composition of dirno podzolic soils in White Russia Agroklimiya 12 : 75–79.
9. Misra, G., and R. C. Tiwari. 1968. Retentions of applied Cu^{++} by soils. Effect of carbonates, organic matter, base saturation, and unsaturation. Plant and Soil 24 : 369.
10. Nelson, W. L., and G. Stanford. 1958. Changing concepts of plant nutrient behaviour and fertilizer use. Advances in Agronomy 10 : 120–123.
11. Sommer, A. L. 1931. Copper as an essential element for plant growth. Plant Physiol. 6 : 339–345.
12. York, E. T., R. Brodifield, and M. Peach. 1954. Influence of lime and potassium on yield and cation composition of plants. Soil Sci. 77 : 53–63.