Factors affcting content in soil and its availability to plant

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The objectives of this research were: (i) to investigate the distribution of native and added Cu in some soils of Egypt with diverse soil properties, (ii) to evaluate the plant availability of the various Cu fractions, and examine the effect of soil properties on the distribution and plant availability of the soil different Cu fractions, and (iii) to examine the effect of incubation periods on availability of copper in soils.To reach these objectives, a green house and laboratory studies were conducted. The soils in these experiments were selected to have wide variations in physical and chemical properties. Wheat plants were planted in soil samples representing Nile alluvial soils (El-Giza Farm), calcareous soils (El-Nobariya) and sandy soils (Ismaliya).Sequential fractionations were conducted to partition total soil Cu into water soluble, exchangeable, carbonate , occluded , organically bound, and residual forms.Simple correlations were calculated between the various properties of the studied soils and Cu fractions to evaluate the properties most effective on the distribution of soil total Cu and the above mentioned fractions as well . The obtained results could be summarized as follows:1- Chemical and physical properties 1.1. Nile alluvial soilsTextural class of the alluvial soils is clay. The clay content varied from 44.1 to 60.3%. total calcium carbonate is very low and varied from 1.1 to 2.3%.The analytical data show that soil reaction of the Nile alluvial soils varied from pH 7.23 to 7.86 indicating that the soils are neutral to slightly alkaline. The amounts of total soluble salts as expressed by the electrical conductivity (dSm’) of the soil saturation extract varied from 0.74 to 6.49 dSm-I indicating that these soils are none saline to slightly saline. The cationic composition of the soil saturation extract is dominated by Na+ followed by Ca++ and Mg++, while K+ ion is the least abundant soluble cation. Soluble anions is dominanted by SO4= followed by Cl- and HCO3”.1.2. Calcareous soilsTextural class varied from sandy clay to clay. CaCO3 content ranged from 20.0 to 29.2% with an increase in carbonate content in the surface layers, while organic matter content is very low and ranged from 0.01 to 1.09%.Soil reaction (pH) varied from 8.27 to 8.99 indicating that those soils are moderately alkaline to strongly alkaline. EC, values varied from 1.43 to 14.21 dSm’ indicating that the soils are none saline to moderately saline. Soluble cations in the calcareous soils is dominated by Na+ followed by Ca++ and Mg++ while K+ ion is the least, while soluble anions is dominate by Cl- and/or SO4= and HCO3- is the least abundant soluble anion.”1.3. Sand soils:Sandy soils are classified as coarse textured soil where sand content is more than 90% CaCO3 content is very low (0.48%). Organic matter content is very low and not exceeding 0.26%. Soils are slightly alkaline and none saline. Soluble cations are dominated by Na+ followed by Ca++ and Mg++ while K+ ion is the least abundant cation. Soluble anions is generally dominated by CF and/or SO4 followed by HCO3-.2.1. Total copper:In the alluvial soils of Egypt total copper content varied from 35 to 155 lug g’, while in the calcareous soils it ranged between 13 and 971..tg g- 1. Sandy soils have 371.1g g-1 total Cu content.It may be noticed that the total copper content in the studied soils followed the orderAlluvial soils > calcareous soils > sandy soils.Computation of the correlation coefficients dictates that the total copper is significant and positively correlated with clay% and organic matter content. In contrast, total copper is significant negatively correlated with CaCO3 and ECe.Multiple regression equation is :Total Cu = - 113.811 + 0.482 clay% - 1.089CaCO3% + 5.0390M% + 19.62pH + 0.74 silt% -2.942EC2.2. DTPA-extractable copper:DTPA-extractable Cu varied from 3.71 to 9.68, 0.37 to 6.17 jAg g-i in the Nile alluvial and calcareous soi s respectively, while in the sandy soil it was 0.71ggDTPA-extractable Cu is positively and hig ly significant correlated with clay% and OM% but negatively and highly significant correlated with CaCO3% and pH.Multiple regression equation isDTPA-Cu= -26.452 + 0.062 clay% -0.258CaCO3 0.4560M% + 3.608pH + 0.0895 silt % + 0.005E3. Content of copper fraction in the studied soils 3.1. Total copperTotal copper content in the Nile alluvial soil varied from 35 to 155 ìg g' with an average 81.86pg g-1, wh le calcareous soils showed a total copper content that ranged be een 23 and 97pg g-1 with an average of 49.7 lig g'. Variatio s in the total Cu content are due to variation in soil texture and o ganic mattercontent.3.1.1. Soluble copperSoluble Cu extracted by water in the Nile alluvial soils ranged from 0.8 to 1.6pg g' being about 0.52-1.6 % of the total, while in the calcareous soils, solub Cu varied from 0.01 to 1.8lig g' with about 0.04-3.6 % of otal Cu.3.1.2. Exchangeable copperExchangeable Cu content in the Nile alluvial soils ranges from 0.6 to 2.0 lig g-I representing from 0.7 to 2.9 % of total Cu while in the calcareous soils, exchangeable Cu fluctuates between 0.2 and 2.0p.g g-1 making 0.37 and 2.08 % of total copper.3.1.3. Copper bound by CaCO3The values of Cu bound to CaCO3 in the Nile alluvial soils are varying from 0.0 to 2.4pg g-I respectively 0.0 and 2.40 % of total Cu. In the calcareous soils copper bound by CaCO3 varied from 0.8 to 3.61.1g g-1 making to 1.48 and 7.20 % of total Cu. The calcareous soils possessed the highest average content of copper bounded by CaCO3.3.1.4. Occluded copperThe distribution of occluded copper in the Nile alluvial soils ranged from 1.0 to 2.4Ag g-1 constituting 1.47 and 2.40% of total Cu. In the calcareous soils the occluded copper varies from 0.8 to 6.0gg g-1 being within the range of 1.48 and 6.18 % of total Cu.3.1.5. Copper bounded by organic sitesValues of bound to organic sites in the Nile alluvial soils ranged from 2.2 to 5.6 fig g-I and fell within the range of 3.24 to 8.92% of total Cu, while in the calcareous soilscopper bound by organic sites ranged from 3 to 6.4pg g-1 and fell within the range of 5.55 and 24.61% f total Cu.3.1.6. Residual copperResidual copper content in the Nile alluv 1 soils varied widely from 17.1 to 80.0pg g-I and fell within e average of 48.85 to 51.61% of total Cu. In the calcareous soi s, the residual Cu values ranged from 10.2 and 44.9 12g g-1 be ng within the average of 15.05 and 69.25% of total Cu.On the basis of results obtained in this study the Cu fractions in the alluvial soils were in the order:Residual> organic > occluded > carb o nate> water soluble> exchangeable.In the calcareous soils the order of fraction as:Residual > organic> occluded>carbonate>exchan eable >water soluble4. Effect of some soil characteristics on Cu ractions in soils:4.1. Nile alluvial soilsWater soluble Cu was positively correlated ith clay% (r =0.526) and negatively correlated with total Cu (r -0.551).Exchangeable Cu was negatively and significantly correlated with EC, (r = -0.680).Occluded Cu was positively and significantly correlated with pH (r = 0.508*) and negatively correlated with EC (r = -0.720*)Organic Cu was positively and significantly correlated with silt% (r = 0.678*).Residual Cu was positively and significantly correlated with each of clay %(r=0.610*) and OM% (r = 0.870*) and highly and significantly correlated with total Cu (r = 0.900") and negatively correlating is found between residual and CaCO3 % (r = 0.708*).The multiple regression equations are:Water soluble Cu = -3.749-0.013 clay% - 0.012 silt% + 1.267 OM% + 0.602pH — 0.052EC -0.012 total Cu.Exchan-Cu = -1.789 + 0.007 Clay% + 0.005silt% + 0.598CaCO3% + 1.2030M% -0.285EC — 0.01total Cu.Carbo-Cu = 1.19 -0.026clay% + 0.045silt% -0.156CaCO3% + 2.0160M% -0.189EC -0.029total Cu.Occl-Cu = 1.184 + 0.012clay% + 0.061silt% + 0.343CaCO3% -0.5260M% -0.383EC +0.002total Cu.Organic-Cu = 4.096 +0.06lclay% +0.183silt% + 0.332CaCO3% -3.3770M% -0.272EC +0.004total Cu.-0.324si1t% 210M% -4.2. Calcareous soilsWater soluble Cu was positively and correlated with clay% (r=0.526).Exchangeable-Cu was negatively and correlated with each of OM% (r = -0.719) 0.575), while positively correlated with t 0.610*).Occluded Cu was not significantly relate variables.Carbonate Cu was a negatively and significa with OM% (r = -0.840).Organic Cu showed a negative and signific with clay% (r = -0.680) and positively correl (r =0.540).Residual Cu was positively and significan with each of clay% (r = 0.610) and silt% (r the other hands pH displayed a signific correlation with residual Cu (r = 0.640*significantlysignificantlyd ECe (1* - tal Cu (r =o any soilly correlatedt correlation ted with EC,ly correlated 0.717*). On t negativeResidual-Cu= -140.543 +0.592c1ay% +13.673%CaCO3% +60. 0.642EC +0.337total Cu.The multiple regression equations are:Water soluble Cu = -1.305+ 0.117 clay% - 0.089 silt% + 0.109 CaCO3% - 0.094EC - 2.4980M% -0.012 total Cu.Exchan-Cu = -1.305 + 0.005 Clay% - 0.0332si1t% + 0.103CaCO3% - 1.6750M%

-0.170EC - 0.0113total Cu.Carbo-Cu = 3.369 + 0.058clay% - 0.092silt% + 0.151CaCO3% - 3.5580M% - 0.161EC - 0.038total Cu.Occl-Cu = 9.626 + 0.113clay% - 0.339si1t% + 0.237CaCO3% -6.1190M% - 0.468EC - 0.071total Cu.Organic-Cu = 7.894 - 0.184clay% + 0.017silt% + 0.159CaCO3% + 0.1180M% + 0.012EC - 0.029total Cu.Residual-Cu = -54.917 + 0.009clay% +2.032silt% - 0.703CaCO3% +31.460M% + 0.627EC +0.585total Cu.5. Chemical fractionation of Cu prior to soil cultivation:In the alluvial soil, the amounts of water soluble, exchangeable, carbonate, occluded, organically bound and residual fractions were 1.2, 2.0„1.8, 1.8, 5.6 and 44.90 pgand constituted 1.74, 2.9, 2.6, 2.6, 8.12 and 65.07% of total Cu, respectively, while in the calcareous soils these fractionsof Cu were 0.8, 1.0, 3.0, 1.2, 5.0 and 27.5Oug g-1 and constituted 2.05, 2.65, 8.69, 3.07, 12.82 and 70.51% of total Cu. In the sandy soils, the fractions of Cu were 0.8, 1.4, 2.4, 1.2, 3.0 and 18.1 jug g-1 and constituted 2.16, 3.78, 3.48,3.24, 8.11 and 48.92% of total Cu, respectively. The data reveal that water soluble Cu constituted the least amount of Cu in the studied soils, while residual and organically Cu constituted the highest portion of soil Cu in the alluvial, calcareous and sandy soils.6. Dry matter, copper concentration and uptake: 6.1. Dry matterDry matter yield of the wheat plants (shoots and roots) at 0.5, 1 and 2.0 lig g-1 copper addition rates reveal that the addition of 2 tig g-1 copper increased the dry weight of shoots and roots of wheat plants in the alluvial soil which on the average amounted to 17.07 and 2.32 (g/pot) and in sandy soil the addition of 2 jig g-1 copper increased the dry weight of shoots which on the average amounted to 14.31 (g/pot).While the addition of 0.5 pg g' copper increased the dry weight of roots which on the average amounted to7.33(g/pot) .While in the calcareous soil addition of 0.5 lag g' copper increased the dry weight (shoots and roots) of wheat plant being on the average 4.6 and 0.5 (g/pot), respectively.6.2. Copper concentration:Data of copper concentration in wheat plants grown on the alluvial, calcareous and sandy soils at the additions rates of 1.0 and 2.0 lag g-1 Cu shows that application of Cu treatment significantly increased Cu concentration in both shoots and roots of wheat plants grown on the alluvial and calcareous soils compared to those of the plants grown on the sandy soil. 6.3.Copper uptake:Copper uptake by wheat plants (shoots) grown on the alluvial soils at the application of 0.5, 1.0 and 2.0 ttg g'iCu varied from 240.07, 284.48 and 272.30 i.tg /pot, respectively, while in the calcareous soils the values were 55.52, 17.89 and 37.85 lig /pot while in the sandy soils was 134.73, 141.89 and 166.66 tig /pot, respectively.The average of copper uptake by wheat plant (roots) grown on the alluvial, calcareous and sandy soils at the additions of 0.5, 1.0 and 2.0 pg g-1 Cu were 49.01, 36.64 and 37.24 tig /pot in the alluvial soils. In the calcareous soils were 7.04, 5.87 and 8.38 ttg /pot; while in the sandy soils were 196.16, 168.71 and 173.32 tig /pot. It is clear that the highest values of copper uptake by wheat plant (shoots) are found in the plants grown on the alluvial soils and the lowest ones are found in plants grown on the calcareous soils, whilest values are corded in thethe copper uptake by plant (roots), the high detected in the sandy soils and the lowest are r calcareous soils. 7. Fractionation of Cu after cultivation:7.1. The amounts of Cu in the soluble C Carbo-Cu, Occl-Cu, organic-Cu and resid-Cu to 0.5, 0.2 to 0.7, 0.4 to 0.6 , 1.3 to 3.0, 1.0 to to 41.75 pg g'Cu and constituted 0.0 to 0.99%, 0.51 to 0.85%, 0.87 to 4.22%, 1.45 56.14 to 58.8% of total Cu under the applicati 1.0 and 2.0 pg respectively.7.2 In the calcareous soils, the amounts of Cu, Exchan-Cu, Carbo-Cu, Occl-Cu, Orga-Cu varied from 0.15 to 0.40, 0.60 to 1.30, 1.07 to and 23.15 to 28.57 pg g' and constituted 0 1.54 to 3.17%, 2.74 to 6.59%, 5.13 to 6.9% 72.33% of total Cu under the application of 0. pg g'Cu, respectively.7.3. In the sandy soils, the Cu fractions cultivation and application of 0.0, 0.5, 1.0 and were 0.3 to 0.95, 0.4 to 1.0, 0.63 to 1.2, 1.3 to and 21.45 to 23.15 lig g-1 that constituted of 0. 2.62, 1.71-3.08, 3.46-5.26, 0.54-8.16 and 55 total Cu, respectively.Exchan-Cu, tinged from 0 .65 and 39.05 .7%, 0.28 to o 2.11% and n of 0.0, 0.5,u in soluble-and Risd-Cu .7, 1.6 to 2.5 38 to 1.03%, and 56.71 to , 1.0 and 2.0content after 2.0 pg g'Cu .0, 0.2 to 3.0 1-2.44, 1.08-9-60.53% of8. Effect of incubation on DTPA extractable - Cu: 8.1. Alluvial soils:In the incubation experiment, DTPA extractable-Cu was progressively and significantly increased as a result of increasing rate of Cu application from zero to 2 pg g-1 Cu in each of the following incubation periods; 3 days, 1, 2, 4 and 6weeks. However, it was sharply increased during the first 2 weeks of incubation then it slightly decreased during the other incubation periods. 8.2.Calcareous soils:Results show that application rate of 0.5, 1.0 and 2.0 jig g 1Cu as CuSO4.5H20 resulted in progressively significant increase in DTPA-extractable Cu at the one and two weeks of incubation periods in comparison with that of the first 3 days of incubation period then slightly decreased at 4 and 6 weeks of incubation, where the values of DTPA-Cu were significantly decreased in comparison with the values at 2 weeks of the incubation. 8.3.Sandy soils:The highest DTPA-extractable Cu was obtained from the application of 2 j.tg g-1Cu after 4 weeks incubation while the lowest one being obtained from the application of 0.5 jig g-1Cu after 2 weeks incubation. The increase of DTPA-Cu with increasing incubation time reflectes the fact that the concentration and/or bonding strength of legends in the soil extracts changes with time due to mineralization Cu.Finally it can be concluded that:-•Sesquioxides and organic matter ar components responsible for the adsorpt copper.•The residual copper is the potentially av for plants.•The efficient use of copper to wheat pl be increased if applied two weeks in th calcareous soils, and 4 weeks in sandy s plant reach their most active rate of absothe major on of addedilable sourceis may could alluvial and it before the tion.