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Original Article

Effect of Incorporation of Crops Residue into Soil on Some Chemical Properties of Soil and Bioavailability of Copper in Soil

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ABSTRACT

Objective: Returning crop residue to the soil exerts favorable effects on physical and chemical properties of soil. In fact, the plant residues can affect soil conditions such as pH and important role in soil fertility and cycling of elements in the soil may have. In addition to the role of the organic matter from decomposition of crop residue in increasing the concentration of micronutrients in soil solution is very important. Present research was conducted with the objective of studying the effect of the kind of crop residues: *sunflower* (*Helianthus annnus* L. cv. Allstar), *sudan grass* (*Sorghum bicolor* L. cv. Speed Feed), *trifolium* (*Trifolium pretense* L.) and *safflower* (*Carthamus tinctorius* L. cv. Koseh-e-Isfahan), with control on chemical properties of soil and effect on bioavailable of copper. **Methods:** In this study complete randomized block field experiment, consisting of 3 replications and 5 treatments. After 3 weeks, increasing crop residues, soil samples collected and were used to measure some properties of soil and concentration of Cu in soil. **Results:** Results showed that crop residues significantly decreased soil pH and the largest increase was observed for *Trifolium* treatment. EC significantly increased by affected crop residues application. The crop residues significant increased the concentration of dissolved organic carbon (DOC). the largest effect was dependent for *Trifolium* treatment. The crop residues significant increased the concentration of DTPA-extractable Cu. The highest effect was obtained for *Trifolium* treatment. Therefore, *Trifolium* residues application decreased the amount of soil pH and consequent increase of DOC which in turn elevated the concentration of DTPA- extractable Cu. *Trifolium* was the most effective in increasing the phytoavailability of Cu in soil.

1.INTRODUCTION

Crop residues are the parts of plants left in the field after the crops have been harvested and thrashed. Crop residues are good sources of plant nutrients, are the primary source of organic material added to the soil, and are important components for the stability of agricultural ecosystems. Indeed, crop residues are as a kind of organic amendments that the use of them could be a viable means of improving the productivity of the soils. Recycling of crop residue has demonstrated to be one of the ways of improving soil nutrient content and maintaining soil productivity. Also, they can reduce fertilizers usage in soil (Beres and Kazinczi, 2000). Crop growth depends on, among other things, nutrients. Both macro- and micronutrients are essential for plant growth and if a plant does not get enough of a particular nutrient it needs, the deficiency symptoms show in the general

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appearance of the plant. Macronutrients are those elements needed in large amounts by the crop, and large quantities have to be applied if the soil is deficient in one or more of them, while micronutrients are those elements required in very small quantities. On the other micronutrients is very necessary for optimum growth of plants. As noted crops residues as a source of organic matter are an important source of micronutrient and can play an important role in the soil cycling of micronutrients. Several reports of the effect of returning crop residues on soil properties are presented. Reported, that crop residues are considered as an important source of several micronutrients. For example about 50 to 80% of Zn, Cu and Mn taken up by rice and wheat crops can be recycled through residue incorporation (Prasad and Sinha, 1995). Therefore, returning of crop residues can help improve soil availability of micronutrients. Indeed the crop residues management can cause element mobility, immobile forms and makes its entry into the food chain. In addition, crop residues may be effective on some soil chemical conditions such as pH. Moreover the role of organic acids released from decomposition of crop residues, is very important. Because, they are effective on the changes soil pH and availability of micronutrients. Organic acids released from decomposition crop residues can alter the mobility and bioavailability of metals such as Cu and Mn in the soil by modifying soil pH or by releasing soluble organic compounds to complex Cu. The organic acids released by incorporation of crop residues in the soil solution have the ability to complex metals, but depending on the type of organic acids (Number and carboxyl groups), metal concentration and pH of solution. In addition to the role of the organic matter in increasing the concentration of micronutrients in soil solution, attention should be also paid to the role of the kind and the quantity of the root's exudates released in response to the incorporation of different crop residues in soil. Thus the use of incorporation of crop residues due to the presence of organic compounds (organic acids) released from the decomposition of plant residues effective on the availability of elements, can be a good solution to increase the solubility of micronutrients and ultimately increase the performance of plants is in the next planting. The aim of this study was to investigate the changes some soil properties and phytoavailability of Cu concentration as affected by the crop residues.

2. MATERIALS AND METHODS

2.1. Experimental location and soil properties

The site selected for the field experiment was in an experimental station called Rodasht, located in an area in the southeast city of Esfahan, in the central part of Iran. This area has a relatively flat topography with medium to heavy textured soils. The climate condition is dry with low annual rainfall (<100 mm) and high evapotranspiration (>1,500 mm). The soil in the experimental site was classified as *Typic Haplocalcids* (Soil ClassificationWorking Group, 1998). Selected soil properties are shown in Table 1.

Table1.

Selected soil properties

Classification	Clay	Silt	Sand	pH	EC	OM	$CaCO_3$	N	Olsen-P	NH4-OACK	Cu.DTPA
		%			dS/m		%			mg/kg	
Typic Haplocalcids	42.5	36.3	21.2	7.5	6	0.4	33	0.05	26.2	289	0.14

2.2. Experiment treatments

Treatments consisted of control plus 4 crop residues: *sunflower* (*Helianthus annnus* L. cv. Allstar), *sudan grass* (*Sorghum bicolor* L. cv. Speed Feed), *trifolium* (*Trifolium pretense* L.) and *safflower* (*Carthamus tinctorius* L. cv. Koseh-e-Isfahan) in 3 replications. A control treatment with no crop residues was also used. The experiment was conducted in a complete randomized block field experiment with the crop residues treatments. This made a total of 15 plots (5*3).

2.3. Experiments

The crop residues crashed into the size of 0.5-2 cm. Then, the crushed residues of each treatment were incorporated into the soil. The application rate of the residue was 7 ton per hectare. This amount is equivalent to the average harvest index of crop residues in the study area (Ministry of Agriculture, www.maj.ir).

2.4. Data analyses

All statistical analyses were carried out using SAS program. Comparison of the mean values of treatments was tested using one-way analysis of variance (ANOVA). Significant differences between pairs of mean were identified using the LSD test at the 5% level (SAS Institute, 2000).

3. RESULTS AND DISCUSSION

3.1. Properties of plant residues

Table 2 shows C: N ratio and Cu concentration of crop residues. Before added the crop residues, carbon to nitrogen ratio and concentration of Cu in crop residues were determined. The highest and lowest C: N was obtained for *Sorghum* and *Trifolium* residues respectively. Also the highest concentration of Cu was observed for *Trifolium* residues. The low concentration of carbon in the soil solution show that crops residues accumulated at the soil surface, therefore the decomposition of crop residues is slowly. According to the table 3 the carbon to nitrogen ratio less than *Trifolium* show rapidly was decomposed and organic compounds produced (especially organic acids) by the decomposition of *Trifolium* residues can be effective on some soil properties such as decreasing soil pH.

Table2.

C: N ratio and Cu concentration of crop residues

Plant residues	C: N	Concentration of Cu(mg/kg)
Sorghum	54.2	4.9
Safflower	49.4	6.1
Sunflower	40.8	7.5
Trifolium	19.2	8.2

3.2. Effect of crop residues on some of soil chemical properties

3.2.1. pH

All the treatments significant decreased soil pH in comparison with the control treatment (table 3). Crop residues decreased soil pH by about 0.3 and pH unit on average respectivly. The decrease of pH by *Trifolium* treatment was higher than in the other treatments in crop residues.

Indeed crop residues into soil as a source of organic matter are able to least temporarily reduce the pH of calcareous soils. Also, soil pH can affect the bioavailability of metals in soil. Changes in soil pH values increased or decreased ability to uptake nutrients from the soil for the plants to be effective. Brun *et al.,* (1998) reported that soil pH influenced heavily micronutrient bioavailability, for example Cu bioavailability was higher as the soil pH decreases. On the other, decrease in soil pH, are depended the intensification of the processes of decay and decomposition of organic matter and nitrification processes, and oxidation of organic compounds in the soil. However, changes in soil properties such as pH and buffering capacity to the time interval until the last add organic fertilizer to the soil depends. A decrease in soil pH was also observed after returning crop residues than fallow treatment (Table 3). This can be as result of the role of organic ligands released after degradation of crop residues. Higher microbial activity and higher CO_2 release into the soil in

the presence of residues of the crop residues can also be effective in reducing soil pH in comparison with the fallow treatment (Table 3). Lower C: N ratio of *Trifolium* residues (19.2) (Table 2) in comparison with the other crop residues resulted in higher degradation by soil microorganisms. In addition of greater stimulating effect on microbial activities that results in lower soil pH, the *Trifolium* residues released higher organic compounds into the soil after degradation (Table 3). These organic compounds have ability of forming complexes with metals in soil (Sing *et al.,* 2005).

Table3.

Comparison of data average of soil properties

Crop residues	pH	EC(dS/m)	DOC(mg/l)
Sorghum	7.5^{b}	6.9^{a}	46.5^{b}
Safflower	7.4^{c}	5.6^{b}	43.7^{c}
Sunflower	7.4^{c}	5.8^{ab}	40.1^{d}
Trifolium	7.3^{d}	5.3^{c}	52.3^{a}
Control	7.7^{a}	5.2^{c}	32.4^{e}

3.2.2. Electrical conductivity (EC)

All the treatments increased soil EC in comparison with the control treatment (table 3). The highest effects were obtained for Sorghum treatment. *Trifolium* treatment was no significant difference to fallow treatment. Indeed returning crop residues into soil caused increase soil solution salinity. Decomposition of crop residues caused release component from crop residues, that can increased the amount of ions in soil solution and it can effective on increase EC in soil.

3.2.3. Dissolved Organic Carbon (DOC)

All the treatment significantly increased soil dissolved organic carbon (DOC) in comparison with the control treatment (table 3). The highest effects were obtained for Trifolium. Also, the lower effect was obtained for sunflower. As previously mentioned, crop residues are considered as a source of organic matter. So they can increase dissolved organic carbon (DOC) in soil. Antoniadis and Alloway (2002) found that increasing soil organic matter that causes increased dissolved organic carbon (DOC) content of the soil. Dissolved organic carbon (DOC) is a general description of dissolved organic matter in the soil and is a small part of it (McGill *et al.,* 1986). But nevertheless, it has a very important role in soil biological activity (Changitny, 2003). Diekow *et al.* (2005) reported that higher residue input associated with legume-based cropping systems increased soil organic C significantly. Mitchell and Entry (1998) found that long-term planting of legumes as a winter cover crop resulted in higher soil organic C levels (9.5 g C kg-1) in the plow layer (0–20 cm depth) compared with treatments that did not include a winter cover crop (4.2 g C kg-1). Therefore addition crop residue Instead burning and removal of crop residue cause increase soil organic C. As Rasmusen *et al.* (1980), Biederback *et al.,* (1980) reported losses in surface soil organic carbon levels through burning and removal of crop residue. The highest organic matter levels were as a result of the decomposition of the crop residue. This is because organic matter is the major product of crop residue decomposition. Such increase in organic matter levels had also been associated with treating soil with crop residue reported by many researchers Lal (1976), Grifith (1977) and Abu-Seid (1979).

The organic matter from the residue treatment improved the soil pH status by increasing the soil buffer capacity. Agboola and Fagbenro (1985) reported that organic matter constituted a large portion of the soil exchange complex and being negatively charged, retains nutrient cations (such as Cu). Indeed, added organic matter can immobilize the metals by forming solid organo-metal complexes (especially Cu). This process could reduce or increase the solubility of some metals in soil. On the other hand, it is important that an increase in dissolved organic matter (DOM), can contribute to the enhancement of metal concentration in soil solution (Weng *et al.,* 2001). Several investigations have revealed that the soluble organics are able to raise the metal carrying capacity of soil solution (Naidu and Harter, 1998). Therefore crop residues with increasing dissolved organic carbon (DOC) content can affect the availability of micronutrients such as copper in soil. As in this study, the use of crop residues was observed increasing dissolved organic carbon compared to the fallow treatment, therefore with the increasing availability of copper in the soil, can effective to increase plant uptake.

3.3. The effect of crop residues on the DTPA extraction concentration of Cu soil

All the treatment significantly increased the concentration of DTPA-extractable Cu in soil (table 3). The highest effect was obtained for *Trifolium* treatment (fig. 1). There was no significant difference between *Sunflower* and *Sufflower* treatments (fig 1). Incorporation of crop residues by affected on reduce soil pH that it can increases the solubility of copper compounds and manganese compounds, also with increases organic matter content of soil and increases complexes of them can caused increase the amount of copper and manganese available. Also crop residues, containing copper and manganese concentrations were which can increases the concentration of copper and manganese in the soil, and effected on increasing the bioavailable of them in soil. The chelating agent DTPA has been widely used for the diagnosis of plant availability of the metals in soil at regular or even higher concentration (Singh *et al.,* 1998). Stevenson (1991) reported applications of organic fertilizers with improving soil physical properties and biological increased the concentration and availability of micronutrients in the soil. Eghball et al.,(2004) observed that the use of organic fertilizers and compost to improve the physical properties and increase the availability of zinc for corn.

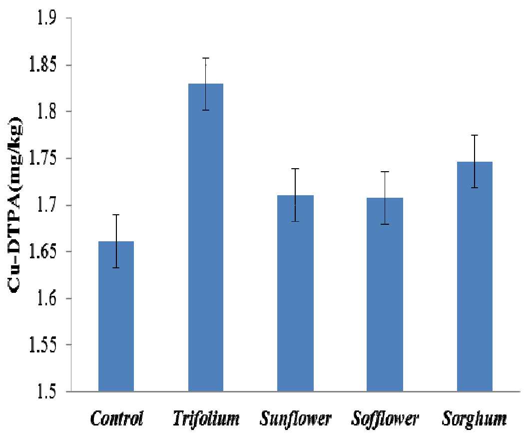

Figure1. Effect of Crop residues on the DTPA-extractable Cu

3.4. The relationships between DOC concentration of soil with DTPA-extractable Cu concentration of soil

The concentration of DOC in soil showed a significant positive correlation ($r^2 = 0.88^{**}$) with the concentration of DTPA-extractable Cu in soil (fig.2). The chelating agent DTPA has been widely used for the diagnosis of plant availability of the metals in soil at regular or even higher concentration (Singh *et al.,* 1998). In most cases, the DTPA-extractable Cu (DTPA-Cu) was found to be correlated with the Cu concentration in crops (Obrador *et al.,* 1997; Fuentes *et al.,* 2004; Cattani *et al.,* 2006). On the other in relation with copper, DOC is an important factor, because copper has a strong tendency to form complexes with organic matter and copper is known to form strong bonds with soil organic matter. This suggests that crop residues application cause increasing the organic compounds into the soil and increased copper and manganese complexation with organic matter in the soil and resulting could be to cause increasing phytoavailability of them in the soil. Therefore, *Trifolium* residues application decreased the amount of soil pH and consequent increase of The concentration of DOC which in turn elevated the concentrations of DTPA- extractable Cu. *Trifolium* was the most effective in increasing the phytoavailability of Cu in soil comparative other crop residues .

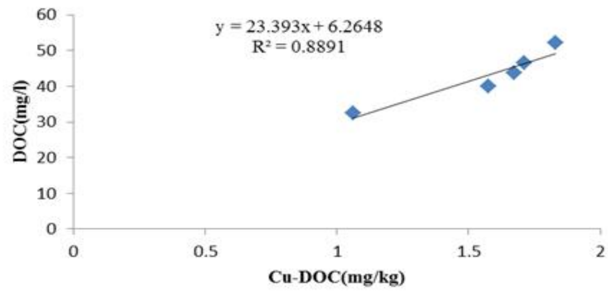

Figure2. Correlation of between DOC concentration and DTPA-extractable Cu concentration of soil

CONCLUSION

The study showed that returning crop residue to the soil could be beneficial; in ameliorating soil chemical conditions. It was specifically concluded that the use of adequate quantity of *Trifolium* straw (legume residues) improves the fertility status of the soil**.**

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