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EFFECT OF CONVERTER SLUDGE AND COW MANURE ON CORN FE CONCENTRATION

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ABSTRACT
Iron is an essential element for plant growth. Low iron and other micro nutrients availability are the main problems in calcareous soils of arid and semi-arid of Iran regions. Physiological processes involved in Fe chlorosis generally occur in the roots and in the leaves. Even on calcareous soils and even in plants with Fe chlorosis, the Fe concentration in the roots is several times higher than the Fe concentration in the leaves. The aim of study was to evaluate the effect of converter sludge and cow manure on corn iron availability in a loamy soil in Markazi province. A factorial experiment using randomized complete block design was used in three replications. Treatments were consisted of applying three loading rates of cow manure (0 (C_0), 15 (C_1) and 30 (C_2) ton ha^{-1}), two level of converter sludge [0 (S_0) and 0.5 (S_1) % (W/W)] and soil contaminated with 0 (Pb_0), 200 (Pb_{200}), 300(Pb_{300}) and 400(Pb_{400}) mg Pb kg^{-1} soil. Applying 15 and 30 ton ha^{-1} cow manure significantly increased the OC and CEC of the soil studied. Increasing the loading rates of cow manure from 15 to 30 ton ha^{-1} in a soil contaminated with 200 mg Pb kg^{-1} soil significantly increased the Fe concentration by 45.15 percent. The similar increasing was observed for root Fe concentration by 74.19%. Iron and lead showed antagonistic effects, as; increasing the loading rate of Pb from 200 to 400 mg Pb kg^{-1} soil in converter sludge enriched cow manure ($C_2S_1Pb_{200}$) significantly decreased the root iron concentration of corn plant by 15.16 percent. The results of this experiment showed the antagonistic effects of iron and lead can affect the heavy metal availability that is a positive point in contamination soils. On the other hand, using converter sludge as an iron enrichment fertilizer can increase the iron availability in a Pb contaminated soil that is very important in environmental studies.

KEYWORDS: Converter sludge, cow manure, heavy metals, iron, Pb.

INTRODUCTION

Fe deficiency is one of the most common problems Plant nutrition In soils of arid and semi-arid are as especially in calcareous soils (Tmothy and eliot,2005).Fe is known as one of the most abundant elements in the soil, but because the chemical properties of this element an also Physical and chemical conditions of soils in arid and semi-arid, Its solubility is generally low and less than the required by plants. (kumpieneatel, 2007). Fe is an essential element for the growth of all plants .In case of lack of Fe , chlorophyll (chlorophyll) does not produce adequate amounts of leaf cells and the leaves look pale .Fe in plant has a role in making chlorophyll ,energy Transfer ,forming and fabrication some enzymes and nitrogen fixation (Li and Yang, 2014؛ Xiong *et al.*, 2014). In plant short age or deactivation of Fe make Cause of chloros is or yellowing of leaves, whereas still Its veins remain green. In sever shot age of Fe Leaves become White and finally becomes necrotic. Fe is one of the most abundant elements in the soil. Its low solubility is cause of create non-absorbable Fe for plant (Ito *et al.*,201). Fe oxidation from two to three valence may be change the iron availably that is a very important point in semi and arid of Iran regions (Xiong *et al.*, 2014; Tat *et al* 2013). Converter sludge is By-product of Isfahan steel Company .This product be formed in the step of oxidation of molten iron in company of Steel production. In this step, when oxygen injected into the furnace (converter) spread out dust from the furnace. These particles damage the Installations and devices so collected with water and after drying kept in stock.

Every ton of steel produce 13 to 18 kg converter sludge is in powder form that is existence a number of macronutrients element (calcium, magnesium and phosphorus) and micronutrients element (iron and manganese) at high concentrations. Its powder form (high specific surface) and relatively existence large amounts of Fee especially divalent Fe strengthen possibility of its use as a Fe Fertilizer. (United Nations, 1990). With the rapid development of industry and agriculture in many parts of the world, heavy metal pollution in soil has become a global problem.(Alrashid and Sulaiman, 2013؛ Wa *et al.*, 2014). Although heavy metals can be naturally through the erosion of rocks cumulate in the soil, but this natural resource has less important compared to the pollution caused by human activities Including mining, building industrial plants, fossil fuels, chemical and organic Fertilizers, industrial waste and sewage sludge . (Tokalioglu *et al.*, 2003)

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One of the main results and the inevitability of industrial development is entry of many pollutants in different parts of the environment including soil, water and air. Heavy metals are one of the causes of environmental pollution. Accumulation of heavy metals in agricultural soil causes a significant increasing in the uptake of metals by plants. Consequently, it is dangerous to human health (Ok *et al* ,2011؛Zeng *et al.*, 2011) Therefore, it is necessary to clean up contaminated soils of heavy metals (Yao *et al.*, 2012؛ Shi *et al*., 2009). Heavy metals such as arsenic, antimony, cadmium, chromium, mercury, zinc, Pb are very important in relation to soil contamination. Increasing the amount of this metals is cause of creation disorders in plant metabolism including reduction photochemical efficiency of photosystem II as a result of the toxicity of cadmium and nickel. Transport of heavy metals into the food chain is a serious risk that to reduce its risks according to the standards of Europe have published limits for contaminants in food, including cadmium and lead (Celement *et al*, 2006).

Lead with atomic number 82 and the Pb sign is in the periodic table. lead is a heavy, gray, soft and malleable element that with a molecular mass of 21.207 grams in per mole, is located in the fourth group of the periodic table (1VB) This is a toxic element that can damage nervous connections and cause blood and brain disorders . Long-term exposure to this element and its salts, particularly soluble salts of lead can cause kidney disease and abdominal pains. (Taylor *et al.*, 2014؛ Almeida *et al.*, 2013). Lead poisoning occurs when increase the concentration of lead in the blood .Lead poisoning has been known from 2000 BCE .Dissolution of Pb pipes was considered one ways of entering the drinking water of cities .Pb in the body may be com position inside bone and replaced by calcium. Signs and symptoms of lead poisoning are include anorexia, anemia, abdominal pain, muscular, progressive paralysis of the body and create a water hazard at the junction of the teeth and gums (Poliuca *et al*, 1990). The use of organic Fertilizers because of having beneficial effects on physical and chemical properties of soil has been known as an important method in Soil Fertility .However, excessive use of Fertilizers leads to accumulation of heavy metals in the soil and enter the food chain. Nowadays, organic Fertilizers have been highly used due to their rich in nutrients such as nitrogen, phosphorus and potassium. The results of several studies indicated an increase in the availability of heavy metals by the use of organic Fertilizers (Moradi *et al.*, 2005؛ Hemmat *et al.*, 2010). Although the role of mineral fertilizers on the changes in heavy metal availability cannot be ignored. Generally, availability of elements in organic compounds is much lower than the metal salt of these elements. According to many researchers, the availability of metals in soil treated with organic compounds is much less than the treated soil metals and mineral resources (Basta et al, 2005; Bolan *et al*, 2004). Probably the common divalent of Fe and Pb, these elements may be having antagonistic effects. So that, this research was conducted to evaluate the effect of converter sludge and cow manure on corn iron availability in a Pb contaminated soil in Markazi province.

MATERIALS AND METHODS

This study was conducted to investigate the effect of converter sludge and cow manure on corn Fe concentration. Treatments were consist of applying 0 (C0), C1 (15) and C2 (30) ton ha^{-1} of enriched cow manure with converter sludge in amount of 0 and 5.0% soil (W/W). In addition soil was contaminated with 0, 200, 300 and 400 mg Pb kg^{-1}. A factorial experiment using randomized complete block design was used in three replications as a pot experiment.
Initially, Pb salt as lead nitrate was added to the soil at concentrations above and its humidity was kept at 70% farm field capacity. Then the samples were incubated for two weeks to reach equilibrium. On the other hand, cow manure enriched with the converter sludge at the rates of 0 and 0.5 % by weight and regularly wet and dried to reach the equilibrium. After two weeks, the cow manure enriched samples were air-dried, ground and mixed with the soil in mentioned proportions and the samples were incubated for one month to reach equilibrium. Five seeds were planted in each pot. During the period of study, there was no use of Fertilizer or pesticide and watering pots were evenly once time in every 3 or 4 days. During the experiment, all of the pots received the similar environmental conditions (heat and light). After two months of the begging the experiment, roots and stems were harvested and washed twice with distilled water. Then the roots were dried in an oven at 65 ° C. and Pb availability was measured by atomic absorption spectroscopy using Perkin Elmer 3030. Statistical analyzes were performed by using SAS software and comparisons were compared by Duncan test and graphs were plotted by using Excel software.

RESULTS AND DISCUSSION

Physical and chemical properties of the treatments are shown in Table 1. To investigate the effect of converter sludge and cow manure on corn Pb concentrations a soil with a low organic carbon percentage , low lime and relatively non-

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saline soil with medium texture was selected. Some soil physical and chemical properties has been tested is shown in Table 1.

Table 1. Physical and chemical characteristics of soils in this experiment

Parameters	Unit	Amount
PH	-	**7.2**
EC	dS m^{-1}	**1.00**
OC	mg kg^{-1}	**0.1**
soil Texture	-	**Loam**
$CaCo_3$	Percent	**14**
Total Pb	mg/kg	**3**
Total Cd	mg/kg	**2**
Fe	mg/kg	**3**
CEC	Cmol kg^{-1} soil	**11.9**
Iron	mg kg^{-1}	**3**

The converter sludge used in this study is a by-product of Isfahan Steel Company and as an enrichment of organic Fertilizer (cow manure) has been used in this experiment. The chemical properties of the converter sludge are shown in Table 2.

Table 2. chemical characteristics of converter sludge (%)

Element	Amount	Element	Amount
P_2O_5	0.1	Fe_2O_3	57.2
MnO	3	Fe_0	27.1
ZnO	0.1	Cao	9
V_2O_5	0.7	SiO_2	1.1
S	0.1	MgO	0.3
Na_2O	0.2	Al_2O_3	0.4
K_2O	0.7	Fe_2O_3	57.2

In addition, heavy metals concentration (mg kg^{-1}) in cow manure used in this study is lower than the standard set by USEPA 503.

Effect of cow manure on soil chemical properties

Application of 15 and 30 tone ha^{-1} cow manure increased the soil organic carbon by 67.18 and 80.51%, respectively. As a result increasing organic carbon can affect nutrition availability and can improve the nutritional status of the plant (Fig.1).

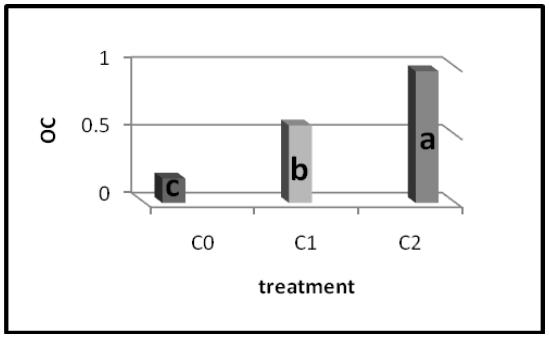

Fig. 1. Effect of application of cow manure on soil organic carbon(%).C_0 C_1 and C_2,are applying cow manure at the rates of 0,15 and 30 ton ha^{-1}.

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Also, the application of 15 and 30 ton ha^{-1} of cow manure caused a significant increasing in cation exchange capacity by 13.27 and 21.54 % compared to the control soil, respectively (Fig. 2).

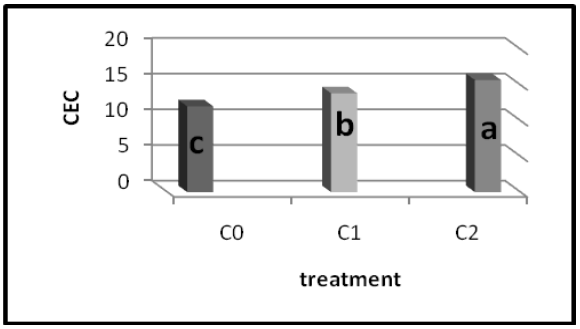

Fig. 2. Effect of application of cow manure on soil CEC .C_0 C_1 and C_2 ,are applying cow manure at the rates of 0,15 and 30 ton $ha^{-1.}$.

Adding cow manure to soil can affect the Soil pH. Increasing the loading rates of cow manure significantly increased the soil pH in this research, as, applying 15 and 30 ton ha^{-1} cow manure significantly increased the soil pH by 0.2 and 0.4 units compared to the soil without appling organic fertilizer (Fig.3).

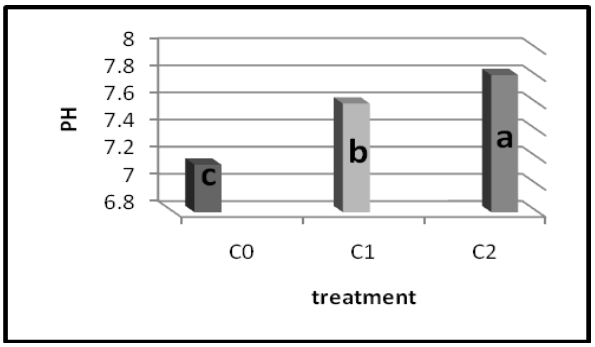

Fig. 3. Effect of application of cow manure on soil PH .C_0 C_1 and C_2 ,are applying cow manure at the rates of 0,15 and 30 ton $ha^{-1.}$.

Effect of converter sludge and cow manure on corn Fe concentration

Analysis of variance table showed a significant effect of applying converter sludge, cow manure and different Pb concentration on corn Fe concentration (Table 3).

Table 3. Effects of converter sludge, cow manure and different pb concentration on corn Fe concentration

variable	DF	Mean Squares
		Root-Fe
Block	2	30.788**
Cow manure	2	746564.80**
Converter Sludge	1	5035551.125**
Pb	3	108688.836**
Cow manure × Converter sludge	2	113245.48**
Cow manure × Pb	6	1292.179**
Converter Sludge × Pb	3	21192.486**
Cow manure × Converter sludge × Pb	6	2641.975**
Error	**46**	**7.707**

**: Significant (1%) ns: Not Significant.

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Effect of cow manure and converter sludge on root Fe concentration

According to this study, Application of 15 and 30 ton ha^{-1} cow manure significantly increased root Fe concentration by 48.95 and 60.03 % relative to the soil without applying cow manure, respectively (Fig.4).

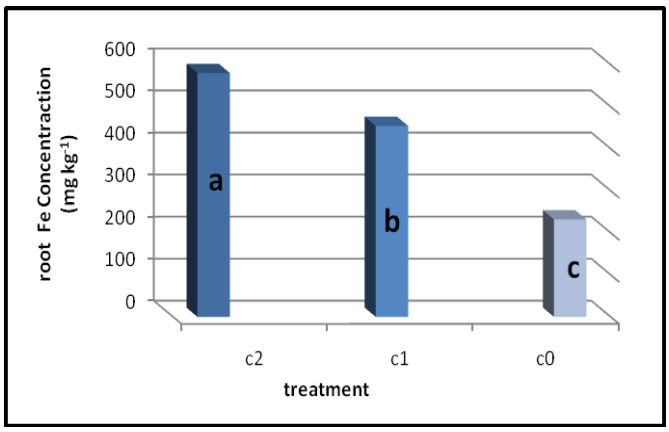

Fig 4. Effect of cow manure on root Fe concentration, C_0, C_1, C_2 are applying cow manure at the rates of 0,15 and 30 ton ha^{-1}, respectively.

On the other hand, application of sludge converter at the dose of 5.0% soil (W/W) caused 80.73 percentage increasing in Fe concentration of corn plant (Fig. 5) that is a positive effect in nutrient management studies. It may be concluded that converter sludge as a by-product of Isfahan Steel Company can be useful as an iron fertilizer and can be affect on iron availability.

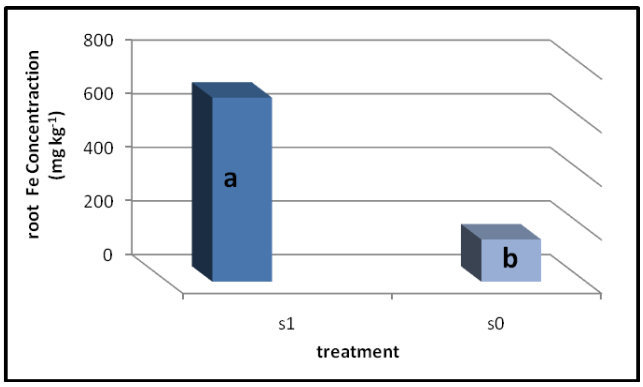

Fig 5. Effect of converter sludge on root Fe concentration, S_1 and S_0 are applying iron slag at the rates of 0 and 0.5% soil (W/W), respectively.

Different Pb concentration had a significant effect on root Fe concentration of corn plant. The results of this study showed that increasing the loading rates of Pb from 0 to 200, 300 and 400 mg kg^{-1} soil significantly decreased the root Fe concentration by 11.89, 21.11 and 34.79 percentage, respectively (Fig.6). It may be concluded that lead and iron have an antagonistic effects, as, increasing the Pb concentration decreased the root Fe convention that is a negative effect in contaminates soils.

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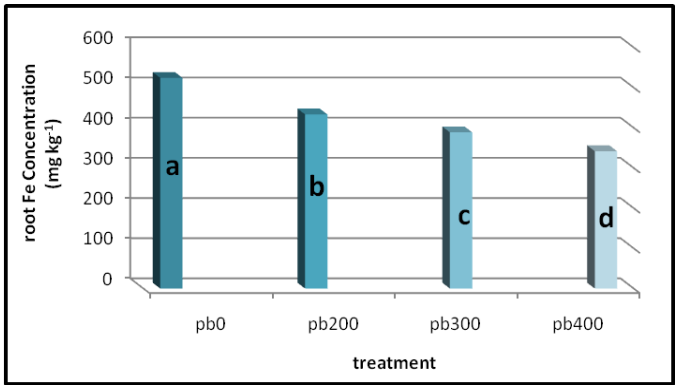

Fig. 6 – Effect of different Pb concentration on root Fe concentration, Pb_0, pb_{200}, pb_{300} and pb_{400} are soil contaminated with 0,200,300 and 400 mg Pb Kg^{-1} soil, respectively.

The analysis variance (Table 3) indicated a significant Interaction effect of cow manure and converter sludge on Fe concentration in root of corn plant. C_2S_1 treatment that is containing 30 ton ha^{-1} cow manure and 0.5 % soil (W/W) converter sludge showed the maximum amount of Fe concentration in the root of corn plant. Applying C_2S_1 treatment significantly increased root Fe concentration by 71.95 percent compared to the similar plant without receiving converter sludge (C_2S_0) (Fig.7). The minimum root Fe concentration was observed in C_0S_0 treatment. Applying 30 ton ha^{-1} converter sludge cow manure (C_2S_1) significantly increased the root Fe concentration by 19.30% relative to C_1S_1 treatment. Furthermore, applying 15 ton ha^{-1} cow manure in a soil without receiving converter sludge significantly increased the root Fe concentration by 76.59% relative to C_0S_0 treatment. These results indicate that adding cow manure and converter sludge can affect the Plant iron availability (Fig.7).

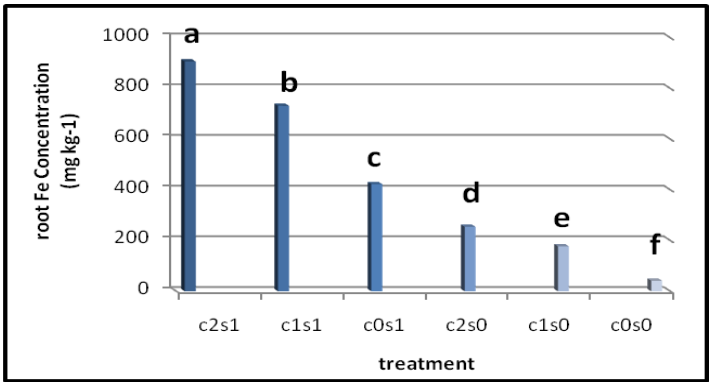

Fig. 7- Interaction effect of cow manure and converter sludge root Fe concentration C_0, C_1, C_2 are applying cow manure at the rates of 0,15 and 30 ton ha^{-1}, S_1 and S_0 are applying iron slag at the rates of 0 and 0.5% soil (W/W), respectively.

The interaction effect of cow manure and soil contaminated with different Pb concentration on root Fe concentration was also significant (Table 3). The greatest and least root Fe concentration was observed in C_2Pb_0 and C_0Pb_{400}. Increasing the loading rates of Pb from 200 (C_1Pb_{200}) to 300 (C_1Pb_{300}) mg kg^{-1} soil significantly decreased the root Fe concentration by 6.57% (Fig.8). In addition, applying 15 ton ha^{-1} cow manure (C_1Pb_{200}) significantly increased the root Fe concentration by 46.03 % relative to the soil without receiving cow manure and contaminated with 200 mg Pb kg^{-1} soil (C_0Pb_{200}).

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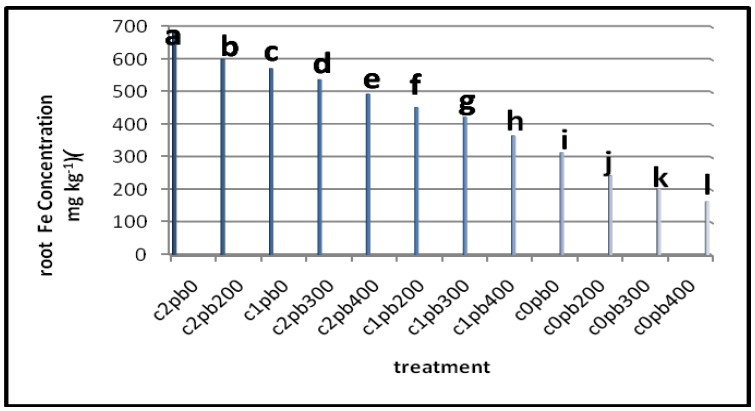

Fig. 8 – interaction effect of cow manure and pb on root Fe concentration C_0, C_1, C_2. Are applying cow manure at the rates of 0,15 and 30 ton ha^{-1}, and Pb_0, pb_{200}, pb_{300} and pb_{400} are soil contaminated with 0,200,300 and 400 mg Pb Kg^{-1} soil, respectively.

The results of Table 3 indicated a significant effect of converter sludge and Soil contaminated with Pb on root Fe concentration of corn plant. Treatment containing enriched cow manure with 0.5% soil (W/W) converter sludge and contaminated soil (S_1Pb_0) showed the maximum root Fe concentration. The minimum root Fe concentration was observed in S_0Pb_{400} treatment that is a soil with 400 mg Pb kg^{-1} soil and without receiving converter sludge (Fig. 9).

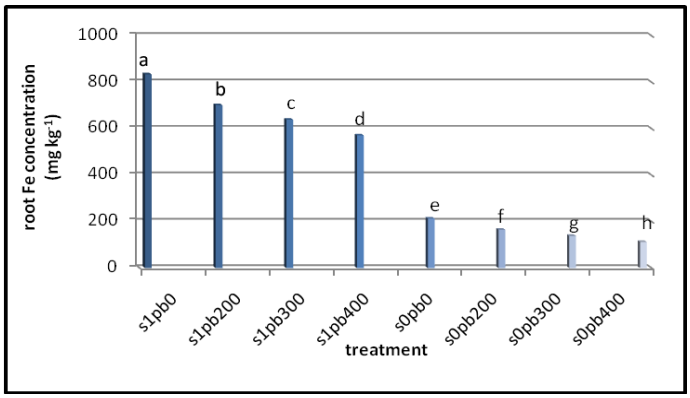

Fig. 9 - Interaction effect of Pb and converter sludge on root Fe concentration, S_1 and S_0 are applying iron slag at the rates of 0 and 0.5% soil (W/W) Pb_0, pb_{200}, pb_{300} and pb_{400} are soil contaminated with 0,200,300 and 400 mg Pb Kg^{-1} soil, respectively.

The results of Table 4 show that (C_2S_1 Pb_0) treatment containing 30 ton ha^{-1} cow manure with 0.5% soil (W/W) converter sludge and non- polluted has the maximum amount of Fe concentration in the root of corn plant.

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Table 4–Interaction effect cow manure, different Pb concentration and converter sludge on root Fe concentration

Treatment	Pb_{400}	Pb_{300}	Pb_{200}	Pb_0
C_0S_1	321.1^{l}	395.56^{k}	451.06^{j}	**521.06^{j}**
C_0S_0	8.13^{w}	12.03^{w}	38.5^{v}	**107.26^{u}**
C_1S_0	131.2^{t}	175.5^{s}	186.1^{r}	**219.06^{p}**
C_1S_1	601.3^{h}	675.1^{g}	721.16^{f}	**927.33^{c}**
C_2S_0	198.06^{q}	231.23^{o}	271.28^{n}	**316.1^{m}**
C_2S_1	791.3^{e}	846.4^{d}	932.8^{b}	**1054.8^{a}**

C_0, C_1, C_2 are applying cow manure at the rates of 0,15 and 30 ton ha^{-1}, S1 and S_0 are applying iron slag at the rates of 0 and 0.5% soil (W/W), Pb_0, pb_{200}, pb_{300} and pb_{400} are soil contaminated with 0,200,300 and 400 mg Pb Kg^{-1} soil, respectively.

Applying 0.5 % (W/W) converter sludge in a 15 ton ha^{-1} cow manure amended soil ($C_1S_1Pb_{200}$) significantly increased the root Fe concentration by 74.19% relative to the soil without receiving converter sludge in a soil contaminated with 200 mg Pb kg-^{1} soil ($C_1S_0Pb_{200}$). Applying 30 ton ha^{-1} cow manure in a non-contaminated soil significantly increased the root Fe concentration by 70.03 percent (Table 4). According to the results of Table 4, applying 30 ton ha^{-1} cow manure enriched with converter sludge (0.5% soil (W/W)) in a soil contaminated with 200 mg Pb kg^{-1} soil in a soil contaminated with 200 mg Pb kg^{-1} soil ($C_2S_1Pb_{200}$) significantly decreased the root Fe concentration by 16.15% relative to the soil contaminated with 400 mg Pb kg^{-1} soil ($C_2S_1Pb_{400}$). Furthermore, increasing the loading rate of Pb from 0 ($C_1S_0Pb_0$) to 300 mg Pb kg^{-1} soil ($C_1S_0Pb_{300}$). Significantly decreased the root Fe concentration by 25.21% that maybe indicate the the antagonistic effect between Pb and Fe availability. In addition, cow manure application increased the root Fe concentration of corn plant, as, increasing the loading rates of cow manure from 0 to 15 ton ha^{-1} in a soil polluted with 200 mg Pb kg^{-1} soil significantly increased the root Fe concentration by nearly 3 times. Lindsay (1992) reported that the incorporation of organic matter with Fe inorganic compounds of Fe can affect the Fe availability. Chen *et al.* (1982) showed that mixing Fe sulfate with cow manure has a great effect on the Fe availability in sorghum of calcareous soils. Abbaspour and *et al*. (2005) showed that application of converter sludge can affect the iron availability in calcareous soil. However, in this study, the concentrations of heavy metals and soil physical and chemical properties were not considered.

CONCLUSION

Low iron and other micro nutrients availability are the main problems in calcareous soils of arid and semi-arid of Iran regions. Converter sludge as a by-product of Isfahan Steel Company affected the iron availability in this research. Based on the results of this research, the application of enriched cow manure with converter sludge significantly increased the Fe concentration in the corn plant. Due to the large amount of iron oxide in converter sludge, it has a large amount of negative charges neutralized which can play an important role in iron availability. Iron and lead showed antagonistic effects, as, increasing the loading rates of Pb from 0 to 400 mg kg^{-1} soil significantly decreased the corn Fe availability that is a negative point in environmental studies. On the other hand, cow manure enriched with converter sludge significantly increased the iron availability that maybe related to the role of organic and inorganic fraction of organic amendments in decreasing Pb availability and thereby, increased the corn Fe concentration. Although the role of converter sludge in increasing iron availability was observed in this research, but it is need to consider the role of physic-chemical properties and soil minerals on iron availability in the future researches.

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