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Original Article

Impact of farm manure application on maize growth and tissue Pb concentration grown on different textured saline-sodic Pb-toxic soils

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Abstract

The impact of applied farm manure (FM) on growth of maize and tissue Pb concentration in maize grown on saline-sodic sandy loam and sandy clayey loam textured Pb-toxic soils was evaluated in present pot study. The soils were spiked with Pb at 200 kg ha^{-1} soil and equilibrated for 60 days at about field capacity. Treatments were comprised of three levels of FM (0, 20 or 40 g kg^{-1} soil) arranged in completely randomized design each replicated thrice. The highest dry matter of maize shoots from sandy loam soil was recorded with the applied 40 g kg^{-1} FM. From sandy loam soil, maximum dry matter of shoots was noted with FM at 20 and 40 g kg^{-1}. Applied FM at 20 and 40 g kg^{-1} produced statically similar dry matter of maize roots in sandy clayey loam soil. While in sandy loam soil, 20 g kg^{-1} FM application resulted in significantly ($p \leq 0.05$) higher dry matter of maize roots than control treatment and 40 g kg^{-1} FM application. The applied FM at 20 and 40 g kg^{-1} consequence in statically similar shoot and root Pb concentration grown on both textured Pb-toxic soils but lower compared to that of the control soils. For post-experiment soils, minimum plant available Pb in sandy loam soil with FM at 40 g kg^{-1} was recorded while in sandy clayey loam, minimum plant available Pb was observed with the addition of FM at 20 and 40 g kg^{-1}.

Keywords: Farm manure, Organic matter, Pb concentration, Salinity, Sodicity, Pb venomous soil

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Introduction

Lead (Pb) is a toxic metal that is entering soils mostly via anthropogenic deeds (Pourrut et al., 2011). Murtaza et al. (2012) stated that due to scarcity of irrigational water in Pakistan, farmers use waste effluent, being a resource, as an alternate, en route for quality water in favour of crop production (Ghafoor et al., 2001). Nevertheless, this practice has some ecological insinuation as elevated absorption of Pb and other toxic metals in normal and salt-affected soils environment. The manufacturing industries effluent is laden with toxic metals which are released into waste water; where it is carried to the farmer's fields around the major cities for irrigational purposes. Incessant usage of raw metropolitan bilge water can escort to build up of Pb and other toxic metals in agricultural soils.

In plants, if concentration of Pb exceeds in toxicity could reason diminutive plant growth, loss of chlorophyll and root blackening. It also holds down photosynthetic rates, disturb mineral nourishment and water equilibrium, and alter hormonal eminence and affects structure of cell wall (Sharma and Dubey, 2005; Pourrut et al., 2011). Sauve et al. (2000) narrated that Pb preservation in soils is generally ascribed to exchange of ions or definite sorption on organic matter (OM), silicates and metal oxide-hydroxides. From the soils, declining Pb uptake by plants make possible permissible level in crops. It may be decreased by its sorption or precipitation from the soil solution. The most vital factor to reduce Pb phyto-availability is the use of OM (Jahiruddin et al., 1985).

The applied OM can affect the rearrangement of heavy metal (HM) in soil i.e. exchangeable forms can be changed into OM associated fractions with or the residual fractions. Organic matter influence on toxic metal fractionation depends upon two factors: (i) soil humification and (ii) pH of the soil. For instance, the configuration of soluble organo-metallic complexes strengthens the solubility of metals at high pH whereas; resultantly this effect is hindered in calcareous soils (Jahiruddin et al., 1985). The configuration of metal-organic compounds influenced the behaviour of toxic metals in two opposing ways, complexation by insoluble OM (high molecular weight humic acids) decrease bioavailability, whereas the formation of soluble organic complexes (organic acids, hydroxamate siderophores) could enhance bioavailability.

After wheat and rice maize is the 3rd vital crop all around the globe (Pal et al., 2006). In most of the regions including Africa, Asia and North America maize is used as a staple food. The annual production of maize in Pakistan is 6.3 M t from an area of 1.3 M ha with 4.79 t ha^{-1} average yield (GoP, 2018). Regardless of elevated yield potentials, the average yield of maize in Pakistan is lesser than that of other maize cultivating top countries across the globe. The maize varieties are susceptible to different factors such as disease attacks, insect pests and drought stress. In addition to such factors the salinity and HM toxicity also plays critical role in affecting growth and yield of maize production (Ghani, 2010).

Metal concentration could increase or decrease in plants because of rise in soil salinity. The Pb uptake by corn shoots enlarged as influenced by high NaCl salinity than those developed under less saline conditions (Izzo et al., 1991). Keeping all the other soil characteristics alike, it has been pragmatic that, soils having elevated clay contents liable to keep bigger quantity of toxic metals compared to coarse-textured soils (Ahmad et al., 2011).

To date, no report is available in literature regarding impact of farm manure application on maize growth and tissue Pb concentration particularly in different textured saline-sodic soils. Therefore, the present experiment was commenced as 1) to assess the outcome of FM on availability of Pb to maize in texturally different saline-sodic Pb toxic soils 2) to assess the efficacy of applied FM to halt Pb in different textured Pb toxic soils.

Material and Methods

To assess the consequences of applied FM on the phyto-availability of Pb to maize plants, the pot trial was performed at the Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad. Two types of saline-sodic soils were collected from selected spots around Faisalabad Metropolitan.

After sampling soils were air dried, sieving by using 2 mm sieve and separated accordingly. Soils were examined for physical and chemical characteristics i.e., texture, pH_s, EC_e, CEC, OM (Iqbal et al., 2015), total Pb (Amacher, 1996) and plant available Pb (Soltanpour, 1985; Iqbal et al., 2016) before and at the termination of pot study.

Table-1: Characteristics of soils used in study (mean ± SD, n=3)

Characteristic	Value	
Textural class	Sandy loam (SL)	Sandy clay loam (SCL)
Sand (%)	69.25 ±0.49	63.50 ±0.48
Silt	14.17 ±0.26	15.01 ±0.52
Clay	16.76 ±0.30	21.97 ±0.57
pH$_s$	7.97 ±0.27	7.81 ±0.23
EC$_e$ (dS m^{-1})	7.28 ±0.23	7.24 ±0.22
TSS (mmol$_c$ L^{-1})	85.13 ±0.82	85.42 ±0.29
CO_3^{2-} (mmol$_c$ L^{-1})	Absent	0.41 ±0.08
HCO_3^- (mmol$_c$ L^{-1})	7.54 ±0.37	7.87 ±0.24
Cl^- (mmol$_c$ L^{-1})	18.80 ±0.69	21.20 ±0.50
*SO_4^{2-} (mmol$_c$ L^{-1})	58.92 ±0.80	56.29 ±0.59
Ca^{2+} + Mg^{2+} (mmol$_c$ L^{-1})	13.97 ±0.65	12.73 ±0.61
Na^+ (mmol$_c$ L^{-1})	65.24 ±0.93	70.82 ±0.37
K^+ (mmol$_c$ L^{-1})	1.77 ±0.06	0.49 ±0.06
SAR (mmol L^{-1})$^{1/2}$	24.63 ±0.96	27.54 ±0.66
**Ca^{2+} + Mg^{2+} (cmol$_c$ kg^{-1})	3.74 ±0.29	4.50 ±0.82
Na^+ (cmol$_c$ kg^{-1})	1.17 ±0.07	1.68 ±0.07
K^+ (cmol$_c$ kg^{-1})	0.62 ±0.04	0.38 ±0.04
CEC (cmol$_c$ kg^{-1})	5.45 ±0.05	6.54 ±0.05
OM (%)	0.92 ±0.05	0.87 ±0.05
SP (%)	28.42 ±0.52	29.27 ±0.71
Plant available Pb (mg kg^{-1})	1.87 ±0.05	1.59 ±0.08
Total Pb (mg kg^{-1})	9.50 ±0.29	5.88 ±0.46

The soils were spiked with Pb at 200 kg ha^{-1} as $Pb(NO_3)_2$. Farm manure was added into soil on air dry weight basis, i.e. 20 or 40 g kg^{-1}. In this study, amendments at designed rates were applied 60 days prior to sowing. Soils of each treatment were packed in white glazed pots at 12 kg per pot, replicated thrice in completely randomized design. The maize hybrid-6525 was sown in pots using 5 seeds per pot. The fertilizers used for the crop were urea, DAP and SOP, respectively. In each pot, two plants were retained after 15 days of the germination. Crop was reaped after 60 days of germination. Root and shoot samples were collected independently.

Oven dried samples were digested in di-acid (3:1, HNO_3 + $HClO_4$) for Pb determination (AOAC, 1990). Farm manure used in the experiment was analyzed for Pb (AOAC, 1990), while fertilizers were analyzed for water soluble Pb (Table 3) with flame atomic absorption spectrophotometer (FAAS).

Pumped ground water was examined for soluble cations and anions by titration method while Pb was determined with FAAS following Iqbal et al. (2015) (Table 2).

The obtained data was statistically analyzed following ANOVA via MSTATC Version 1.10 computer software package (Steel et al., 1997).

Table-2: Ionic composition of water used for irrigation (mean ± SD, n=3)

Parameter	Value
EC (dS m^{-1})	0.62 ±0.02
TSS (mmol$_{c\ L}$$^{-1}$)	6.20 ±0.30
CO_3^{2-} (mmol$_{c\ L}$$^{-1}$)	Absent
HCO_3^- (mmol$_{c\ L}$$^{-1}$)	3.03 ±0.15
Cl^- (mmol$_{c\ L}$$^{-1}$)	2.52 ±0.24
*SO_4^{2-} (mmol$_{c\ L}$$^{-1}$)	0.61 ±0.03
Ca^{2+} + Mg^{2+} (mmol$_{c\ L}$$^{-1}$)	4.24 ±0.20
Na^+ (mmol$_{c\ L}$$^{-1}$)	1.78 ±0.17
RSC (mmol$_{c\ L}$$^{-1}$)	Nil
SAR(mmol L^{-1})$^{1/2}$	1.23 ±0.06
Pb	Traces

Table-3: Concentration of Pb (mg kg $^{-1}$) in farm manure and fertilizers (mean ± SD, n=3)

Amendment/Fertilizer	Pb
Farm manure (FM, mg kg^{-1})	1.30 ± 0.09
Diammonium phosphate (DAP, mg kg^{-1})	0.46 ± 0.03
Urea	Traces
Sulphate of potash (SOP)	Traces

Results and Discussion

The phyto-availability and destiny of HM in environment is highly influenced by their reactions with OM in soil. The OM also affects metal retention and transformations in soil. The metal apportionment in soil depends on the nature, stability and application rate of OM. In this regard the results of current study are presented in the following sections.

Effect of farm manure on maize shoot dry matter in texturally different saline sodic Pb-toxic soils

Statistical analysis showed that interaction FM × soil affected significantly ($P \leq 0.05$) the shoot dry matter (SDM). The highest SDM was 21.78 g pot^{-1} that was recorded in sandy clayey loam soil where the applied FM was 20 g kg^{-1}. While 65.63% change was noticed in comparison with the control treatment. From sandy loam soil, maximum SDM of 14.49 g pot^{-1} amended with FM at 20 g kg^{-1} was harvested, the increase was 34.1% compared with that of control. Furthermore, minimum SDM was recorded in the controls of sandy clayey loam and sandy loam soils, i.e. 13.1 and 10.8

g pot^{-1} respectively. In both the soils, applied FM at 20 and 40 g kg^{-1} produced statically similar SDM.

The high SDM with FM can be attributed due to the reason that Pb complexing characteristics of OM and better accessibility of plant nutrients from scarcely soluble hydroxides and upon mineralization of FM (Stevenson, 1991; Nardi et al., 2002). The decomposition of added FM proved to be beneficial in adding more plant nutrients to the crops which increased SDM. In the present experiment, high SDM from sandy clayey loam soil in comparison with sandy loam soil can be induced because of better nutrients availability owing to higher CEC of the former than the later soil. Similar trend in results regarding SDM with OM application had been reported by Rotkittikhun et al. (2007) who established that applied of pig manure at 20% was mainly valuable for getting better biomass of *Vetiveria zizanioides* in Pb-mine soils. Ye et al. (1999) concluded that adding pig manure considerably improved the development of *T. maxima* grown in lead mine soils. Yang et al. (2003) described that shoot dry matter of *Vetiveria zizanioides* in control Pb/Zn mine tailings was less and increased considerably when these tailings were amended with domestic refuse at 37.5 t ha^{-1}.

Table-4: Impact of farm manure on maize shoot dry matter in texturally different saline-sodic Pb toxic soils

Treatment	Shoot dry matter (g pot^{-1})		FM mean
	Sandy loam	Sandy clay loam	
200 kg Pb ha^{-1} saline-sodic soil	10.8 c	13.1 b	11.9 B
200 kg Pb ha^{-1} saline-sodic soil + 20 g kg^{-1} FM	14.4 b (34.1)	21.7 a (65.6)	18.1 A (51.4)
200 kg Pb ha^{-1} saline-sodic soil + 40 g kg^{-1} FM	13.5 b (25.5)	22.3 a (69.6)	17.9 A (49.7)
Texture mean	12.9 B	19.0 A	1.5
LSD	1.2		

The increase or decrease over respective control is illustrated through the values given in parenthesis. The values pursue by similar letter(s) are not statistically different at $p \leq 0.05$.

Ahmad et al. (2011) described that applied farm manure at 15 and 30 t ha^{-1} in Pb and Cd metals spiked soils considerably improved the dry matter yield of wheat crop over that from the control. In the present experiment, treatments which decreased SDM (Table 4) might be attributed to high Plant available Pbin soils which increased Pb concentration in maize shoots and might have decreased epidermal cell size, mesophyll, thickness, chlorophyll and carotenoids contents and vessels diameter (Kovacevic et al., 1999). Shoot tissues proved more sensitive than roots, which could decrease the shoot biomass production compared to that of roots (Kahle, 1993).

Effect of farm manure on maize root dry matter in texturally different saline-sodic toxic soils

Applied FM in sandy clayey loam soil at 20 and 40 g kg^{-1} produced statistically ($P \leq 0.05$) similar RDM of 5.7 and 5.6 g pot^{-1}, increase being 52.6 and 51.0%, respectively over that with the control treatment. The addition of 20 g kg^{-1} FM produced RDM of 6.1 g pot^{-1} which is higher than that from the control and 40 g kg^{-1} FM application in sandy loam soil,. The applied FM at 40 g kg^{-1} in this soil produced RDM which is statistically similar to that of the control. The RDM yield from sandy clayey loam soil was considerably higher than that from the sandy loam soil.

Table-5: Impact of farm manure on maize root dry matter in texturally different saline-sodic Pb toxic soils

Treatment	Root dry matter (g pot^{-1})		FM mean
	Sandy loam	Sandy clay loam	
200 kg Pb ha^{-1} saline-sodic soil	3.37 b	3.76 b	3.56 C
200 kg Pb ha^{-1} saline-sodic soil + 20 g kg^{-1} FM	6.16 a (82.7)	5.74 a (52.6)	5.95 A (67.1)
200 kg Pb ha^{-1} saline-sodic soil + 40 g kg^{-1} FM	3.77 b (11.8)	5.68 a (51.0)	4.7 B (32.8)
Texture mean	4.43 A	5.06 A	0.78
LSD	1.10		

The increase or decrease over respective control is illustrated through the values given in parenthesis. The values pursue by similar letter(s) are not statistically different at $p \leq 0.05$.

The high RDM with FM can be attributed due to the Pb complexing characteristics of OM (Stevenson, 1991; Nardi et al., 2002). Decomposition of added

FM also played a vital role. In pot study, the decomposition of added FM during the initial period of pot study provided more plant nutrients to maize crop which increased RDM (Singh et al., 1997).

In the current trial, treatments which decreased RDM seem due to high Plant available Pb in soil. Due to which, there was a high concentration of Pb in maize roots (Table 5) which decreased growth through the hindrance of cell division in root tips (Eun et al., 2000), mitotic irregularities, chromosome stickiness (Wierzbicka, 1994), irregular shaped nuclei with decomposed nuclear material and outflow of K^+ from root cells (Malkowski et al., 2002).

Effect of farm manure on Pb concentration in maize shoots from texturally different saline-sodic Pb-toxic soils

Manure and texture significantly ($P \leq 0.05$) affected the shoot Pb concentration. While, the FM × texture interaction non-significantly affected the shoot Pb concentration in both the soils. However, shoot Pb concentration in sandy clayey loam soil decreased by 41.9% with FM at 40 g kg^{-1} and in sandy loam soil, decrease was 28.4% with FM at 20 g kg^{-1} contrasted to that with the control. Shoots attained the higher concentration of Pb in controls of both the soils compared to FM receiving treatments.

Applied FM at 20 and 40 g kg^{-1} in both the soils had a similar effect and decreased the shoot Pb concentration compared to that with the control. Overall, the shoot Pb concentration in sandy clayey loam soil was lower compared to in shoots from sandy loam soil.

In order to avoid Pb concentrations entering in the food chain lower Pb concentration in shoots are preferred (Pitchel et al., 2000; Taylor and Percival, 2001). The reduction in Pb concentration of maize shoots with the applied FM in both the soils could be attributed to FM which contained relatively high proportion of humified OM to form stable complexes with soluble Pb (Shuman, 1999; Strawn and Sparks, 2000).

The decrease in shoot Pb concentration and phytotoxicity to maize could be due to addition of FM which has immobilized Pb in both the soils through its adsorption and precipitation process with soluble P (Geebelen et al., 2002; Seaman et al., 2003).

Table-6: Impact of farm manure on Pb concentration in maize shoots from texturally different saline-sodic Pb toxic soils

Treatment	**Pb concentration (mg kg $^{-1}$) in maize shoots**		**FM mean**
	Sandy loam	**Sandy clay loam**	
200 kg Pb ha^{-1} saline-sodic soil	25.9	19.5	25.2 A
200 kg Pb ha^{-1} saline-sodic soil + 20 g kg^{-1} FM	18.5 (-28.4)	12.3 (-36.9)	15.4 B (-38.8)
200 kg Pb ha^{-1} saline-sodic soil + 40 g kg^{-1} FM	19.3 (-25.3)	11.3 (-41.9)	15.5 B (-38.2)
Texture mean	22.4 A	15.1 B	2.71
LSD	2.21		

The increase or decrease over respective control is illustrated through the values given in parenthesis. The values pursue by similar letter(s) are not statistically different at $p \leq 0.05$.

At the end of this pot study, a decrease in plant available Pb was recorded over that of the controls with 2 and 40 g kg^{-1} FM amended soils was observed. It can be concluded that in FM amended soils there was less available Pb to plants compared with the controls. This low soil Pb caused lower Pb concentration in shoots of maize crop.

Effect of farm manure on Pb concentration in maize roots from texturally different saline-sodic Pb-toxic soils

The Pb concentrations in roots were considerably affected by applied manure and soil texture. Minimum concentration of Pb recorded in the roots of plants grown in sandy loam and sandy clayey loam soil (i.e. 31.1 mg kg^{-1}), and Pb concentration in sandy loam soil was found as 41.85 mg kg^{-1} with FM at 20 g kg^{-1}. The highest concentration of Pb was observed in root samples of both controls soil samples. Furthermore, applied FM at 20 and 40 g kg^{-1} in both the soils affected a similar decrease in root Pb concentration. Overall, Pb concentration found in roots grown in sandy clayey loam soil was considerably lesser than that of the roots grown in sandy loam soils.

The decreased Pb concentration in maize roots with FM in soils might be attributed to the fact that FM contained a relatively high proportion of humified OM which formed stable complexes with Pb (Shuman, 1999, Strawn and Sparks, 2000). Moreover, the decrease in concentration and toxicity to maize roots with FM may be due to immobilization of Pb in both the soils via precipitation as in soluble compounds like lead phosphates (Geebelen et al., 2002; Seaman et al., 2003).

Table-7: Impact of farm manure on Pb concentration in maize roots from texturally different saline-sodic Pb toxic soils

Treatment	Pb concentration ($mg\ kg^{-1}$) in maize roots		FM mean
	Sandy loam	Sandy clay loam	
200 kg Pb ha^{-1} saline-sodic soil	57.4	45.4	51.4 A
200 kg Pb ha^{-1} saline-sodic soil + 20 g kg^{-1} FM	41.8 (-27.3)	31.1 (-31.4)	36.5 B (-29.0)
200 kg Pb ha^{-1} saline-sodic soil + 40 g kg^{-1} FM	45.5 (-20.6)	31.9 (-29.6)	38.7 B (-24.6)
Texture mean	48.2 A	36.22B	5.58
LSD	4.55		

The increase or decrease over respective control is illustrated through the values given in parenthesis. The values pursue by similar letter(s) are not statistically different at $p \leq 0.05$.

At the end of pot study, a decrease in plant available Pb was recorded over that of the controls with 20 and 40 g kg^{-1} FM amended soils. It can be concluded that in FM amended soils the available concentration of Pb was lesser in comparison with the control plants where no FM was applied. The Pb concentration in maize roots grown in sandy clayey loam soil was lesser in comparison to that of the roots grown in sandy loam soil. This might be attributed to the presence of high clay content in sandy clayey loam and the available clay content retained higher amount of Pb in the roots grown in such plants (Francois et al., 2004). In a nutshell, Pb concentration in roots was higher than its shoots. This is because the cell walls of roots accumulate Pb and allows only limited concentration of Pb to reach the shoots. Thus, roots were found with higher concentration of Pb in comparison with shoots (Huang et al., 1997).

Effect of farm manure on plant available Pb in post maize texturally different saline-sodic Pb-toxic soils

Results depicted that the acquired concentration of Pb in sandy loam soil was 109.45 mg kg^{-1} and that in sandy clayey loam soil was 105.68 mg kg^{-1}. However, the applied FM and soil texture affected plant available Pb concentrations in post experiment soil (Table 8). The minimum plant available Pb concentration was 32.9 mg kg $^{-1}$ and that was observed in sandy loamy soil. The FM applied in this soil was 40 g kg^{-1}, which resulted in decline of 50.4% Pb concentration over that of the control. In sandy clayey loam soil minimum plant available Pb concentration of was recorded, i.e. 32.6 and 32.5 mg kg^{-1}.

Maximum plant available Pb concentration of 47.4 and 66.4 mg kg^{-1} for controls of both the sandy clayey loam and sandy loam soils, respectively were recorded. Overall, considerably lower plant available Pb was recorded in the sandy clayey loam than that in sandy loam soil. In sandy clayey loam soil, FM at 20 and 40 g kg^{-1} affected similarly the plant available Pb, but was considerably lower than that in controls. While in sandy loam soil, FM at 20 g kg^{-1} decreased the plant available Pb concentration from 66.4 (control) to 48.7 mg kg^{-1} which further decreased to 32.9 mg kg^{-1} with FM at 40 g kg^{-1}.

After maize harvest, decline in Plant available Pb with FM might be due to the fact that FM initially contained a high proportion of humified OM which further increased with time to help for formation of stable complexes with lead (Shuman, 1999, Strawn and Sparks, 2000). Moreover, the immobilizing effect of OM to lower Pb in owing to precipitation as lead phosphate (Walker et al., 2003). Friedland (1989) also reported that FM decreased the total, soluble and exchangeable lead in soils, probably through chelation, complexation and/or adsorption of Pb in soils with affected FM.

A decrease in plant available Pb in sandy clayey loam soil was observed in comparison with sandy loam soil. It might be due to higher clay content. Higher clay content retains higher amount of Pb because of its available high surface area (Ahmad et al., 2011). Secondly, clay also absorbs Pb thus forms inner sphere complexes at the edges and results in decreased Pb (Francois et al., 2004).

Table-8. Impact of FM on plant available Pb in post maize texturally different saline-sodic Pb toxic soils

Treatment	Plant available Pb (mg kg^{-1}) in post maize soil		FM mean
	Sandy loam	Sandy clay loam	
200 kg Pb ha^{-1} saline-sodic soil	66.4 a	47.4 b	56.9 A
200 kg Pb ha^{-1} saline-sodic soil + 20 g kg^{-1} FM	48.7 b (-26.5)	32.6 c (-31.1)	40.5 B (-28.7)
200 kg Pb ha^{-1} saline-sodic soil + 40 g kg^{-1} FM	32.9 c (-50.4)	32.5 c (-31.4)	32.7 C (-42.5)
LSD	2.16		1.52
Texture mean	49.2 A	37.5 B	
LSD	1.24		

The increase or decrease over respective control is illustrated through the values given in parenthesis. The values pursue by similar letter(s) are not statistically different at $p \leq 0.05$.

Conclusion

In present study, maximum dry matter was observed in sandy loam soil with manure i.e. 20 and 40 g kg^{-1}. Minimum dry matter of maize shoots was recorded for the control treatment of both the soils. While in sandy loam soil, 20 g kg^{-1} FM application resulted in considerably higher dry matters of maize roots than that of control and 40 g kg^{-1} FM application. The FM at 20 and 40 g kg^{-1} resulted in statically similar the shoot and root Pb concentration grown in both the soils. Maize shoots attained elevated concentration of Pb in controls of both the soils compared to FM-amended soils.

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