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Micro Mineral Profile in Soil and Forage as Affected by Poultry Manure: A Case Study of Non Conventional Fertilizer

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Research Article

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ABSTRACT

In present study concentration of some trace minerals was determined in soil and different parts of *Avena sativa* treated with poultry waste grown in the pots. Nine different treatments of poultry waste used were: 0 (control), 60, 90, 120 and 150 kg/ha applied to soil as full doses before sowing, and 60, 90, 120, and 150 kg/ha was applied as two equal splits. The samples of soil were obtained after mixing the poultry waste with soil in each pot before sowing. Different parts (root, stem, leaves, and pods) of plants were taken after 90 days of sowing and after grain filling. Samples of soil and forages were collected and analyzed and after that soil, seeds, leaf and roots were analysed. The study showed that soil and forage Cu and, forage Zn were deficient, while soil Zn and both soil and forage Fe were optimum in relation to needs of both forage crops and livestock. Lead (Pb) and cadmium (Cd) concentration in soil was found non-significantly affected by the treatments of poultry waste and their levels were found to patterns of increase. Chromium concentration in soil was significantly affected by treatment of poultry waste while in forage it is found non-significant; it was higher but below the toxic level. Pb was found non-significant in forage and seems to be inconsistent Based on these findings, it can be suggested that the soil treatment with poultry manure, no potential risk of toxicity of metals can be anticipated as with other synthetic fertilizers being used for enhancing the soil and plant mineral concentrations. The low level of various elements in soil treated with poultry waste found in this study may be due to low amounts of trace elements in the waste or role of other edaphic factors involved in the release of minerals from the waste cannot be ruled out. The soil amendment and specifically tailored mineral mixture with appropriate proportion of these trace elements are the dire needs for livestock consuming *Avena sativa* in pasture treated with poultry waste.

INTRODUCTION

Livestock is an important agriculture sector in Pakistan including cattle, buffalo, sheep, goat and camel as livestock as Pakistan is large milk producer and the demand is rising day by day. The role of livestock can be judged from the fact that about 35 million people are engaged in raising 2-3 cattles/buffaloes and 5-6 sheep/goat in their backyard and are deriving 22-25% form it (Pakistani livestock census 2006). In 2002-03, domestic livestock were estimated that 23.3 million cattle, 24.8 million buffalo, 24.6 million sheep, 52.8 million goats. Dairy farming may prove a profitable business for small land holders; more than 70% farmers hold less than 5 acres. Livestock a valuable, sub-sector of agriculture, has a significant contribution to the economy of Pakistan as it's contributes about 51.8 % towards agricultural GDP and nearly 11.3 % to GDP of Pakistan (Economic survey, 2008-2009). Pakistan falls in fifth position among largest milk producing country. Production value of milk is greater than the value of the two major crops wheat and cotton[1]. Other beneficial aspect of the livestock is in increasing the fertility and productivity of land and proved as best comrade of farmer[2]. In developing countries 95% nutritional requirements of ruminants is fulfilled by roughages and even in advance countries, where grains are used to feed animals, 75% nutritional need of growing livestock is fulfilled by forages plants[3]. Mineral inconsistency in soil and plants is thought to be the major cause of morphological and physiological disorders in animals[4]. The livestock production is seriously affected by mineral deficiency in plants and soil. Mineral deficiency causes forage indigestibility and ultimately decreases the production efficiency of livestock[5]. Accumulation of excessive copper in liver induces copper toxicity; forage plants analysis is best indicator of mineral status of ruminants as compares to that of soil[6]. Poultry centre in country with more than 530 million birds, Pakistan is net importer of agriculture commodities. Annual imports of total about US$2 billion and include wheat addible oils pulses and consumers foods. Legumes fodder are excellent source of protein and energy for small livestock in dry seasons dry fodders still capable of providing sufficient energy and fibres of ruminant livestock. Oat is rich in body building nutrients Mg, Zn, P, vitamin A, B1, B2. Poultry waste has long been used as soil amendments to provide nutrients[7]. The objectives of this study was to evaluate the concentration of micro minerals in the soil and forages after the treatment of poultry waste to assess the mineral accumulation potential in this waste for enhancing the fertility of soil for forage plants.

MATERIALS AND METHODS

This experimental work was conducted during December 2008 to April, 2009 at the University of Sargodha, Pakistan, which falls under semi-arid climatic conditions. Avena sativa seeds were sown in the first week of December 2009 in pots filled with loamy soil at a rate of 10 seeds per pot. Following were the climatic conditions during the experiment: 18-25/10-17^{o} C day/night temperature, 55-60 % RH and 12-hour photoperiod. Poultry waste was added to the soil contained in the pots before sowing and/or before flower initiation. Split doses were applied twice, 1st just after sowing and 2nd at an interval of one month before flowering .While full dose was applied at once before sowing. The detail of varying poultry waste treatments is given in Table 1. The complete randomized design (CRD) was used in this study. Polythene pots were used for sowing the seeds of plant and each plastic pot was lined with polyethylene bag. Seven kg soil was taken in each plastic pot that was lined with polyethylene bag. Different parts of plants were harvested at maturity. Five replicates of plants from each dose were taken. All protective measures were adapted to make certain a good crop health. All the pots were irrigated with tap water throughout the experimental period.

Sample Collection

Soil and Plants

Samples of each soil and plants were taken randomly from pots that were given different doses of poultry waste. The samples of soil were obtained after mixing the poultry waste with soil in each pot before sowing. Harvest of different parts (root, stem, leaves, and pods) of plants was taken after 90 days of sowing after grain filling. All plant samples were washed well with distilled water. These samples were then air-dried, stored in labelled sealed paper bags and placed in an oven for drying for three days at 70 ^{o}C.

Wet digestion and analysis

One gram air- and oven-dried soil and plant samples were transferred to digestion tubes and 5 ml of H_2SO_4 were added to each tube. All tubes were then incubated overnight at room temperature. Then H_2O_2 (25 ml) was poured down through the sides of the digestion tubes and placed them on a hot plate to heat them until the complete digestion of the material. The volume of the extract was made up to 50 ml with distilled water. After filtering the extract, it was used for the analysis of minerals concentration. The contents of copper, zinc, iron, lead, cadmium, and chromium in soil and plant parts were determined using an atomic absorption spectrophotometer (Model #AA-6300, Shimadzu, Japan).

Statistical Analysis

The data obtained from all analyses was tested for significance at 0.05, 0.01 and 0.001 by using the software SPSS[8]. Standard error values were worked out to compare the mean values of each attribute.

Table 1. Different treatments of poultry waste applied to soil before and after sowing the forage crop

Treatment	1	2	3	4	5	6	7	8	9
	Full dose applied before sowing					Dose in two equal splits (1st split applied before sowing and the 2nd before flowering)			
Applied dose (kg h^{-1})	0 (Control)	60	90	120	150	60	90	120	150

RESULT AND DISCUSSION

Copper

Soil

The Cu concentration level found in soil was non-significantly affected (P>0.05) by treatments (Table 1).The range of Cu soil content was from 2.96 to 2.26 mg/kg. Inconsistent pattern of variation pattern was observed during present study. The highest concentration of copper was found in the 5th.treatment (Fig.1.1). The values found during present study were lower than critical value given by NRC[9]. These values were also lower from the values already investigated by Jerez *et al.*[10] in Florida values higher than the critical level studied by Khan *et al.* [11].

Forage Plant

From the analysis of variance applied on the data of Cu concentration in forage depicted that there was non-significant effect of treatment (P>0.05) on roots, leaf and seed was observed (Table. 1). The Cu concentration in the seed decreased gradually. Cu mean values were ranged from 3.40 to 2.11 mg/kg in seed. The highest value was found at 6th treatment. While in root it ranged from 2.91 to 2.38 mg/kg. In all the treatments, values increased and decreased in leaf ranged from 3.34 to 1.91 mg/kg. There was a gradual increase and decreased from 1st to 9th treatment. Low concentration of Cu in forages grazed by ruminants in studied area was of indicative of quantity and availability of this element in soil[12]. Data seemed to be demonstrated that the forage Cu concentration of forage species were affected by the soil, where they are grown. This finding corroborates with findings of Norton and Poppi[13] that the reported trace mineral values of forages are more indicative of the soil types than any other factor. High Mo intake depressed Cu availability and may produce physiological changes in ruminants [14] and has been studied by previous study that toxicity aggravates Cu in some parts of the world[6].

Table 1: Analysis of variance for Cu concentrations in soil, leaf, seed and root for various treatments.

Source of variation	Degree of freedom	Mean squares			
		Soil	Root	Leaf	Seed
Treatments	8	0.170^{ns}	0.096^{ns}	0.519^{ns}	0.519^{ns}
Error	18	0.333	0.251	0.61	0.612

ns= non significant

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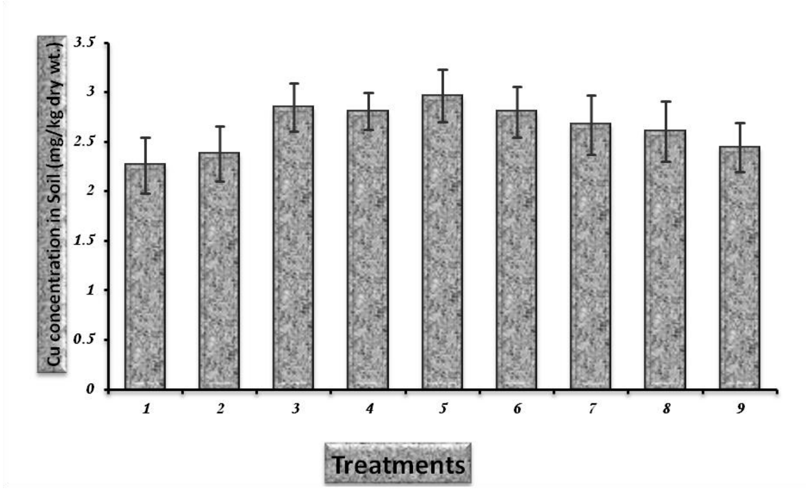

Figure 1: Variations in level of Copper in Soil for various treatments.

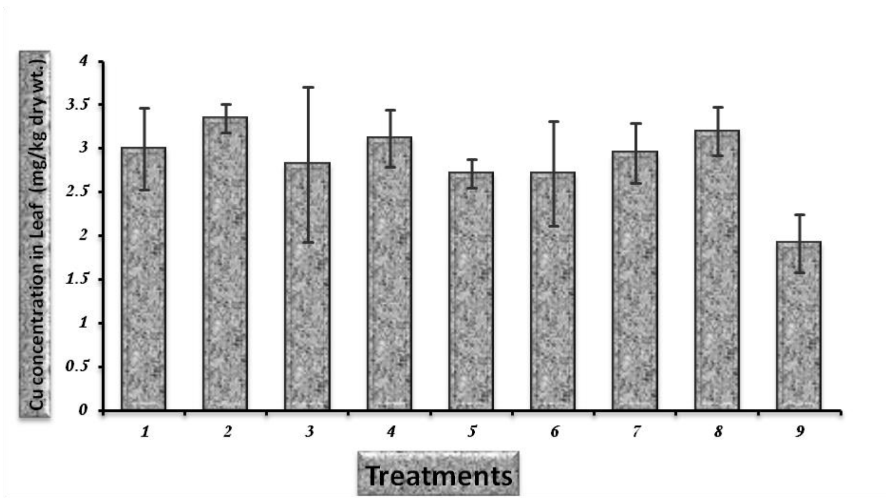

Figure 2: Variations in level of Copper in leaf for various treatments

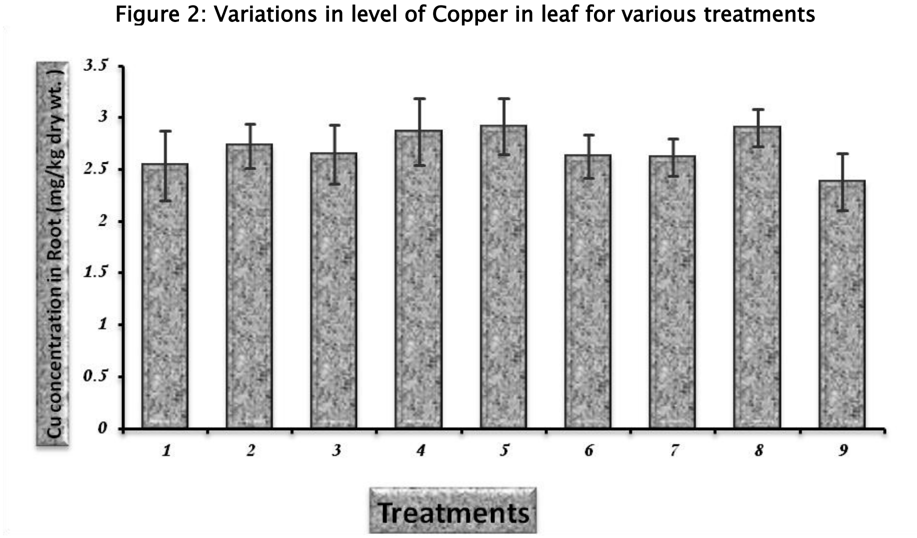

Figure 3: Variations in level of Copper in root for various treatments.

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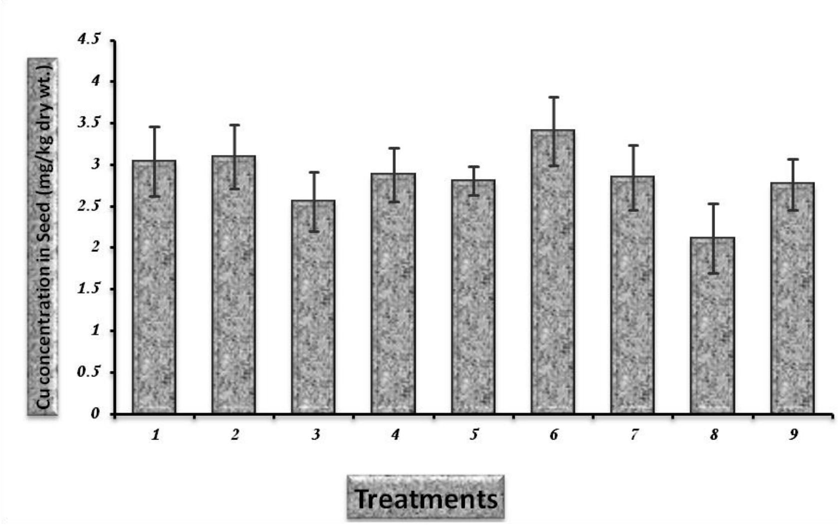

Figure 4: Variation in levels of Copper in Seed for various treatments

Zinc

Soil

From the Analysis of variance the data of soil was shown non-significant effect (P>0.05) of treatments (Table 2). Mean content in soil ranged from 19.96 to 11.34 mg/kg. The highest soil Zn was found in 9th treatment and the lowest in 2nd treatment during present study. According to Dabkowsca-Naskret[15], low level of available Zn because of neutral soil reaction is due to form of Zn bound to Iron oxide (FeO) making it unavailable to plants, but in our study sufficient amount of Zn was found than the requirement of normal plant growth.

Forage

The forage Zn concentration was non-significant (P>0.05) for seeds and roots for different treatments (Table 2). There was gradual increase and decrease found during all the treatments in all cases. The mean Zn values varied from 19.84 to 14.15 mg/kg. But slight decrease was observed during treatment 4th to treatment 9th in case of root. In leaf and seed increased and decreased values were observed. The values for forage Zn was lower than those already reported by Tiffany *et al.*[16] in Florida. All the forage values were deficient than the critical levels established for ruminants by NRC[9]. Zn content of forages was fairly lower than the standard. Similar forage Zn concentration in some forage had been reported by Fujihara *et al.*[17] in China and Espinoza *et al.*[18] in Florida. Zn concentration may be occasionally high as 30 ppm. But decline rapidly as plant matures and decrease to lower level[19]. Contrary to present findings various workers has reported higher values of Zn in forages[20, 21].

Table 2: Analysis of variance for Zn concentrations in soil, leaf, seed and root for various treatments

Source of variation	Degree of freedom	Mean squares			
		Soil	Root	Leaf	Seed
Treatments	8	10.346^{ns}	9.198^{ns}	11.899^{ns}	9.998^{ns}
Error	18	4.424	4.756	9.762	9.814

ns= non significant

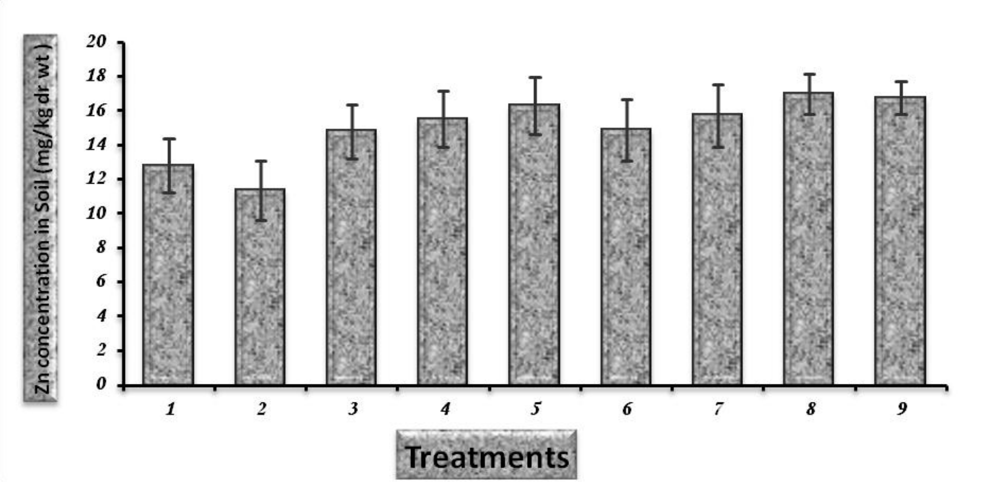

Figure 1: Variations in level of zinc in soil for various treatments

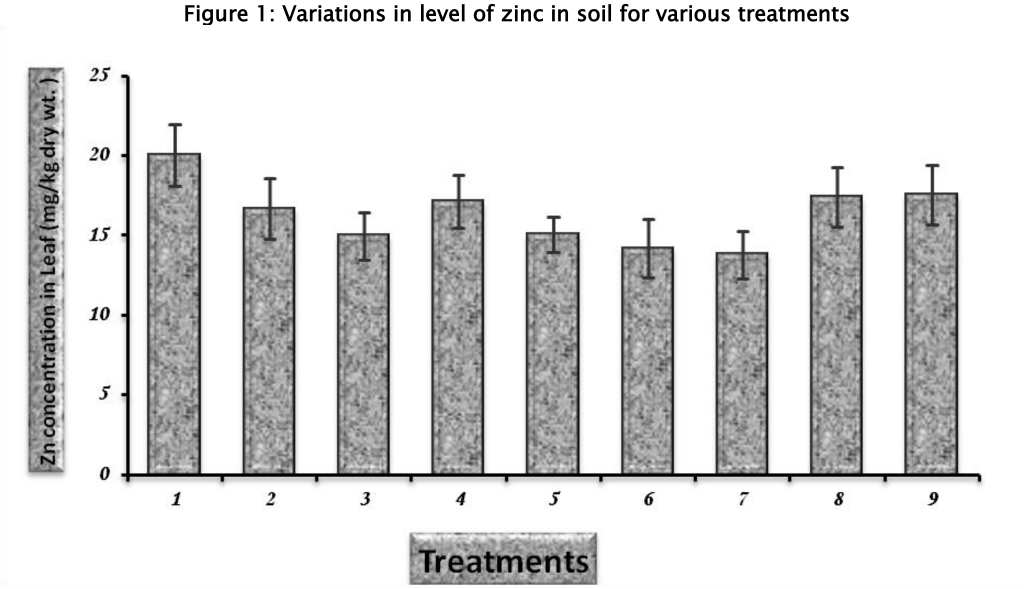

Figure 2: Variations in level of zinc in leaf for various treatments

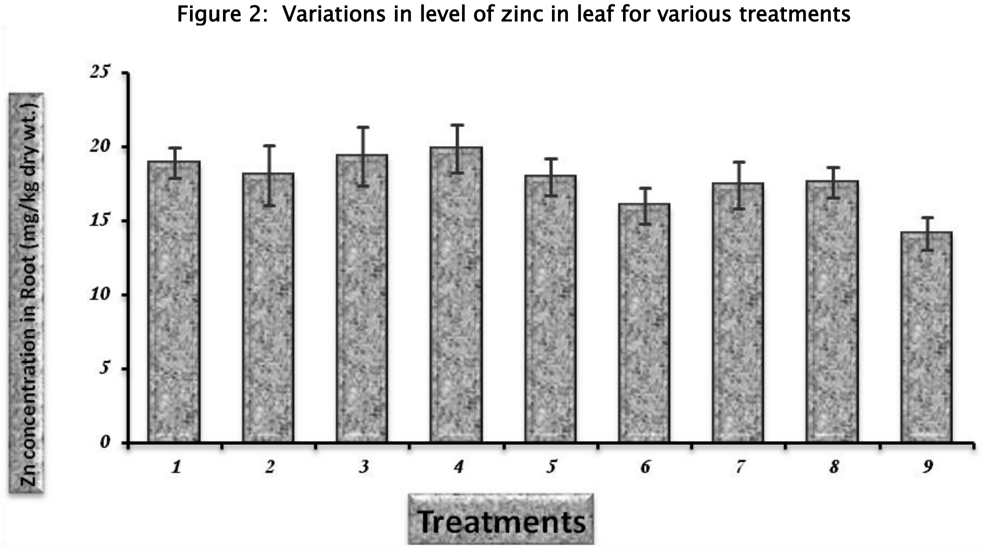

Figure 3: Variations in level of zinc in root for various treatments.

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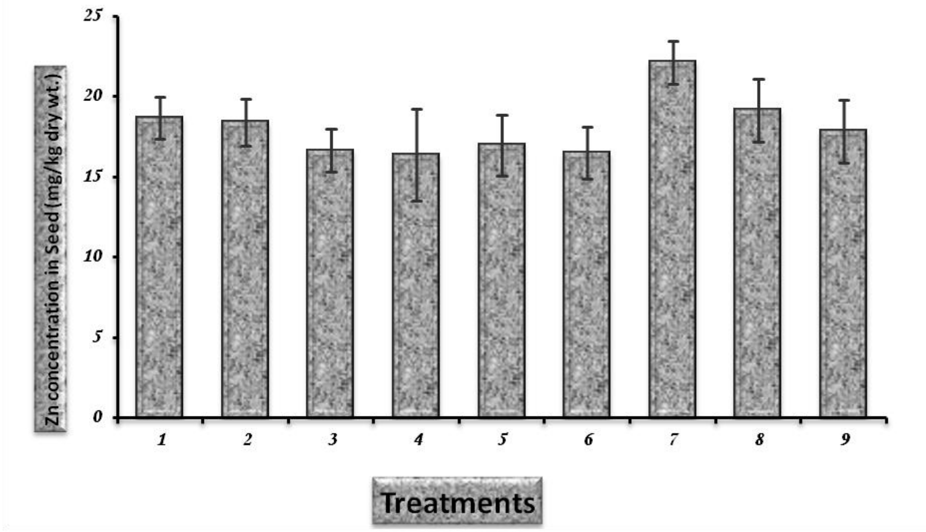

Figure 4: Variations in level of zinc in Seed for various treatments

Iron

Soil

There was a significant ($P < 0.05$) effect of Fe concentration on different treatments (Table 3). It ranged from 3.17 to 1.33 mg/kg during all treatments. Its concentration of iron has gradual increase found during all treatments. Higher value was found at sampling period 1st and lowest at 4th one (Fig.1). Mean Fe value was more than the critical value 0.25 mg/kg for Florida soil. Similar values were found given by Mooso[22] and higher concentration from the concentration found during present study was reported by Markel *et al.*[23].

Forage

There were non significant ($P>0.05$) effect of Fe concentration on treatments found by the analysis of variance for seeds, root and shoot (Table 3). Fe concentration was highest in treatment 6th and lowest at treatment 1st during our investigation. It ranged from 2.05 to 1.33 mg/kg in roots, and 3.93 to 2.86 mg/kg in leaf. Highest value in leaf was found in seeds of 8th treatment (Fig.2-4). The values of leaf and root were decreased and increase gradually. The forage Fe concentration was higher than the values already recommended 50 mg/kg by Jones [24]. There was slight increase and decrease from period 1st to 4th followed by inconsistence pattern.

The low forage Fe concentration was reported by McDowell *et al.* [19] than the values present in our investigation. And higher values were found by Probawo *et al.* [20] in Indonesia and Orden *et al.* [25] in Philippines. Higher Fe concentration in forage caused toxicity in grazing animals because highest value of Fe 131mg/kg could cause severe toxicity [26].

Table 3: Analysis of variance for Fe concentrations in soil, leaf, seed and root for various treatments

Source of variation	Degree of freedom	Mean squares			
		Soil	Root	Leaf	Seed
Treatments	8	1.143*	0.170^{ns}	0.691^{ns}	0.292^{ns}
Error	18	0.414	0.272	0.976	0.260

*****= significant at 0.05 levels, **ns**= non significant

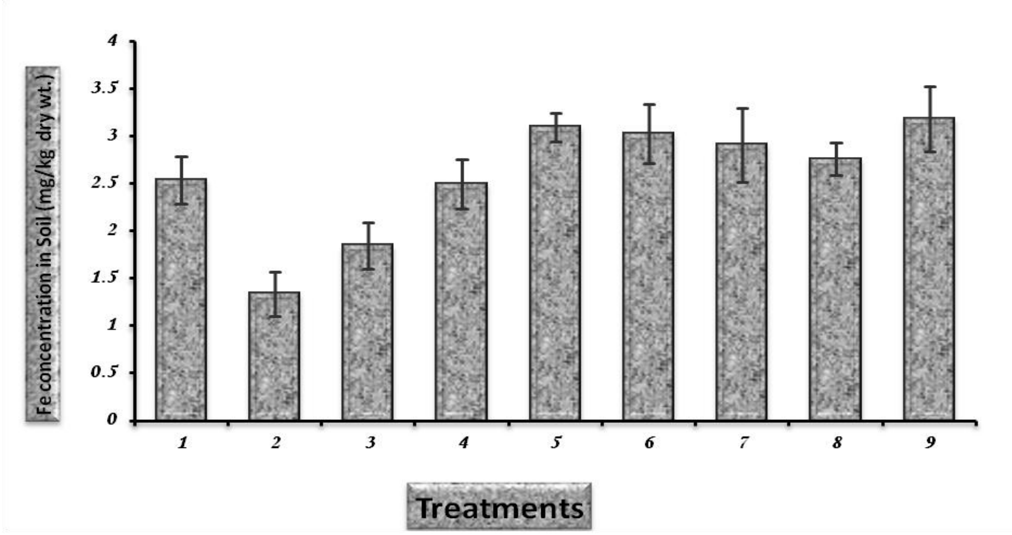

Figure 1: Variations in level of iron in Soil for various treatments

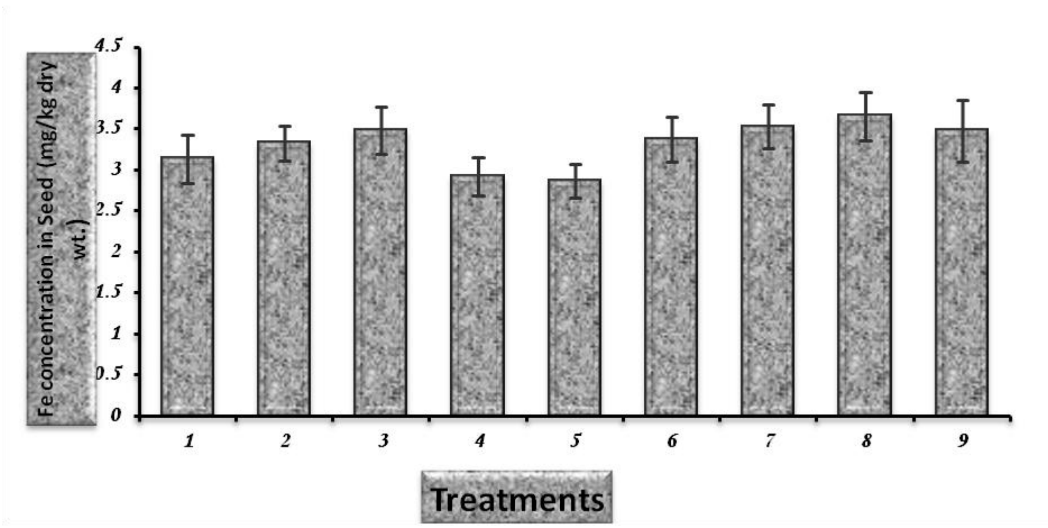

Figure 2: Variations in level of iron in Seed for various treatments

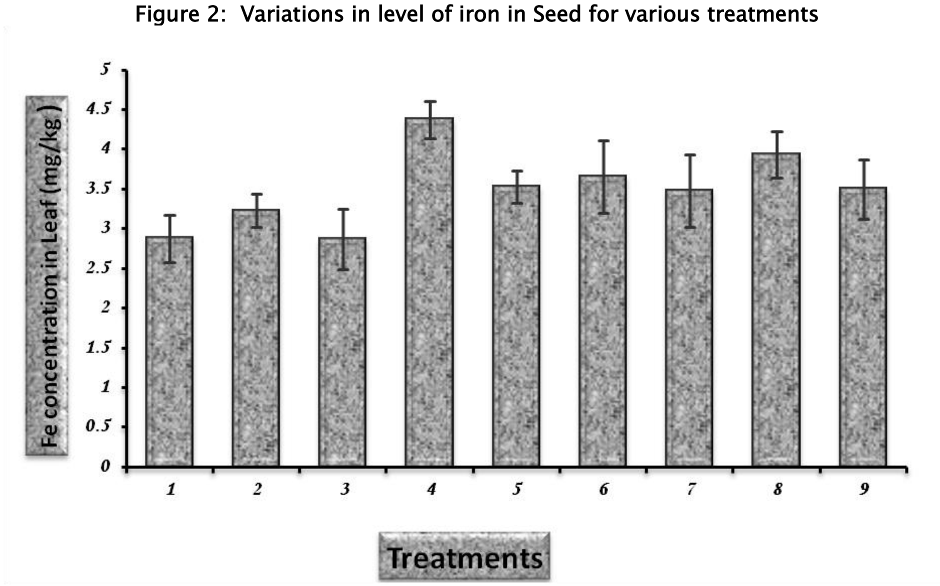

Figure 3: Variations in level of iron in leaf for various treatments

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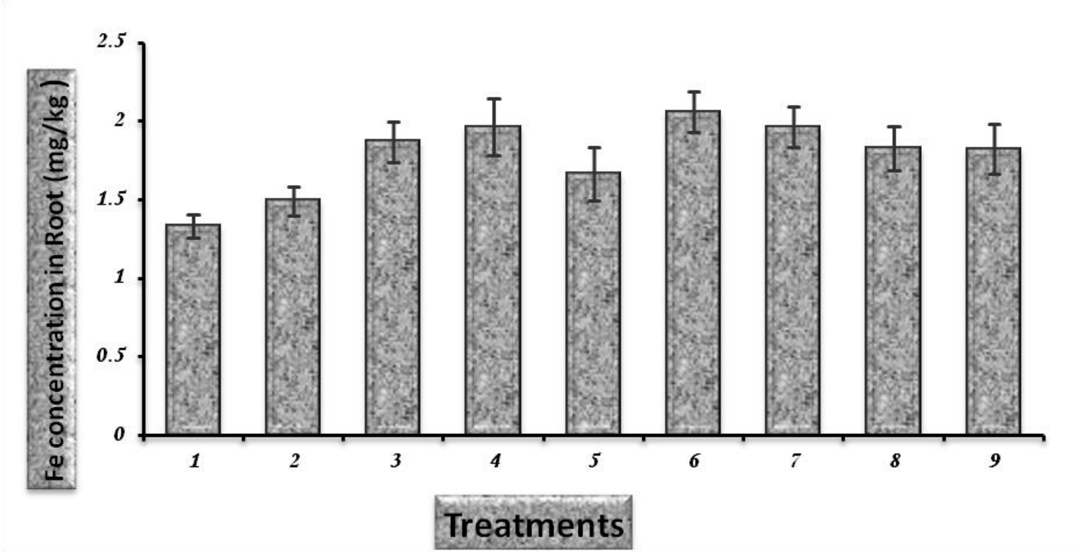

Figure 4: Variations in level of iron in root for various treatments

Lead

Soil

From the data of Analysis of variance for soil Pb depicts that its concentration have non significant affect (P>0.05) in different treatments (Table 5). The levels of Pb in soil were increase during all the treatment .The mean soil Pb level varied from 0.70 to 2.50 mg/kg. The Pb value was highest during 8th and lowest at the 1st sampling period (Fig.1).The soil Pb levels ranged from 5 to 25 mg/kg as reported by Hayashi *et al.*[27], the levels absorbed in our study were much higher than those but not exceeded from its toxic level. These levels of soil Pb were lower than those already given by Oluokun *et al.*[28] in Nigeria, but above then those reported by Aksoy *et al.* [29] in Turkey which investigating on bio monitoring of heavy metal pollution in that region. According to Ross[30] the Pb levels in soil were below than the toxic level exposing no danger to life of plants and animals.

Forage

From the data of analysis of variance there was non- significant effect (P > 0.05) for root, seed and leaf (Table 5). Highest level Pb was found during T_9 in root and lowest was at T_1 in root. The mean lead contents range from 1.11 to 1.50 mg/kg in various treatments. There was a inconsistent pattern of increase found during all the doses apply in present investigation (Fig.2-4). The mean forage lead range from 32.5 to 61.2 mg/kg among various sampling times. According to range reported by Ross[30] lead concentration in forage was low from the toxic level in plant and no risk for livestock utilizing these forages. The mean lead value in forage samples were below than those established earlier by Oluokun *et al.* [28] and higher than those given by Mlay and Mgumia[31] and lower than findings of Aksoy[29].

Table 5: Analysis of variance for Pb concentrations in soil, leaf, seed and root various treatments

Source of variation	Degree of freedom	Mean squares			
		Soil	Root	Leaf	Seed
Treatments	8	0.844^{ns}	0.084^{ns}	0.172^{ns}	0.426^{ns}
Error	18	0.656	0.105	0.111	0.201

ns= non significant

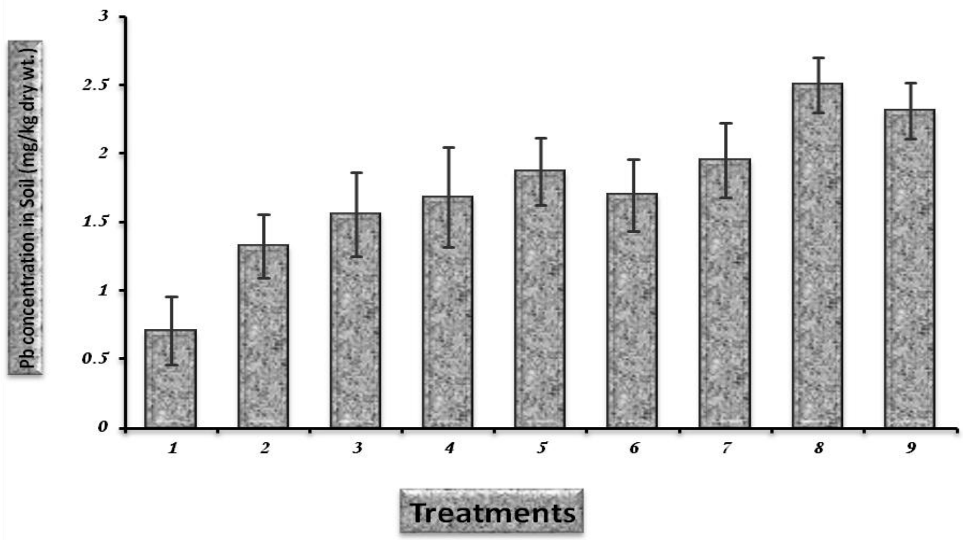

Figure 1: Variations in level of lead in Soil for various treatments

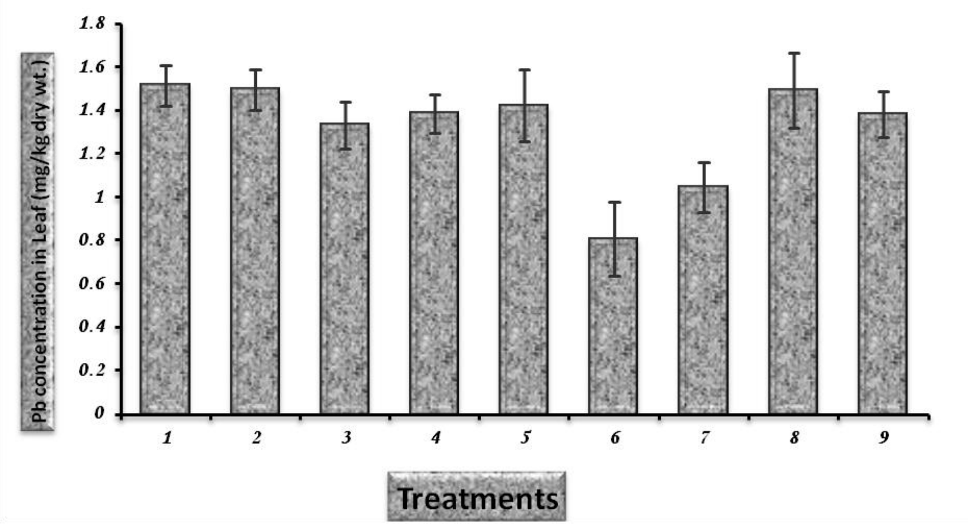

Figure 2: Variations in level of lead in leaf for various treatments.

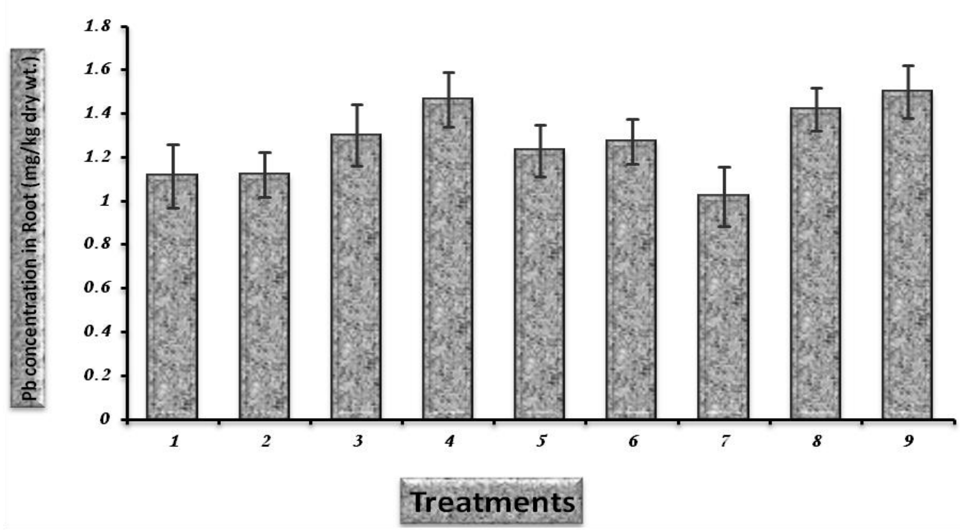

Figure 3: Variations in level of lead in root for various treatments.

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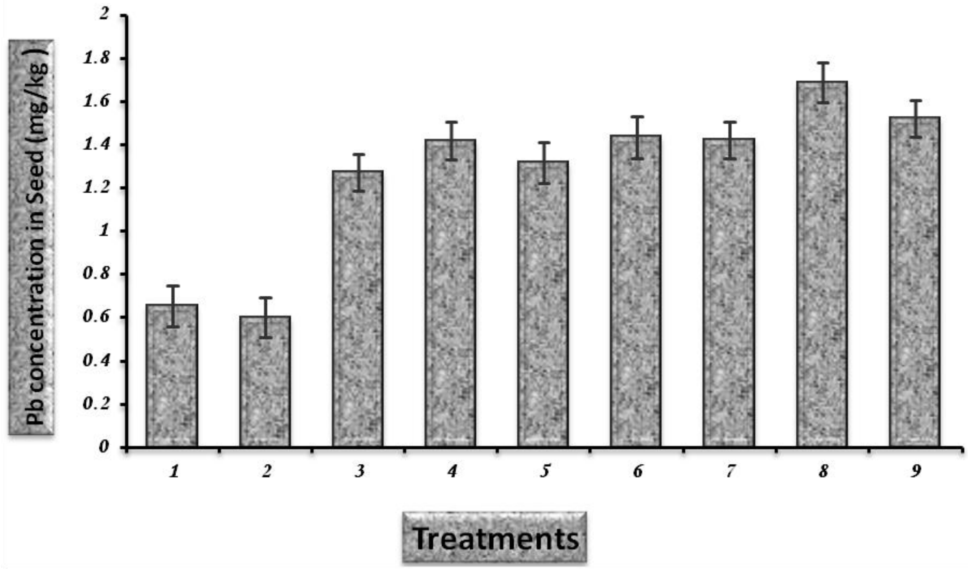

Figure 4: Variations in level of lead in seed for various treatments.

Cadmium

Soil

Cadmium level present in soil are varied non significantly ($p_{>}0.05$) during various treatments (Table 6). The soil Cd was higher at treatment 9th and lower at treatment 2nd, the values of Cd in soil ranged from 2.13 to 1.19 mg/kg during all treatments (Fig. 1).
In top layer of soil there is a mean Cd level of 2 to 3 times higher than the maximum available limit 3mg/kg[32]. Ross[30] reported that soil Cd level of 3 to 8 mg/kg considered as toxic, then according to this criteria the level of soil Cd in the our findings were below than the toxic level. On the other hand our findings are below from Cd in soil has been given earlier by Aksoy *et al.* [29] in Turkey and higher values were established by Oluokun *et al.* [28] in Nigeria.

Forage

From the data of Analysis of variance for Cd value showed non-significant effect of treatments on its concentration ($P > 0.05$) for the whole plant. The highest value was shown at T_6 in seed and lowest T_3 in root. Cd level range was from 1.64 to 2.40 mg/kg in seed and in leaf all the values are decrease and increase gradually (Fig.2-4).

All mean forage Cd was lower from the toxic level reported by Ross[30] exposing low potential threat for livestock consuming forages in pastures. These concentrations were higher than those suggested previously by Aksoy *et al.* [29] in Turkey.

Table 6: Analysis of variance for Cd concentrations in soil, leaf, seed and root various treatments.

Source of variation	Degree of freedom	Mean squares			
		Soil	Root	Leaf	Seed
Treatments	8	0.457^{ns}	0.839^{ns}	0.289^{ns}	0.241^{ns}
Error	18	0.621	0.617	0.237	0.308

ns= non significant

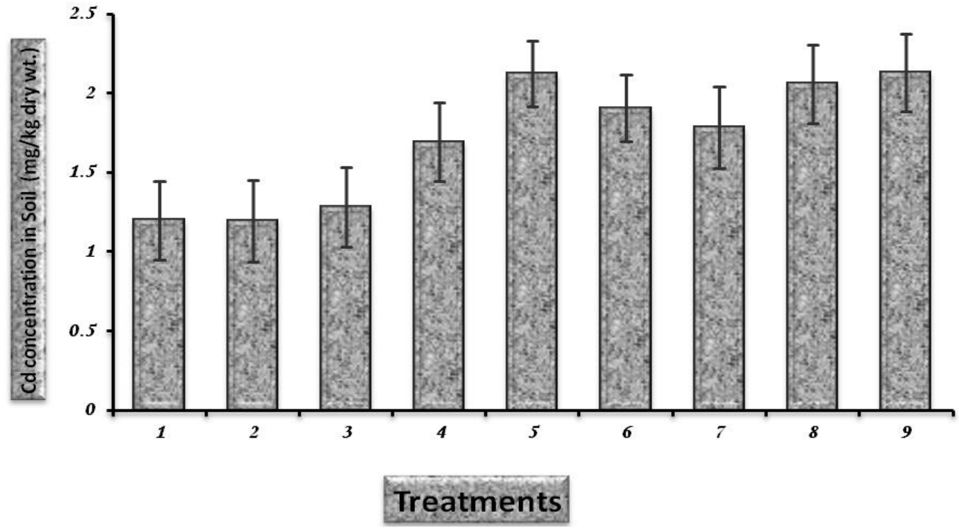

Figure 1: Variations in level of Cadmium in Soil for various treatments.

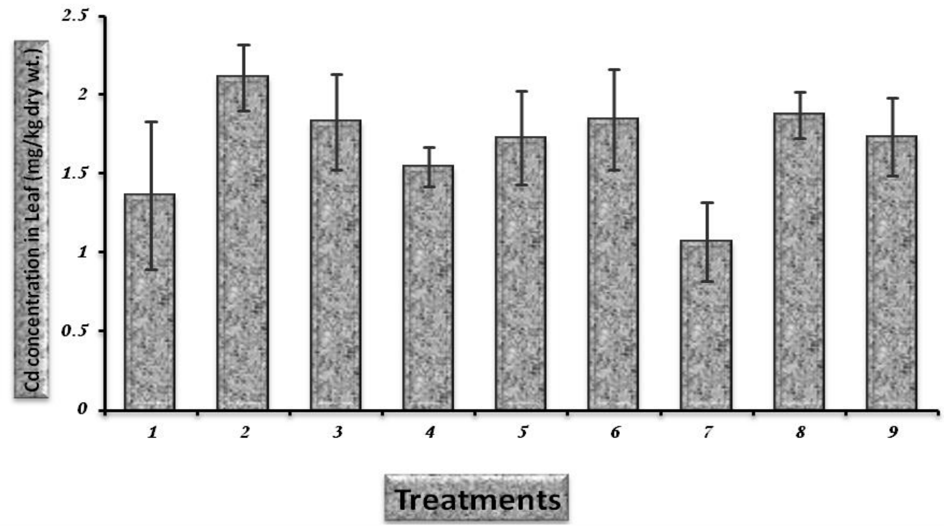

Figure 2: Variations in level of Cadmium in leaf for various treatments.

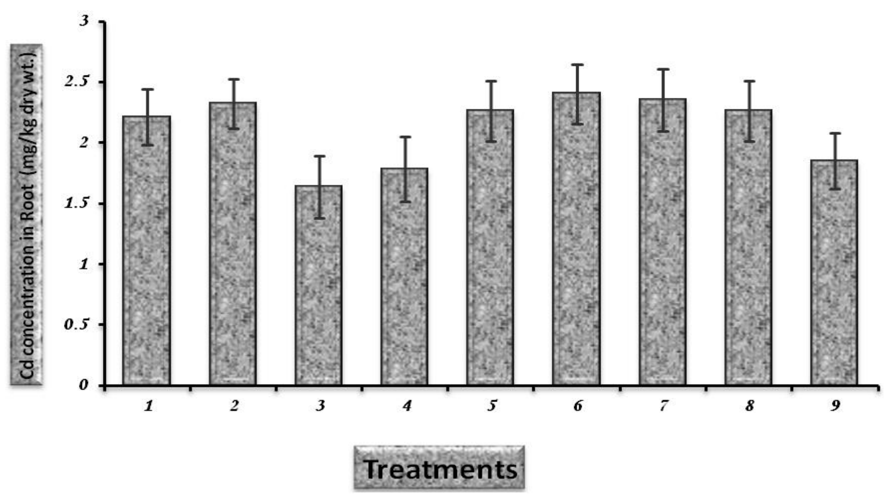

Figure 3: Variations in level of Cadmium in root for various treatments.

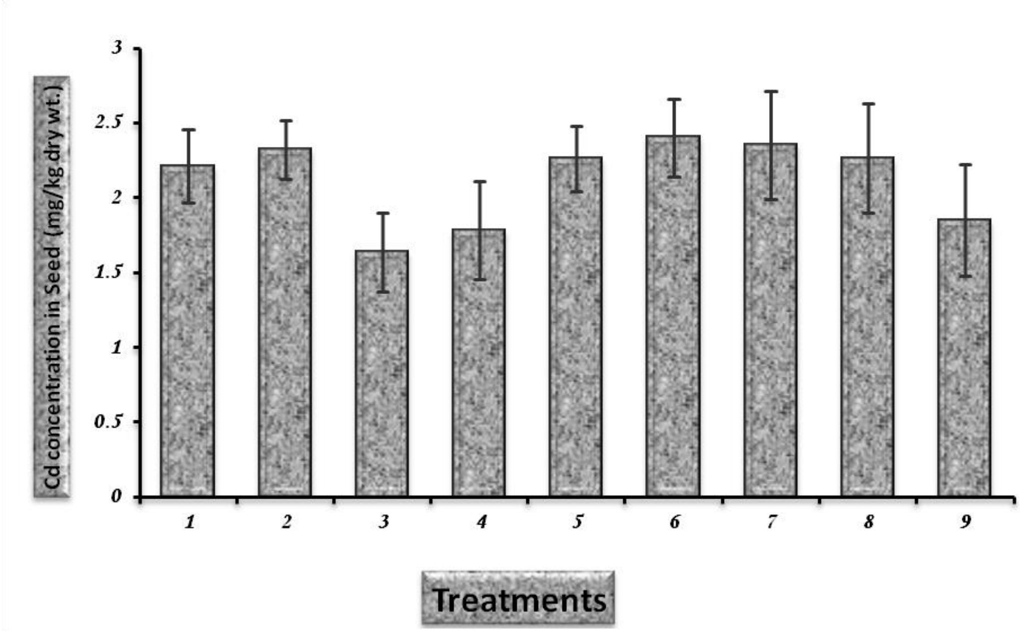

Figure 4: Variations in level of Cadmium in Seed for various treatments.

Chromium

Soil

From the analysis of variance the Cr concentration in soil significantly affect ($P_{<}$ 0.05) by treatments (Table 7). The Cr concentration in the soil decrease and increased from 1st to last treatment gradually (Fig:.1).

Cr level has a range of 0.55 to 1.78 mg/kg for soil. The highest value was found at 6th and lowest during 3rd. The toxic level of chromium in soil is around 2-50 ppm[33]. The Cr concentration level is Higher than the values was reported by Marín *et al.* [34]. All the values were below than the toxic values reported by Bergmann[33].

Forage

From the analysis of variance applied on the data of Cr concentration in forage noted that there is highly non significant effect ($P_{>}$ 0.05) for roots, leaf and seed during various treatments (Table 7).

The Cr concentrations were equally increased and decrease during all the treatments in entire plant. (Fig: 2-4). Cr level in leaf range from 1.77 to 0.99 mg/kg. The highest value was found at treatment 9th in root and lower during T_5 in seed. The Cr values are similar with the findings of Aman *et al.* [35]. The Cr level is more than the level described by Marín *et al.* [34]. The Cr level is less than the toxic level so there is safe for ruminant use.

Table 7: Analysis of variance for Cr concentrations in soil, leaf, seed and root various treatments.

Source of variation	Degree of freedom	Mean squares			
		Soil	Root	Leaf	Seed
Treatments	8	0.535*	0.205^{ns}	0.130^{ns}	0.028^{ns}
Error	18	0.175	0.273	0.190	0.028

*= significant at 0.05 levels,**ns**= non significant

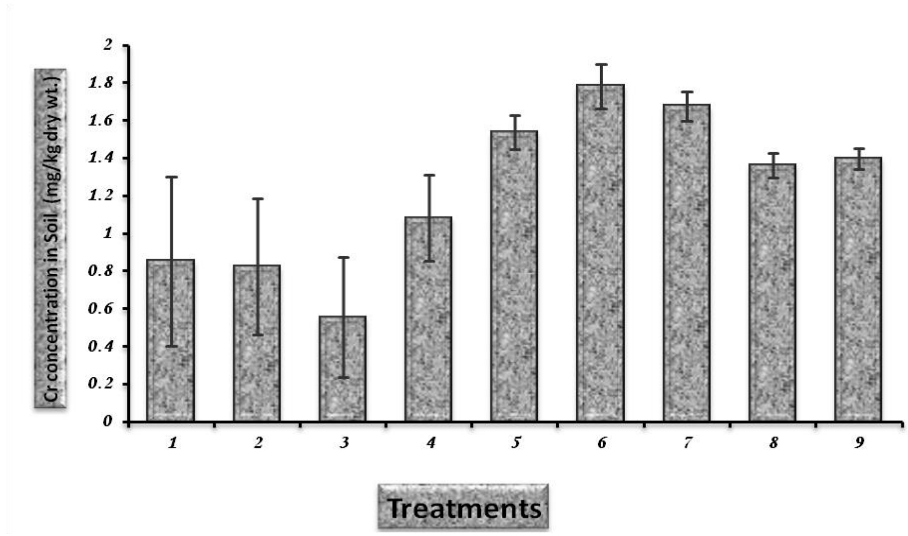

Figure 1: Variations in level of chromium in seed for various treatments

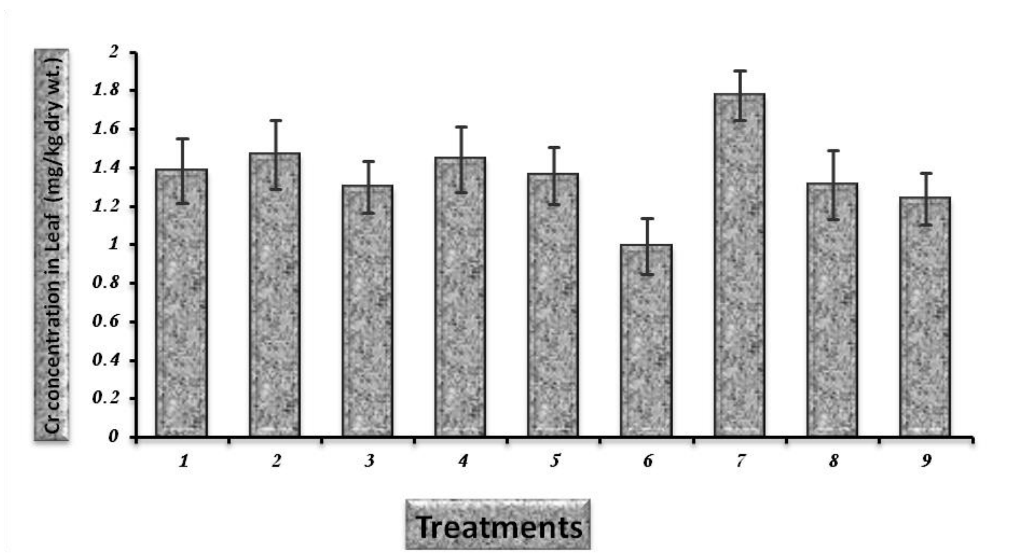

Figure 2: Variations in level of Chromium in leaf for various treatments.

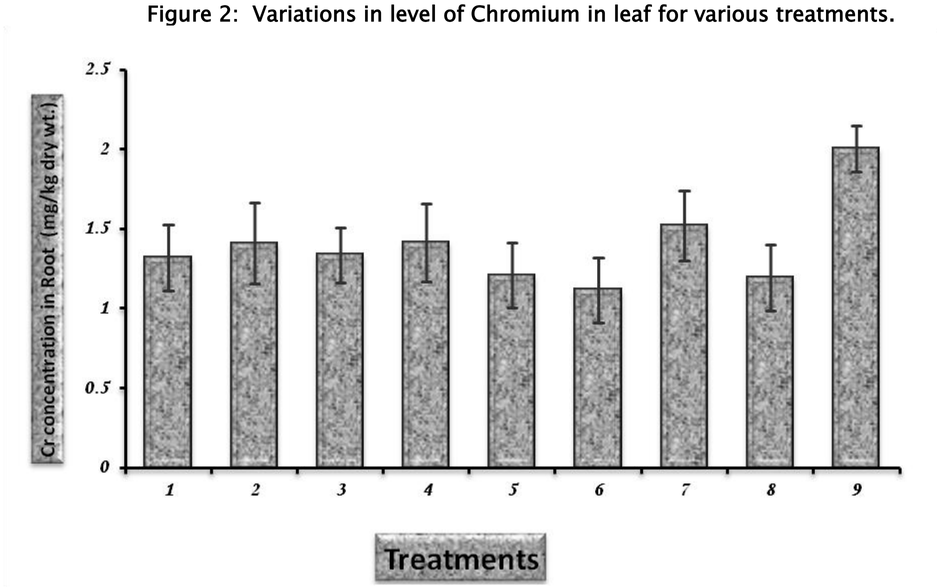

Figure 3: Variations in level of Chromium in root for various treatments.

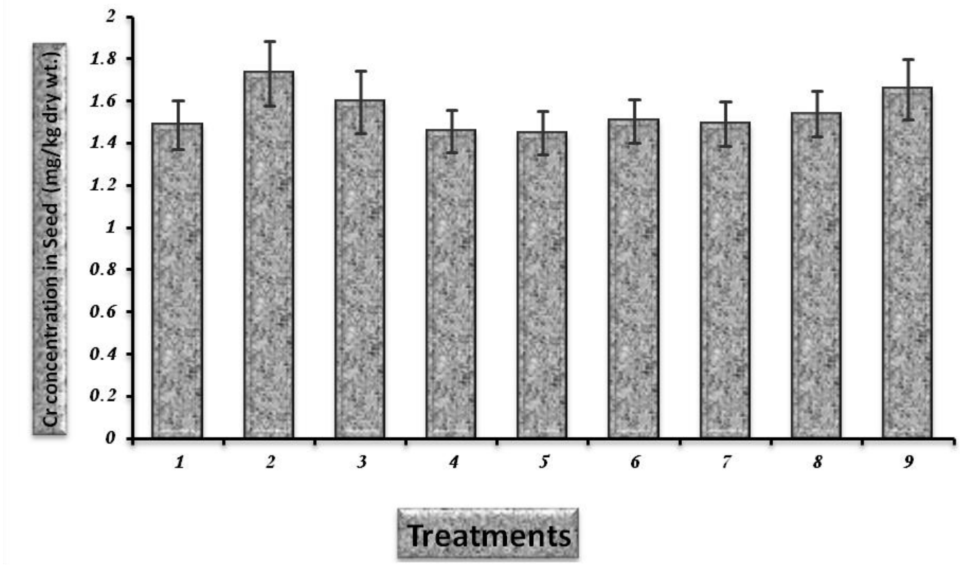

Figure 4: Variations in level of chromium in Soil for various treatments.

CONCLUSION

Based on soil and forage analyses it is concluded that studied minerals content in this research work may be affecting crop – livestock production system in this semi-arid region of Punjab, Pakistan. Therefore, supplementation studies are needed to determine the need and economic benefit of trace minerals supplementation.

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