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EVALUATION OF POSSIBLE TOXICOLOGICAL EFFECTS OF HEAVY METAL CHROMIUM ON WHEAT IN SOIL IRRIGATED WITH INDUSTRIAL, MUNICIPAL AND GROUND WATER: PUBLIC HEALTH IMPLICATIONS

KAFEEL AHMAD[1], ABID EJAZ, ASMA ASHFAQ[1], JAVED SHOUKAT[2], ABRAR HUSSAIN[3], SHAHZADI MAHPARA[4], HAFSA MEMONA[5], ALLAH BAKHSH GULSHAN[6], TASNEEM AHMAD[7], NAUNAIN MEHMOOD[8,9], MUHAMMAD AJMAL ALI[10] AND MUHAMMAD S. ELSHIKH[10]

[1]Department of Botany, University of Sargodha, Sargodha, Pakistan
[2]Institute of Food Science and Nutrition, University of Sargodha, Sargodha, Pakistan
[3]Department of Botany, Township Campus, University of Education Lahore, Lahore Pakistan
[4]Department of Plant Breeding and Genetics, Ghazi University, Dera Ghazi Khan, Pakistan
[5]Department of Zoology, Queen Mary Postgtratuate College, Lahore, Pakistan
[6]Department of Botany, Ghazi Uni etsity, Dear Ghazi Khan, Pakistan
[7]Pakki Thatti R&D Farm, Toba Tek Singh, Pakistan
[8]Department of Zoology, University of Sargodha, Sargodha Pakistan
[9]Department of Veterinary Medicine, University of Sassari, Sassari, 07100, Italy
[10]Department of Botany and Microbiology, College of Science, King Saud University, Riaydah 11451, Saudi Arabia
**Corresponding author's email: zafar.khan@uos.edu.pk*

Abstract

Increased area under organic cultivation is being driven by an improvement in nutritional quality and safety, as well as environmental concerns. Chromium (Cr) is a persistent contaminant that harms all living things including plants. Various manufacturing industries pollute the environment with an excessive quantity of Cr. This study was planned to conduct a practical evaluation of Cr toxicity in our food chain. The research was conducted in city Sargodha, Pakistan which pointed out experimental performance of this heavy metal transfer from nine different sources of fertilizer concentrations (100 g & 200 g) applied on ten wheat varieties under cultivation. The research also highlighted a comparison of pot and field sites under same influencing factors to make it precisely hypothetical. The analysis of soil amended with poultry waste (200 g) showed the maximum (0.439 mg/Kg) concentration of Cr, whereas least value (0.11 mg/Kg) was observed in soil in controlled site. The highest Cr uptake in roots (7.9 mg/Kg) was observed in wheat cultivar MILLAT-11 and the lowest in IHSAN-16 (5.5 mg/Kg) with municipal solid waste application of 200 g (9.14 mg/Kg) as highest and control factor (3.16 mg/Kg) as the lowest one. The highest uptake in shoots was observed in 11CO23 (7.75 mg/Kg) and lowest in JOHAR-16 (5.41 mg/Kg) with press mud (200 g) (9.03 mg/Kg) as highest and poultry waste (100g) (4.65 mg/Kg) as the lowest. The highest uptake in grains was observed in MILLAT-11 (7.70 mg/Kg) and the lowest in DHARABI-11 (5.47 mg /Kg) with farm yard manure (200g) (9.08 mg /Kg) as highest and controlled factor (3.74 mg/Kg) as the least one. In pot and field sites, all indices were below the critical range but exceptional in bio-concentration factor where dose concentration was increased. It was concluded that Cr uptake in wheat increases with application of waste in soil but varies depending on plant genetics. Genetics also seems to be in action as absorption capacity in some varieties varies considerably and clearly draws an attention about the need of further studies on genetic basis. However, an effort was made to reveal certain unknown aspects of phytoremediation and metal toxic absorption in our staple food crops that require ongoing research to maintain safety levels of chromium in an ecosystem.

Key words: Bio-concentration factor, Cr toxicity, Health Risk Index, Waster water irrigation system, Public hazards, Sargodha.

Introduction

Wheat (*Triticum aestivum*) has accompanied humans since remote time period (estimated back from 3000 to 4000 BC) in their mode of evolution and continuous development, evolving from its primitive form into its presently cultivated different species (Curtis *et al*., 2002). This seasonal crop is adapted to many suitable environments and is grown in tropical, sub-tropical and temperate regions (Mondal *et al*., 2013). Its widespread use is not only limited in its own primary production regions but also imported to every corner of possible human habitats (Shewry, 2009). The importance of this plant among all cereal crops cannot be denied as it occupies 27% total cereal production worldwide (Curtis *et al*., 2002).

Recently the usage of wheat bran (WB) is also increased and its incorporation in food products reaches around 1000 worldwide (Prueckler *et al*., 2014). This WB is experimentally proven to be a rich source of vitamin categories, essential minerals and bioactive constituents for promotion of good health (Onipe *et al*., 2015). Many studies have been conducted to further analyze nutritional composition of wheat (Rosa *et al*., 2013). Organic manures and inorganic supplements greatly influence the chemical composition of minerals in wheat (Bourn & Prescott, 2002). In earlier times, it was not in practice to cultivate crops for increasing the nutritional values (Lindsay, 2002; Welch & Graham, 2002). Due to high demand in supply of foods internationally, serious threats are posed to soil health and water which may appear soon in upcoming decades (Laghari *et al*., 2015).

Pakistan is among one of the major wheat producing countries (Ali *et al*., 2017). Products obtained from wheat flour need to be analyzed for comparative studies regarding usage for humans and animals (Giraldo, 2019). Farmers need to be given some sort of incentives to take care of environment while production of quality crops (Padel *et al*., 1999).

Chromium as a heavy metal is posing serious hazardous impacts for biota which cannot be left to circulate in food chains (Mathur *et al*., 2016). Chromium (Cr) toxicity is causing one of the most damaging effects to plant development and productivity thereby becoming a serious danger to long-term agricultural output (Rafaqat *et al*., 2015). Cr has negative impacts on seedling growth and morphology, and a variety of stress-related metabolic reactions impede seed germination, causing root structural damage even at low concentrations (Aleria *et al*., 2006). In recent years, there has been increased interest in the potential of plants with the ability to accumulate Cr compounds for bioremediation studies concerning Cr pollution (Shanker *et al*., 2005). Various industries pollute the environment with an excessive quantity of Cr which may result in rising Cr levels in agricultural soils, reducing the yield and quality of commercially important crops significantly (Wakeel *et al*., 2020). The chromium stresses lower carbon dioxide incorporation capabilities mostly owing to stomatal closure, which reduces water loss through transpiration while maintaining cellular carbon dioxide availability (Vernay *et al*., 2007). Chromium may easily accumulate in roots, shoots, and grains, depending on the proportion of the metal in the parent material (Liu *et al*., 2008). Cr strongly affects plants to reduce their root hair production, wilts the leaves, and decreases Cu absorption capacity (Mallick *et al*., 2010). Cr-contaminated food can put people's health at danger by causing serious clinical problems. As a result, it's critical to track Cr's biogeochemical activity in the soil-plant system (Shahid *et al*., 2017). Much work has recently been made in clarifying the processes of Cr absorption, transport, and accumulation in soil-plant systems, with the goal of lowering Cr toxicity and ecological risk in soil; however, these subjects have not yet been critically evaluated and summarized (Ao *et al*., 2022). This study was planned to conduct a practical evaluation of Cr toxicity in our food chain. The objectives of this study were to determine the status of Cr in water, soil, root, shoot and grains of wheat varieties grown in amended soil and to check the mobility and correlation of this metal among root, stem, and grains and to assess the different health indices concerning human and livestock.

Materials and Methods

Study area: The study area was selected to meet the research requirements and to make it productive in performance. A technical survey was performed to finalize Kaloya Farms for experiments at a village named 102 northern Branch District Sargodha, Punjab Pakistan. Its environment is subtropical to temperate having an altitude of about 180 m. Our research was carried during winter in which specified area has a temperature range of 7°C to 25°C.

Plant, varieties and treatments selection: The wheat plant was selected as it is proven to be efficient in understanding phytoremediation. It can be easily grown in pots and fields to compare and highlight efficient results. It is a staple food for humans and other animals and it is really a timely demand to figure out toxic components in our diet. Ten wheat varieties were selected which were commonly grown and are famous for their output with regard to farmer's feedback along with consultation of Agriculture specialists from AARI and BAARI institutes. Sample seeds were also taken as pure breeds from these institutions. Commonly used fertilizers and soil polluted near industries are to be taken into consideration for the selection of treatment. Further, two different doses were planned for each fertilizer.

Treatments applied: The soils were being treated with the following combinations.
T 1 for the municipal waste in solid form (100 g) & T2 for municipal waste in solid form (200g)
T 3 for the poultry waste (100g) & T 4 for the poultry waste (200 g)
T 5 for the press mud (100g) & T 6 for the press mud (200 g)
T 7 for the farm yard manure (100g) & T 8 for the farm yard manure (200 g)

Wheat varieties selection: The top varieties were selected on the basis of local farmer's feedback in the region. Following are the details of officially approved varieties along with their symbols used in the text.
V 1 for the MILLAT-11, V 2 for the AARI-11, V 3 for the GALAXY-13, V 4 for the GOLD-16, V 5 for the JOHAR-16, V 6 for the UJALLA-16, V 7 for the DHARABI-11, V 8 for the IHSAN-16, V 9 for the 11CO23, V 10 for the CHAKWAL-50.

Soil preparation, sowing and thinning: Soil was prepared by mixing it with 100 g and 200 g of fertilizer sources for each one kilogram of soil. The treatments were already air dried in open air to make a constant factor for uniformity in results. The soil for pot plant was collected along the canal bank at a local place whereas field was divided with blocks (5x5 feet size) with each one being separated from other by having 8-10 inches high layer of soil. Each pot was filled with 8kg of total mixture and 10 seeds were sown in each pot. Each field block was sown with 700 seeds at the same time. Thinning was done after germination to keep seven plants in each pot to make uniformity and enough space for plants to grow.

Samples collection: Soil, root and shoot samples were taken at maturity along with final products in the form of grains. Soil samples were taken 1-2 inches deep from the top level in pot and field sites. Sterilized equipment was used to collect the root, forage and grain samples. To eliminate dust particles and other impurities, the chosen samples were washed with distilled water and diluted HCl. These samples were saved in brown paper bags and plastic bags. Grains were removed from spikes for further analysis. During the sampling, five samples of each variety were obtained. These samples were dried in the air and then put in an incubator at 50°C for 15 days to eliminate all moisture (Singh *et al*., 2010).

Samples digestion: For Cr metal analysis, 1 mL sulphuric acid and 2 mL hydrogen peroxide were used to digest each type of material weighing 0.5 g with the help of electric balance. The samples were placed in the digesting chamber for over 30 minutes before being retrieved and chilled. Then hydrogen peroxide was added with a measured volume of 2 mL and repeated the process until the liquid within the beaker became transparent.

Then, by using distilled water, the volume was increased up to 50 mL. It was filtered and kept in clean, labeled plastic bottles in the laboratory.

Metal analysis: Before running the samples in atomic absorption spectrophotometer, standard solutions were prpared to calibrate the instruments for the accuracy in results. Samples were exposed to mineral analyses by using Atomic Absorption Spectrophotometer.

Statistical review: Analysis of data for variance, particle component analysis and post hoc multiple comparison fisher LSD were put on collected data (Steel *et al*., 1997).

Pollution load index (PLI): Pollution load index was calculated (Liu *et al*., 2005) as per following formula:

$$PLI = (M)^{IS} / (M)^{RS}$$

Bio-concentration factor: To calculate the transfer of metal from soil to wheat (grain), bio-concentration factor was worked out (Cui *et al*., 2004) as per following.

$$BCF = (M)^{wheat} / (M)^{soil}$$

Health risk index: The Health Risk Index (HRI) was calculated by following formula devised by Stephen *et al*., (2001).

$$HRI = DIM / R_fD$$

Results

The samples collected from all grown varieties under the influence of provided treatments showed a wide range of varietal results. Table 1 given below shows Cr in roots of wheat plants grown up by taking minerals from the soil which was amended with four types of waste fertilizers given in two different concentrations. The ANOVA analysis yielded highly significant results for Cr concentration in roots in both sites. Fisher's LSD was used as a statistics tool to find Cr metal concentration as a comparison in roots of wheat varieties grown in pots versus in plots for the representation of open field (Tables 2-3). The gradual differences in root Cr values have been observed among different varieties when compared with our controlled conditions at the same sites. The Cr values in all investigated varieties were observed increasing in the variety V1 (7.91±0.22 mg/Kg) in pot whereas in V9 at field site it was 5.75±0.24 mg/Kg. However, wheat variety V3 (7.39±0.21 mg/Kg) in pot and V5 (5.55±0.18 mg/Kg) in field site was identified as one of the varieties with the lowest value for Cr in root for the same ingredient under investigation. These stated results are crucially valuable when compared to the overall means of the 10 wheat types tested in this conducted experiment. The box plot for Cr concentration in root are shown in the Fig. 1.

Tables 2 and 3 showed the tendency of the same element exhibiting different behavior when analyzed against Treatment factor, further depending on the type of fertilizer sources utilized with respect to its concentration used and compared with the control. The paramount values of stated element in all investigated treatments were highest in the Treatment T2 (9.14±0.09 mg/Kg) in pot and T2 (7.15±0.12 mg/Kg) in field site. Given that T9 (5.79±0.04 mg/Kg) in pot and T9 (3.69±0.03 mg/Kg) in field site was identified as one of the varieties with the lowest value for Cr root for the same ingredient under investigation. Overall, we found that our findings are totally significant in terms of the concentration of Cr in roots under the impact of various treatments. The box plot for Cr concentration in root among a few different wheat samples varietals grown in the field treated with various sources of amendments are shown in the Fig. 2.

Tables 4 and 5 given below is for the mean comparisons, Fisher's LSD was used as a statistics tool to find Cr metal concentration as a comparison in shoots of wheat varieties grown in pots versus in plots for the representation of open field. The gradual differences in shoot Cr values have been observed among different varieties when compared with our controlled conditions at the same sites. The paramount values of stated element in all investigated varieties were raised highest in the developed variety V9 (7.78±0.22 mg/Kg) in pot whereas in V4 (5.85±0.24 mg/Kg) in field site. Given that V2 (7.41±0.17 mg/Kg) in pot and V5 (5.41±0.16 mg/Kg) in field site were identified as one of the varieties with the lowest value for Cr shoot for the same ingredient under investigation. These stated results are crucially valuable when compared to the overall means of the 10 wheat types tested in this conducted experiment. The box plot for Cr concentration in shoot among a few different wheat samples varietals grown in filled pots treated with various sources of amendments are shown in the Fig. 3.

Table 1. Analysis of data for Cr variance against Pot and Field.

Table 1. Analysis of data for Cr variance (Pot)					**Table 1. Analysis of data for Cr variance (Field)**		
Source of variation	**Degrees of freedom**	**Mean squares**			**Mean squares**		
		Root	**Shoot**	**Grain**	**Root**	**Shoot**	**Grain**
Variety (V)	9	0.989**	0.642*	0.307ns	0.260ns	0.736**	0.369ns
Treatment (Tr)	8	94.63**	87.62**	93.287**	92.31**	94.684**	89.26**
Ctrl. vs Tr	1	181.6**	168.5**	189.5**	213.0**	201.6**	200.3**
Waste (W)	3	0.446ns	0.319ns	0.294ns	0.132ns	0.293ns	0.351ns
Dose (D)	1	573.4**	528.9**	554.0**	524.3**	553.7**	511.7**
W x D	3	0.213ns	0.843*	0.595ns	0.258ns	0.378ns	0.331ns
V x T	72	0.594**	0.600**	0.546**	0.462**	0.631**	0.485**
Error	360	0.285	0.307	0.285	0.269	0.234	0.277
Total	**449**	ns = Non-significant (p>0.05); * = Significant (p<0.05); ** = Highly significant (p<0.01)					

Table 2. Mean comparisons of root, Cr *Fisher's LSD* against Pot.

Table 2. Variety x treatment interaction mean ± SE for Cr Root (Pot).

	Treatment									
Var.	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	Mean
V1	8.25±0.56HI	9.10±0.33A-G	7.54±0.64J	9.21±0.27A-F	6.89±0.36J-O	9.08±0.27A-G	6.39±0.27L-V	8.93±0.24C-G	5.84±0.06S-Y	7.91±0.22A
V2	6.62±0.35K-R	9.13±0.22A-G	6.88±0.39J-P	8.22±0.34I	6.78±0.31K-Q	8.87±0.20D-I	6.96±0.32J-N	9.01±0.28B-G	5.84±0.23S-Y	7.59±0.20BCD
V3	6.41±0.26L-U	8.59±0.41F-I	6.80±0.33K-Q	9.22±0.09A-F	6.28±0.14O-X	8.86±0.16D-I	5.99±0.19R-Y	8.51±0.52GHI	5.84±0.16S-Y	7.39±0.21D
V4	6.48±0.32K-S	9.32±0.22A-D	6.19±0.40Q-Y	9.07±0.22A-G	6.29±0.40O-W	8.74±0.26D-I	6.35±0.22M-W	8.88±0.17D-I	5.56±0.06Y	7.43±0.23CD
V5	6.91±0.17J-O	9.37±0.15A-D	6.32±0.13N-W	8.85±0.14D-I	6.64±0.30K-R	9.64±0.11AB	6.55±0.18K-R	9.02±0.15A-G	5.86±0.09S-Y	7.68±0.22B
V6	6.27±0.04O-X	9.56±0.12ABC	6.41±0.23L-U	9.20±0.13A-F	6.33±0.08N-W	9.26±0.23A-F	6.63±0.17K-R	8.82±0.07D-I	5.76±0.07U-Y	7.58±0.23BCD
V7	6.53±0.06K-R	9.09±0.11A-G	6.46±0.10L-T	8.70±0.14D-I	7.00±0.15J-M	8.73±0.08D-I	6.29±0.19O-X	8.89±0.17D-H	5.69±0.07WXY	7.49±0.19BCD
V8	5.81±0.05T-Y	8.95±0.32C-G	6.79±0.08K-Q	8.73±0.13D-I	6.61±0.12K-R	8.80±0.06D-I	7.04±0.12JKL	9.01±0.14B-G	6.21±0.10P-Y	7.55±0.19BCD
V9	6.63±0.30K-R	9.31±0.12A-D	6.30±0.21N-W	8.61±0.24E-I	6.71±0.40K-Q	8.89±0.07D-H	6.76±0.21K-Q	9.68±0.09A	5.73±0.05V-Y	7.62±0.22BC
V10	6.58±0.10K-R	9.03±0.47A-G	6.28±0.20O-X	9.06±0.20A-G	7.14±0.28JK	9.27±0.14A-E	6.69±0.07K-Q	9.32±0.25A-D	5.63±0.14XY	7.66±0.22B
Mean	6.65±0.12C	9.14±0.09A	6.60±0.11C	8.89±0.07B	6.67±0.09C	9.01±0.06AB	6.56±0.07C	9.01±0.08AB	5.79±0.04D	

Means sharing similar letter in a row or in a column within a box are by statistically non-significant (p>0.05)

Table 3. Mean comparisons of root, Cr *Fisher's LSD* against Field.

Table 3. Variety x treatment interaction mean ± SE for Cr Root (Field).

	Treatment									
Var.	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**Mean**
V1	4.82±0.04P	7.08±0.45C-L	4.79±0.04P	6.98±0.41E-N	4.72±0.04P	7.60±0.67A-E	4.72±0.07P	6.73±0.48G-O	3.79±0.02Q	5.69±0.22A
V2	4.74±0.06P	7.23±0.13C-I	4.65±0.04P	7.33±0.32B-G	4.78±0.05P	6.39±0.12NO	4.85±0.04P	7.23±0.26C-I	3.44±0.24Q	5.63±0.21A
V3	4.63±0.06P	6.85±0.50F-O	4.76±0.03P	7.67±0.27A-D	4.78±0.05P	6.29±0.04O	4.73±0.05P	6.49±0.22L-O	3.79±0.07Q	5.56±0.19A
V4	4.78±0.02P	6.82±0.26F-O	4.76±0.05P	6.95±0.21F-N	4.80±0.05P	7.70±0.49ABC	4.69±0.03P	7.32±0.35C-G	3.70±0.08Q	5.72±0.22A
V5	4.75±0.02P	6.93±0.33F-O	4.75±0.06P	6.53±0.19K-O	4.76±0.05P	6.59±0.08I-O	4.79±0.03P	7.17±0.07C-K	3.72±0.03Q	5.55±0.18A
V6	4.78±0.06P	7.69±0.44ABC	4.71±0.04P	6.80±0.15F-O	4.77±0.05P	7.18±0.45C-J	4.74±0.06P	7.13±0.43C-L	3.70±0.05Q	5.72±0.22A
V7	4.67±0.06P	7.96±0.36AB	4.69±0.06P	6.64±0.13H-O	4.69±0.03P	6.95±0.35F-N	4.72±0.06P	6.53±0.12K-O	3.66±0.04Q	5.61±0.21A
V8	4.75±0.05P	6.55±0.19J-O	4.69±0.04P	6.42±0.46MNO	4.85±0.03P	7.24±0.58C-H	4.82±0.03P	6.92±0.38F-O	3.74±0.05Q	5.55±0.20A
V9	4.72±0.05P	7.42±0.48A-F	4.65±0.04P	8.02±0.36A	4.68±0.04P	7.03±0.29D-M	4.72±0.04P	6.82±0.36F-O	3.67±0.04Q	5.75±0.24A
V10	4.55±0.01P	6.99±0.09E-N	4.77±0.05P	6.76±0.08G-O	4.69±0.05P	6.91±0.44F-O	4.78±0.05P	7.24±0.12C-H	3.73±0.03Q	5.60±0.20A
Mean	4.72±0.02B	7.15±0.12A	4.72±0.01B	7.01±0.11A	4.75±0.01B	6.99±0.13A	4.75±0.02B	6.96±0.10A	3.69±0.03C	

Means sharing similar letter in a row or in a column within a box are by statistically non-significant (p>0.05)

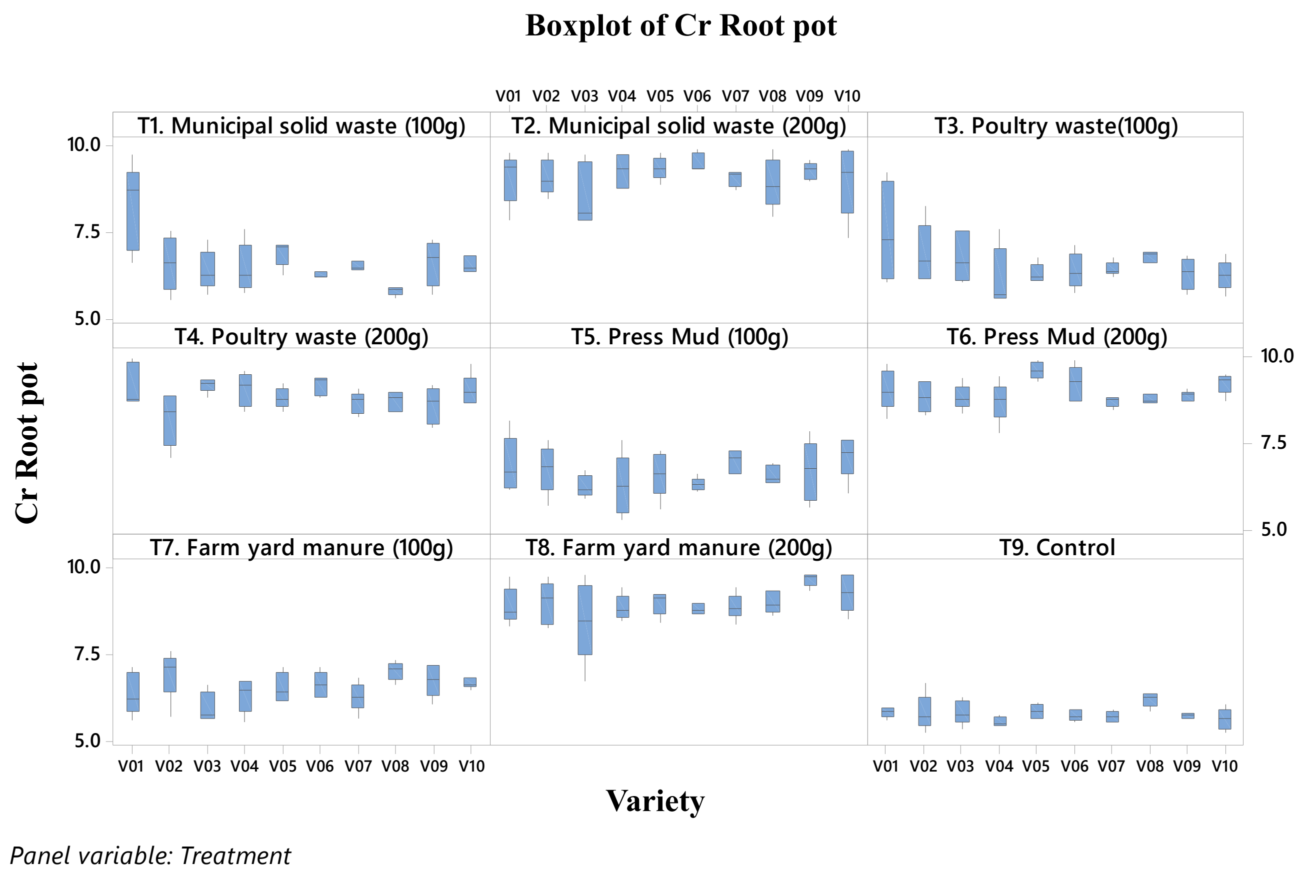

Fig. 1. Boxplot for Cr Root (Pot).

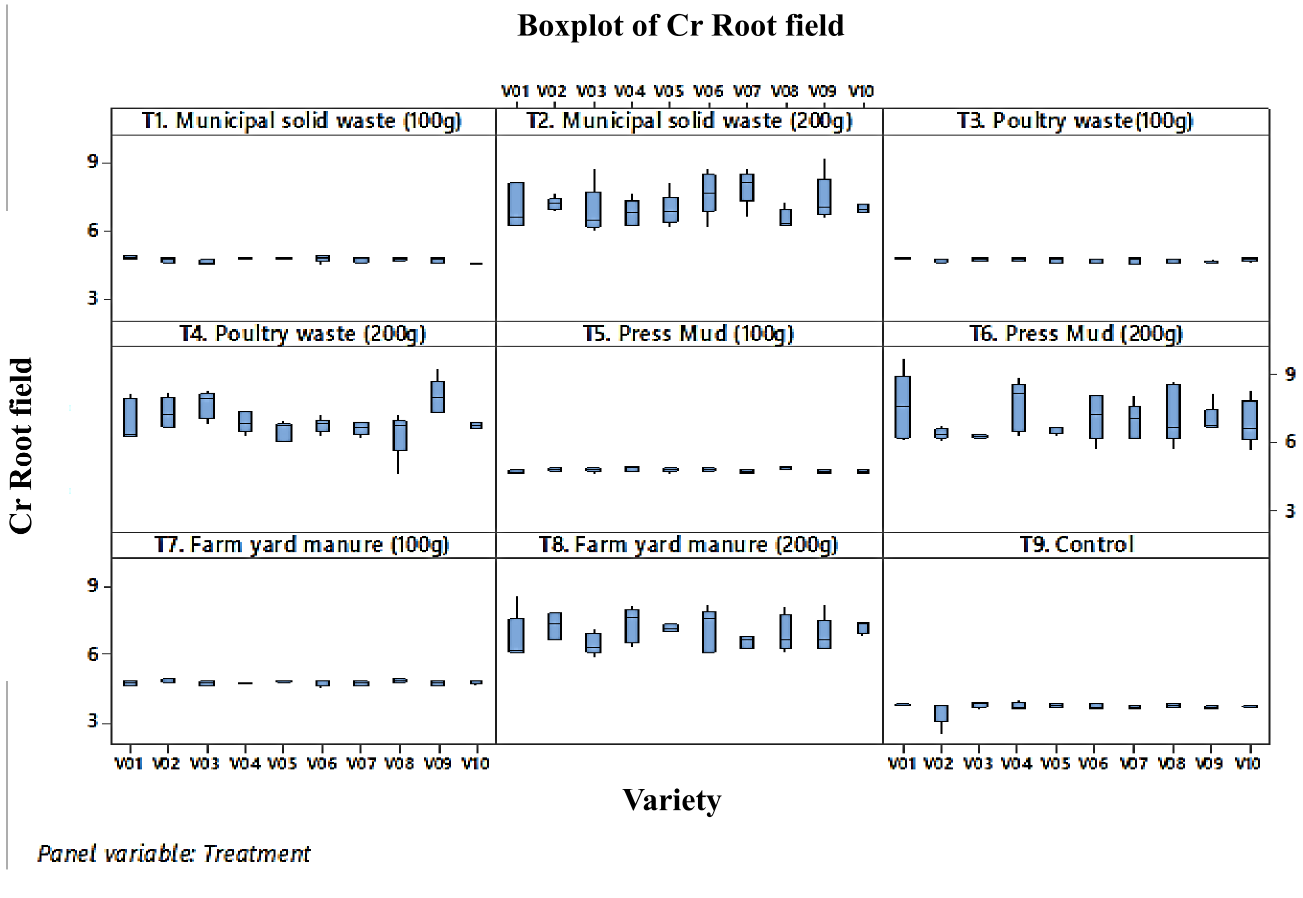

Fig. 2. Boxplot for Cr Root (Field).

Table 4. Mean comparisons of shoot, Cr *Fisher's LSD* against Pot.
Table 4: Variety x treatment interaction mean ± SE for Cr Shoot (Pot).

	Treatment									
Var.	T1	T2	T3	T4	T5	T6	T7	T8	T9	Mean
V1	6.94±0.42K-Q	9.05±0.28A-I	7.23±0.35KL	9.14±0.22A-I	6.63±0.33K-U	8.75±0.20E-J	6.50±0.45M-V	8.83±0.29B-J	5.84±0.09V-Z	7.66±0.20ABC
V2	6.55±0.32L-U	8.80±0.45C-J	6.82±0.09K-S	7.28±0.46K	6.88±0.53K-R	8.70±0.19G-J	7.05±0.31K-N	8.31±0.50J	6.31±0.25P-X	7.41±0.17D
V3	6.65±0.19K-U	8.96±0.30A-J	6.88±0.22K-R	8.85±0.24B-J	6.56±0.16L-U	8.55±0.23IJ	6.45±0.34M-W	8.56±0.32HIJ	5.47±0.11Z	7.44±0.20CD
V4	6.70±0.19K-T	9.10±0.18A-I	6.38±0.22N-X	9.02±0.30A-I	6.11±0.23T-Z	9.12±0.21A-I	6.78±0.15K-T	8.78±0.16D-J	5.76±0.05XYZ	7.53±0.21BCD
V5	6.63±0.38K-U	9.44±0.18A-D	7.01±0.20K-O	9.59±0.20A	6.82±0.17K-S	9.21±0.18A-I	6.31±0.07P-X	9.05±0.31A-I	5.99±0.21U-Z	7.78±0.22A
V6	6.60±0.18K-U	9.05±0.16A-I	6.41±0.08M-X	8.62±0.18G-J	6.87±0.13K-R	9.48±0.09ABC	6.37±0.12N-X	9.01±0.37A-I	6.09±0.13T-Z	7.61±0.20A-D
V7	6.35±0.23O-X	9.30±0.14A-G	6.48±0.20M-W	8.73±0.25F-J	6.64±0.33K-U	8.85±0.17B-J	6.46±0.11M-W	9.15±0.10A-I	6.17±0.07S-Y	7.57±0.20A-D
V8	7.09±0.36KLM	9.42±0.24A-E	6.23±0.15R-Y	8.94±0.23A-J	6.26±0.06Q-Y	9.40±0.07A-F	6.74±0.19K-T	8.95±0.14A-J	5.61±0.17YZ	7.63±0.23A-D
V9	6.95±0.22K-P	8.59±0.15HIJ	7.21±0.12KL	9.11±0.13A-I	6.15±0.22S-Z	9.15±0.15A-I	7.27±0.36K	9.51±0.09AB	5.81±0.04W-Z	7.75±0.20AB
V10	6.71±0.47K-T	9.02±0.33A-I	6.90±0.33K-R	8.70±0.20G-J	6.62±0.26K-U	9.14±0.42A-I	6.28±0.08P-Y	9.25±0.08A-H	5.61±0.14YZ	7.58±0.22A-D
Mean	6.72±0.09C	9.07±0.08A	6.75±0.08C	8.80±0.11B	6.55±0.09C	9.03±0.07A	6.62±0.08C	8.94±0.09AB	5.86±0.05D	

Means sharing similar letter in a row or in a column within a box are by statistically non-significant (p>0.05).

Table 5. Mean comparisons of shoot, Cr *Fisher's LSD* against Field.
Table 5. Variety x treatment interaction mean ± SE for Cr Shoot (Field).

	Treatment									
Var.	T1	T2	T3	T4	T5	T6	T7	T8	T9	Mean
V1	4.82±0.04P	6.87±0.25F-L	4.62±0.04P	6.86±0.33F-M	4.80±0.02P	7.73±0.21BC	4.72±0.05P	6.43±0.12K-O	3.76±0.03QR	5.62±0.20BC
V2	4.83±0.04P	7.34±0.39C-G	4.28±0.39PQ	7.05±0.27D-J	4.69±0.07P	7.31±0.33C-H	4.63±0.03P	6.98±0.24D-K	3.66±0.06R	5.64±0.22BC
V3	4.81±0.02P	6.74±0.54H-N	4.74±0.05P	6.96±0.28E-K	4.83±0.04P	6.17±0.16NO	4.75±0.06P	7.56±0.48CD	3.85±0.07QR	5.60±0.20CD
V4	4.73±0.05P	6.95±0.24E-K	4.72±0.04P	8.17±0.51AB	4.78±0.03P	7.55±0.28CDE	4.70±0.05P	7.35±0.40C-G	3.73±0.04QR	5.85±0.24A
V5	4.78±0.05P	6.53±0.20J-O	4.69±0.03P	6.35±0.05L-O	4.77±0.04P	6.13±0.06O	4.74±0.02P	6.98±0.34D-K	3.76±0.06QR	5.41±0.16D
V6	4.72±0.07P	7.76±0.45BC	4.74±0.03P	6.96±0.17D-K	4.73±0.06P	7.52±0.35CDE	4.71±0.03P	6.66±0.29I-O	3.80±0.06QR	5.73±0.22ABC
V7	4.84±0.01P	7.43±0.26C-F	4.64±0.04P	6.76±0.12G-N	4.61±0.04P	7.12±0.32D-J	4.67±0.05P	6.67±0.37I-O	3.77±0.06QR	5.61±0.20C
V8	4.76±0.03P	6.40±0.07K-O	4.70±0.05P	7.21±0.46C-I	4.81±0.04P	7.52±0.31CDE	4.72±0.07P	8.53±0.48A	3.78±0.06QR	5.82±0.24AB
V9	4.66±0.05P	7.07±0.42D-J	4.66±0.02P	7.26±0.30C-I	4.85±0.05P	7.12±0.33D-J	4.72±0.05P	7.28±0.23C-H	3.73±0.02QR	5.70±0.21ABC
V10	4.72±0.05P	6.26±0.06MNO	4.69±0.05P	6.89±0.16F-L	4.62±0.05P	7.43±0.29C-F	4.73±0.06P	6.98±0.40D-K	3.82±0.05QR	5.57±0.19CD
Mean	4.77±0.02C	6.94±0.11B	4.65±0.04C	7.05±0.11AB	4.75±0.02C	7.16±0.11A	4.71±0.01C	7.14±0.13A	3.76±0.02D	

Means sharing similar letter in a row or in a column within a box are by statistically non-significant (p>0.05).

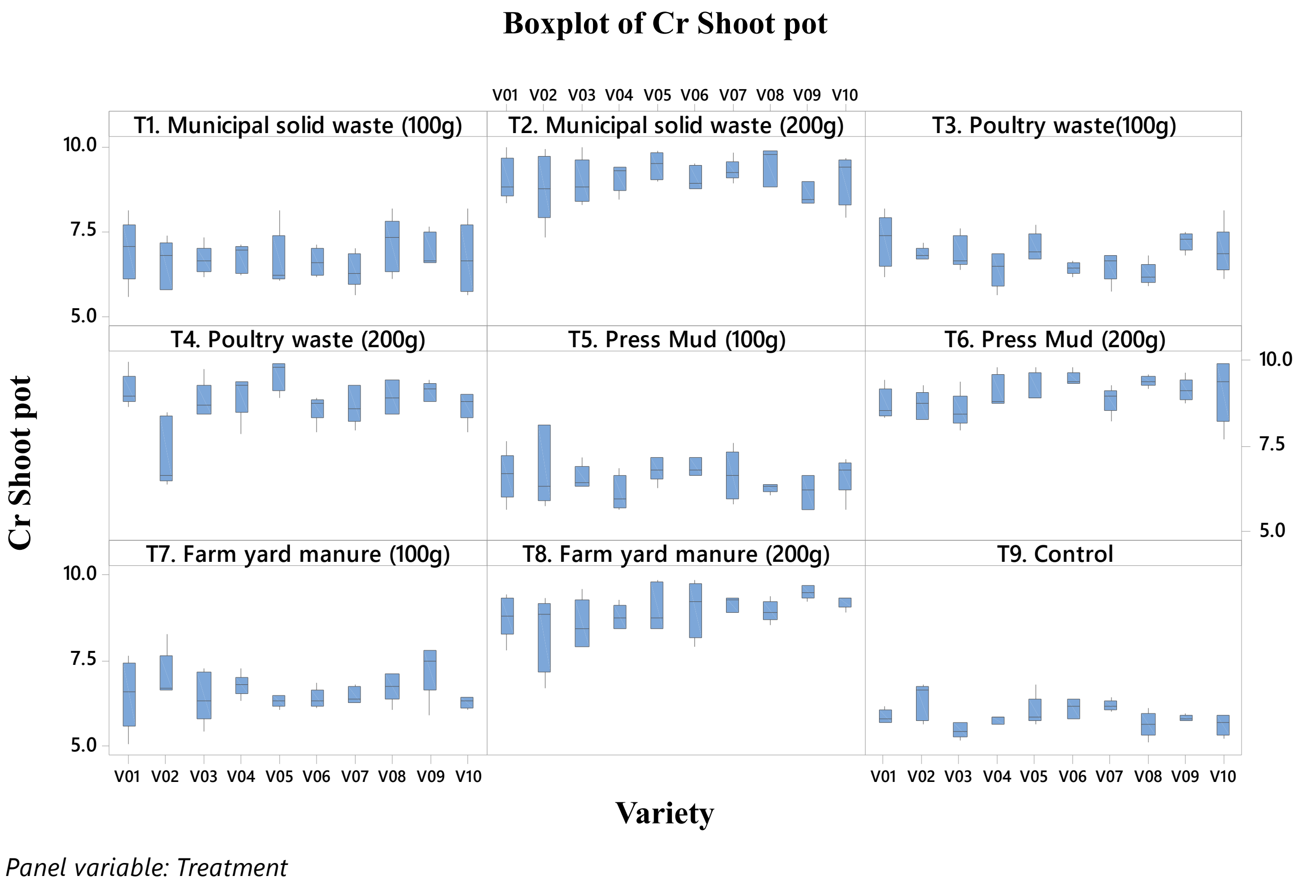

Fig. 3. Boxplot for Cr Shoot (Pot).

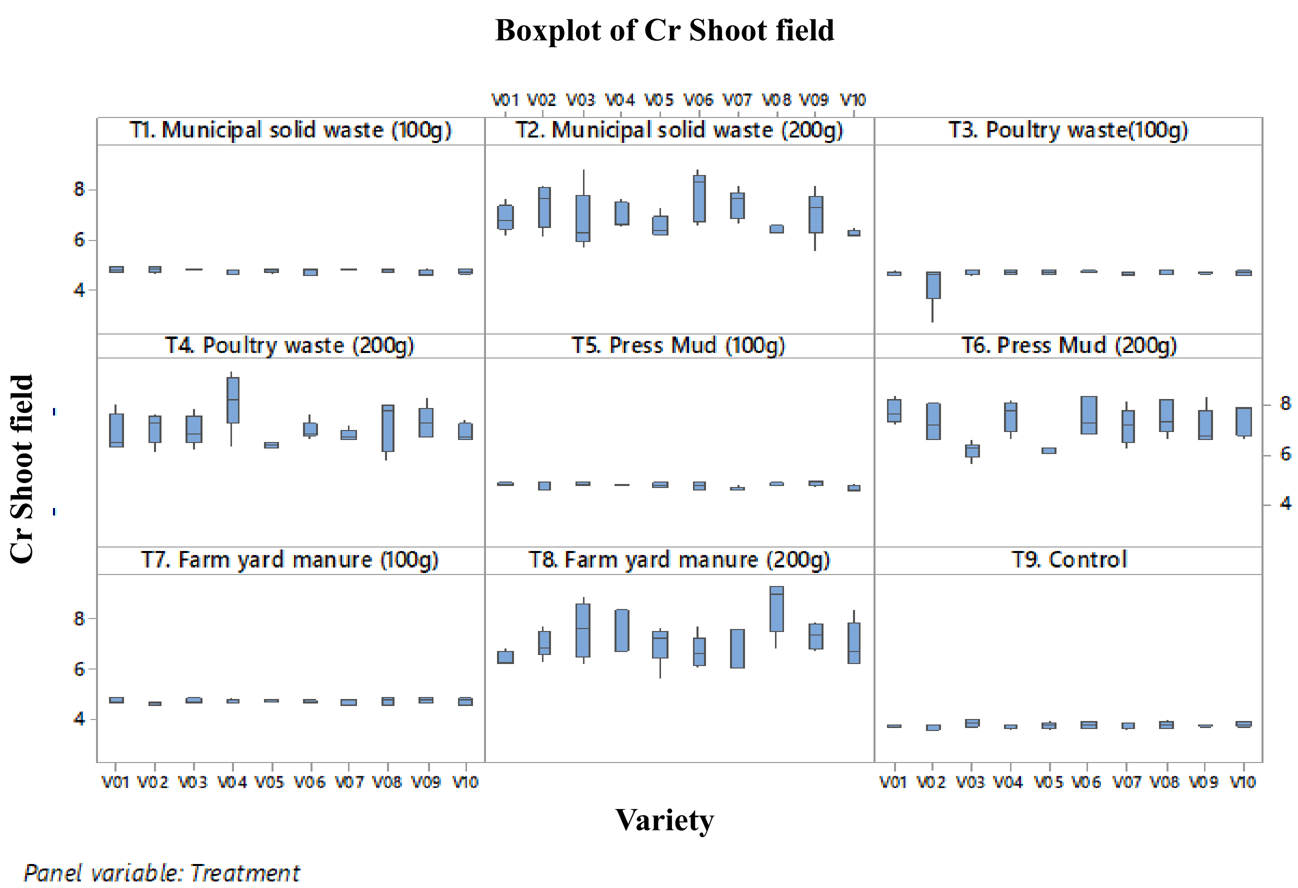

Fig. 4. Boxplot for Cr Shoot (Field).

Tables 4 and 5 showed the tendency of the same element exhibiting different behavior when analyzed against Treatment factor, further depending on the type of fertilizer sources utilized with respect to its concentration used and compared with the control. The paramount values of stated element in all investigated treatments were raised highest in the Treatment T2 (9.07±0.08 mg/Kg) in pot whereas T8 (7.14±0.13 mg/Kg) in field site. Given that T9 (5.86±0.05 mg/Kg) in pot and T9 (3.76±0.02 mg/Kg) in field site was identified as one of the varieties with the lowest value for Cr shoot for the same ingredient under investigation. Overall, we found that our findings are totally significant in terms of the concentration of Cr metal in shoots under the observed impact of various treatments. The box plot for Cr concentration in shoot among a few different wheat samples varietals grown in the field treated with various sources of amendments are shown in the Fig. 4.

Tables 6 and 7 given below are for the mean comparisons, Fisher's LSD was used as a statistics tool to find Cr metal concentration as a comparison in grain of wheat varieties grown in pots versus in plots for the representation of open field. Varieties of grain have been found to have gradually varying Cr values when compared to our controlled circumstances at the same sites. The paramount values of stated element in all investigated varieties were raised highest in the developed variety V4 (7.76±0.23 mg/Kg) in pot whereas V7 (5.70±0.22 mg/Kg) in field site. Given that V5 (7.48±0.23 mg/Kg) in pot and V9 (5.47±0.18 mg/Kg) in field site was identified as one of the varieties with the lowest value for Cr *grain* for the same ingredient under investigation. These stated results are crucially valuable when compared to the overall means of the 10 wheat types tested in this conducted experiment. The box plot for Cr concentration in seeds among a few different wheat samples varietals grown in filled pots treated with various sources of amendments are shown in the Fig. 5.

Tables 6 and 7 showed the tendency of the same element exhibiting different behavior when analyzed against Treatment factor, further depending on the type of fertilizer sources utilized with respect to its concentration used and compared with the control. The paramount values of stated element in all investigated treatments were highest in the Treatment T8 (9.08±0.08 mg/Kg) in pot and also in T8 (7.11±0.12 mg/Kg) in field site. Given that T9 (5.77±0.06 mg/Kg) in pot and T9 (3.74±0.02 mg/Kg) in field site was identified as one of the varieties with the lowest value for Cr grain for the same ingredient under investigation. Overall, we found that our findings are totally significant in terms of the concentration of metal Cr in grain under the impact of various treatments. The box plot for Cr concentration in seeds among a few different wheat samples varietals grown in the field treated with various sources of amendments are shown in the Fig. 6.

Table 8A and 8B showed comparisons as a mean for soil in pot and field. Post Hoc and Fisher's LSD, the Cr metal contents found in soil reflected a great deal of differences in different types of manures with varied concentrations and especially when compared with our control samples. The results of comparison on the basis of treatments indicated that T4 (0.439±0.021 mg/Kg) was at the uppermost level in Cr pot soil contents whereas T9 (0.195±0.015 mg/Kg) was categorized at the uppermost level among the Cr levels in soil field. The result comparison on the basis of treatments indicated that T4 (0.257±0.041 mg/Kg) was at the nethermost level in Cr pot soil contents whereas T9 (0.030±0.003 mg/Kg) is categorized as nethermost among the Cr levels in field site soil. Overall, fully significant results have been observed in soil studies when compared on the basis of sites. Figure 7 illustrates the comparison level of Cr contents in grain samples in the form of Box plot from pot and field among ten varieties when were grown under the influence of diverse treatment sources.

PLI, DIM, BCF and HRI: Different applied treatments on model plants were assessed to find out the relationship of wheat plant regarding PLI, BCF, DIM and HRI. Cr content levels were compared with respect to varieties and treatments in the current study.

Table 9 illustrates the findings of PLI, BCF, DIM and HRI with respect to the treatments. By moving from left towards right in a table, these parameters were calculated on the base of standard calculations given in materials and methods.

When compared to our control samples, the Cr PLI detected in wheat grain reflected a considerable variation due to the fact that they were cultivated in different types of manures with varying amounts. The paramount values of PLI in all investigated treatments were highest in the Treatment T4 in pot whereas T1 in field site. Given that T9 in pot and T9 in field site were identified as one of the treatments with the lowest value for PLI. Figure 8 illustrates the comparison level of Cr PLI contents in grain samples in the form histogram from pot and field among ten varieties when were grown under the influence of diverse treatment sources.

The Cr BCF detected according to factor of treatment in wheat grain reflected a considerable variation due to the fact that they were cultivated in different types of manures with varying amounts. The paramount values of BCF in all investigated treatments were raised highest in the Treatment T5 in pot whereas T9 in field site. Given that T2 in pot and T1 in field site were identified as one of the treatments with the lowest value for BCF. Figure 9 illustrates the comparison level of Cr BCF contents in grain samples from pot and field among ten varieties which were grown under the influence of diverse treatment sources.

The Cr DIM detected according to factor of treatment in wheat grain reflected a lot of variation due to the fact that they were cultivated in different types of manures with varying amounts. The paramount values of DIM in all investigated treatments were raised highest in the Treatment T4 and T6 in pot whereas T8 in field site. Given that T9 in pot and T9 in field site were identified as one of the treatments with the lowest value for DIM. Figure 10 illustrates the comparison level of Cr DIM contents in grain samples among ten varieties which were grown under the influence of diverse treatment sources.

Table 6. Mean comparisons of grain, Cr *Fisher's LSD* against Pot.

Table 6. Variety x treatment interaction mean ± SE for Cr Grain (Pot).

	Treatment									
Var.	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**Mean**
V1	7.25±0.30KL	8.89±0.31D-J	6.37±0.41P-X	8.76±0.12D-J	7.00±0.46K-P	9.14±0.27A-I	6.84±0.44K-R	8.95±0.37C-J	6.07±0.17T-b	7.70±0.20A
V2	6.53±0.23M-T	8.72±0.19D-J	7.16±0.21KLM	9.23±0.27A-G	6.94±0.54K-P	8.68±0.19E-J	6.45±0.26N-V	8.47±0.08J	6.42±0.27P-W	7.62±0.18A
V3	7.09±0.28K-O	9.17±0.37A-H	6.54±0.29M-T	9.29±0.27A-F	6.44±0.20N-V	9.07±0.35B-J	7.04±0.17K-P	8.68±0.38E-J	5.44±0.13ab	7.64±0.22A
V4	6.43±0.19O-V	9.75±0.05A	6.57±0.19M-T	9.33±0.15A-E	7.03±0.27K-P	9.00±0.34C-J	6.66±0.20K-T	9.23±0.17A-G	5.79±0.06V-b	7.76±0.23A
V5	6.51±0.10M-U	9.14±0.16A-I	5.77±0.19W-b	9.21±0.20A-G	6.57±0.21M-T	8.66±0.31F-J	6.60±0.18L-T	9.27±0.21A-F	5.61±0.11Y-b	7.48±0.23A
V6	6.88±0.25K-Q	9.01±0.09C-J	6.50±0.11M-U	8.57±0.25G-J	7.28±0.70K	8.52±0.18HIJ	6.20±0.24R-Z	9.59±0.14ABC	5.86±0.19U-b	7.60±0.21A
V7	7.10±0.13K-N	8.97±0.19C-J	6.48±0.27N-U	8.54±0.38HIJ	6.46±0.17N-U	8.82±0.07D-J	6.76±0.14K-S	9.31±0.07A-F	5.42±0.14b	7.54±0.21A
V8	6.10±0.16S-a	8.69±0.10E-J	6.37±0.22P-X	9.04±0.16B-J	6.52±0.20M-U	9.70±0.06AB	6.45±0.12N-V	9.24±0.11A-F	5.57±0.12Zab	7.52±0.23A
V9	6.77±0.19K-R	8.75±0.42D-J	6.79±0.06K-R	8.90±0.07D-J	6.70±0.14K-T	9.35±0.26A-D	6.26±0.24Q-Y	9.14±0.23A-J	5.72±0.16X-b	7.60±0.21A
V10	6.59±0.13L-T	8.49±0.18IJ	6.72±0.07K-T	9.07±0.15B-J	6.96±0.16K-P	9.03±0.17C-J	6.52±0.22M-U	8.96±0.19C-J	5.75±0.22X-b	7.57±0.19A
Mean	6.72±0.08BC	8.96±0.08A	6.53±0.08C	8.99±0.07A	6.79±0.11B	9.00±0.08A	6.58±0.08C	9.08±0.08A	5.77±0.06D	

Means sharing similar letter in a row or in a column within a box are by statistically non-significant (p>0.05).

Table 7. Mean comparisons of grain, Cr *Fisher's LSD* against Field.

Table 7. Variety x treatment interaction mean ± SE for Cr Grain (Field).

	Treatment									
Var.	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**Mean**
V1	4.73±0.06Q	6.73±0.29G-P	4.69±0.05Q	6.80±0.27F-P	4.76±0.03Q	7.01±0.26E-M	4.80±0.03Q	6.65±0.04H-P	3.66±0.05R	5.54±0.18A
V2	4.75±0.05Q	6.77±0.32F-P	4.69±0.05Q	6.94±0.36E-M	4.76±0.04Q	6.93±0.26E-N	4.67±0.06Q	7.41±0.48B-F	3.80±0.05R	5.63±0.21A
V3	4.78±0.06Q	7.27±0.33B-I	4.72±0.04Q	6.58±0.22J-P	4.76±0.04Q	6.62±0.28I-P	4.74±0.04Q	8.19±0.29A	3.77±0.02R	5.71±0.22A
V4	4.80±0.07Q	7.07±0.36E-M	4.72±0.07Q	7.25±0.70B-I	4.81±0.03Q	7.32±0.31B-G	4.77±0.04Q	7.20±0.41C-K	3.68±0.05R	5.74±0.23A
V5	4.72±0.06Q	7.29±0.36B-H	4.63±0.04Q	6.23±0.13OP	4.72±0.05Q	6.84±0.41E-O	4.78±0.02Q	6.84±0.34E-O	3.83±0.05R	5.54±0.19A
V6	4.80±0.04Q	7.79±0.66ABC	4.77±0.06Q	7.22±0.32C-J	4.77±0.05Q	6.55±0.19K-P	4.72±0.04Q	7.09±0.50E-M	3.72±0.03R	5.71±0.23A
V7	4.62±0.03Q	7.77±0.19A-D	4.76±0.04Q	6.87±0.43E-O	4.77±0.02Q	7.12±0.58D-L	4.74±0.05Q	6.93±0.18E-M	3.67±0.08R	5.70±0.22A
V8	4.79±0.04Q	7.01±0.41E-M	4.68±0.07Q	7.46±0.50B-E	4.74±0.03Q	6.62±0.28I-P	4.73±0.04Q	6.47±0.15L-P	3.75±0.07R	5.58±0.20A
V9	4.64±0.05Q	6.17±0.10P	4.76±0.04Q	6.78±0.06F-P	4.71±0.06Q	7.30±0.30B-H	4.71±0.06Q	6.46±0.21M-P	3.71±0.02R	5.47±0.18A
V10	4.67±0.02Q	6.73±0.37G-P	4.66±0.04Q	7.24±0.35B-J	4.64±0.06Q	6.28±0.29NOP	4.75±0.03Q	7.89±0.25AB	3.78±0.06R	5.63±0.21A
Mean	4.73±0.02C	7.06±0.12AB	4.71±0.02C	6.94±0.12AB	4.74±0.01C	6.86±0.11B	4.74±0.01C	7.11±0.12A	3.74±0.02D	

Means sharing similar letter in a row or in a column within a box are by statistically non-significant (p>0.05)

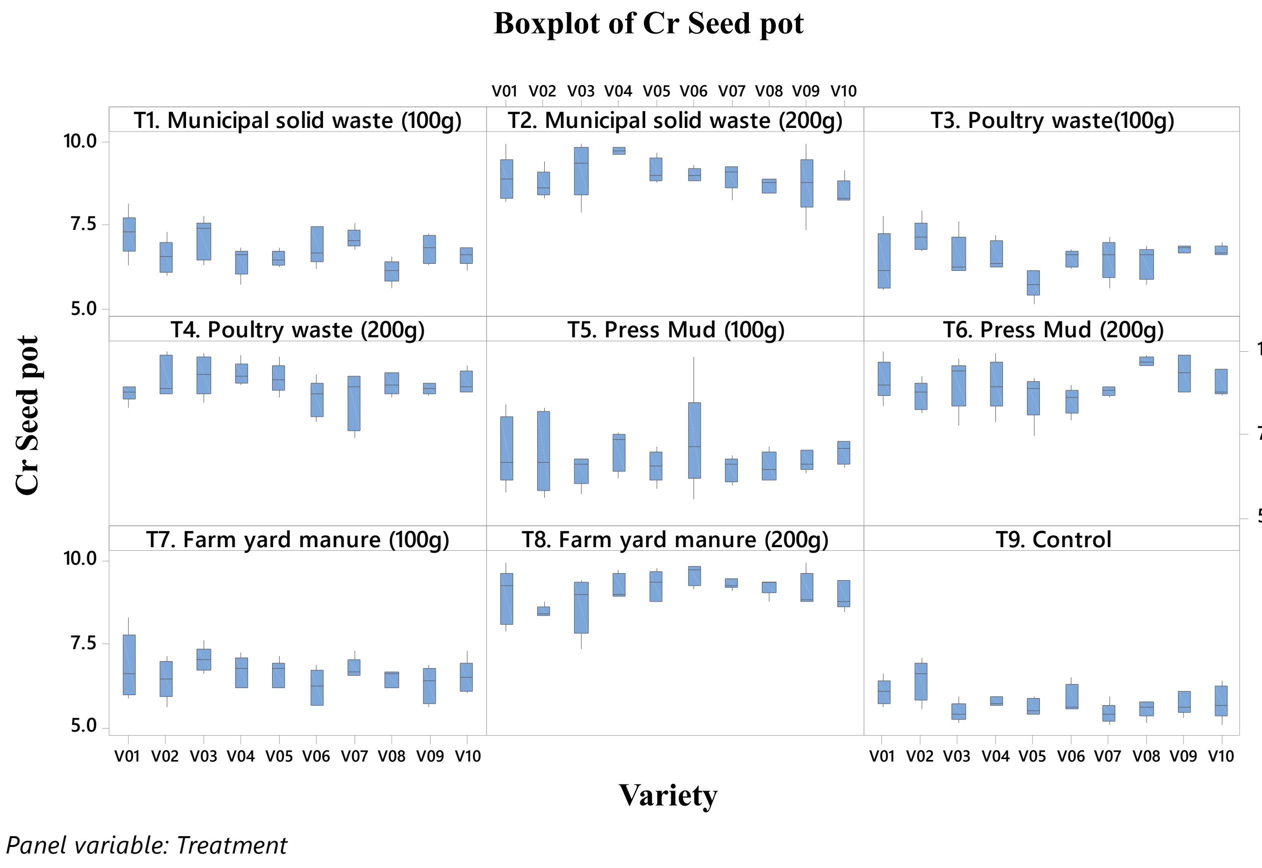

Fig. 5. Boxplot for Cr Seed (Pot).

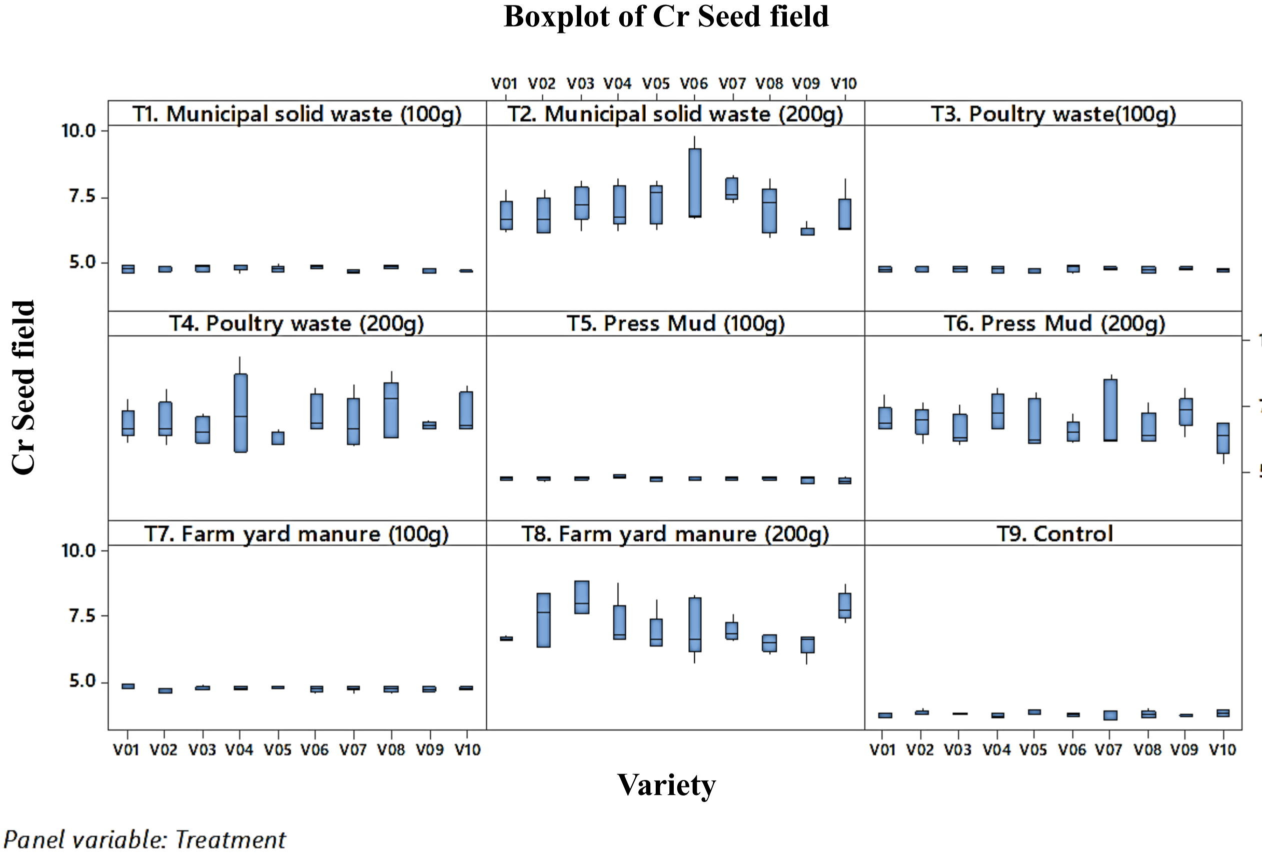

Fig. 6. Boxplot for Cr Seed (Field).

Table 8. A & B: Analysis of data for Cr Soil variance & Cr soil amendments.

Table 8A. Analysis of variance for Cr soil.

Degrees of freedom		Pot	Field
Treatment (Tr)	8	0.0521**	0.0154**
Ctrl. vs Tr	1	0.0853**	0.0797**
Waste (W)	3	0.0004ns	0.0054ns
Dose (D)	1	0.3240**	0.0025ns
WxD	3	0.0022ns	0.0083ns
Error	36	0.0019**	0.0048**
Total	**44**		

Table 8B. Analysis of Cr in soil with amendment.

Soil amendment	Pot	Field
T1	0.261 ± 0.017B	0.330 ± 0.039A
T2	0.413 ± 0.026A	0.234 ± 0.020B
T3	0.241 ± 0.021BC	0.238 ± 0.014B
T4	0.439 ± 0.021A	0.257 ± 0.041AB
T5	0.223 ± 0.024BC	0.215 ± 0.043B
T6	0.435 ± 0.018A	0.237 ± 0.042B
T7	0.249 ± 0.008BC	0.241 ± 0.015B
T8	0.407 ± 0.017A	0.271 ± 0.030AB
T9	0.195 ± 0.015C	0.119 ± 0.007C

Table 9. PLI, DIM, BCF, HRI of Cr against treatments.

Treatments	PLI		BCF		DIM		HRI	
	Pot	Field	Pot	Field	Pot	Field	Pot	Field
T1	0. 004	0. 005	25. 747	14. 333	0. 00292	0. 00206	0.0019	0.0014
T2	0. 006	0. 004	21. 695	30. 171	0. 00389	0. 00307	0.0026	0.0020
T3	0. 004	0. 004	27. 095	19. 790	0. 00284	0. 00205	0.0019	0.0014
T4	0. 007	0. 004	20. 478	27. 004	0. 00391	0. 00302	0.0027	0.0020
T5	0. 003	0. 003	30. 448	22. 047	0. 00295	0. 00206	0.0020	0.0014
T6	0. 008	0. 004	20. 690	28. 945	0. 00391	0. 00298	0.0026	0.0020
T7	0. 004	0. 004	26. 426	19. 668	0. 00286	0. 00206	0.0019	0.0014
T8	0. 006	0. 004	22. 310	26. 236	0. 00395	0. 00309	0.0026	0.0021
T9	0. 003	0. 002	29. 590	31. 429	0. 00251	0. 00163	0.0017	0.0011

Table 10. BCF, DIM, HRI of Cr against different varieties.

Varieties	BCF		DIM		HRI	
	Pot	Field	Pot	Field	Pot	Field
V1	24. 839	24. 087	0. 00335	0. 00241	0. 00223	0. 00161
V2	24. 581	24. 478	0. 00331	0. 00245	0. 00221	0. 00163
V3	24. 645	24. 826	0. 00332	0. 00248	0. 00221	0. 00165
V4	25. 032	24. 957	0. 00337	0. 00249	0. 00225	0. 00166
V5	24. 129	24. 086	0. 00325	0. 00241	0. 00217	0. 00161
V6	24. 516	24. 826	0. 0033	0. 00248	0. 0022	0. 00165
V7	24. 323	24. 783	0. 00328	0. 00248	0. 00218	0. 00165
V8	24. 258	24. 261	0. 00327	0. 00243	0. 00218	0. 00162
V9	24. 516	23. 783	0. 0033	0. 00238	0. 0022	0. 00159
V10	24. 419	24. 478	0. 00329	0. 00245	0. 00219	0. 00163

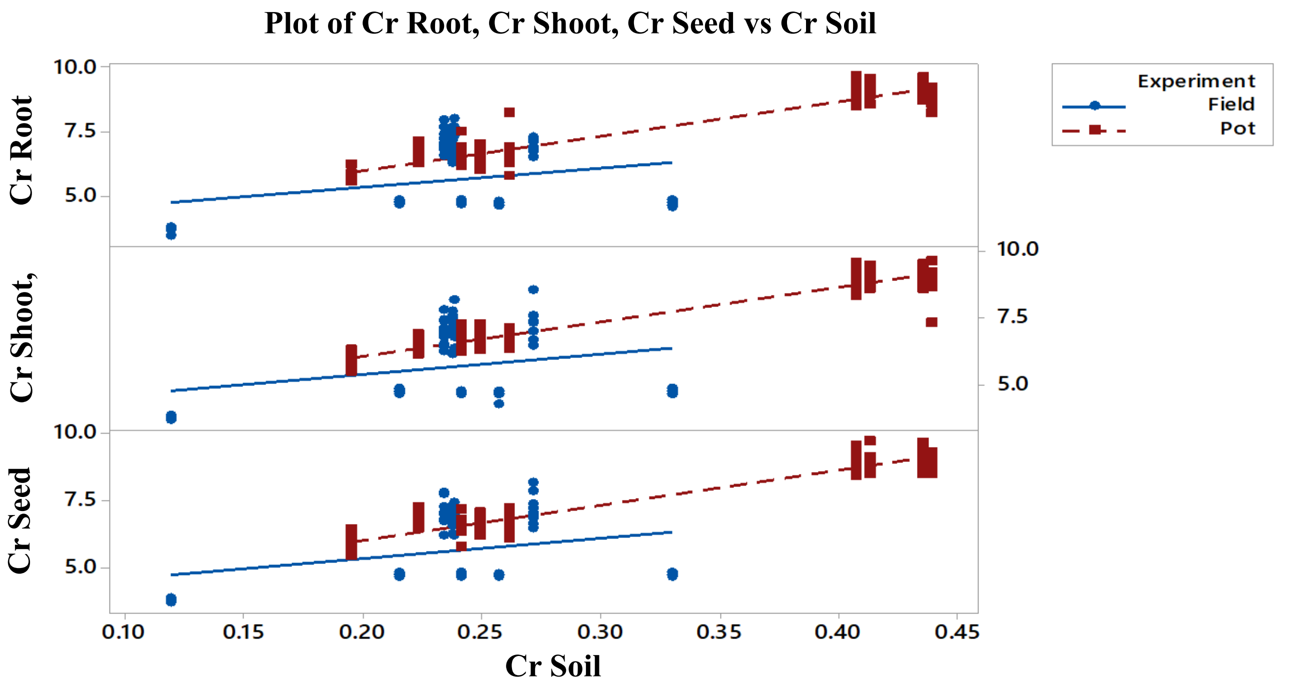

Fig. 7. Cr Boxplot for comparative analysis in pot and field experiments.

The Cr HRI detected according to factor of treatment in wheat grain reflected a considerable lot of variation due to the fact that they were cultivated in different types of manures with varying amounts. The paramount values of HRI in all investigated treatments were raised highest in the Treatment T4 in pot whereas T8 in field site. Given that T9 in pot and T9 in field site were identified as one of the treatments with the lowest value for HRI. Figure 11 illustrates the comparison level of Cr HRI contents in grain samples among ten varieties which were grown under the influence of diverse treatment sources.

Table 10 illustrates the findings of BCF, DIM and HRI with respect to the varieties. By moving from left towards right in a table, these parameters were being calculated on the base of standard calculations given in materials and methods.

The Cr BCF detected according to factor of varieties in wheat grain reflected a considerable lot of variation due to the fact that they were cultivated in different types of manures with varying amounts. The paramount values of BCF in all investigated treatments were raised highest in the Variety V4 in pot as well V4 in field site. Given that V8 in pot and V5 in field site were identified as one of the varieties with the lowest value for BCF. Figure 12 illustrates the comparison of Cr BCF contents in grain samples from pot and field among the ten varieties.

The Cr DIM detected according to factor of varieties in wheat grain reflected a considerable variation due to the fact that they were cultivated in different types of manures with varying amounts. The paramount values of DIM in all investigated treatments were raised highest in the Variety V4 in pot as well V4 in field site. Given that V9 in pot as well as V9 in field site was identified as one of the varieties with the lowest value for DIM. Figure 13 illustrates the comparison level of Cr DIM contents in grain samples from the ten varieties grown under different conditions.

The Cr HRI detected according to factor of varieties in wheat grain reflected variation due to the fact that they were cultivated in different types and varying amounts of manures. The value of HRI in all investigated treatments was maximum in the Variety V9 in pot and V4 in field site. Given that V4 in pot and V9 in field site were identified as one of the varieties with the lowest value for HRI. Figure 14 illustrates the comparison level of Cr HRI contents in grain samples among the ten wheat varieties.

Discussion

According to the reports published by WHO and FAO, the safety levels for Cr usage in eatables are 0. 05 and 0. 10 mg/L, respectively as already reported in earlier publications (Ayers & Westcot, 1985). Due to addition of household garbage and poultry waste into open lands, Cr levels are much more increased in soils from where plants are taking this metal into their bodies (Aggelides *et al*., 2000). In agriculture sector, feces of domesticated animals are also present in running water which are increasing the threshold levels in the Cr concentration (Dewani *et al*., 1997). Our Cr concentration in collected samples was found according to the values observed by Nazir *et al*., (2015). They observed in their experiment the rising level of Cr which was up to the range of 1. 313 to 2.886 mg/L. The level of Cr is rising day by day due to multiple factors (Khattak *et al*., 2006). The rising levels of Cr was also studied by Soomro *et al*., (2014) when they experimented heavy metal concentrations in Phuleli.

In present research, all soil samples taken from amended fertilizers with the soil were found to be high in Cr as compared to the controlled sites as per previous observations (Amlinger *et al*., 2007). The safest levels of growing wheat in specific soil having Cr levels according to the recommendations from (WHO, 1993-1996) should not be exceeding from 400 mg/L. The trend for Cr in soil was observed in an order of increasing levels from controlled to T1 and was leading to the T2. The current observed values are slightly higher than what was observed by Khan *et al*., (2015). Other researchers also reported same trends (Khan *et al*., 2013). The study conducted in a pot showed varied concentrations of Chromium constituents in soil. The results on the basis of treatments indicated that T4 (0.439±0.021A) was at the uppermost level in Cr pot soil contents whereas T9 (0.195±0.015C) is categorized as at the uppermost among the Cr levels in soil field. The comparison on the basis of treatments indicated that T4 (0.257±0.041AB) was at the nethermost level in Cr pot soil contents whereas T9 (0.030±0.003C) is categorized as nethermost among the Cr levels in field site soil. Overall, fully significant results have been observed in soil studies when compared on the basis of sites. The reported values of Cr in soil are slightly lower than the observations made by researcher Nazir *et al*., (2015).

The nine different treatments applied for Cr soil in pots can be seen in terms of their decreasing order by the following comparison. T4 > T6 > T2 > T8 > T1 > T7 > T3 > T5 > T9.

The nine different treatments applied for Cr soil in field can be seen in terms of their decreasing order by the following comparison. T1 > T8 > T4 > T7 > T3 > T6 > T2 > T5 > T9.

The Cr concentration is higher than what was previously recorded by Marín *et al*., (2000). As wheat is considered as an Agronomic crop and some findings suggest that its permissible limits can be different from non-agronomic crops (Delate *et al*., 2004). Some previous findings considered that permissible limits of 2.30 mg/Kg could be effective for cultivation.

Gayathri *et al*., (2011) conducted research on poultry wastes and found some growth patterns of maize grown under different treatments. In current research, the contents of Cr in roots found to be high as compared to shoot and grains in both sites. Our root samples showed the higher Cr values than shoot and grain samples. The Cr contents are high in values according to level reported by Marín *et al*., (2000). The typical values of roots are very near to the point found by Nazir *et al*., (2015) when they conducted experiment on roots and leaves of *Acacia modesta, Dodonaea viscose* and *Tamarix aphyda.* Srivastava & Chopra (2014) reported the issue of press mud materials from sugar industries contributing to high level of metal accumulation.

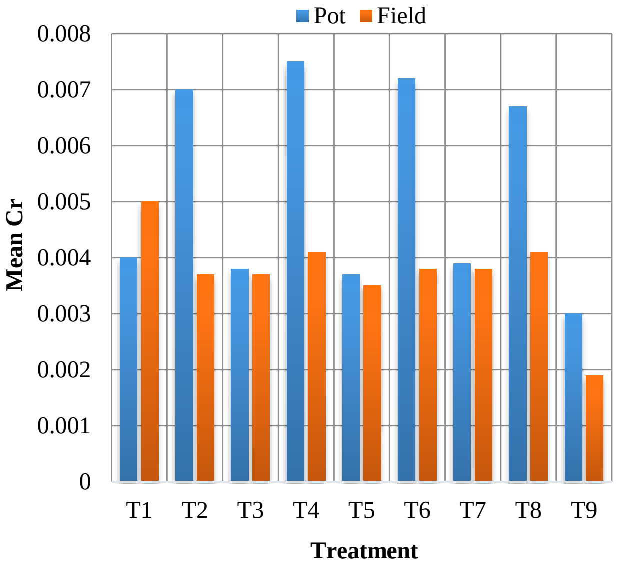

Fig. 8. PLI for Cr in pot and field experiments (Treatment).

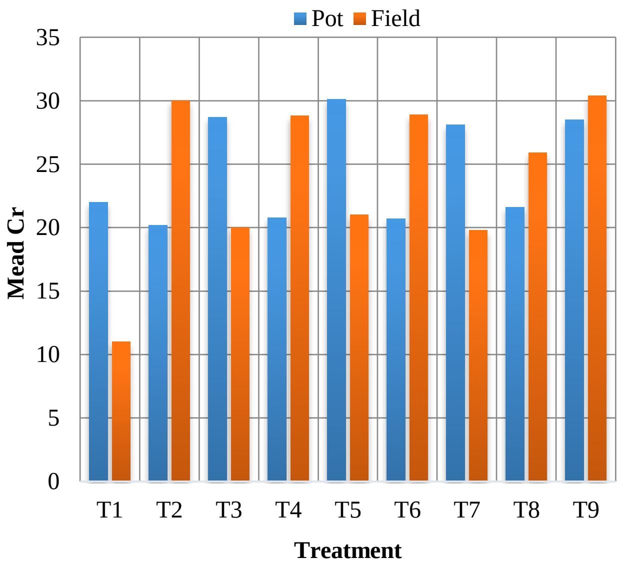

Fig. 9. BCF for Cr in pot and field experiments (Treatment).

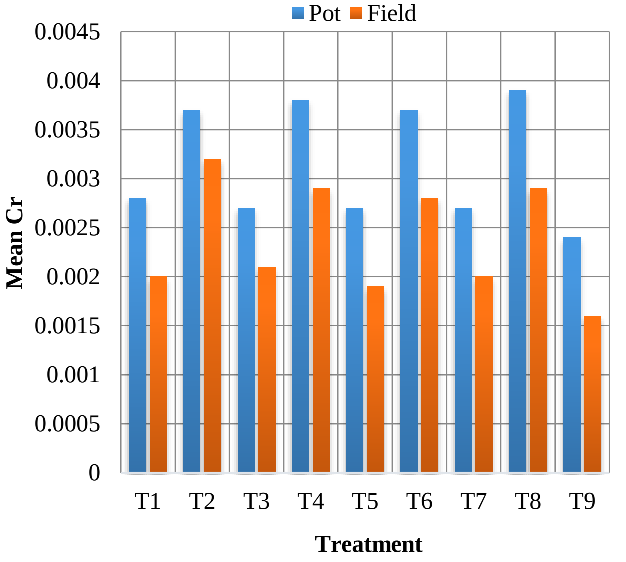

Fig. 10. DIM for Cr in pot and field experiments (Treatment).

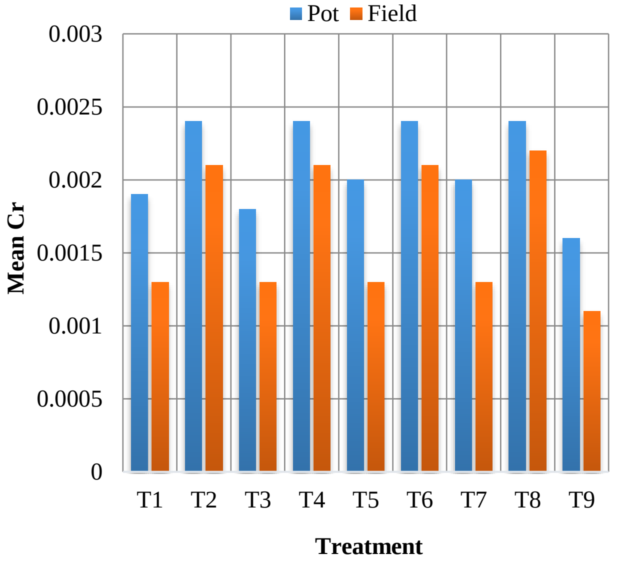

Fig. 11. HRI for Cr in pot and field experiments (Treatment).

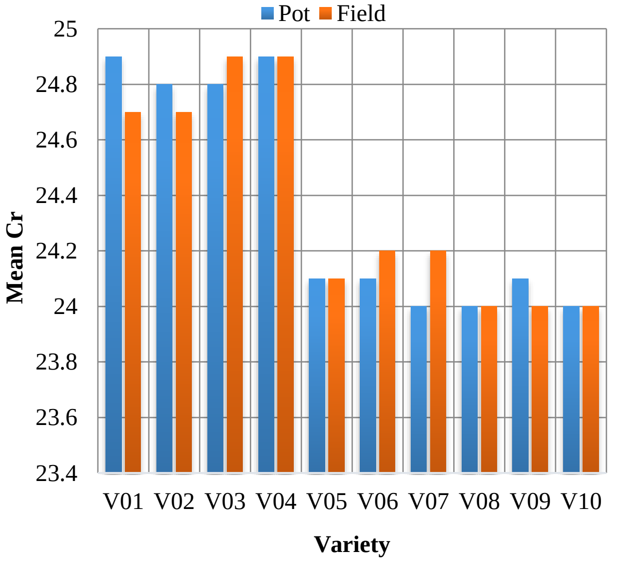

Fig. 12. BCF for Cr in pot and field experiments (Variety).

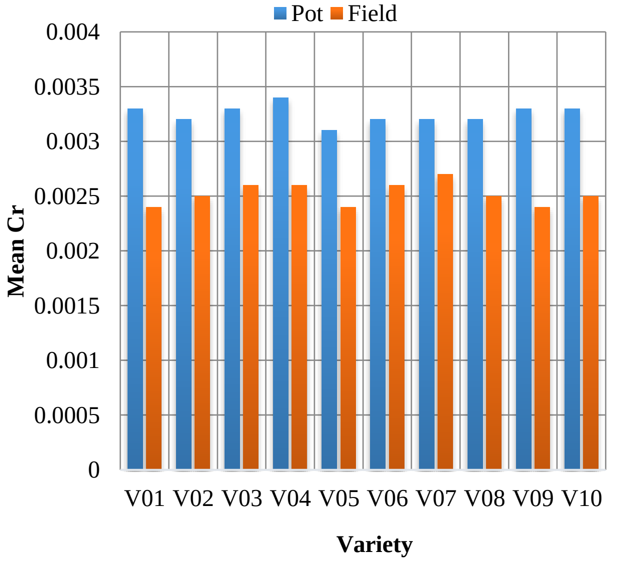

Fig. 13. DIM for Cr in pot and field experiments (Variety).

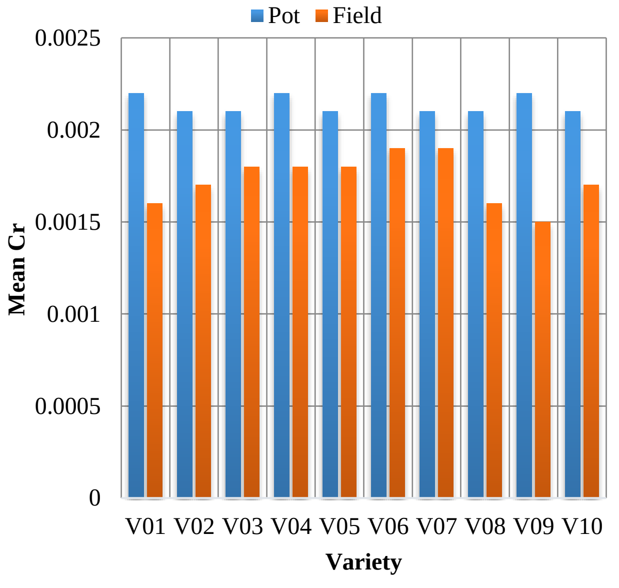

Fig. 14. HRI for Cr in pot and field experiments (Variety).

The ten different varieties grown for Cr pot analysis in root can be seen in terms of their decreasing order in field by the following order V1 > V5 > V10 > V9 > V2 > V6 > V8 > V7 > V4 > V3.

The nine different treatments applied for Cr root in pots can be seen in terms of their decreasing order by the following comparison T2 > T6 > T8 > T4 > T5 > T1 > T3 > T7 > T9.

Budak *et al.*, (2011) conducted research on application of Chromium in some plants and found high levels of Cr in analyzed samples similar to our findings. The stated results are reflecting the similar trends to what were already proposed (Jamil *et al.*, 2008). The same type of trend has also been observed by Othman *et al.*, (1997) in wheat crops when they had conducted analysis for different metals including Cr. Moore *et al.*, (2011) reported that Cr levels are rising in fields irrigated or supplied with additional sources without check and balance. The Cr results showed highest levels in roots and further differences were due to some other physiochemical properties in different species. The same findings were reported by Nehra *et al.*, (2002) who conducted a research on spinach and especially observed particular trends when given different sources of fertilized contents to the soil. The findings were according to the experiments done on different plant parts (Khan *et al.*, 2015).

The ten different varieties grown for Cr field analysis in root can be seen in terms of their decreasing order in field by the given following comparison V9 > V4 > V6 > V1 > V2 > V6 > V10 > V3 > V5 >V8.

The nine different treatments applied for Cr root in field can be seen in terms of their decreasing order by the following comparison T2 > T4 > T5 >T7 > T3 > T1 > T6 > T8 > T9.

Payus & Talip (2014) found that less amount of metal transfer is happening between root and shoot. The Cr results showed highest levels in shoots and further differences are due to some other physiochemical properties in different species. The same type of intake trend has been observed in an earlier study (Cui *et al.*, 2004). The paramount values of stated element in all investigated treatments were raised highest in the Treatment T2 (9.07±0.08A) in pot whereas T8 (7.14±0.13A) in field site. Given that T9 (5.86±0.05D) in pot and T9 (3.76±0.02D) in field site was identified as one of the varieties with the lowest value for Cr shoot for the same ingredient under investigation. These findings are in accordance to the findings of researchers performing related experiment (Dowdy & Larson, 1975).

The ten different varieties grown for Cr pot analysis in shoot can be seen in terms of their decreasing order in field by the given following comparison V5 > V9 > V1 > V8 > V6 > V10 > V7 > V4 > V3 > V2.

The nine different treatments applied for Cr shoot in field can be seen in terms of their decreasing order by the following comparison T2 > T6 > T8 > T4 > T3 > T1 > T7 > T5 > T9.

Moyin-Jesu (2015) conducted research on cabbage by application of different organic fertilizers. His findings showed different levels of accumulation in various sources. According to the findings of this study, the results are significant when compared to the overall means of the 10 wheat types included in this experiment, which are similar to earlier reported cases (Zhuang *et al.*, 2005). The studies by Jayakumar & Jaleel (2009) also observed some kind of related trends. Kisku *et al.*, (2000) found soil irrigation problems with sources diverse in these toxic metals and contributing to the high levels in plant shoots.

The ten different varieties grown for Cr field analysis in shoot can be seen in terms of their decreasing order in field by the given following comparison V4 > V8 > V6 > V9 > V2 > V1 > V7 > V3 > V10 > V5.

The nine different treatments applied for Cr shoot in field can be seen in terms of their decreasing order by the following comparison T6 > T8 > T4 > T2 > T1 > T5 > T7 > T3 T9.

According to the research done by Tegegne (2015) on cereal crops, the grains which are coming from safe Cr level soil are healthy enough to be utilized for animal consumption. The hazardous levels of their toxicity can be fatal for its consumption (Szabó *et al.*, 2009). Many resources of Cr pollution toxicity have been observed in medicines sector and food processing products including wheat grains. Similar finding was also reported by Alghobar & Suresha (2015).

The ten different varieties grown for Cr pot analysis in seed can be seen in terms of their decreasing order in field by the given following comparison V5 > V9 > V1 > V8 > V6 > V10 > V7 > V4 > V3 > V2.

The nine different treatments applied for Cr seed in pots can be seen in terms of their decreasing order by the following comparison T8 > T6 > T4 > T2 > T5 > T1 > T7 > T3 > T9.

The comparison of pot and field can be explained on the basis of leaching capabilities as pot environment is reserved for keeping all the ingredients inside the pot. The already reported experiments on *Helianthus annulus* and examined uptake ability of Cr regarding sites reported by Chen & Cutright (2001). According to the findings of this study, the results are significant when compared to the overall means of the 10 wheat types included in this experiment, which are similar to earlier reported case (Singovszka *et al.*, 2015). Overall, we found that our findings are totally significant in terms of the concentration of metal Cr in grains under the impact of various treatments. Brar *et al*., (2000) reported differential metal uptake potential in plants. The grains of wheat are used as major source of nutrition and used worldwide, due to continuos addition of unchecked materials into the soil for harvesting purpose may cause serious health issues especially in children's and even leading to cancer (Pathak *et al*., 2010).

The ten different varieties grown for Cr field analysis in seed can be seen in terms of their decreasing order in field by the given following comparison V4 > V3 > V6 > V7 > V2 > V10 > V8 > V1 > V5 > V9.

The nine different treatments applied for Cr grain in field can be seen in terms of their decreasing order by the following comparison T8 > T2 > T4 > T6 > T5 > T7 > T9 > T1 > T3.

The safe level of Cr in eatables especially in meat is considered to be within a range of 50 mg/Kg standards set by WHO. These high concentrations may build up in the tissues of consumers or also some of it may be excreted from the body which may lower its toxicity (Furness *et al*., 1986). The accumulated metals in the body are originating from the sources of food being eaten and posing human body with a greater risk of health. The edible parts are on the top of list for causing these problems as reported by Mcbride (1994). Within the body, the major sources are definitely the food consumed as reported by Gabol *et al*., (2014).

In the present study, PLI values for Cr are in the weakest categories regarding their numerical value, corresponding to the findings of Pathak *et al*., (2011) who found PLI values for the various metals forming low levels of accumulation specifically for Cr. Alghobar & Suresh (2015) also found PLI values for Cr in soil-reduction states irrigated with contaminated water.

The pollution index value of 1.0 indicates that these metals may pose a threat to the environment. Soil pollution can be investigated using a pollution loading index (Angula, 1996). High levels of iron in water and fertilizer sources are believed to increase the level of these minerals in the soil. Our findings from this study indicate that PLI <1 in both sites is below the values obtained by Angulo (1996) but exceeded the standards obtained by Khan *et al*., (2015). The PLI index was intended to evaluate soil pollution, and its Cr readings showed that not all soil samples were contaminated by Cr.

The nine different treatments applied for Cr can be seen in terms of their PLI pot and field decreasing order by the following comparison.

PLI pot: T6 > T4 > T2 > T8 > T1 > T3 > T7 > T5 > T9

PLI field: T1 > T2 > T3 > T4 > T6 > T7 > T8 > T5 > T9

Srivastava & Chopra (2014) reported that Cr has an important impact on accumulation in the body tissues when he found high PLI in the soil which was irrigated with sugar mill effluents in two plant seasons. When the respective ingredient level is high (> 1), it indicates high distribution and availability of minerals in contaminated soils and leads to an increase in the concentration of heavy metals in the irrigated areas of large plants, vegetables and weeds (Begum *et al*., 2015).

In this study, BCF of Cr values are <1, showing limited Cr transfer from soil to grains. Asdeo (2014) found a BCF value of less than 1 of Cr when he analyzed maize and sorghum grains. Cr <1 readings at both sites, except BCF values, indicated that a tiny quantity of Cr translocated from root to shoot and were lower than Payus and Talip (2014) and Begum *et al*., (2015) and exceed the findings of Satpathy *et al*., (2014).

The nine different treatments applied for Cr can be seen in terms of their BCF pot and field decreasing order by the following comparison.

BCF pot: T5 > T9 > T3 > T7 > T1 > T8 > T2 > T6 > T4

BCF field: T9 > T2 > T6 > T4 > T8 > T5 > T3 > T7 > T1

The ten different varieties grown for Cr can be seen in terms of their BCF pot and field decreasing order by the following comparison.

BCF pot: V4 > V1 > V3 > V2 > V6 > V9 > V10 > V7 > V8 > V5

BCF field: V4 > V3 > V6 > V7 > V9 > V2 > V10 > V8 > V1 > V5

Budak *et al*., (2011) also measured the transfer of various metals to shoot from the root of the rice factory and found that the BCF Cr value was between 0. 5-0. 8. Budak *et al*., (2003) conducted a study measuring the growth and translation of four species belonging to ornamental plants exposed to various congestion for ten weeks. Both studies revealed similar BCF levels.

The nine different treatments applied for Cr can be seen in terms of their DIM pot and field decreasing order by the following comparison.

DIM pot: T8 > T4 > T6 > T2 > T5 > T1 > T7 > T3 > T9

DIM field: T8 > T2 > T4 > T6 > T1 > T5 > T7 > T3 > T9

The ten different varieties grown for Cr can be seen in terms of their DIM pot and field decreasing order by the following comparison.

DIM pot: V4 > V1 > V3 > V2 > V10 > V7 > V8 > V5 > V6 > V9

DIM field: V4 > V3 > V6 > V7 > V2 > V10 > V8 > V1 > V5 > V9

Maximum researchers have stated the influence of the traffic load on heavy metal contents in topsoil's and their variability with distance (Ward *et al*., 1977; Rodriguez & Rodriguez, 1982; Zhang *et al*., 1999; Turer & Maynard, 2003).

The higher the HRI value, the higher will be the probability of the hazardous risks for human body. The HRI value proposed by USEPA is a broad indicator of risk by comparing the amount of contaminated reference to the average reference volume and is widely used in the testing of metals in contaminated foods (Storelli, 2008).

The nine different treatments applied for Cr can be seen in terms of their HRI pot and field decreasing order by the following comparison.

HRI pot: T8 > T4 > T6 > T2 > T7 > T1 > T5 > T3 > T9

HRI field: T8 > T4 > T6 > T2 > T7 > T1 > T5 > T3 > T9

The ten different varieties grown for Cr can be seen in terms of their HRI pot and field decreasing order by the following comparison.

HRI pot: V4 > V1 > V2 > V3 > V10 > V7 > V8 > V5 > V6 > V9

HRI field: V4 > V3 > V6 > V7 > V2 > V10 > V8 > V1 > V5 > V9

Concentration of these heavy metals in soils is associated with geochemical cycles and biological processes and could be greatly influenced by high traffic load and transportation activities. In the food chain, primary producers, i.e., plants, are capable of absorbing these metals from the soil (Kakulu & Abdullahi, 2004; Rajaram & Das, 2008). These metals contaminate the soil when they undergo chemical reactions and come in direct contact with roots of plants (Udosen *et al*., 1990). When these plants in the form of vegetables are consumed by man, trace metals become bioaccumulated and eventually result in several ailments which may subsequently cause death (Odiette, 1999). In some cases, plants accumulate some of these metals which are not injurious to them but may be poisonous to animals grazing on the plants (Raven & Evert, 1976). Nabulo *et al*., (2006) reported that leaves of roadside crops can accumulate trace metals at high concentrations, causing a serious health risk to consumers.

Conclusion

Wheat plants can accumulate Cr metal in a high concentration especially in the edible part like grains. Therefore, an appropriate precautionary advisory at international level is required to grow it in safe environment and it is also advised that amendments be used in accordance with international guidelines. More research needs to be carried out to determine whether wheat plants are super accumulators of this metal, and if so, which variety and to what amount. Sargodha is an agricultural district with significant potential of export of agricultural commodities, but at the same time, it is under the influence of industrialization. Because wheat flour is a part of our daily diet and is commonly used as a staple food, it is recommended to develop the maximum and the minimum limits for farmers regarding the use on a large scale in suitable situations, as it may or may not be desirable to use without having check and balance in agricultural practices. As a result, it is recommended to utilize organic supplements intelligently instead of other pricey and typical industrialized inorganic fertilizers to save money, while also improving soil and consumer health.

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