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Full Length Article

Wheat Straw Biochar Promotes the Growth and Reduces the uptake of Lead, Cadmium and Copper in *Allium cepa* L.

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Abstract

Heavy metal contamination to the food chain is an emerging issue due to the use of poor-quality water for irrigation. Onion (*Allium cepa* L.) is the most commonly used vegetables in Pakistan which is known to accumulate high concentration of lead (Pb) and cadmium (Cd), while it shows growth inhibition at higher concentration of copper (Cu). In this study, we locally produced biochar from wheat straw and applied to the soil at the rate of 3% (v/v), which was irrigated by water containing different concentration of Pb (10, 20 & 40 mg L^{-1}), Cd (3, 5 & 7 mg L^{-1}) and Cu (10, 20 & 30 mg L^{-1}) for 35 days. Dry weight and heavy metal uptake by *A. cepa* L. were measured. Results showed that plants grown in soil amended by wheat straw biochar produced more dry weight *i.e.*, 30-40% higher in case of Pb, 50-70% in case of Cd and 60-75% in case of Cu. Similarly, the levels of Pb, Cd and Cu uptake in plants grown in wheat straw biochar amended soil was lower by 60, 60 and 55%, respectively, compared to the plants grown in non-amended soil. It is concluded that the use of locally produced wheat straw biochar as soil amendment promotes *A. cepa* L. growth as compared to non-amended soil, ultimately reducing the heavy metal uptake in plant and keeping it confined to the soil. Thus, the use of wheat straw biochar can be cost effective and beneficial in the areas where agricultural crops are being irrigated by heavy metal contaminated water. © 2019 Friends Science Publishers

Keywords: Heavy metals; Biochar; Onion; Food quality; Vegetables

Introduction

Rapid industrialization holds a key role in the development sector in countries like Pakistan, but this rapid industrialization distruct the balance of whole ecosystem. One of the serious threats imposed to our soil and ground water by industrial effluents is heavy metal contamination, specifically of lead (Pb), cadmium (Cd) and copper (Cu). These metals when reach in ground water ultimately contaminate various crops and vegetables, ultimately reaching the food chain (Khan *et al*., 2014; Baldantoni *et al*., 2016).

The permissible limit for Pb in soil is 0.3 mg kg^{-1}, as guided by the European Union Standards (2002). Mostly the vegetables available in Pakistan although eatable but have Pb concentration above the permissible limits (Perveen *et al.*, 2012). Lead is reported to be highly toxic for human health and found to be involved in oxidative stress, bringing about the creation of unevenness between the generation of free radicals and the capacity of natural framework to promptly detoxify oxygen responsive species (Flora *et al*., 2007). In case of Cd the maximum permissible limit in soil is 3.0 μg kg^{-1} by European Union Standards (2002). The concentration of Cd in ground water as well as soil samples in various regions of Pakistan was found to be higher than the allowed limits. In ground water, the average range of Cd found was to be 0.001-0.21 mg L^{-1} (Lone *et al.*, 2003), while in soil it ranges between 0.02-184 mg kg^{-1} (Muhammad *et al*., 2011). As for as the toxicity of Cd is concerned, it effects deleteriously to human body, usually when it is taken up by human, it will transport throughout the body by bonded to the metallothionein and causes injury to tissues by limiting the amount of oxygen in body (Matović *et al.*, 2011). Cd is also found to be the cause of genetic alterations in the expression of DNA (Wang *et al.*, 2012) and also inhibit the transport pathways (Thévenod, 2010). The permissible limit for Cu in diet of an adult human is 0.9 mg day^{-1} (Trumbo *et al.*, 2001). Total concentration of Cu in industrial areas of Islamabad ranged from 8.88-357.4 mg kg^{-1} (Malik *et al*., 2010), while in sediments, the highest concentration observed to be 272 mg kg^{-1}, at the most downstream parts of Karachi (Siddique *et al.*, 2009). At concentrations above the tolerable limit,

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Cu is known to show inhibition in growth of plants and also disturb the important cellular processes such as respiration or photosynthesis (Gaetke *et al*., 2014). *A. cepa* L. is not only the part of our staple food but also consumed to cure certain diseases including asthma (Bloem *et al*., 2005). In different cultivated regions of Pakistan 6.83 mg kg^{-1} Pb and 0.45 mg kg^{-1} of Cd was recorded in edible parts of onion (Din *et al*., 2013). The excessive accumulation of Cu in onion has deleterious effects that reduces 60-90% of the root length as compared to untreated ones and at concentration of 10 mg L^{-1} of Cu even the absence of newly formed leaf tissues was observed (Geremias *et al*., 2010). Various types of natural amendments that have been utilized for the treatment of polluted soil including; excrements, biosolids, sawdust and wood-fiery remains, manures got from various source materials, sewage slop, bark chips, and woodchips (Gul *et al*., 2015). Biochar is one of these soil amendments which is obtained by the pyrolysis of waste of various sources, for example, agriculture or forests (Wang *et al*., 2010). Biochar has the capacity to exchange ions and is alkaline in nature (Paz-Ferreiro *et al*., 2014). Recent studies showed a decreased metal uptake in plants and better growth rates, when the soil bed is amended by biochar (Park *et al*., 2011). The properties of biochar rely on the sort of feedstock utilized alongside the pyrolysis conditions (Wu *et al*., 2012). Wheat straw biochar when applied, soil exhibit same rate of NO_2 production as that of un-amended soil, which shows that wheat straw biochar applied to soil has potential to maintain C sequestration in soil, without increasing the production of NO_2 (Cheng *et al*., 2012). A study was conducted in rice paddies of China to observed the effects of wheat straw biochar on Cd uptake which concluded that the uptake of Cd decreased upto 54% in year 2009 and 45% in year 2010 in treatments having higher percentage of wheat biochar (Cui *et al*., 2011). Similarly, when 1-5% of wheat straw biochar was added to maize growing soil, the concentration of Cu in maize reduced from 48 mg kg^{-1} to 35 mg kg^{-1}, Cd reduced from 0.62 mg kg^{-1} to 0.40 mg kg^{-1} and Pb reduced from 7.8 mg kg^{-1} to 5.5 mg kg^{-1}. In case of dry mass, the dry matter of maize shoots increased to its highest weight from 54% to 102%, with addition of 5% wheat straw biochar (Al-Wabel *et al*., 2015).

The present study has been conducted in order to assess the potential of locally produced wheat straw biochar on the growth of *Allium cepa* L. and heavy metals availability to the selected plant. The biochar was analysed for X-Ray Diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR). Accumulation of Pb, Cd and Cu was analysed in different tissues of *Allium cepa* L.

Material and Methods

Biochar Production

For the production of biochar, wheat straw was collected from the agricultural field on the backside of National Center for Bioinformatics building, Quaid-i-Azam University, Islamabad. Biochar was prepared in muffle furnace at temperature of 500°C, with the increasing rate of 5°C min^{-1} and the residence time of 2 h under oxygen limited conditions. The process yielded approximately 35% of the pyrolyzed product.

Analysis of Soil

Soil analysis was performed to measure various parameters before the experimentation. These parameters include soil pH, EC and soil texture.

Soil pH and Electrical Conductivity (EC)

To check pH of soil, 1:5 mixture of soil and water was prepared, where 5 g soil was mixed thoroughly in 25 mL of water. Soil pH and EC was determined by the pH/EC meter (Eutech, Model pc 510).

Soil Texture

Soil texture was measured using hydrometer following Kettler's *et al.* (2001) protocol. Soil texture triangle was used to determine soil type.

Analysis of Biochar

The biochar produced was further analyzed for X-Ray Diffraction (XRD) and Fourier-transform Infrared Spectroscopy (FTIR) at National Center for Physics, Islamabad. For viewing graphical representation of FTIR results Origin 8 software was used, while for finding out the functional groups present in wheat-straw biochar based on comparing wavelengths of peaks found in FTIR results an online database designed by Oregon State University was used. X-Ray diffraction of biochar was done on X-Ray diffractometer with 10.154056 wavelength power. Fourier-transform infrared spectroscopy was done on Jasco 6600 Purklin D8 Advance machine with wavelength power of 400 to 4000 cm^{-1}.

Seed Collection and Sowing

Seeds of onion variety (Hazara) were purchased from Mityari, Hyderabad and were allowed to germinate in peat moss. After germination the seedlings were allowed to grow for five weeks in the same soil and were watered using tap water (with non-detectable concentration of heavy metals).

Seedlings Transplantation

After five weeks, the seedlings were transferred to a mixture of 3:1 soil/sand with 3% (v/v) of biochar. Each pot, containing almost 500 g soil/sand mixture with 3% (v/v) of biochar, was planted with single seedling. For each metal, plant pots were divided into two groups, with biochar and without biochar (as a control). Moreover, the

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group of pots containing biochar were divided into further three sub-groups for three different concentrations of each metal and all the experiment was conducted in triplicates. The details of all the treatments is provided in Table 1.

Irrigation

Initially the pots were watered with tap water (with non-detectable concentration of heavy metals) for one week and later the pots were watered containing particular metal for five weeks *i.e.*, Pb (0, 10, 20 and 40 mg L^{-1}), Cu (0,10, 20 and 30 mg L^{-1}) and Cd (0, 3, 5 and 7 mg L^{-1}).

Harvesting and Heavy Metal Analysis

After five weeks of heavy metal exposure, the plants were harvested and were separated into roots, leaves and bulblets. Then the samples were air dried at 75°C for 48 h until constant weight. The dried plants material was further processed by acid digestion. Each plant part was crushed down in mortar and pestle, 0.1 g was mixed with Aqua Regia solution and was digested on hot plate at 120°C. The samples were filtered through Whatman Filter Paper and were analysed by atomic absorption spectrophotometer (AAS) (Perkin Elmer, AAS 700), for assessing the uptake of Pb, Cd and Cu.

Statistical Analysis

Statistical analysis was performed by using the software SPSS version 20 (designed by IBM, United States). Duncan's test was applied to measure the level of significance between various treatments ($p \leq 0.05$). Standard error was calculated using mean of three replicates.

Results

Soil Parameters

The pH of soil was 8.5, alkaline in nature, while the EC of soil was 0.27 dS m^{-1}. Hydrometery method confirmed the soil to be loamy in nature. The mineral composition of loamy soil constitutes of about 40:40:20% concentration of sand:silt:clay, respectively.

After the completion of experiment, soil recovered from the pots was analyzed for pH test and found that pH has been raised to 8.9.

X-Ray Diffraction (XRD) of Wheat Straw Biochar

X-Ray diffraction analysis of wheat-straw biochar confirmed the presence of tetrameric phosphonitrilic isothiocyanate ($N_4P_4(NCS)_8$) in biochar (Fig. 1). The structure of tetrameric phosphonitrilic isothiocyanate contains a backbone of two basic elements including nitrogen and phosphorus (N-P). Both of these elements play a key role in promoting the nutrition and fertility of soil.

Table 1: Experimental design of the study

Treatments	Pb levels (mg L^{-1})		Cu levels (mg L^{-1})		Cd levels (mg L^{-1})	
	-BC	+BC	-BC	+BC	-BC	+BC
T1	0	0	0	0	0	0
T2	10	10	10	10	3	3
T3	20	20	20	20	5	5
T4	40	40	30	30	7	7

Where -BC = No biochar and +BC = Biochar @ 3% (v/v)

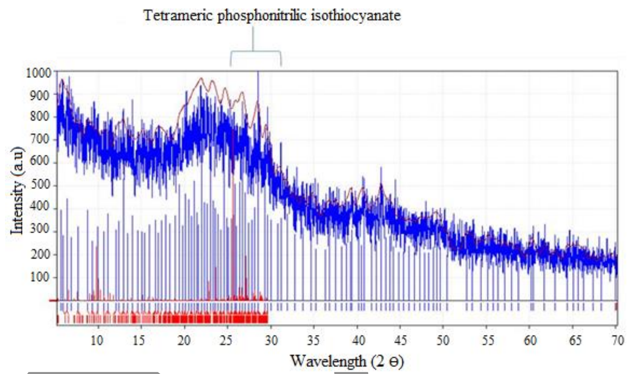

Fig. 1: Graphical display of XRD, showing the presence of Tetrameric phosphonitrilic isothiocyanate in wheat-straw biochar, confirmed by the built-in mineral database of Match 3 software

Fourier-Transform Infrared Spectroscopy (FTIR) of Wheat Straw Biochar

FTIR analysis of wheat-straw biochar confirmed the presence of ethyl acetate in it by comparing the selected wavelength with online functional group database, designed by Oregon State University. It contains both C-O and C=O functional groups, which enhances the binding capacity of biochar.

The graphical view of infrared spectroscopy, as shown in the Fig. 2, demonstrates the peak is formed between wavelengths of 1000 to 1500 cm^{-1}, which confirmed the presence of a single dominant group in wheat-straw biochar, which is ethyl acetate. While the other region showing a mesh of overlapping waves represents fingerprint region.

Dry Weight of *Allium cepa* L.

After harvesting dry weight of plants belonging to all groups of metal treatments was measured and the weight of plants grown in soil amended by wheat-straw biochar were compared with the weight of plants grown in non-amended soil. Dry weight of plants grown in wheat straw biochar amended soil came up to be 30-40% higher at all three concentrations of Pb *i.e.*, 10, 20 and 40 mg L^{-1} as shown in Fig. 3.

Dry weight of plants increased slightly in wheat-straw biochar amended soil than the control (Fig. 4) at 3 mg L^{-1} Cd, but for the further increment of Cd concentration, the weight of plants decreased. But for the plants grown in non-amended soil, no significant change in growth pattern was observed.

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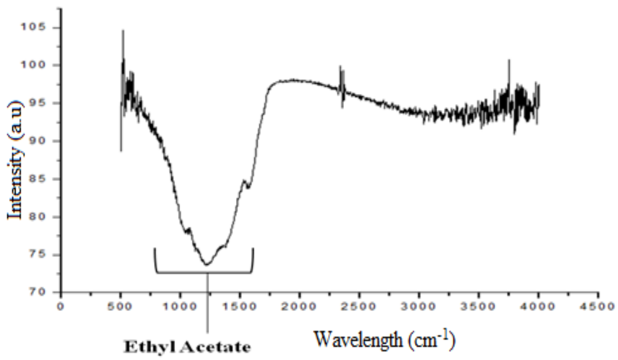

Fig. 2: Graphical display of FTIR produced by Origin 8 software, showing the dominancy of ethyl acetate in wheat-straw biochar, confirmed by comparing the selected wavelength with online functional group database, designed by Oregon State University

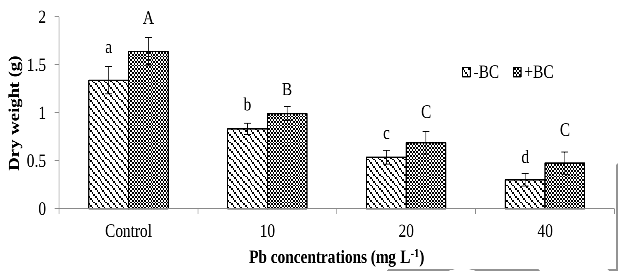

Fig. 3: Dry weight of *Allium cepa* growing in non-amended (-BC) and amended soil (+BC) (by 3% wheat-straw biochar), watered with different concentration (0, 10, 20 and 40 mg L^{-1}) of Pb. Each bar shows the average of three values ± SE. Different alphabets represent significant difference at $p < 0.05$, according to Duncan's test. Small letters represent differences in case of -BC while capital letters represent in case of +BC

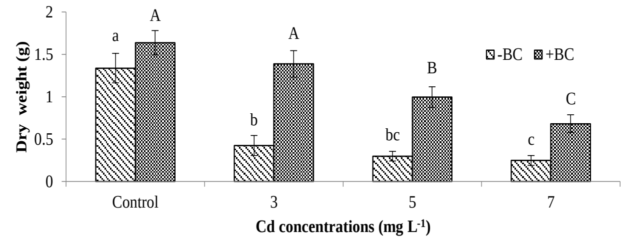

Fig. 4: Dry weight of *Allium cepa* growing in non-amended (-BC) and amended soil(+BC) (by 3% wheat-straw biochar), watered with different concentration (0, 3, 5 and 7 mg L^{-1}) of Cd. Each bar shows the average of three values ± SE. Different alphabets represent significant difference at $p < 0.05$, according to Duncan's test. Small letters represent differences in case of -BC while capital letters represent in case of +BC

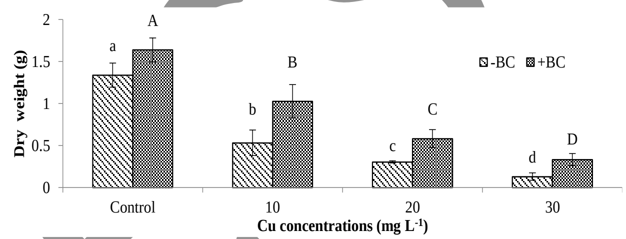

Fig. 5: Dry weight of *Allium cepa* growing in non-amended (-BC) and amended soil(+BC) (by 3% wheat-straw biochar), watered with different concentration (0, 10, 20 and 30 mg L^{-1}) of Cu. Each bar shows the average of three values ± SE. Different alphabets represent significant difference at $p < 0.05$, according to Duncan's test. Small letters represent differences in case of -BC while capital letters represent in case of +BC

Dry weights of plants were significantly higher *i.e*., 50-70% in the case of amended soil as compared to its respective non-amended soil at all Cd levels, as shown in Fig. 4.

In case of Cu, dry weight of plants grown in all the treatments decreased gradually with the increment of Cu concentration. However, dry weights were significantly higher *i.e*., 60-75% when there was biochar as compared to its respective control (without biochar), at all Cu levels (Fig. 5).

Heavy Metal Accumulation by *Allium cepa* L

Pb accumulation: Lead uptake by onion plants while growing in wheat-straw biochar amended soil and non-amended soil in its different parts is shown in Fig. 6. In the roots of plants growing in amended soil, the concentration of Pb accumulated at 10 mg L^{-1} was 40% less than that found in plants growing in non-amended soil. Similarly, at higher concentrations of 20 mg L^{-1} and 40 mg L^{-1} the content was measured to be 50% and 60% lower in wheat-straw biochar amended soil growing plants, respectively, as compared to the plants grown in non-amended soil (Fig. 6a).

In case of bulblets data, similar trend was observed when the amended soil grown plants were compared with those grown in non-amended soil. The concentrations of Pb found in bulblets of plants grown in wheat-straw biochar amended soil at 10 mg L^{-1} was nearly 50% lower than that found in bulblets of plants grown in non-amended soil. At higher concentration, the results again supported the plants grown on amended soil, where the levels of Pb found in bulblets at 20 and 40 mg L^{-1} were 50% lower in amended soil grown plants (Fig. 6b). Pb accumulation in leaves showed the steady increasing trend in the concentrations of Pb, being accumulated in the leaves can be seen with the increase in the concentrations of Pb provided in the soil. But when we compared the results for plants grown in amended versus those grown in non-amended soil, the graph shows that the bars for amended soil grown plants are lower at the rate of 30, 35 and 50% against the concentration of 10, 20 and 40 mg L^{-1} as compared to non-amended plants, respectively (Fig. 6C).

Cd Accumulation

There was a significant difference between Cd levels in roots of plants growing in amended and non-amended soil.

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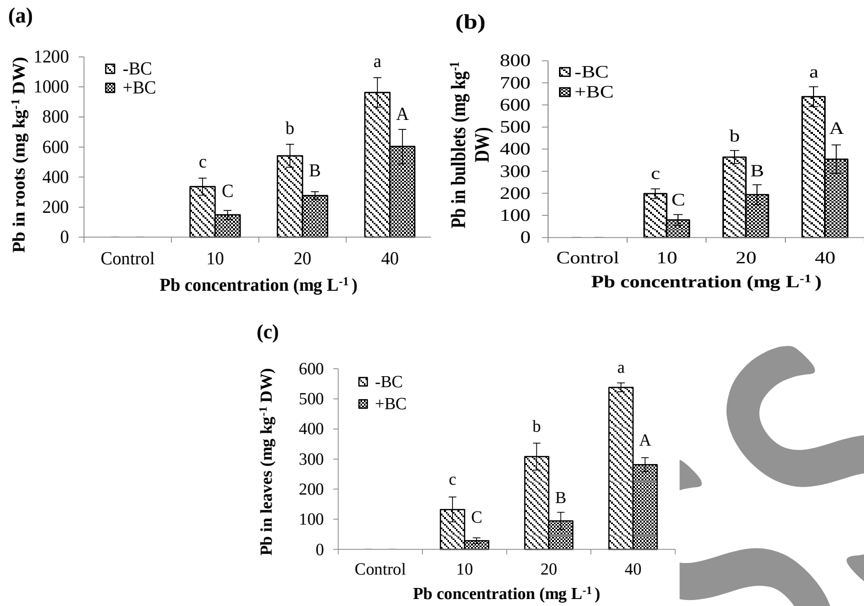

Fig. 6: Pb uptake by *Allium cepa* growing in non-amended (-BC) and amended soil (+BC) (by 3% wheat-straw biochar) when watered with different concentration (0, 10, 20 and 40 mg L^{-1}) of Pb. Each bar shows the average of three values ± SE. Different alphabets represent significant difference at $p < 0.05$, according to Duncan's test. Small letters represent differences in case of -BC while capital letters represent in case of +BC. Lead uptake in **(a)** roots **(b)** bulblets and **(c)** in leaves

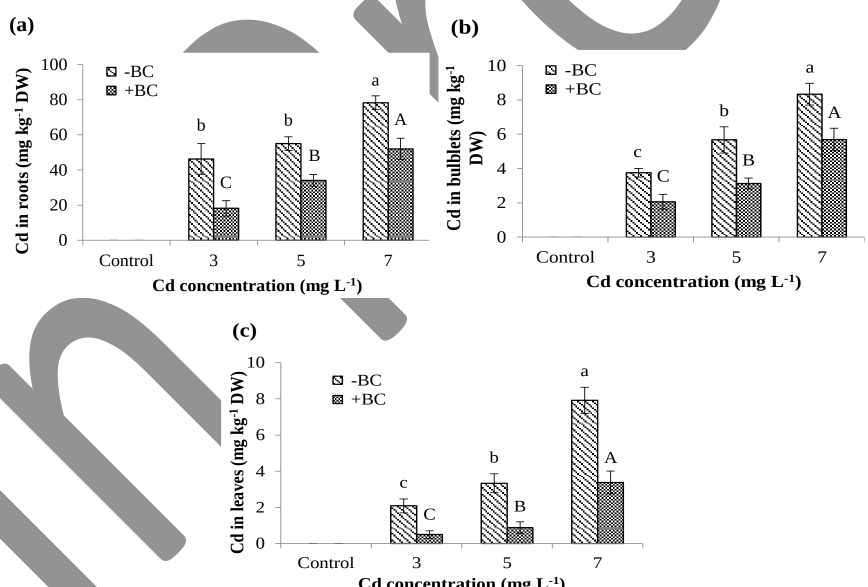

Fig. 7: Cd uptake by *Allium cepa* growing in non-amended (-BC) and amended soil (+BC) (by 3% wheat-straw biochar) when watered with different concentration (0, 3, 5 and 7 mg L^{-1}) of Cd. Each bar shows the average of three values ± SE. Different alphabets represent significant difference at $p < 0.05$, according to Duncan's test. Small letters represent differences in case of -BC while capital letters represent in case of +BC. Cadmium uptake in **(a)** roots **(b)** bulblets and **(c)** in leaves

The concentration of Cd accumulated by the roots of plants growing on wheat-straw biochar amended soil is found to be 55% lower as compared to the roots of plants growing on non-amended soil, at a provided concentration of 3 mg L^{-1} (Fig. 7a). Similarly, the concentration of Cd at 5 and 7 mg L^{-1} was found to be 30-35 mg kg^{-1} DW and 45-60 mg kg^{-1} DW in plant with biochar, respectively, which is significantly lower than that found in non-amended soil growing plants that is 50-60 mg kg^{-1} DW and 75-85 mg kg^{-1} DW, respectively (Fig. 7a). In case of bulblets, the trend was quite similar as in roots. At lower concentration of 3 mg L^{-1}, Cd accumulated in bulblets growing on wheat-straw biochar amended soil is found to be 50% lower than the plants growing on non-amended soil.

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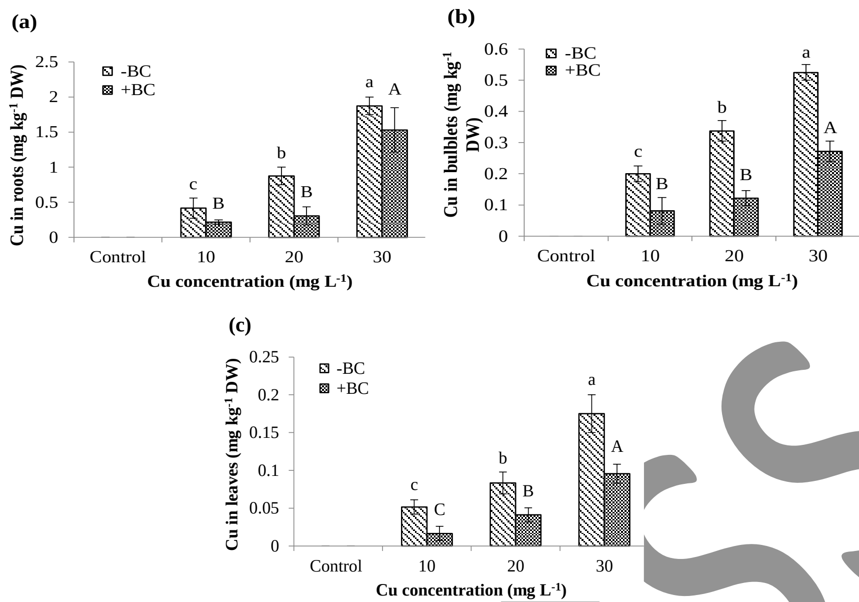

Fig. 8: Cu uptake by *Allium cepa* growing in non-amended (-BC) and amended soil (+BC) (by 3% wheat-straw biochar) when watered with different concentration (0, 10, 20 and 30 mg L^{-1}) of Cu. Each bar shows the average of three values ± SE. Different alphabets represent significant difference at $p < 0.05$, according to Duncan's test. Small letters represent differences in case of -BC while capital letters represent in case of +BC. Copper uptake in **(a)** roots **(b)** bulblets and **(c)** in leaves

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At higher concentrations of 5 and 7 mg L^{-1} the percentage is found to be 50 and 35% lower in the bulblets of the plants growing on wheat-straw biochar amended soil in comparison with non-amended soil (Fig. 7b). The levels of Cd accumulated in leaves of plants are quite lower than other parts. For the plants grown in wheat-straw biochar amended soil, the concentration of Cd accumulated in the leaves of plants at 3 mg L^{-1} is examined to be 75% lower than that found in plant on non-amended soil. Same difference in percentage was found at the successive concentration of 5 mg L^{-1}, while at 7 mg L^{-1}, the level of Cd accumulated in leaves of plants growing on amended soil is 85% lower than that found in plants growing on non-amended soil (Fig. 7c).

Cu Accumulation

Cu accumulation in onion plants growing on both wheat-straw biochar amended soil and non-amended soil are shown in Fig. 8. Wheat-straw biochar acted as a positive amendment to reduce metal uptake by plants. At 10 mg L^{-1} the amount of Cu accumulated by the roots in case of amended soil is even less than 0.5 mg kg^{-1}, while the concentration found in the roots in case of non-amended soil is significantly higher. At higher concentration of 20 mg L^{-1}, the amount of Cu found in roots in the case of amended soil is 70% less as compared to the non-amended soil and similarly the percentage difference found at 30 mg L^{-1} is about 30% between the wheat-straw biochar amended and non-amended soil (Fig. 8a). The range of Cu found in bulblets of amended plants at initial concentration of 10 mg L^{-1} is 50% less when compared with the plants growing on non-amended soil. The accumulation level did not raise much even at double of the previous concentration and the range difference between both the amended and non-amended soils came up to be 0.1-0.15 mg kg^{-1} DW in wheat-straw biochar amended soil while 0.3-0.35 mg kg^{-1} DW in non-amended soil. In case of further increased concentration up to 40 mg L^{-1} the concentration of Cu in bulblets in case of amended soil ranged between 0.23-0.31 mg kg^{-1} DW which was significantly lower as compared to that found in the bulblets in case of non-amended soil that was 0.5-0.55 mg kg^{-1} (Fig. 8b). The level of Cu accumulated by plants in to their leaves was lower than the other parts. The concentration of Cu accumulated in the leaves in case of wheat-straw biochar amended soil at 10 mg L^{-1} is within the range of 0.01-0.03 mg kg^{-1} DW which is comparatively much lower than that accumulated in case of non-amended soil. Similarly, at higher concentration of 20 and 30 mg L^{-1} the level of Cu accumulated in the leaves in case of amended soil ranged between 0.03-0.05 and 0.07-0.12 mg kg^{-1} DW, respectively, which is much lower in comparison to that found in case of non-amended soil (Fig. 8c).

Discussion

The aim of this study was to check the potential of locally produced wheat-straw biochar in remediating the contaminated soil and limiting the uptake levels of heavy metals by the food crop used *i.e.*, *Allium cepa*. Biochar is carbon rich product, formed as a result of pyrolysis of various type of organic feedstocks (Sohi, 2012). Many studies showed that the addition of biochar in the soil results in improved soil quality, as produced by the addition of peat moss or other soil organic amendments (Hansen *et al*., 2011). Application of biochar to agricultural soil promotes the fertility of soil, along with increasing the productivity of agricultural crops. Biochar also improves nutrient and water use efficiency.

The results of XRD analysis of produced biochar in current study showed that the biochar is rich in nutrients. Tetrameric phosphonitrilic isothiocyanate ore contains a basic backbone of nitrogen and phosphorus (N-P) which make it fertile (Fig. 1). XRD results of biochar obtained from different feedstocks confirmed the presence of nutrients such as nitrogen and phosphorus. These nutrients possess potential of increasing the fertility of soil and ultimately improving the productivity of agricultural crops (Singh *et al*., 2010). Biochar produced at 500°C yielded calcite, dolomite and sylvite ores. Similarly, quartz (SiO_2) ore was found in the biochar formed from peanut straw (Yuan *et al*., 2011). Both nutrients play a key role in promoting the growth of plants and the fertility of soil (George *et al*., 2008). Electrical conductivity (EC) of soil is normally directly proportional to the salinity of soil. More EC would result in more salinity of soil, and ultimately the fertility of the soil is decreased. The EC of soil (without biochar amendment) used in the current experiment came to be quite low and imparts for the good quality soil. The soil texture analysis revealed that the soil was loamy in nature. Loamy soil comparatively retains more nutrients as compared to other types of soil. Moreover, loamy soil exhibits higher capability to hold moisture content inside. All these properties of soil would have imparted for the better growth of plants.

Similarly, when the results of dry biomass of the plants were observed, it was assessed that the dry biomass produced by the plants grown in biochar amended soil was comparatively higher in case of all three metals (Pb, Cd and Cu) as compared to the plants grown in non-amended soil. Value of pH is inversely proportional to the mobility of heavy metals in the soil. The higher is pH, the lower would be the mobility of heavy metals in soil (Sukreeyapongse *et al*., 2002). Due to the addition of wheat straw biochar pH increased to 8.9, that proves biochar to be effective in reducing the heavy metal mobility when mixed in soil. Biochar also contains some functional groups that acts as a helping arm in binding the heavy metals at the surface of biochar thus reduces the mobility in soil (Uchimiya *et al*., 2012). FTIR analysis in current study confirmed the presence of ethyl acetate functional group ($C{=}O{-}CH_3$) in the wheat-straw biochar (Fig. 2). Ethyl acetate is the ester of ethanol and acetic acid and falls in the list of oxygen based functional groups. FTIR spectra of straws from canola, corn, soybean and peanut confirmed the presence of oxygen containing functional groups *e.g*., $-COOH^-$, -COH, -OH and CO_3^{2-}. Among these functional groups $-COOH^-$ and -OH contributes significantly to the surface charge of the biochar (Yuan *et al*., 2011). Among the oxygen based functional groups those containing C=O group exhibits great affinity for Cu^{2+} and Cd^{2+} (Regmi *et al*., 2012). It has been concluded in another study that biochar which is rich in oxygen based functional groups have more tendency to bind heavy metals, specifically the soft metals such as Pb and Cu (Uchimiya *et al*., 2011).

A two-year study conducted to analyze the uptake of Cd by wheat expressed that $CdCl_2$ extracted Cd was reduced by 10.1, 23.4 and 40.2% as compared to the control in 2010 and by 1.8, 23.1 and 72.1% than the control in 2011 for the three treatments of biochar i.e., 10, 20 and 40 t ha^{-1}, respectively. Similarly, 5% of biochar treatment greatly decreased the extractable concentration of Cd and Cu and it also decreased the concentration of extractable Pb from soil, with *Sedum plumbizincicola* grown in it. For shoots, the concentration of Cd reduced with the application of both rice straw and bamboo biochar by up to 20 to 49%, respectively (Lu *et al*., 2014). In another study, application of 5% biochar reduced acid soluble Pb found in soil, from 8.1% (control) to 3.6% at the tillering stage and from 8.7% to 4.03% at the maturity stage of rice. In stem and leaves, the concentration of Pb at the tillering stage reduced by 79.8% to 75.6%, respectively (Li *et al*., 2016). So, when the results of heavy metal uptake by *A. cepa* L. were analyzed in the present study, it was found that the uptake of all three metals (Pb, Cd and Cu) was reduced in all parts of the plant *i.e*., roots, bulblets and leaves, by application of wheat straw biochar, as biochar binds the metals in the root zone of the plants so reducing the availability to the plant (Cui *et al*., 2011).

Conclusion

The current study was conducted to assess the efficiency and potential of locally produced wheat straw biochar to reduce the uptake of Pb, Cd and Cu in *Allium cepa* L. and promoting the biomass *i.e*., dry weight of the plant. Based on the results it can be concluded that the use of wheat straw biochar has a potential to be applied in fields which are irrigated by heavy metal containing waste water. As the results of the current study demonstrated that not only the dry mass of wheat straw biochar amended soil grown plants was found to be higher than the plants grown in non-amended soil, but the heavy metal (Pb, Cd and Cu) uptake in such plants was also reduced. Thus, the use of wheat straw biochar commercially in the agricultural fields, being contaminated by industrial wastewater containing heavy metals, can minimize the risk of heavy metal accumulation in the food chain and could lower the chance of occurrence of multiple health problems.

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