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IMPACT OF CADMIUM ON GROWTH AND PHYSIOLOGY OF TOMATO PLANT GROWN IN SOIL AUGMENTED WITH BIOCHAR

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Abstract

Biochar is very important vector for the reclamation of heavy metals in soil. The present research work was conducted to examine the effect of Cadmium (Cd) on the growth and physiology of tomato plant in soil augmented by biochar. This study was designed in complete randomized block manner (CRBD) under control conditions of glass house. Two concentrations of Cd salt in the form of low (10ppm) and high (100ppm) concentrations were used during the experiment in the form of single as well as in combination with 2% of biochar). Five tomato seedlings were planted into pots in replicates. Pots were watered at fix intervals of time for 60 days. After harvesting desired parameters in the form of growth as well as physiological parameters were studied. It was observed that biochar applied in single form increased the all selected parameters of plant while low Cd decreased the parameters to less extent. Elevated biochar concentration affected the plant parameters to very greater extent comparing to control. Similarly, low Cd concentration with biochar did not show any significant effect but high Cd concentration with biochar showed enhanced alleviating effect on the all parameters of plant.

Key words: Biochar effects, Growth, Physiological aspects, Tomato plants

Introduction

'Heavy metals' are a mix of components which ensure their 'specific gravity' other than 5g/cm^{3}and are created naturally just as through human actives in the earth. The potential sources in nature are through the topographical enduring, mining, refining, modern exercises which improve the aggregation of heavy metals in soil (Abrahams, 2002). Heavy metals i.e., nickel, cadmium, lead, chromium, zinc, and mercury are deliberated as most lethal when provided unnecessarily to the soil yet some of them in their change structures are fundamental for the development of plants like zinc, nickel and copper (Adriano, 2001).

Cadmium enters in soil through different ways and perhaps they diffuse in water, soil and climate by regular procedure or by anthropogenic exercises of person. Heavy metals from enterprises and advance innovations cause an expansion in the contamination by collecting in the earth while a few soils have effectively high foundation of heavy metals because of volcanic action or enduring of parent materials and along these lines cause an increment in the metal contamination (Yang *et al*., 2012).

Biochar is a result of biomass got from warming in an appropriate temperature system without oxygen or from a gasification framework. Right off the bio, this term was developed by diminish Read as 'agrichar' utilized for richness of soil (Bates, 2010). Biochars can be incorporated by natural issue under various states of temperatures with various characters. Distinctive biomass sources like Debris of plants and agribusiness items, green vegetables, excrement of creatures and leftover of compost (Lima *et al*., 2008). Synthetic piece of biochar show that it comprises of blend of combined item and debris with the commitment of 90 % carbon (Lu *et al*., 2018).

Biochar can be created by poultry litter, sewage sludge, rice-husk, wheat straw and a few different biomasses (Khan *et al*., 2013). Biochar isn't utilized for refuting the heavy metals in the soil however it is additionally advantageous for enlightening the nature of farming area with the end goal of development. Biochar is mostly used in Australia and in every Asian nation as significant agricultural item. This might be because of counter impact of biochar along with heavy metals, that medical advantages and soil richness is being seen in these districts.

Lu *et al*. (2018) considered the idea of biochar regarding its relationship with the soil and harvests, in like manner one sort of biochar-has increaseed the development and yield of bean and no development were seen within the sight of charcoal biochar, this might be because of the accessibility of pollutes in the soil.

Materials and Methods

The experiment was carried in-pots, filled with (uniform textured) soil altered with precise concentrations of biochar and Cd. The experimental place was 'glass house' of Bio Park at Bahhauddin-Zakariya University (BZU). Soil sample was taken from the garden, dried, crushed and sieved and the separation of dead leaves, debris and stones of less than 2 mm, was done. The plastic pots of 6 inches (in diameters) were filled with 5 kg of uniformly mixed soil.

Biochar was prepared by the help of pyrolyzer (installed at the Soil Science Department of BZU, Multan). For this procedure raw wheat straw was collected from he agricultural field and was dried in air. Air-dried wheat straw with other raw material was pyrolyzed in specially designed pyrolyzer at 400 $^{\circ}$C of temperature for 40 min. in oxygen nonexistence.

After-that the pyrolyzer-drum was gone for-cooling till the material was fully-cooled. The biochar synthesized material was grinded enough to pass through 5 mm diameter of sieve which was stored in plastic bag for further usage. Replicates of pots were filled with 5 kg of already prepared soil, amalgamated with 'Cd' (in the form of salt) and 2 % biochar. However the replicates of control pots were deprived of biochar and Cd. Growth and physiological parameters were selected for the study and their analysis was done according to method of Estefan *et al.*, (2013). The 'treatment design' of the experiment has been written the following table. 1.

Table. 1: Levels of treatment during the experiment

Name of treatment	Quantity	Notation
Control	No, biochar and no Cd	T0
Biochar	2% /100 wt. of soil	T1
Low cadmium	10mg/kg of soil	T3
High cadmium	100mg/kg of soil	T4
Low Cd+2% biochar	10mg/kg of soil +2% biochar/100 wt. of soil	T5
High Cd+ 2% biochar	100mg/kg of soil +2% biochar/100 wt. of soil	T6

Results and Discussion

Effect of Cd and biochar on shoot length: The impact of various degrees of Cd and biochar has been appeared in the figure 1. As per results there is most extreme shoot length by impact of biochar while within the Cd supplement (in all treatments) shoot length has been decreased and even biochar didn't impact with elevated Cd level so the biochar didn't show any upgrading impact and it was smothered.

The outcomes indicated that when contrasted with control, biochar improved the shoot length about 10 %, while low Cd decreased the shoot-length in a slight manner yet significant Cd level altogether decreased the shoot length around 40-half by comparing with control although biochar and low Cd raised the shoot length somewhat. Biochar limited the impact of negligible Cd, while in nearness there was no biochar effect in the presence. There was about 60 % diminishing in the shoot length when contrasted with control so for this situation biochar has no limiting effect on the shoot length.

Numerous creators have contemplated the effect of biochar on vegetables and plants, as there is critical impact of biochar on-the plant stature yet heavy metals have sometimes affected the plant tallness (Xing *et al*., 2016). Biochar can build the accessible supplements in the soil like Mg, phosphate and so on and can improve the yield (Chintala *et al*., 2014). By the expansion of biochar, the soil properties are altered with the fact it builds the supplements accessibility in the soil. Heavy metals functional in 'single structure' can deliver the more noteworthy effect on the soil, water and different environments. The significant effects of Cd have been constantly found on the yields as decrease in the development and biomass (Wang *et al*., 2016).

Effect of Cd and biochar on root length: The Cd and biochar impact on root length has been given in the figure 2. The outcomes indicated that biochar at conc. of 2 %, increased the root length while Cd even at its low concentration reduced the root length. However, elevated Cd level altogether reduced the root length. The impact of low Cd level was minimized by the assistance of biochar and impact of biochar was decreased when Cd conc. was increased. The outcomes have additionally indicated that biochar increaseed the root length around 20 % when contrasted with control while about 15-20 % decrease was found in the root length affected by low Cd and same inhibitory outcome has been seen at higher conc. of Cd. About 20 % root length has been decreased by high Cd contents when contrasted with control. Effect of low conc. of Cd was decreased somewhat by biochar and there was just diminishing of 5-8% in the root length when contrasted with control. While critical decrease at high accumulation of Cd even with biochar has been found in the root length. Half decrease in the root length has been shown at high conc. of Cd by 2 % of biochar which demonstrated that biochar didn't limit the impact of Cd on the root length.

Chintala *et al*., (2014) has also called attention to that biochar can increase the soil richness by increasing the grouping of supplements like 'phosphate and magnesium' which assume significant job in the improvement of yields. While then again Dai *et al*., (2013) likewise affirmed during his study that that the greater part of heavy metals have infiltrating and blocking effects where Cd is one of them. The supplements are decreased in quantity and the root length is decreased in rhizosphere and along these lines the harmfulness of soil is increased.

Effect of Cd and biochar on fresh weight of shoot: The impact of Cd on the shoot fresh weight has been appeared in the figure 3. The Cd demonstrated its pretty much 'inhibitory impact' on the fresh weight while biochar attempted to limit its dangerous effect. The outcomes indicated that 2 % of the biochar increased the fresh weight by 20 % when contrasted with control. Low degree of Cd decreased the fresh weight by 10-15 % when contrasted with control while noteworthy decline was noticed by the high conc. of biochar of about 25 % when contrasted with that of control. The impact of Cd was adjusted by the addition of biochar alongside the low conc of Cd while high conc. of Cd demonstrated its bad impact and expansion of biochar didn't confined the negative effects of Cd. About 40 % reduction was found when contrasted with control.

By and large, these outcomes indicated that Cd decreased the fresh weight pretty much in all treatments while biochar limited its negative effect just at low Cd. Conc. while when conc. of Cd was increased then biochar didn't show any contributing impact for improving the development of plant. It has been reported by numerous analysts that Cd produces negative effects yet its impact has been constantly limited by the assistance of natural factors like incorporating biochar. Wang *et al*. (2010) delivered similar discoveries that biochar was reasonable as an adsorbent for soil contaminants, for example, heavy metals and lessens their bioavailability.

Effect of Cd and biochar on fresh weight of root: The impact of Cd on the root fresh weight of tomato plant has been shown in the figure 4. The outcomes indicated that biochar increased the root fresh weight while Cd with low conc. additionally decreased the roots' weight yet there was huge decline in the fresh weight of root at higher conc. (100 mg) of

Cd. There was slight impact of biochar on the root crisp load at lower conc. of Cd however no biochar impact was seen at higher conc. of Cd.

There was about 10 % increase in the root fresh weight of tomato at 2 % biochar. However, 2 % of biochar had a impact on low conc. of Cd and about just 5 % decline was seen in the fresh root wt, though Cd at low conc. decreased the fresh weight of root at around 15-20 % when contrasted with that of control. High conc. of Cd there was reduction of about half in the root fresh wt when contrasted with that of control while when biochar was included with the low conc. of Cd, there was some increase in the root fresh wt however it was still not exactly the Cd. At high conc. of Cd biochar didn't impact and there was still reduction of about 40 % in the root fresh wt when contrasted with that of control.

The above outcomes demonstrated a similar pattern with respect to the effect of Cd on the development of root like in past reported work. The investigation of Ahmed *et al*., (2015) additionally recommended that contaminants in the soil like Pb and Cd can definitely impact the development of plants as these contaminants are effectively consumed by the roots of plants and afterward these stop the supplements from the soil. The translocation of nutrients can be upgraded by the addition of biochar particularly integrated by the wheat straw (Yao *et al*. 2012). Lian *et al*., (2014) likewise finished up with similar discoveries that Cd can decrease the development of plants by thwarting the translocation of supplements accessible in the soil.

Effect of Cd and biochar on leaves number: The impact of Cd and biochar on the quantity of leaves has been shown in the figure 5. The outcomes defined the comparable discoveries like in every single past parameter of plants. The biochar conc. of 2% increased the quantity of leaves while low and high conc. of Cd decreased the quantity of leaves while low conc. of Cd was limited by the biochar. In the event of high conc. of Cd indicated most extreme decreasing effect even within the presence of biochar. The quantity of leaves was decreased altogether on account of high conc. of Cd.

At 2 % biochar, the quantity of leaves was increased by 10 % when contrasted with that of control while low Cd decreased the leaves by 15 % and furthermore high conc. of Cd decreased the leaves by 30 % when contrasted with that of control. However after addition of biochar, it just decreased the 5 % of number of leaves while higher conc. of Cd significantly affected the beneficial outcome and covered the impact of biochar by diminishing the 25 % of number of leaves when contrasted with that of control.

Jung *et al*. (2013) while taking a shot at the translocation of supplements in the leaves additionally found that plants stomatal conductance assumes significant job in the absorbance of heavy metals which impact the development of plants. Yet Denyes *et al*., (2016) demonstrated and rectified the past examination that take-up of overwhelming metals in the plants is most extreme through the roots of plants. Therefore biochar can assume its job for the degradation of supplements. Chen *et al*., (2016) likewise concurs with this thought that biochar after going into soil interrupts the accessible supplements and make them accessible for the plants take-up under the influence of supplement cycle. The majority of specialists have accepted that when biochar enters in to the soil then organic properties of soils are changed because of which supplements just move in the plants.

Effect of Cd and biochar on chlorophyll a of plant: Chlorophyll is the most significant part among the plant parameters. The impact of Cd and biochar on the chlorophyll a has been appeared in the figure 6. The outcomes indicated that biochar at 2 % just increased the amount of chlorophyll a in the plant while the both conc. of Cd decreased the chlorophyll a pretty much, while the low conc. of Cd demonstrated no any significant impact of abatement when provided alongside the biochar however high convergence of Cd decreased the chlorophyll an all the more conspicuously and didn't appeared and impact of biochar.

At 2 % of biochar conc. the chlorophyll a was increased about 20 % when contrasted with that of control while low Cd decreased the chlorophyll a by 25-30 % when contrasted with that of control. High conc. of Cd decreased the chlorophyll a by 30-35 % when contrasted with that of control. Thus it is evident from the results that even in the presence of biochar, higher concentration of Cd negatively affected the chlorophyll a content of the plant which consequently caused the slow or reduced growth of plants.

The investigation of Lehmann *et al*., (2015) likewise showed that by the assistance of biochar soil can be remediated from the significant metals contamination and after utilization of biochar, the surface area of soil is significantly increased which made feasible for the transportation of supplements and different minerals alongside water. Beesley *et al*., (2014) has just affirmed that beneficial outcome of biochar on the development and physiological parameters of plants in sullied soils. Chen *et al*., (2016) found that biochar changed the physical organization of soil after enhancements of biochar (0.5%) due to which metals demonstrated no impact on the photosynthetic pace of plants with the progression of time. They further demonstrated that biochar decreased the accessibility of contaminants in the soil.

Effect of Cd and biochar-on chlorophyll b of plant: The impact of Cd and biochar on the chlorophyll b has been appeared in the figure 4.7. The outcomes have indicated a similar pattern line as in the past parameters. The biochar at its 2 % fixation demonstrated most extreme increaseing impact on the chlorophyll b while low and high convergences of Cd indicated the diminishing impact on the chlorophyll b, while low Cd within the sight of biochar indicated least diminishing impact yet high grouping of Cd indicated greatest diminishing impact and biochar didn't influence such a great amount in hoisting the diminishing impact of Cd.

As appeared in the figure, biochar increased the chlorophyll b around 10-15 % when contrasted with that of control while low Cd decreased the chlorophyll b around 10-15 % when contrasted with that of control. High conc. of Cd decreased the chlorophyll b around 30-35 % when contrasted with that of control. Low conc. of Cd alongside biochar decreased the chlorophyll b (5-10%) so biochar improved the chlorophyll b and Cd indicated no more impact when contrasted with that of control however high conc. of Cd with presence of biochar decreased the chlorophyll b about 30 % when contrasted with that of control and biochar didn't show any effect on the conduct of Cd.

Bernal *et al*., (2007) demonstrated that biochar can't impact the heavy metals tainted soils when the edge of toxicities is increased. During the trial on the impact of Cd on the photosynthetic procedure, it was discovered that stomatal conductance was restarted to bigger degree with increasing the toxicities in control tests. Later on, Fornes *et al*., (2009) proposed similar outcomes and added that biochar has ability to disintegrate natural matter in the soil and thus make them accessible for the use by the plants. Clemente *et al*., (2012) concurred with the past scientist that natural material or biochar give out natural carbon and microbial biomass C and N in soils which upgrade the plant development.

Effect of Cd and biochar on total protein of plant: The impact of Cd and biochar on the protein content (figure 8) indicated a similar example of effect as in the past parameters. Biochar alone, at a conc. of 2 % increased the protein content while low conc. of Cd decreased the protein. Furthermore high conc. of Cd decreased the protein content altogether when contrasted with that of control. Low conc. of Cd when provided along with the biochar, decreased the protein content but didn't affect like in absence of biochar. But there was not any significant effect of biochar on the protein content of the leaves at higher conc. of Cd.

The outcomes demonstrated that biochar increased the protein substance by 10-15 % when contrasted with that of control while lower conc. of Cd decreased the protein substance by about 20% when contrasted with that of control. At the point when high conc. of Cd was provided to the soil in single structure then it decreased the protein substance by about 35 % when contrasted with that of control. Low conc. when provided alongside the biochar then it created no any unsafe impact and same pattern was recorded as in charge however high conc. of Cd decreased the protein substance by about half when contrasted with that of control which demonstrated its critical impact.

Chan *et al*., (2008) after supply of biochar noticed that biochar upgraded the nature of soil and advanced the plant development. They saw that protein substances were increased under the use of biochar by using the carbon in the soil. Saxena *et al*., (2013) reported similar outcomes while chipping away at the genomic parts of some higher plants and suggested that protein holding was a lot of lower in those plants which were developed on the overwhelming metals tainted soil while soils having natural material and compost indicated the most extreme protein holding and structure arrangement.

Effect of Cd and biochar-on amino acids of plant: The impact of Cd and biochar on the amino acids of plant has been appeared in the figure 9. The outcomes demonstrated that amino acids were increased under the impact of single biochar of 2 % while low and high conc. of Cd decreased the amino acids pretty much when contrasted with that of control. The impact of reduction of aminoacids by low Cd was remunerated by the addition of biochar however high conc. of Cd was not affected by addition of biochar and decreased the amino acids all the more fundamentally when contrasted with that of control.

The biochar when added to soil increased the amino acids by 20 % when contrasted with that of control while low conc. of Cd decreased the amino acids by 20 % when contrasted with that of control while high conc. of Cd decreased the amino acids by over 40 % when contrasted with that of control. Low conc. of Cd with the presence of biochar decreased the amino acids by 20 % and clearly biochar supplements didn't show any limiting impact on effects of Cd while high conc. of Cd decreased the amino acids by half when contrasted with that of control and biochar likewise didn't show any improving impact on amino acids.

Cui *et al*. (2011) researched the affectability of protein and amino acids towards the substantial metals concentrations in the soil and found that overwhelming metals from many source created the negative impact on the amino acids arrangement in the vast majority of the blossoming plants. Hale *et al*., (2012) got similar outcomes while working the amino acids in certain plants of family Poaceae in the substantial metals defiled soil and furthermore affirmed that amino acids were sensitive to contaminating heavy metals even in minute concentrations. Yet biochar didn't contributed in all cases. Beesley *et al*., (2014) found the comparative discoveries that biochar has no contributing job in the event of amino acids sequencing in every single higher bush

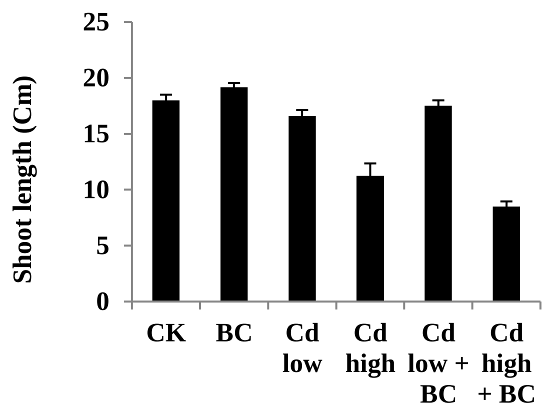


Figure 1: Effect of cadmium and biochar on the shoot length (cm) of tomato plant

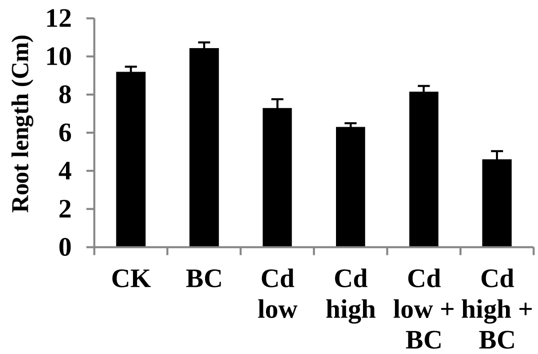
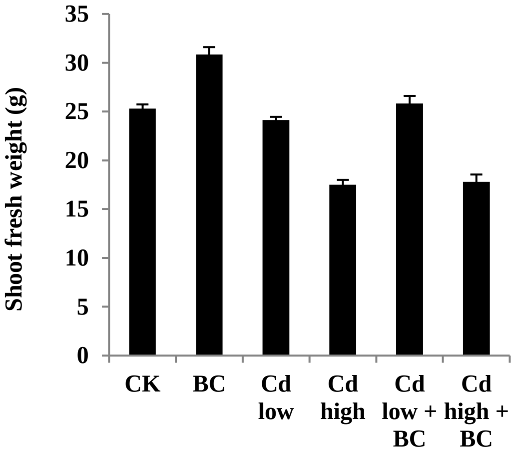
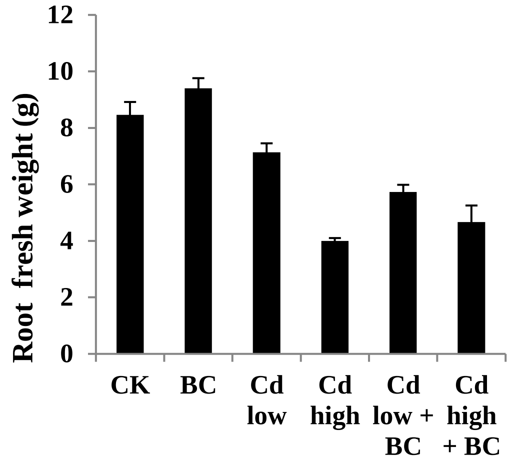
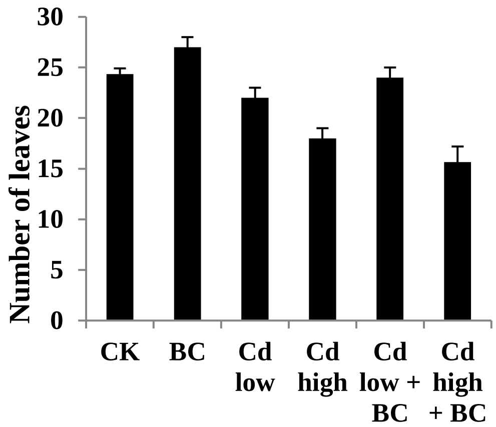
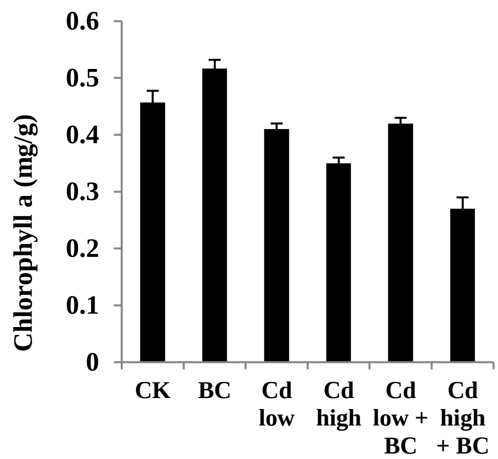


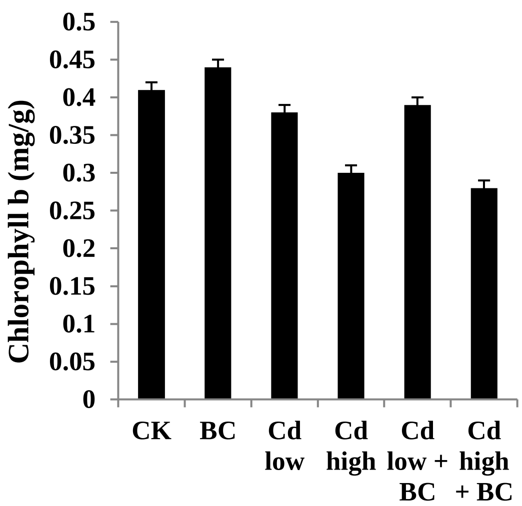
Figure 2: Effect of cadmium and biochar on the root length (cm) of tomato plant











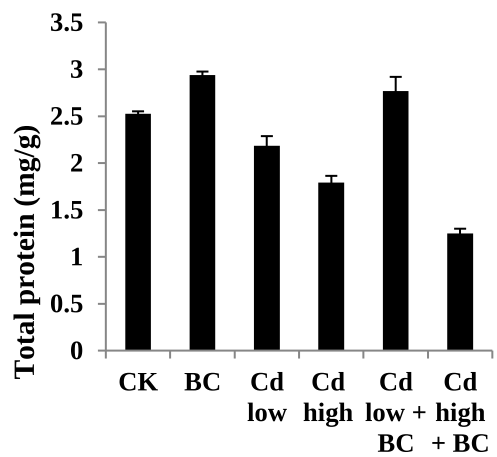


Figure 3: Effect of cadmium and biochar on the shoot fresh weight of tomato plant
Figure 4: Effect of cadmium and biochar on the root fresh weight of tomato plant
Figure 5: Effect of cadmium and biochar on the number of leaves of tomato plant
Figure 6: Effect of cadmium and biochar on the chlorophyll a of tomato plant
Figure 7: Effect of cadmium and biochar on the chlorophyll b of tomato plant
Figure 8: Effect of cadmium and biochar on the total protein of tomato plant

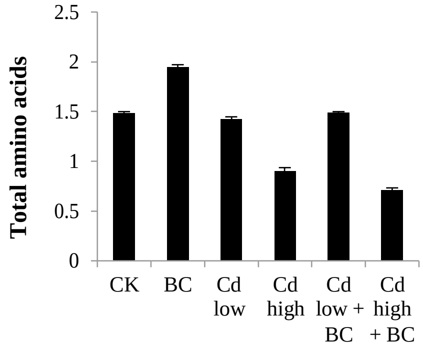


Figure 9: Effect of cadmium and biochar on the amino acids of tomato plant.

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