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Biochar role in improving biometric and growth attributes of *S. oleracea* and *T. corniculata* under cadmium stress

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Abstract

The present work was carried out to investigate the effect of cotton sticks biochar (CSB) on biometric and growth attributes of *S. oleracea* and *T. corniculata* under different levels of cadmium. It was observed that cadmium stress had pronounced effect on both plants and resulted in decline of growth. But with the application of CSB this decline was less than the stressed one. The Biomass (fresh and dry weight of shoot, root and leaves) was also increased to some extent in biochar application and this increase was more clear in some attributes at 5% biochar application with varying level of cadmium (25 mg/Kg, 50 mg/Kg and 100 mg/Kg) as compared to pure stress conditions. It is concluded that amendment of soil with cotton sticks biochar under cadmium stress influence a positive impact on overall growth of the plant.

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Introduction

Soil contamination is an excess of any element or compound, through direct or secondary coverage, which causes a toxic reaction to living organisms including plants and animals (Adriano, 2001; Abrahams, 2002; Vangronsveld *et al.,* 2009). Soil contamination with both organic and inorganic pollutants occurs internationally (Mench *et al.,* 2010) and more environmentally acceptable substitute to untenable trash disposal techniques for treating with this problem have been find out. As the modern program enhance to engineer instinctive processes to meet remediation requirements in the most cost effectual ways possible, the in situ application of betterment to contaminated soils to connect pollutants whilst giving material conditions that increase plant growth and stir up ecological restoration have become more prevalent and widespread (Bernal *et al.,* 2006; Vangronsveld *et al.,* 2009). Cadmium is required by the plants only in very small amount for its growth but when it is present in excess than it enters the root and move towards the aerial parts of the plants (Reeves and Baker, 2000). So, cadmium is very toxic to plants, although its mechanism of toxicity is not fully understood but many studies demonstrated the toxic role of cadmium. As Cd is the cause of growth retardation and disorders in metabolic and physiological activities (Markert *et al.,* 2003). Cadmium tolerance varies with different stages of development in plants but higher concentrations of cadmium appeared to be more harmful at seedling stage. Therefore, cadmium tolerance of juvenile plants of different species has intensively been studied (Sharma *et al.,* 2010). Soil remediation relates to the method of disappearing, neutralizing or falling the harm effects of certain compounds, habitually left by human actions such as drawing out and excess of industry. Each tarnished and/or stained position is potentially exclusive in its description such as the occurrence of any definite pollutants, environment, ground form countryside, declining dynamics, immediacy to susceptible inhabitants etc. For this motive, biochar can be an apparatus to be of assistance with renovation and conservation (Major, 2011). Biochar refers to Black carbon that is provided as a source of carbon sequestration from reusable and conservable biomass (Lehmann *et al.,* 2006). Biochar is progressively more receiving interest as a promising functional substance in environmental and agricultural purpose. It links to the carbon rich residues of partial combustion of biomass below oxygen inadequate circumstances and at comparatively low temperatures (Lehmann *et al.,* 2009). Application of biochar as a substitute to composts or nourishments seems to be a capable option to retain a highest level of carbon in soils as char improving the strength of carbon against microbial activity (Baldock and Smernik, 2002). Charcoal correspond to 1.7 percent of the pre-blaze biomass if a forest is changed by the conventional lacerate and flame technique (Fearnside *et al.,* 2001). The useful manufacturing of charcoal for application of soil is able to enhance the amount that can be functional in such changing agriculture systems (Lehmann *et al.*, 2006). The endurance of an anthropogenic and carbon rich dark soil in various parts of the world and particularly in Amazonia (Amazonian Dark Earths (ADE) or Terra Preta de Indio) creates the same technique that was exited in European countries. The soil fertility was sustained by the Amazon Indians with rich organic inputs as an alternative of clearing new forests when soil fertility decreased without strengthen axes and current tools for deforestation (Denevan, 1996). The anthropogenic accumulation of P and Ca is most probably connected Amazonian Dark Earths (ADE) related with bone apatite (Lehmann *et al.*, 2002; Lima *et al.*, 2002; Zech *et al.*, 1990) and black C as charcoal (Glaser *et al.*, 2001). Biometric, growth and yield attributes of *Spinacia oleracia* and *Trigonella corniculata* were used to observe the effects of high concentrations of cadmium with biochar amendment. The changes in growth pattern of both selected plants with respect to varying concentration of cadmium and biochar were investigated to evaluate the role of biochar in minimizing the cadmium stress.

Materials and methods

For the preparation of biochar, cotton sticks were collected from cotton fields of Nawabpur, Multan. Then, these sticks were cut into small pieces before pyrolysis. Biochar was ready for use after burning of these sticks in pyrolyzer without oxygen. The biochar was grind into fine porous material and preserve in air tight boxes.

For this experiment clay pots were used with their closed holes. Every pot was filled with 5 Kg soil containing respective biochar (3% and 5%) and cadmium concentration (25 mg/Kg, 50 mg/Kg and 100 mg/Kg). The experimental design was completely randomized (CRD) with four replicates for each treatment. The seeds of both plants were obtained from local market of Multan, Pakistan and sown in all the pots. At two leaves stage ten plants were allowed to grow and the others were removed.

Plants were harvested and analyzed for fresh and dry biomass of shoots and roots with their length. The numbers of leaves, their fresh and dry weights were also observed and noticed. Then plant material was oven dried at 80°C for 48 h and dry weight measurements were taken.

Statistical analysis

The data were analyzed statistically by (one way analysis of variance (ANOVA) using MS EXCEL and Duncan's Multiple Range Test was used to show significant differences between treatments.

Results

The shoot attributes are greatly affected by CSB as represented in Figure 1. From the figure it is cleared that biochar had positive influence on shoot length (Figure A) shoot fresh and shoot dry weight (Figure B, C). The shoot length decreased with increasing cadmium concentration and minimum shoot length was observed at 100 mg/Kg of cadmium treatment in the absence of biochar. But when biochar was applied with different cadmium levels (25 mg/kg, 50 mg/kg and 100 mg/kg) than plants suffer less cadmium stress and give more prominent results.

S. oleracea and T. corniculata behave in same way at different levels of cadmium and biochar percentages. As, increased in biochar percentages (3% & 5%) had resulted in more shoot attributes. These percentages are minimized the cadmium stress on both plants. In overall these attributes increased with increasing biochar percentages in the presence of cadmium levels. The 5% biochar also proved helpful in reducing the impact of 100 mg/kg of cadmium on both plants and plants give maximum values of shoot traits at this percentage. The 3% biochar also showed increased in shoot parameters at various cadmium levels as compared to pure cadmium stress.

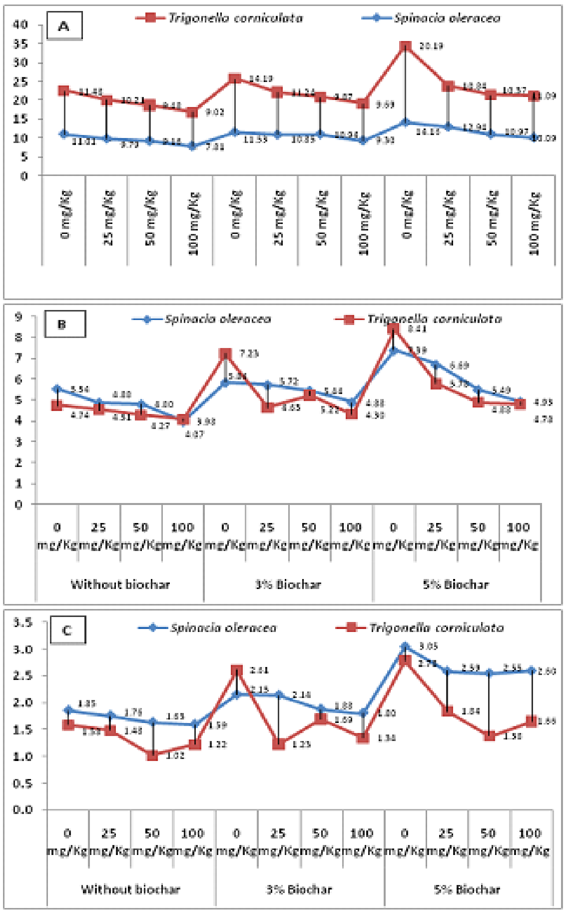

Fig. 1. Influence of biochar on Shoot attributes (A) Shoot length (B) Shoot fresh weight (C) Shoot dry weight under cadmium stress.

The Figure 2 indicates the impact of cadmium and biochar on *S. oleracea and T. corniculata*. From the figure it is understood that the root length of both plants decreased with the increased of cadmium level in the absence of biochar. The maximum root lengths (Figure 2A) were observed at 3% biochar with various cadmium levels but the soil containing only 3%

biochar give more root length as compared to control and 5% biochar treatment. The highest root fresh and dry weight (Figure 2B, 2C) was observed at 5% CBS with 25 mg/kg of cadmium. Collectively different percentages of biochar had positive influence on *S. oleracea and T. corniculata* root traits when grown in the presence of high concentrations of cadmium. The root attributes were greatly affected by different concentrations of cadmium as lowest root traits were recorded at 50 mg/kg and 100 mg/kg of cadmium concentration.

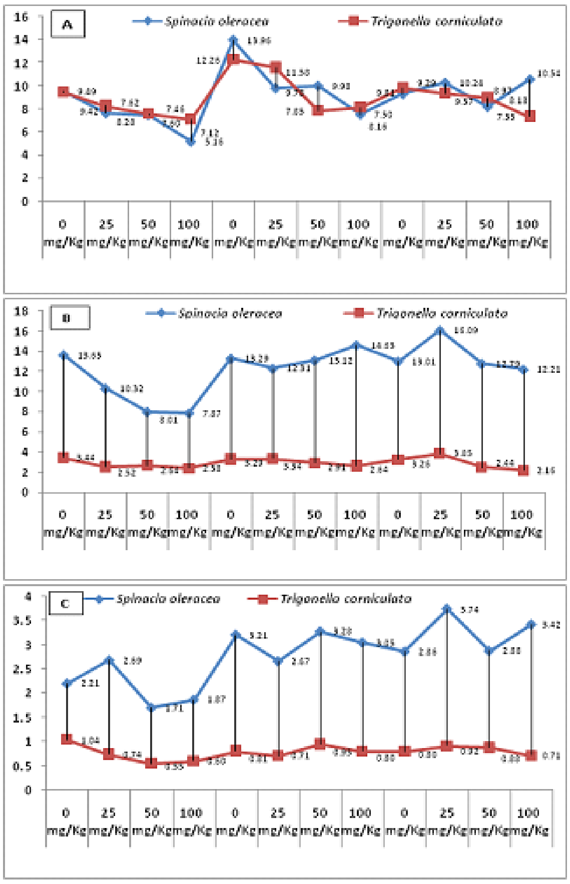

Fig. 2. Influence of biochar on Root attributes (A) Root length (B) Root fresh weight (C) Root dry weight under cadmium stress.

The biometric attributes are presented in Figure 3. *S. oleracea and T. corniculata* had maximum biometric attributes at different percentages of biochar instead of pure cadmium levels treatments. With the increased of biochar level from 3% to 5% the increased in biometric parameters was more observable. The highest leaf fresh and dry weights (Figure 3A, 3B) of both plants were given by 5% biochar application in soil without cadmium stress. But this change was also noticeable when 3% and 5% biochar was applied with different level of cadmium. In this way biochar play a role in reducing the toxicity of cadmium to *S. oleracea and T. corniculata*. In the case of spinach some specific response to varying levels were noticed. As, biometric traits of *S. oleracea* show less decreased up to 50 mg/kg of cadmium but suddenly decreased rapidly at 100 mg/kg of Cd. Whereas, T. corniculata show gradual decreased with increasing Cd concentration. The increased in biometric attributes occur gradually with the application of biochar in soil.

Discussion

As, Spinach is an outstanding resource of vitamins, K, A, C, E, B2, B6, folate and it also has trace minerals which include manganese, zinc, copper, selenium, magnesium, iron, calcium and potassium. It provides excellent supply of omega-3 fatty acids, niacin, protein, and dietary fiber (Wiki, 2008). Contamination of trace metal in spinach generally occurs from pollution of agricultural field areas. Resource of pollution of agricultural field area by trace metals in the natural terrestrial environment includes air pollution from vehicle exhaust fume and industrial deeds (Audu and Lawal, 2005; Jaja and Odoemena, 2004; Odoemena, 1999; Shapek, 1996). In the present study the increased in growth attributes with CSB application with cadmium stress was observed because CSB consist of few essential plant nutrients which considerably effect crop growth (Figure 1, 2 and 3). The shoot, root and biometric traits usually increased with application of biochar. This increased also occur in the presence of high levels of cadmium stress. The reason behind this increase is that crop production and nutrient uptake was noteworthy improved with enchanting biochar treatment rate in amalgamation with other available commercial fertilizer. Production characteristics and water utilize efficiency of crop was enchanted from 50 to 100 percentage when biochar treatment rate was increased in the field (Uzoma *et al.,* 2011). Similar results were observed by Yeboah *et al* (2009) who said that crop growth rate and nutrient uptake was enhanced with greater biochar application rate (Figure 3). The crop production and yield parts showed positive comeback when biochar was utilized as soil improvement because it increases the hydraulic conductivity of field-saturation of the sandy soil; as a result more moisture contents and nutrients were provided to the crop in the growth season (Steiner *et al.,* 2007). In our study the biochar application increased the vegetative growth of *S. oleracea and T. corniculata* which is very useful in our daily life because biochar application to soils resulted in better crop production and positively enhanced crop growth rate and net incorporation rate (Uzoma *et al.,* 2011). Artificial fertilizer utilization can be diminished as biochar decreases the requirement for fertilizer because biochar enhances soil microbial capacity; consequently carbon storage in the soil was increased. Nitrogen fatalities can be controlled by assimilation of biochar as it holds nitrogen, decreases release of nitrous oxide and enhanced cation exchange capacity of root in the soil (Chan *et al.,* 2008).

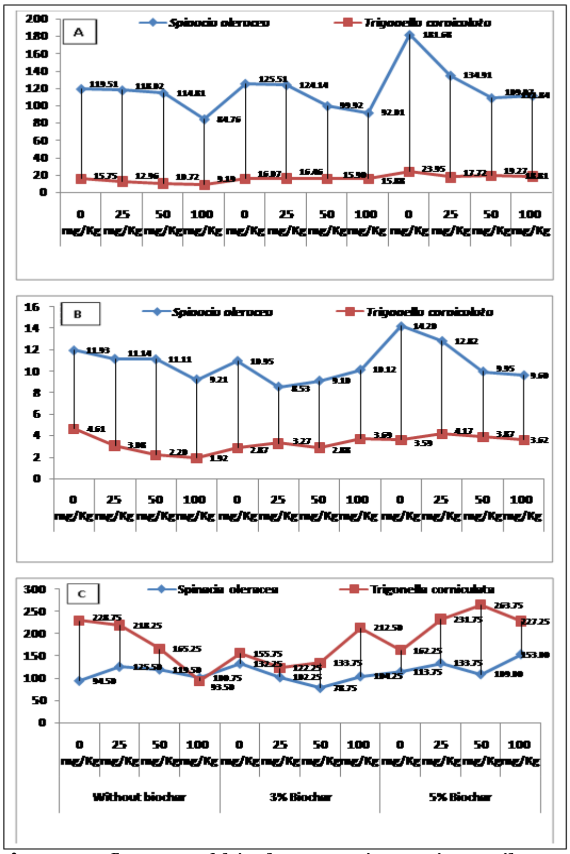

Fig. 3. Influence of biochar on Biometric attributes (A) Leaf fresh weight (B) Leaf dry weight (C) Leaf number under cadmium stress.

Conclusions

The observed changes in the investigated parameters clearly suggested that elevated levels of cadmium had affected growth of *S. oleracea and T. corniculata*. However, the biochar has shown the ability to sequester metal in the soil and restricted transfer of cadmium ions to the aerial tissue. As, biochar amendment in the soil increased the growth of both plants. Therefore, biochar can be a choice in situations where irrigation water contains appreciable amount of cadmium as well as for the utilization of abandoned soils contaminated with this metal.

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