Biochar In Mitigating Adverse Impacts of Drought on Maize Cultivars

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ABSTRACT

Drought is the main abiotic stress that severely reduces maize yield across the globe. To cope up this situation, use of organic amendments is the best option. Biochar is an organic soil amendment that is used to improve soil carbon, organic contents, improve water holding capacity of soil, enhance soil fertility and maintain desired soil. Present study was carried out to screen drought tolerant and drought sensitive cultivars out of six i.e. D-3464, D-6619, D-4464, D-2468, D-3377, D-3366 on the basis of biomass at two growth stages viz vegetative and reproductive stage. And after that we have checked the effect of biochar on mitigating the adverse effects of drought on both drought sensitive and drought tolerant cultivar by using foliar biochar (1%). Results revealed that drought stress negatively affected the morphophysiological attributes at all critical. However, biochar application significantly mitigated the detrimental effects of drought by improving number of leaves, RWC, plant biomass, leaf area, SPAD values as compared to control treatment. Moreover, biochar significantly improved water uses efficiency and physiological attributes of drought stressed. Analysis of variance linked different scales of study and demonstrated the potential of physio-morphological traits to explain the maize cultivars variations under drought condition with response to biochar application. In crux, Foliar biochar application (1%) can be used as an effective stratagem to achieve improved maize morphophysiological traits through mitigating the adverse effects of drought stress.

Keywords: Maize, foliar spray, drought stress

INTRODUCTION

Drought is defined as any lack of water that prevents crops to reach their yield potential or that affects quality of harvested products. Drought affected 10 districts of Sindh badly mostly Karachi and Hyderabad (Adnan, Ullah, & Gao, 2015). The main regions affected by drought in interior Punjab are Bahawalpur, Faisalabad, Mianwali, Multan, Sargodha, and Rahim Yar Khan (Ali, Khalid, Akhter, Islam, & Adnan, 2020).

Corn is one of the world's most important food cropprovides at least 30% of calories to more than 4.5 billion people (Shiferaw, Prasanna, Hellin, & Bänziger, 2011). For example, between 2005 and 2008 the average maize yield was estimated at 1.4 tons per hectare (t/ha) compared to 2.5 t/ha in the Philippines, 3.1 t/ha in Mexico, and 3.9 t/ha in Thailand (Smale, Byerlee, & Jayne, 2013). Out of total maize production, about 60% is used in poultry feeds, 25% in industries and remaining is used as food for human and animals. Maize ranks third in Pakistan. In Punjab Province, both hybrid and non-hybrid maize varieties are being grown.

Generally, drought stress at the early vegetative growth stage slows down the plant growth by inhibiting cell expansion and division; however, the loss in seed yield might be negligible (Wardlaw, 1972). In the development growth stages of maize drought affect cell division and cell proliferation(Aslam, Maqbool, & Cengiz, 2015) while in the reproductive stage drought affecting tassel, embryo, endosperm development, ear, pollination, fertilization grail filling and resulting the loss of crop yield (du Plessis, 2003). Under mild and moderate drought stress, the leaf water content continues to decrease in plant leaves (Bhusal, Han, & Yoon, 2019; Tombesi et al., 2015). Drought affects the plant growth and biomass accumulation by suppressing leaf expansion and stomatal conductance thereby leads to less photosynthetic rate (Osakabe, Osakabe, Shinozaki, & Tran, 2014). Too many factors like plant hydraulic status, phytohormones, osmotic adjustment, ROS signaling are responsible for reduction in plant growth under drought stress (Khan, Asgher, Fatma, Per, & Khan, 2015).Drought not only causes degradation of photosynthetic pigments, but also disorganization of the thylakoid membranes (Batra, Sharma, & Kumari, 2014; Ladjal, Epron, & Ducrey, 2000).

To cope with drought stress, plants employ wide range of response mechanisms at molecular, cellular, and whole plant levels, including stomatal closure, overproduction of abscisic acid (ABA), enhanced activity of antioxidant systems, as well as accumulation of various metabolites (soluble sugars, free amino acids, and polyamines) (Ghotbi-Ravandi, Shahbazi, Shariati, & Mulo, 2014; Zhou & Yu, 2010).

There are many techniques and practices to decrease the harmful effects of drought stress on plant growth and yield; however, one of the useful and safest strategies is applying soil amendments such as biochar. (Alotaibi & Schoenau, 2019). The biochar is a substance having properties similar to charcoal and may be produced due to pyrolysis, gasification or thermolysis (Kobyłecki, 2014; Sun et al., 2014). Previous studies on the effects of biochar inputs to soils have demonstrated increases in pH, nutrient availability, cation exchange capacity, water-holding capacity, soil structure and soil microbial diversity, combined with decreases in nutrient leaching, emissions of nitrous oxide and soil tensile strength (Cernansky, 2015; Scholz et al., 2014). Application of biochar (BC) improves soil structure, water retention and ion-binding capacity, which reduces the vulnerability of plants to drought events (Kuzyakov, Bogomolova, & Glaser, 2014). Biochar amendment improves soil chemical, physical and biological properties that are associated with essential mineral transport into plant tissues (Cheng, Cai, Chang, Wang, & Zhang, 2012). The interactions between roots and soil-biochar particles could affect root physiology (Olmo, Villar, Salazar, & Alburquerque, 2016), and plant growth could be stimulated by the addition of biochar (Bruun, Petersen, Hansen, Holm, & Hauggaard-Nielsen, 2014; Xiao et al., 2016). An improvement in the plant growth, leaf relative water contents, transpiration rate, osmotic potential and photosynthesis has been publicized in maize plants under poor water availability (Ahmed, Arthur, Plauborg, & Andersen, 2016; Haider et al., 2015). However, the involvement of biochar had a remarkable effect on biomass and growth of different parts of the plant. The reasons for increased biomass were due to improvement of water capacity at durable wilting points and safeguarding of water content through its immense porosity. The biochar amendment also exhibits the highest vegetative growth, seed production and enhanced fruit quality (Batool et al., 2015). Under the drought stress condition application of biochar enhance the area of leaf and height of plant in maize (Elmer, 2016). Biochar in drought stressed maize crop increase the osmotic potential, transpiration rate, and leaf RWC (Zheng et al., 2017).

METHOD AND MATERIAL

1. Plant Height and Leaf area

The height of all leaves of each selected plant is measured by measuring tape from the base of the plant to the tip. All the values of plant height sum up and mean of these values is considered as the plant height of that plant. The plant height of all replicates of two cultivars and are calculated by the same method. Same is for leaf area.

2. Chlorophyll content

The chlorophyll content of the leaves of each replicate from was calculated with the help of SPAD chlorophyll meter. The SPAD is used to estimate the chlorophyll content and nitrogen present in the plants which is related with the yield of the crop.

3. Leaf Relative Water Content (RWC)

For evaluation of the water status, relative water content (RWC) of the leaves was determined following the methodology described by (Catsky, 1960). Fresh weight was determined immediately after leaf sampling; turgid weight was measured after submerging the leaf sample during four hours in distilled water; and dry weight was measured after oven-drying the leaves at a temperature of about 80 °C during 48 h. We calculate the relative water content (RWC) by using the equation

$$\text{WC (\%)} = [L fresh\ wt. - L\ dry\ wt.]/[L\ turgid\ wt. - L\ dry\ wt.] \times 100$$

4. Biomass

All plants in the sampling areas were cut at soil level, with the help of cutter separate the root and shoot part of plant weighed to determine the total fresh weights. For screening purposes, Plant biomass was recorded at two growth stages, vegetative as well as reproductive stage.Ten representative plants were chosen as subsamples from each plot/pot. Dry weight of shoot and root was measure after 7 days.

OBJECTIVES

- **To screen out a drought tolerant and drought sensitive variety/cultivar/ Hybrid**
- **To determine the effects of Foliar Biochar on drought tolerant and sensitive variety**

RESULTS/CONCLUSION

On the basis of plant biomass, morphological attributes and relative water content, D.6619 is the sensitive one butD.3366is a tolerant one showed significant differences in response to foliar application. Further analysis is in progress. More data would be shared on demand.

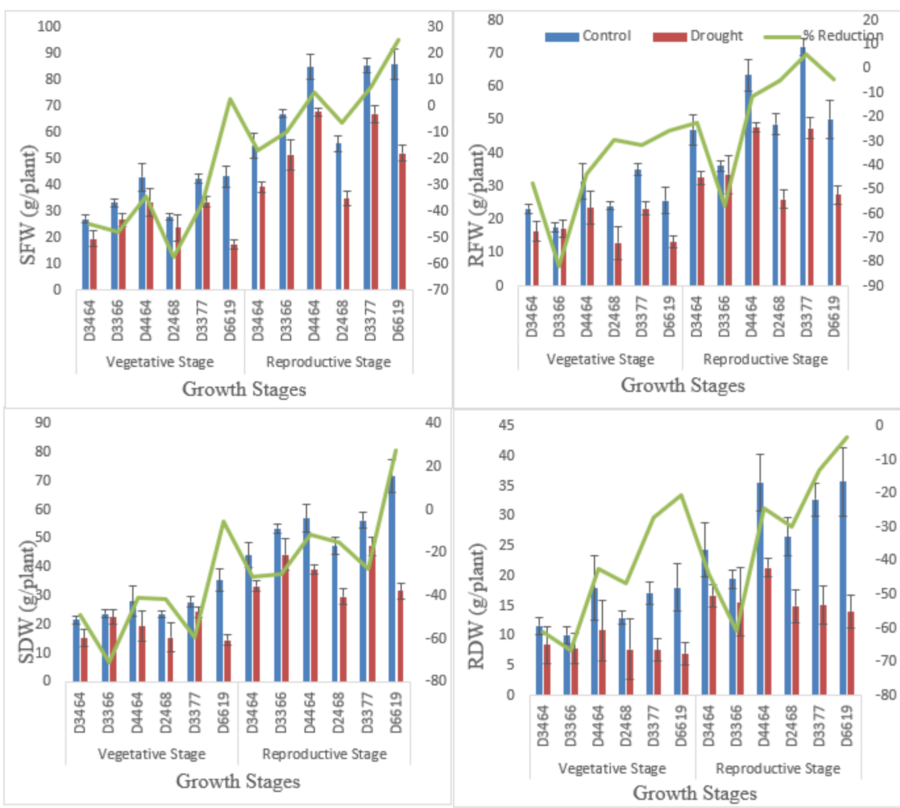

Figure 1. Shoot fresh weight (g/plant), shoot dry weight (g/plant), root fresh weight (g/plant) and root dry weight (g/plant) of six cultivars (D-3464, D-6619, D-4464, D-2468, D-3377, D-3366) of maize (Zea mays L.), grown in control and drought conditions.

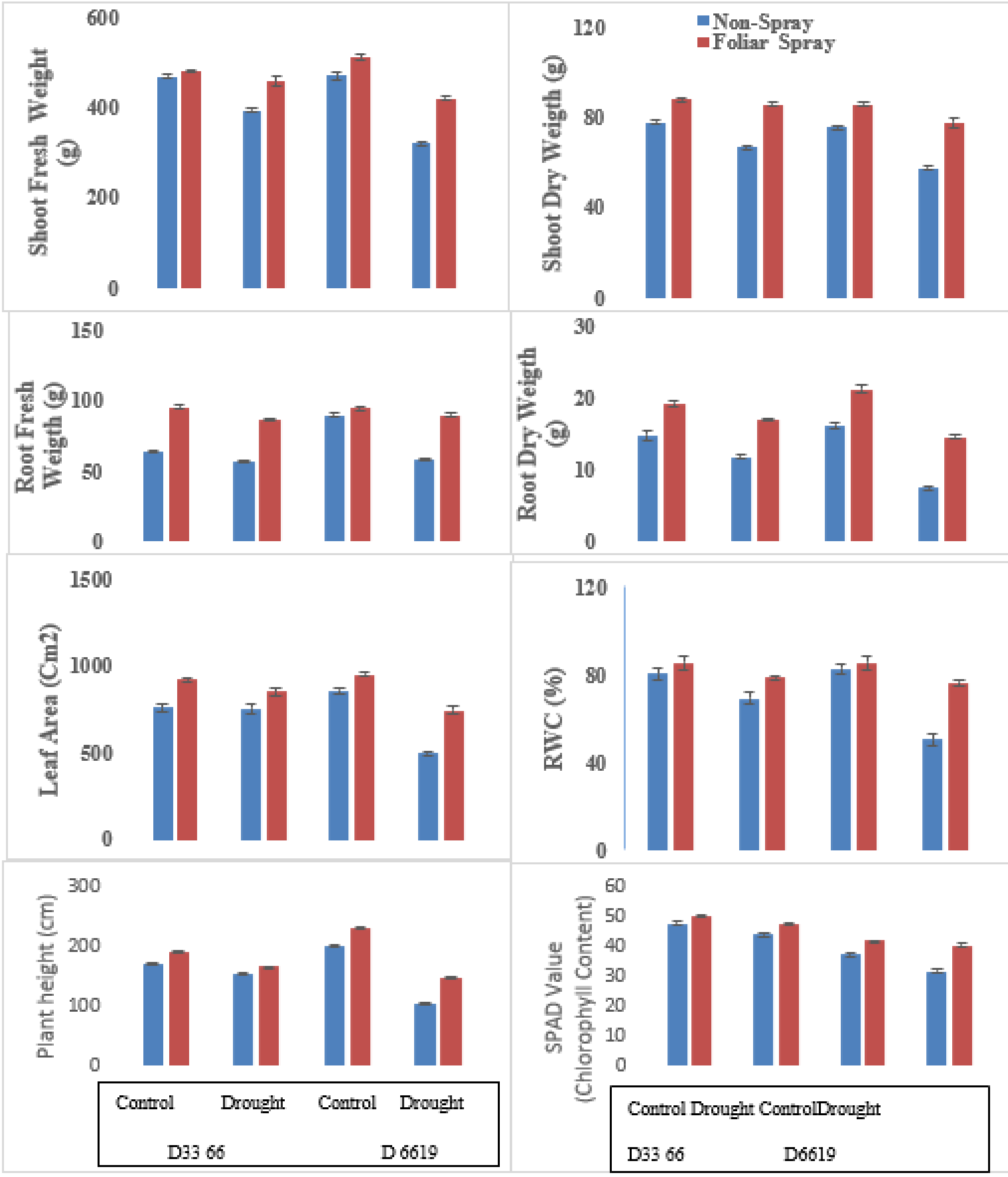

Figure 2. Shoot fresh weight (g/plant), shoot dry weight (g/plant), root fresh weight (g/plant) and root dry weight (g/plant), plant height (cm), Leaf area (cm^2), SPAD values of two cultivars (D-3366, D-6619) of maize (*Zea mays* L.), grown in control and drought conditions with the application of 1 percent foliar. biochar.

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