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plants MDPI

Biochar amendments improve licorice growth and nutrient uptake through altering the root system and soil enzyme activities in loamy sand under salt stress

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Licorice (*Glycyrrhiza uralensis* Fish.) is considered as salt and drought tolerant leguminous plant. We hypothesized that the biochar amendment into the soil might alleviate salt stress in licorice by improving its plant growth, nutrient acquisition. The present study was designed to determine the effect of biochar on licorice plant growth, acquisition of C (carbon), nitrogen (N), and phosphorus (P) and on soil fluorescein diacetate (FDA) and enzyme activities under saline soil condition. Pyrolysis char from maize at 2, 4, and 6 % concentrations were used for pot experiments. The shoot and/or root biomass of licorice grown in soil amended with 2 and 4% MBC under non-saline and saline conditions was increased. The root architectural traits, like root length, surface area, project area, and root volume, as well as nodulation traits, were also significantly modified by biochar application at both 2 and 4% concentrations. The concentrations of N and K in plant tissue were increased under 2 and 4% MBC amendment compared to plants grown without biochar application. Moreover, soil amended with biochar showed a positive effect on soil hydrolase activities. This study demonstrated the beneficial effects of biochar from maize on growth and nutrient uptake of licorice by improving the nodule formation, root architecture, and soil biological activity in saline soil conditions.

Keywords: biochar, licorice, soil enzymes, salinity, nutrients, root

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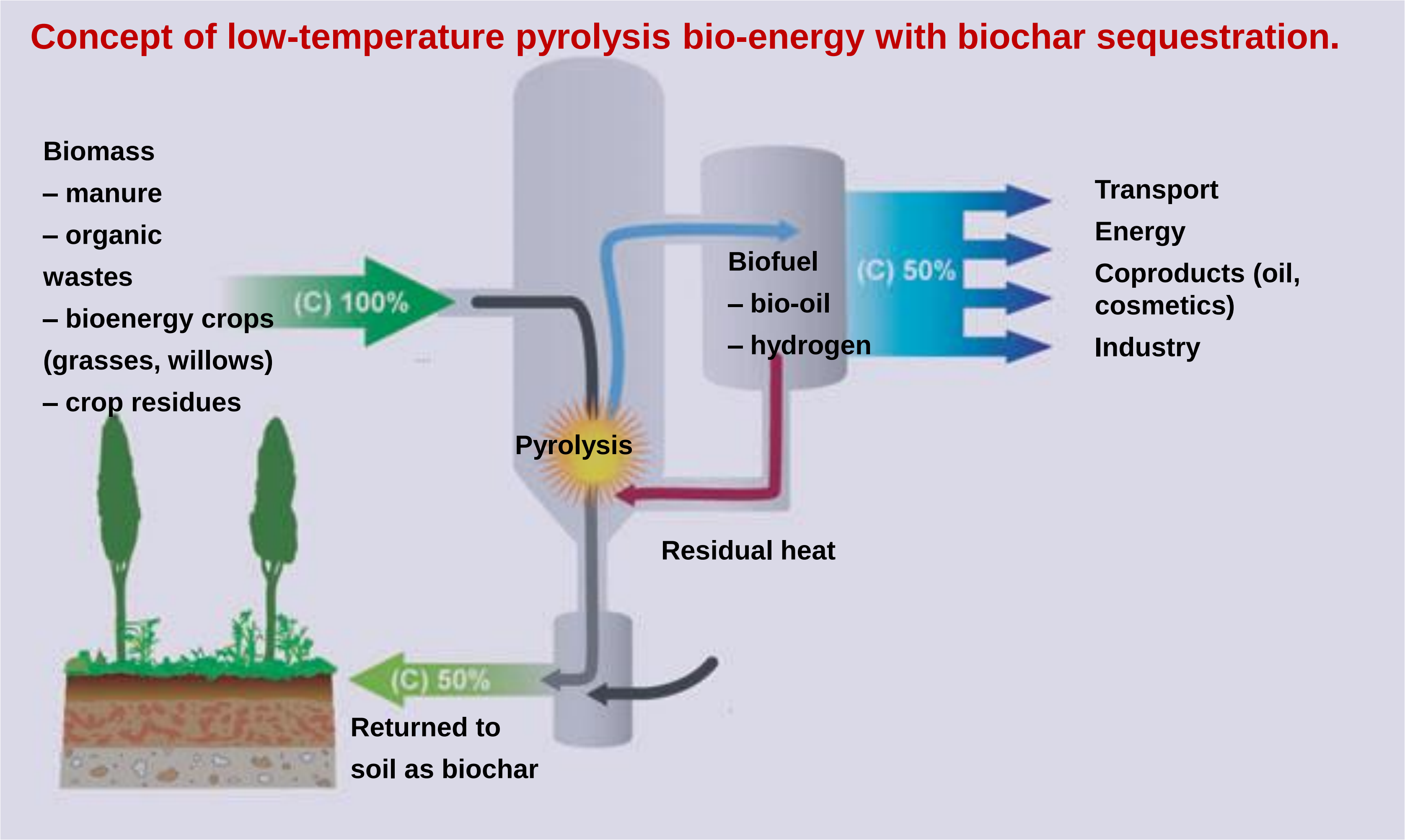
WHAT IS THE BIOCHAR

Terra Preta (fertile anthropogenic dark earths, Amazon basin), which were generated approximately 8000 years ago after soil was amended with bones, charcoal, and manure by indigenous natives (Glaser et al. 2007)

https://en.wikipedia.org/wiki/Terra_preta *Image courtesy of Carbon-terra.eu*

Biochar is a highly porous charcoal made from organic waste and is high in organic carbon, mostly resistant to decomposition



Typically, about 50% of the pyrolyzed biomass is converted into biochar and can be returned to soil.

(Lehmann 2007, Front Ecol Environ).

CLAIMED BENEFITS OF BIOCHAR:

Improved

-soil cation exchange capacity

-water holding capacity

-soil aggregation

Increased

- stable carbon in soil
- nutrient concentration
- soil biological activity

Stimulated

- plant growth
- plant tolerance to abiotic stresses

Aids in pathogen suppression

HYPOTHESIS

We hypothesized that biochar application in soil mitigates salt stress of licorice, improve nutrient acquisition through improving soil biological properties and root growth and that this beneficial effect depends on biochar concentration.

OBJECTIVES

to investigate to understand the effect of different biochar concentrations on plant and root growth and nutrient uptake (C, N, P),

to determine to determine the response of soil enzyme activities linked to carbon, nitrogen and phosphorus cycling in loamy sand under saline and non-saline conditions

MATERIAL AND

- The biochar material was produced from maize by heating at 600°C for 30 min (MBC)
- 2, 4 and 6%

Characterization of chars (Rabie et al. 2014)

Material	DM (%FW)	Ash (%DM)	C (%DM)	N (%DM)	P (g/kg FM)	K (g/kg FM)	pH	EC
MBC-char	92.85	18.42	75.16	1.65	5.26	31.12	9.89	3.08

Loamy Sand soil:

pH, 6.2; organic C content, 0.55%; total N content, 0.07%; P content, 32.0 mg (100 g soil)$^{-1}$; K content, 1.25 g (100 g soil)$^{-1}$; and Mg content, 0.18 g (100 g soil$^{-1)}$.

Liquorice (licorice (*Glycyrrhiza uralensis* Fisch.)

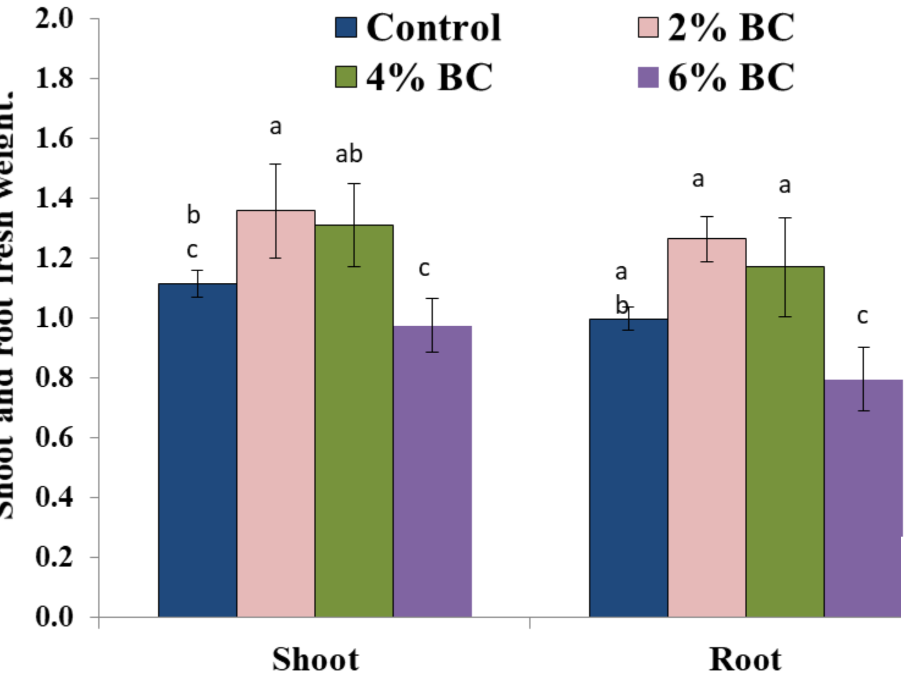
- ✓ Small perennial leguminous herb of the family Fabaceae.
- ✓ The plant is well adapted to grow in saline and arid soils because of itsr deep-reaching root system. shows high stress-resistance
- ✓ Licorice is used in the restoration of soil fertility

https://www.meandqi.com/herb-database/liquorice

Greenhouse conditions:

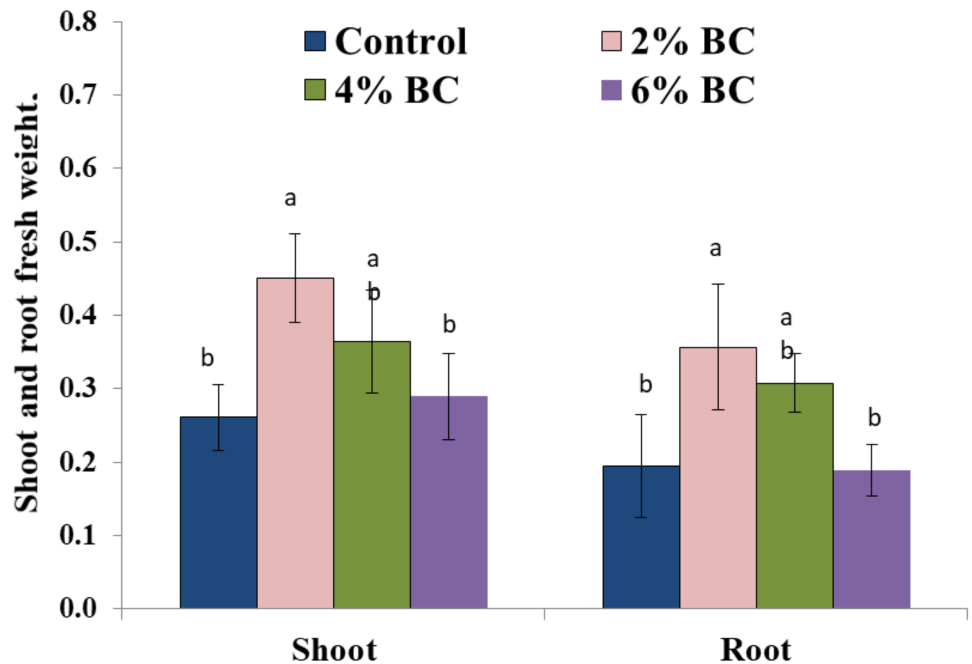
- ❖ Temperature: 24 ◦C /16 ◦C (day/night)
- ❖ Humidity: 50-60%
- ❖ Day lenght: 12 h
- ✓ Plants were grown for 40 days
- ✓ Each treatment : 4 pots (2 plants per pot)
- ✓ saline levels: 50 mM NaCl

Shoot and root growth of licorice grown in soil amended with biochar under non-saline and saline soil conditions.



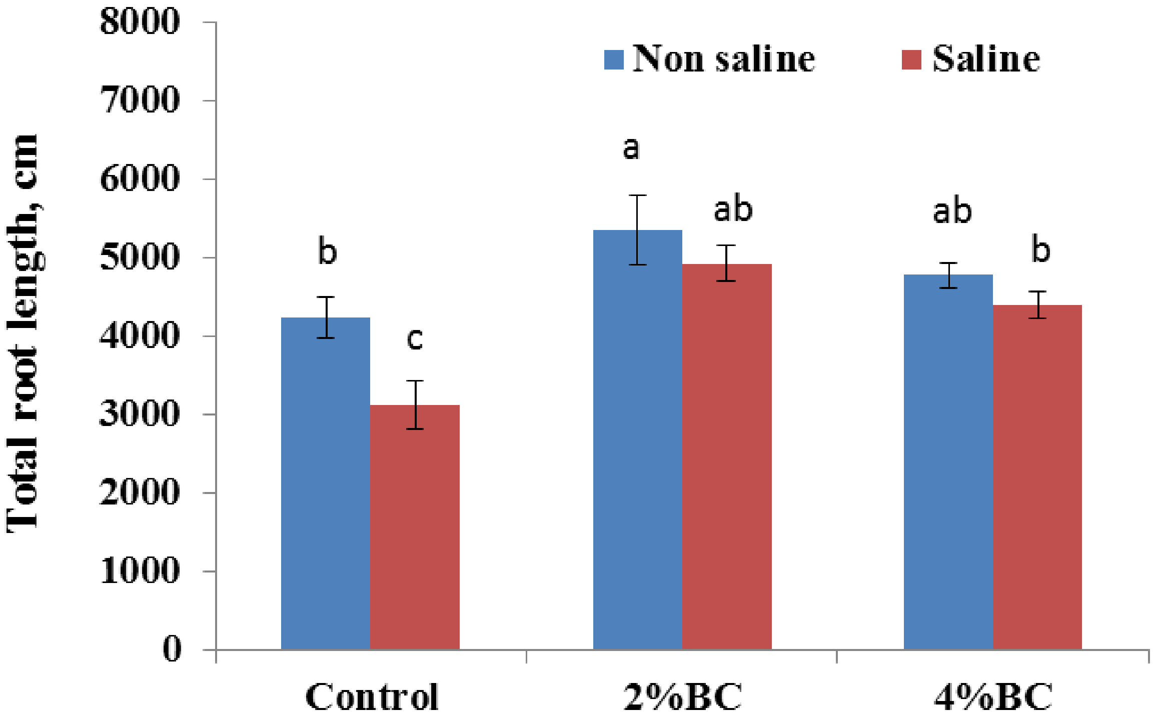
Non saline

Control 2%BC Control 2%BC



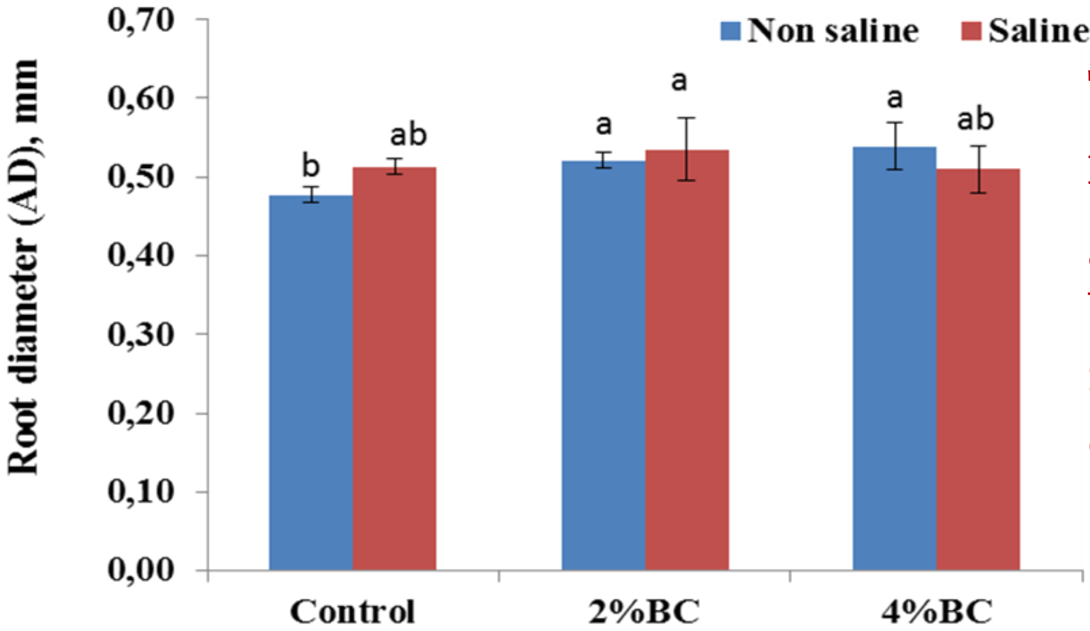
Saline

The root length of licorice grown in soil amended with biochar under non-saline and saline soil conditions.

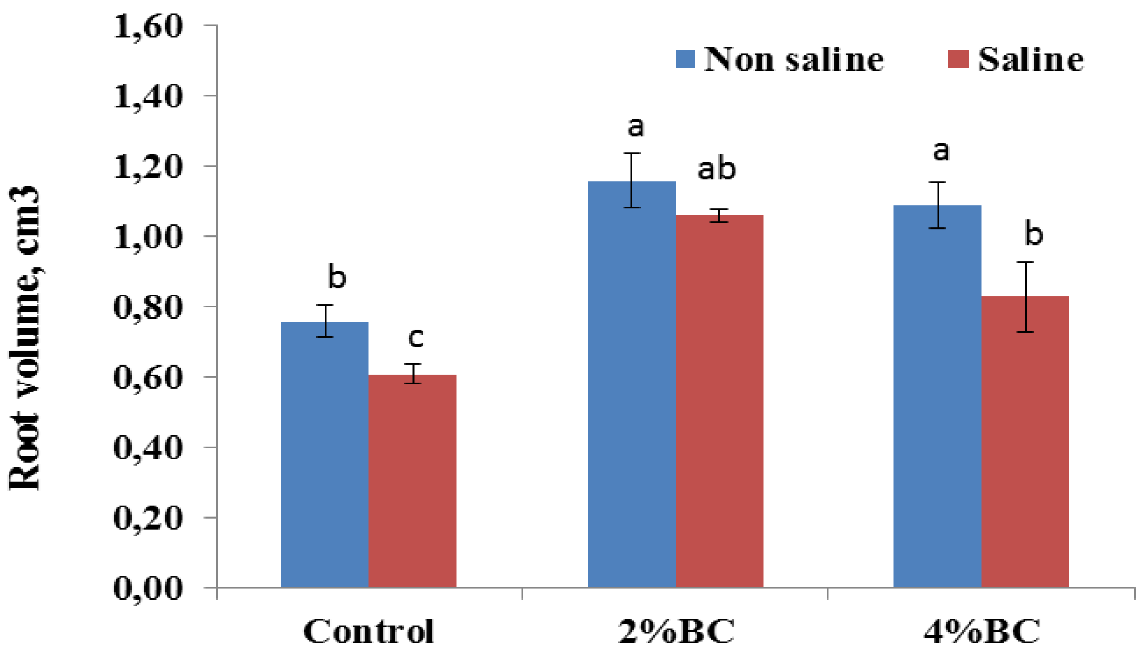


Control 2%BC

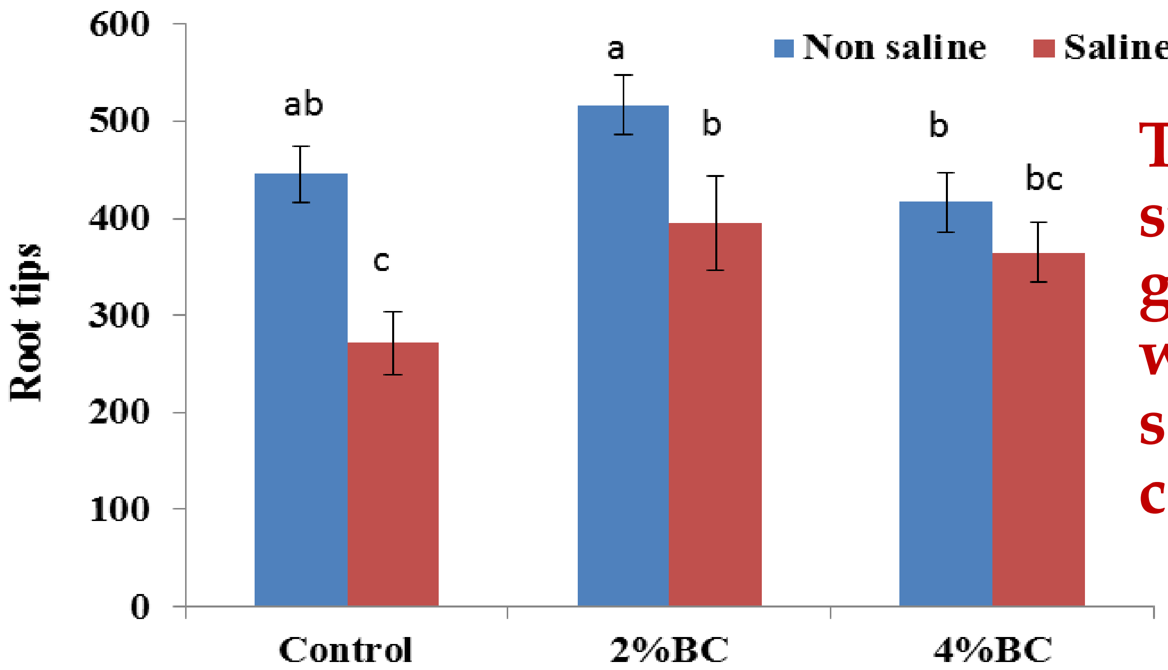
The root diameter and root volume of licorice grown in soil amended with biochar under non-saline and saline soil conditions



Root Diameter

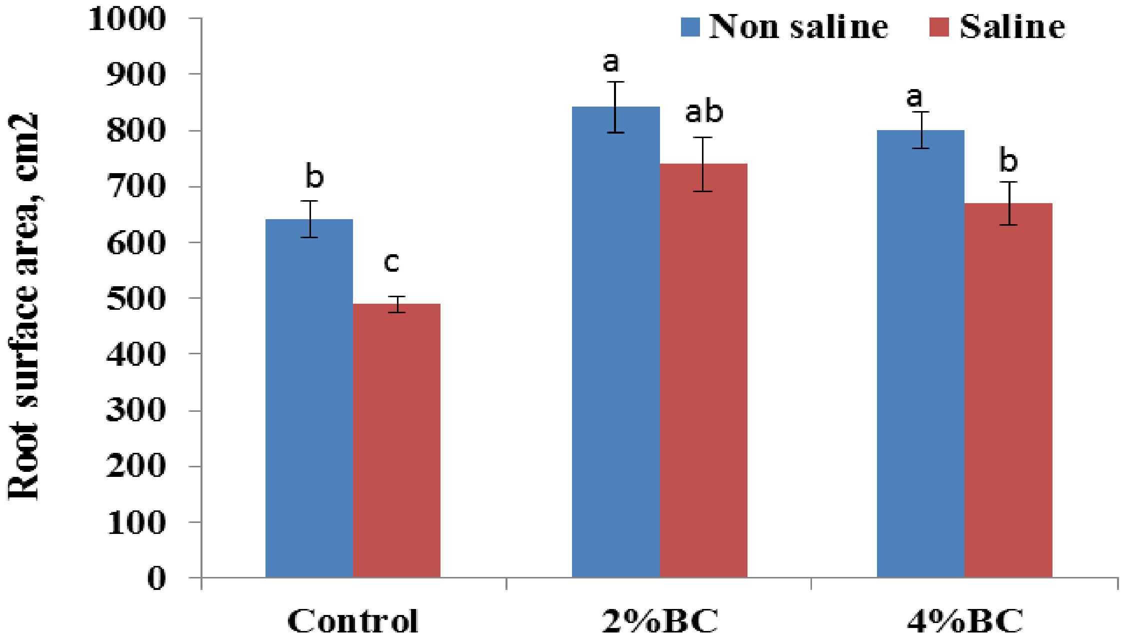


Root Volume



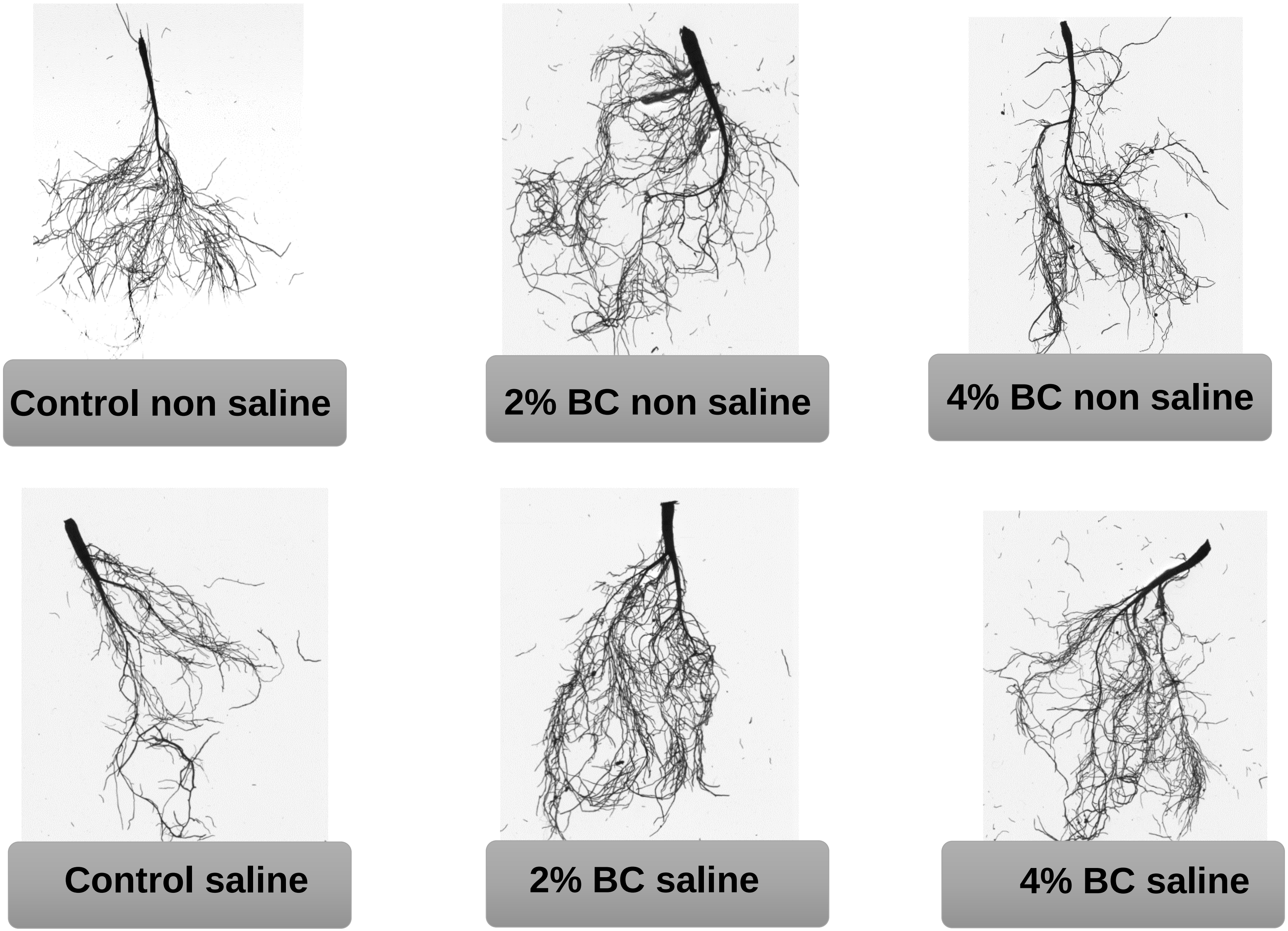
The root tips, and root surface area of licorice grown in soil amended with biochar under non-saline and saline soil conditions

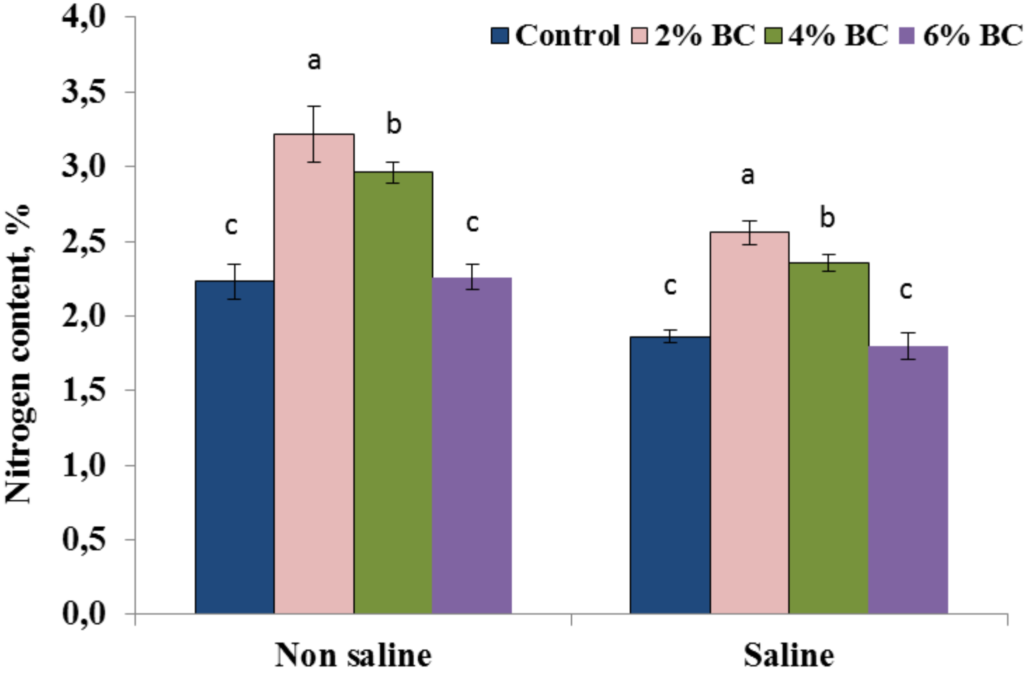
Root Surface Area



Root Tipps

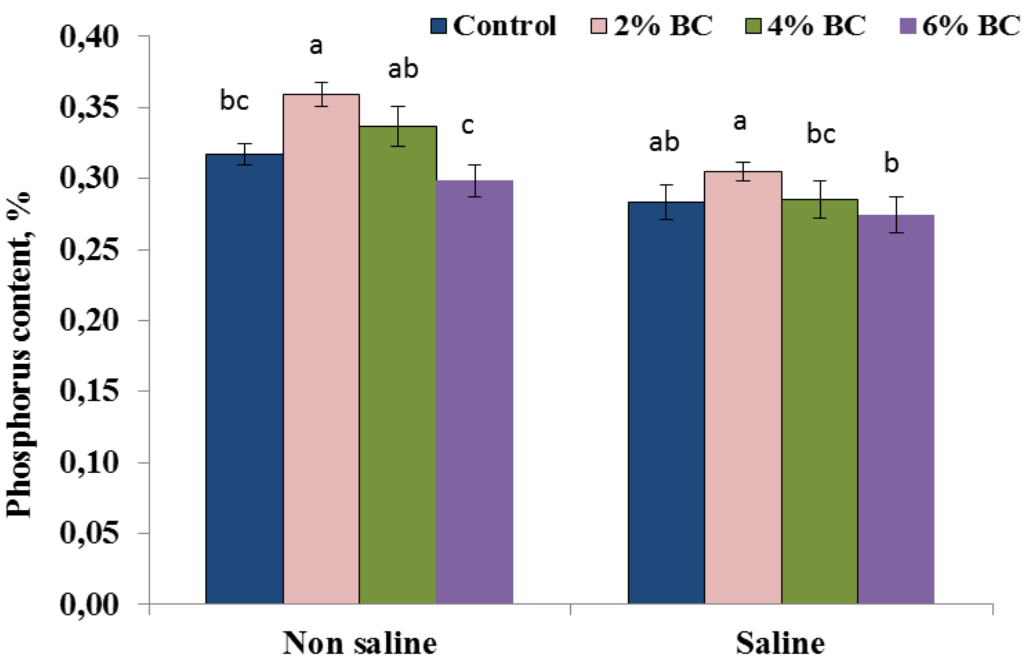
The root architecture of licorice grown in soil amended with biochar under non-saline and saline soil conditions





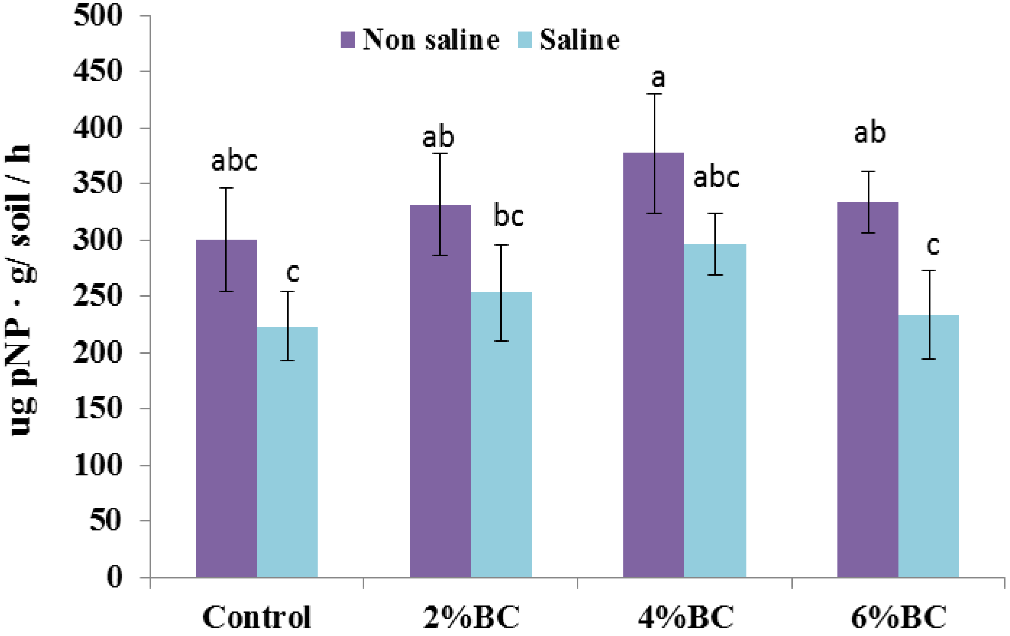
Concentrations (%) nitrogen, and phosphorus in licorice plant tissue grown after application of biochar under non-saline and saline soil condition.

Nitrogen content %

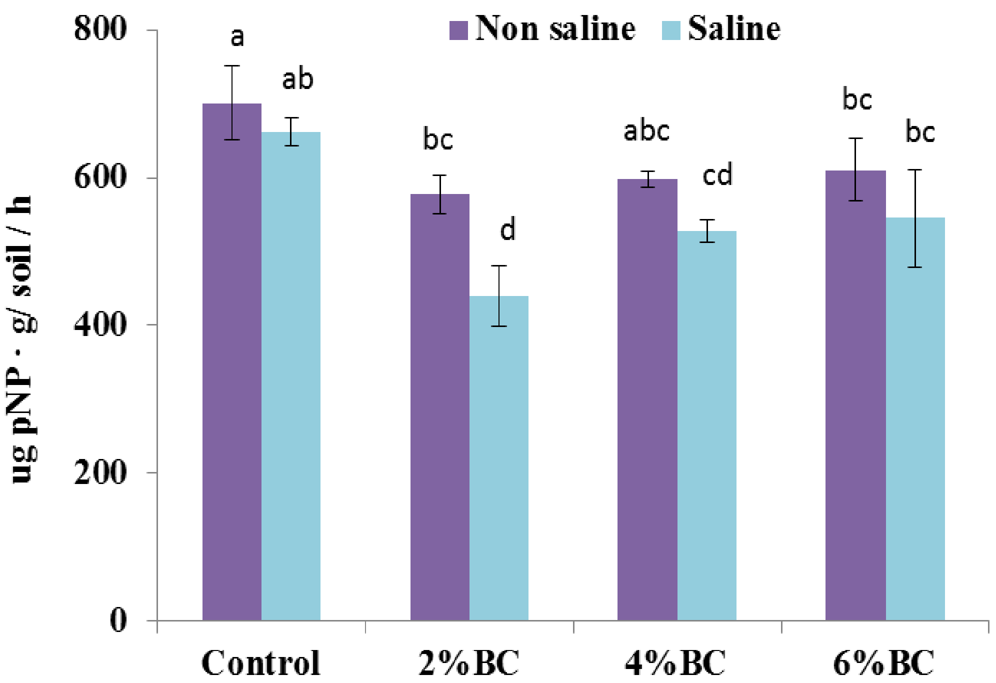


Phosphorus content %

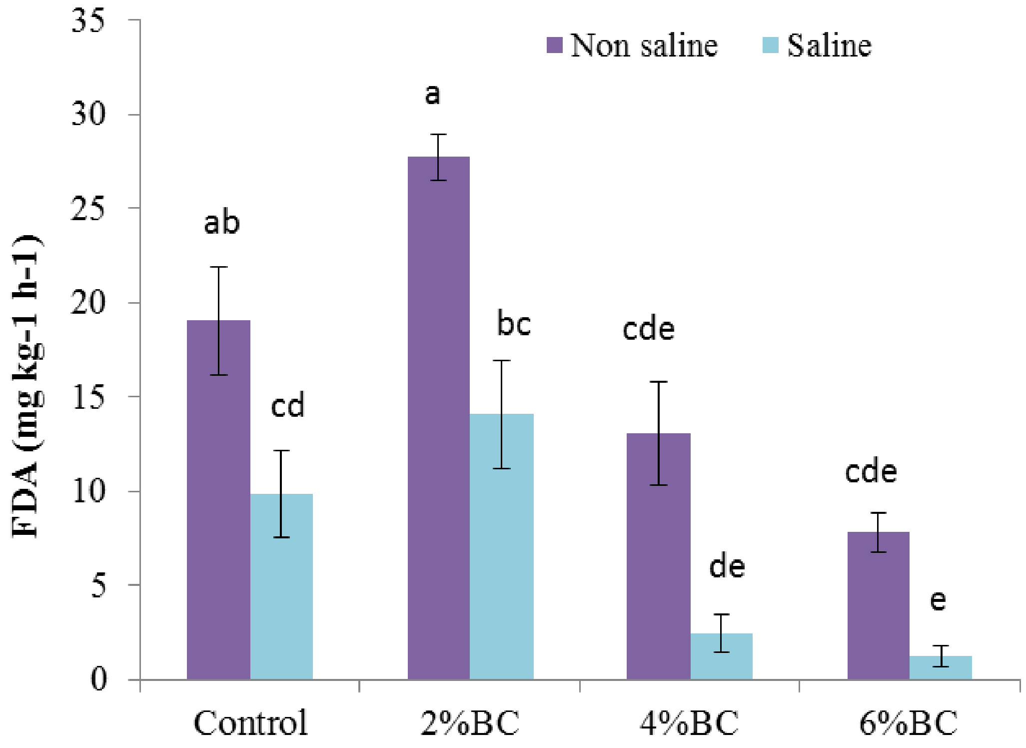
Effect of biochar amendment on soil acidic and alcalic phosphomonoesterase activity under non-saline and saline soil conditions



Acidic phosphomonoestrase

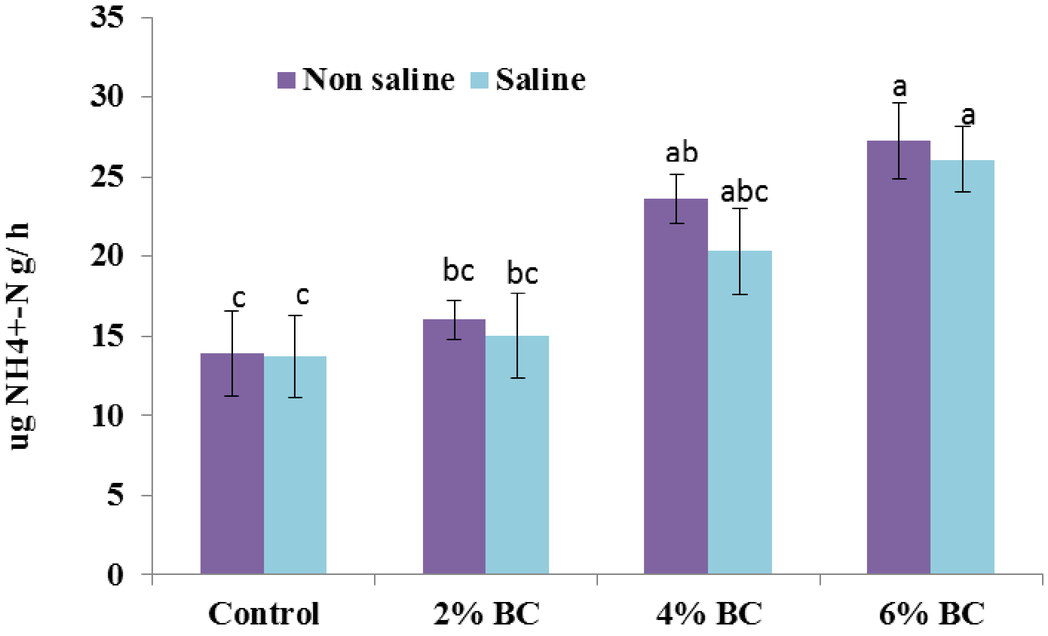


Alcalic phosphomonoestrase



Effect of biochar amendment on FDA hydrolase and protease activity under non-saline and saline soil conditions

FDA activity



Protease

Conclusion

- ✓The results of our study revealed synergistic effects of biochar amendments on plant growth, nutrient uptake, and soil enzyme activities involved in cycling of C, N and P in a sandy loam soil under non-saline and saline conditions.
- ✓A low biochar concentration (2%) in the soil had a more significant effect on plant shoot and root growth, root architecture, and soil enzyme activities as compared to 4 and 6% biochar additions under both non-saline and saline soil conditions.
- ✓This finding underpins the notion of an elaborate relationship between biochar concentration and enhanced plant growth, root system architecture, nutrient acquisition, symbiotic performance and soil biological propertie

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