Sustainable Salinity Management: Biochar Boosts Sweet Potato Growth and Antioxidant Responses in Coastal Agroecosystems

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Introduction

Soil Salinity stress has a significant impact on Sweet potato production in the coastal regions of Bangladesh, reducing soil fertility and crop yield. The K/Na ratio is a key indicator of ion homeostasis and salt tolerance, with improved ratios helping to manage nutrient uptake and reduce sodium toxicity. In addition, oxidative stress from reactive oxygen species (ROS) is mitigated by antioxidant enzymes (POX, APX, GST) and osmolytes such as proline. In this study, the efficacy of Biochar+FRG in increasing salt tolerance, improving the K/Na ratio, increasing antioxidant activity and increasing yield in sweet potatoes grown under saline conditions is investigated.

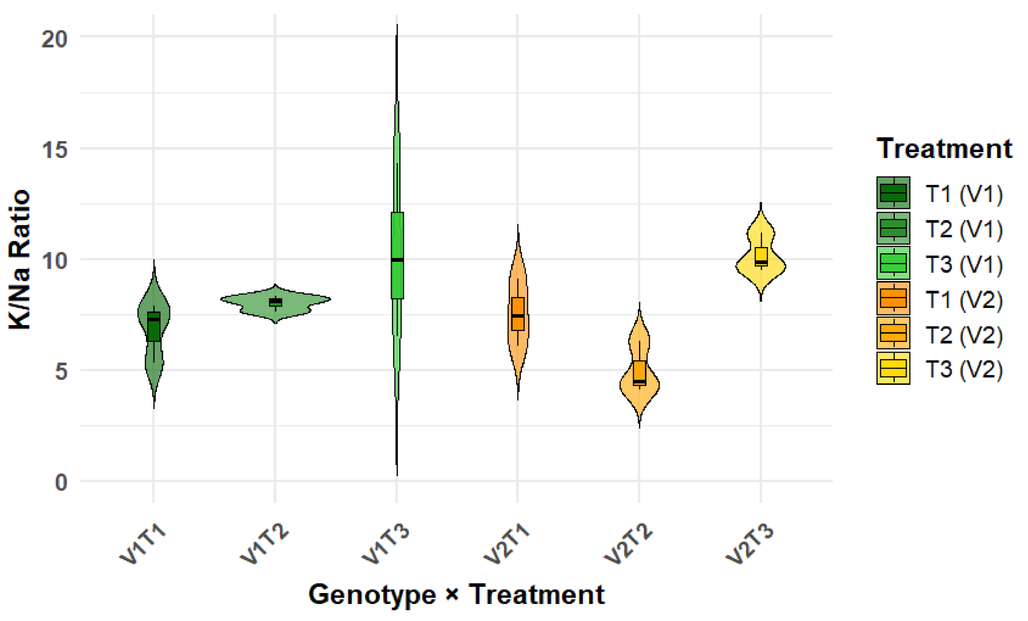
Picture: Biochar & Sweet potato

Conclusions

- Biochar+FRG treatment improved K/Na ratio, enhancing salinity tolerance.
- It increased antioxidant enzyme activities (POX, APX, GST), helping plants manage oxidative stress.
- Yield was higher, especially in BARI SP 16, showing potential for improving crop performance in saline soils.

Results and Discussion

K/Na Ratio



Here,
V1 = BARI SP 16, salt-tolerant
V2 = BARI SP 18, salt-sensitive
T1 = FRG, control
T2 = IPNS
T3 = Biochar + FRG
*FRG=Fertilizer Recommendation Guide 2018, Bangladesh
*IPNS=Integrated Nutrient Management System
**All treatments were applied under saline soil (EC 5.4–9.0 dS/m; initial 2.4 dS/m)*

Figure 1: K/Na ratio of sweet potato genotypes under three treatments. Biochar+FRG improved ion balance, especially in the tolerant genotype. Values are mean ± SE (n = 3). No significant treatment differences (p > 0.05) were found.

- Biochar+FRG treatment significantly improved the K/Na ratio, especially in salt-tolerant BARI SP 16.
- BARI SP 16 showed a greater K/Na ratio improvement than BARI SP 18 under Biochar+FRG.

Improved K/Na ratio suggests Biochar+FRG enhances ion balance and salinity tolerance in sweet potato.

Antioxidants

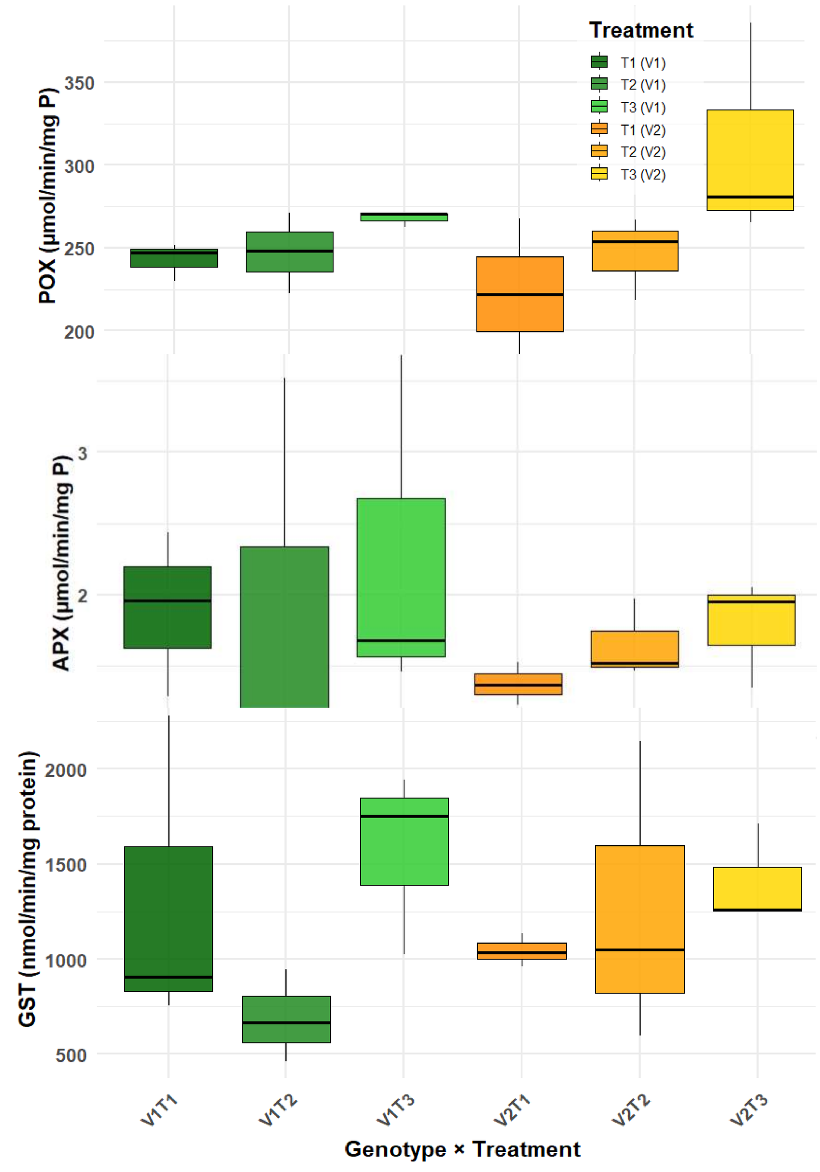


Figure 2: Antioxidant enzyme activities (POX, APX, GST) in sweet potato genotypes under different treatments. Biochar+FRG enhanced antioxidant defenses, especially in the sensitive genotype. Mean ± SE (n = 3); no significant treatment effects (p > 0.05) were found.

- Biochar+FRG treatment significantly increased POX, APX, and GST activities in both genotypes compared to control and IPNS treatments.
- The salt-tolerant BARI SP 16 exhibited higher enzyme activity levels than BARI SP 18 across all treatments.

Increased antioxidant enzyme activities suggest that Biochar+FRG enhances oxidative stress tolerance, particularly in salt-tolerant genotypes.

Yield

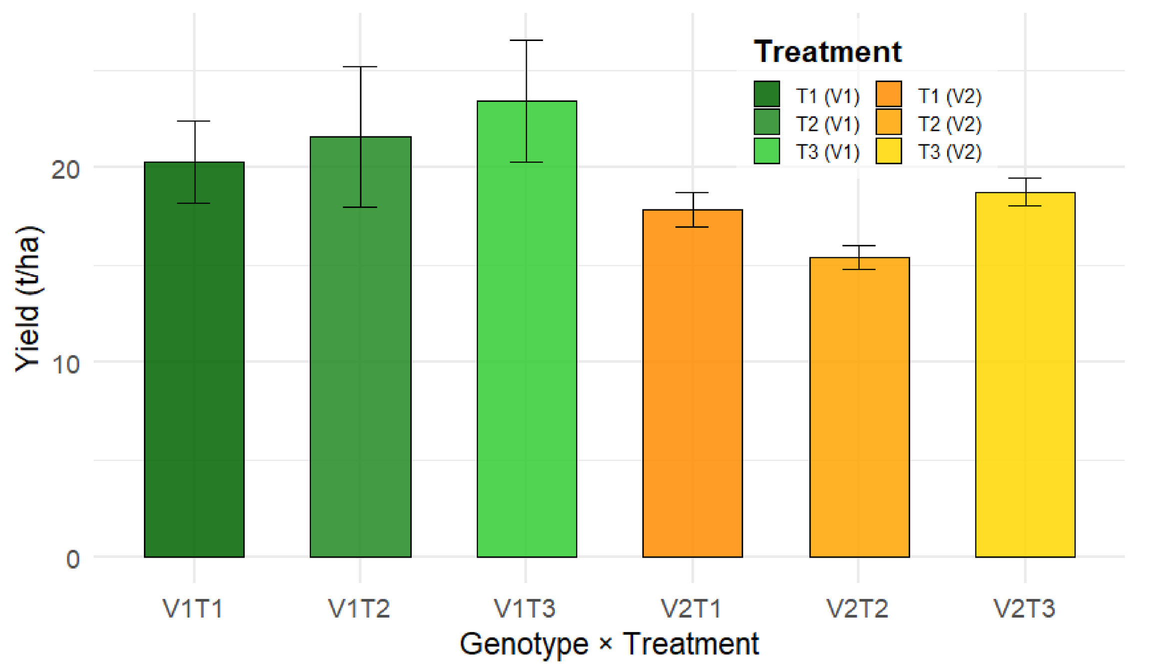


Figure 3. Yield of sweet potato genotypes under three treatments. Biochar+FRG increased yield slightly, with higher response in the tolerant genotype. Values are mean ± SE (n = 3). Differences were not statistically significant (p > 0.05).

- Biochar+FRG treatment significantly increased yield compared to control and IPNS treatments in both genotypes.
- BARI SP 16 showed higher yield improvement than BARI SP 18 under Biochar+FRG treatment.

The higher yield in BARI SP 16 under Biochar+FRG suggests that the treatment improves crop performance, especially in salt-tolerant genotypes.

Materials and Methods

A field experiment (RCBD) was conducted at the ARS BARI Research Station, Satkhira, Coastal Bangladesh, from November 02, 2024 to March 02, 2025. Two Sweet potato genotypes, BARI SP 16 (salt-tolerant) and BARI SP 18 (salt-sensitive), were exposed to FRG (control), IPNS, and Biochar+FRG treatments in coastal saline soil.

Electrical conductivity (EC) was measured at 15-day intervals, and antioxidant enzyme activities (APX, POX, GST) were analyzed, along with proline and ascorbate levels. Destructive sampling occurred two months after planting from young, fully developed leaves to assess growth and physiological responses.

Picture: Experimental field

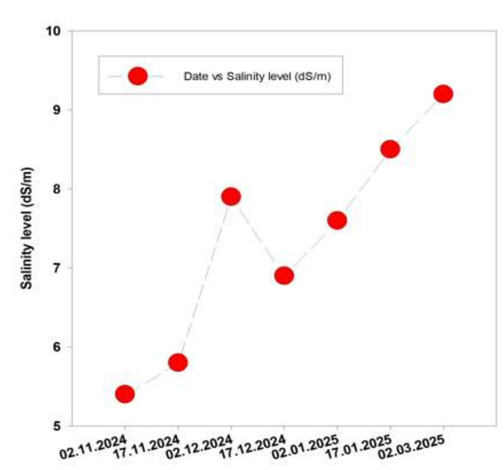


Figure 4: Salinity levels (dS/m) of soil during the experimental period (02.11.2024 to 02.03.2025). Data recorded from the ARS BARI Research Station, Binerpota, Satkhira.

Table: Initial Soil data

Parameters	Value
pH	7.7
EC (dS/m)	2.4
OM%	3.37
Total N%	0.177
P (µg/g)	38.67
K (mq/100g soil)	0.55
Ca (mq/100g soil)	39.01
Mg (mq/100g soil)	11.03
S (µg/g)	105.44
Zn (µg/m)	3.26
Cu (µg/m)	10.44
Fe (µg/m)	134.8
Mn (µg/g)	19.53