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Morpho-Biochemical Responses of Sugarcane Varieties to Salinity Stress During Formative Growth

Dr. Shakuntala Rao1
1 Former Ph.D. Student, I.K. Gujral Punjab Technical University, Department of Biotechnology, Jalandhar, India.
1 ORCID ID: https://orcid.org/0009-0007-5526-8249
1 drshakuntala.biotech@gmail.com, +91 8500807190

INTRODUCTION & AIM

Soil quality is declining worldwide due to over-irrigation, poor drainage, deforestation, and excessive use of fertilizers and pesticides. These factors contribute to soil salinity, which reduces plant growth, crop yield, and agricultural sustainability. Globally, about 6% of land (~400 million hectares) is salt-affected, including 20% of agricultural and 33% of irrigated land (Zan et al., 2019). In India, 6.73 million hectares are affected by salinity, expected to rise to 16.2 million hectares in the next 30 years, causing an annual crop loss of 16.8 million tons (Barman et al., 2021). Sugarcane, a major Indian crop, is highly sensitive to salinity, leading to reduced yield and sugar quality. Sugar production has already declined by 4.6%, and unchecked salinity may damage 30–50% of farmland by 2050 (Cheng et al., 2015). This study evaluated ten sugarcane varieties under normal and saline conditions to identify salt-tolerant genotypes based on seed germination, morphological, and biochemical traits.

METHOD

Experimental Design and Planting:

This study evaluated ten sugarcane varieties (CoSe 01424, CoSe 01434, CoSe 03234, CoS 03251, CoS 03261, CoS 07250, CoS 95255, CoSe 96436, CoS 97261, UP 49) to identify salt-tolerant genotypes suitable for saline soils. Sixty cemented pots were used, each containing 80 kg of soil, and were divided into two groups: normal soil (0.4 dS m^{-1}) and saline soil (8.0 dS m^{-1}). Salinity was maintained in the latter using a precise mixture of sodium chloride, sodium sulfate, and calcium chloride. Each pot received five budded sets of a variety, with three replications to ensure reliable data. Planting was carried out according to a spring schedule, and observations were focused on the formative stage, 90–110 days after planting.

Morphological Measurements:

Morphological traits were systematically recorded for all varieties. Mother shoot height was measured manually to assess plant vigor under both normal and saline conditions. The number of green leaves per plant was counted using standard manual methods, while leaf area was determined using the method of Bueno (1979), providing an accurate assessment of foliage development affected by salinity.

Biochemical Analysis:

Biochemical parameters were analyzed to understand stress adaptation mechanisms. Protein content was quantified following Lowry et al. (1951), free amino acids were estimated using Yemm and Cocking (1955), and proline accumulation was measured according to Bates et al. (1973). Chlorophyll content was assessed using the protocol of Taïbi et al. (2014), reflecting photosynthetic efficiency under saline stress.

Data Collection and Interpretation:

Leaf samples were collected from all varieties during the formative stage to establish correlations between traits. Integrating morphological and biochemical traits enabled the precise identification of salt-tolerant sugarcane varieties suitable for sustainable cultivation on saline soils.

RESULTS & DISCUSSION

Growth Response under Salinity:

Salinity stress significantly influenced sugarcane growth, although the extent varied among varieties. Mother shoot height declined by 43.6%, from an average of 106.6 cm to 60.1 cm under saline conditions. Despite this reduction, CoSe 01424 and CoS 95255 exhibited strong tolerance, maintaining comparatively higher shoot lengths. Leaf count showed only a slight decrease from 9.8 to 9.2, suggesting moderate resilience across most varieties. Leaf area, a key indicator of photosynthetic potential, decreased by 35.4%; however, CoSe 03234 retained the largest leaf size, highlighting its adaptive growth under salt stress.

Biochemical Adaptations:

Salinity induced notable enhancements in key biochemical markers. Average protein content increased by 6.6% in saline soil (100.4 µg/g) compared to normal soil (94.1 µg/g), with CoSe 03234, CoS 03251, and CoS 95255 showing significant protein accumulation. Free amino acids rose by 48%, with CoSe 03234 exhibiting the highest levels. Proline, a crucial osmoprotectant, increased in almost all varieties, with CoSe 03234 and CoS 03251 showing peak accumulation. In contrast, chlorophyll content declined by 20.6% (0.257 µg/g in saline vs. 0.324 µg/g in normal soil), reflecting the negative effect of salinity on photosynthesis. Interestingly, CoSe 03251 maintained the highest chlorophyll under stress (0.451 µg/g), suggesting sustained photosynthetic efficiency.

Screening Salt-Tolerant Varieties:

Integrating growth and biochemical responses, CoSe 03234, CoS 03251, CoSe 01424, and CoS 95255 were identified as salt-tolerant genotypes. These varieties combine reasonable growth maintenance with enhanced accumulation of proteins, free amino acids, and proline under saline conditions. Such biochemical markers at the formative stage effectively indicate salt tolerance and can guide early-stage screening.

Implications for Cultivation:

The findings highlight adaptive mechanisms that allow sugarcane to survive and maintain productivity in saline soils. Farmers can cultivate these salt-tolerant varieties in salt-affected areas, ensuring better yields and supporting sustainable agriculture. Additionally, sugar mills may benefit from consistent quality and quantity of cane production. These insights provide a valuable basis for future breeding programs aimed at developing improved saline-tolerant sugarcane cultivars.

CONCLUSION

- Sugarcane grown in saline conditions showed higher levels of free amino acids, proteins, and proline, while chlorophyll content decreased compared to plants in normal soil.
- These findings can help farmers and sugar mills by guiding the development of salt-tolerant sugarcane varieties.
- Such varieties will enable successful cultivation on salt-affected soils.

FUTURE WORK / REFERENCES

Future research could focus on the molecular mechanisms and genetic improvement of the identified salt-tolerant sugarcane varieties to enhance their adaptation and productivity in saline soils. **"The authors declare no conflict of interest."**

- Pierre, J.S., Rae, A.L., and Bonnett, G.D., (2014), "Abiotic Limits for Germination of Sugarcane Seed in Relation to Environmental Spread", Tropical Plant Biol., 7, pp. 100–110.
- Gangwar, B. D., (1986), "Studies on salt tolerance in sugarcane," Ph.D. thesis submitted to the Rohilkhand University, Bareilly.