Alleviating Drought Stress in Sugarcane (CP69-1062) through Foliar Potassium Silicate Application

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Abstract

Drought stress reduces sugarcane productivity by increasing oxidative damage and impairing juice quality. In a greenhouse pot experiment, foliar potassium silicate (0–750 mg L^{-1}) improved physiological responses and technological juice traits in sugarcane cultivar CP69-1062 under 85% and 30% field capacity. The 250 mg L^{-1} dose was the most effective in enhancing extract purity and sugar yield per plant, while higher doses showed limited benefits.

Introduction

Sugarcane is a major industrial crop and a primary source of sucrose, but its productivity is highly sensitive to drought stress. Water deficit induces oxidative damage through reactive oxygen species (ROS) accumulation, disrupts antioxidant enzyme activity, and reduces juice quality and sugar yield (Singh et al., 2023).

Silicon is a beneficial element that enhances drought tolerance by improving plant structural integrity, stomatal regulation, and redox balance. Foliar potassium silicate is commonly used due to its rapid uptake; however, its role in improving sugarcane physiological and juice-quality responses under controlled drought conditions requires further investigation.

In this greenhouse pot study, sugarcane cultivar CP69-1062 was subjected to two irrigation levels (85% and 30% field capacity), and foliar potassium silicate was applied at key growth stages to evaluate its effectiveness in mitigating drought stress and improving juice quality and sugar yield per plant.

Materials and methods

A greenhouse pot experiment was conducted at the Sugarcane Research, Training and Development Institute, Khuzestan, Iran, during the 2023 growing season. The commercial sugarcane cultivar CP69-1062 was grown in 60-L polyethylene pots filled with sandy-loam soil under controlled environmental conditions.

The experiment was arranged as a factorial based on a completely randomized design (CRD) with three replications. Treatments included two irrigation regimes: 85% field capacity (FC, control) and 30% FC (severe drought), and five foliar potassium silicate doses (0, 100, 250, 500, and 750 mg L^{-1}). Potassium silicate was applied at tillering onset and stem elongation stages. To avoid confounding potassium effects, equivalent potassium was supplied to non-silicon treatments.

Soil moisture was monitored daily and maintained at target FC levels. At harvest, oxidative stress indicators (malondialdehyde, MDA) and antioxidant enzyme activities (SOD, CAT, and APX) were measured using standard spectrophotometric methods. Juice quality traits, including Brix, Pol, purity, and sugar yield, were determined and expressed on a **per-plant basis**, appropriate for greenhouse pot conditions.

Data were analyzed using ANOVA suitable for a factorial CRD, and treatment means were compared using LSD at $P < 0.05$.

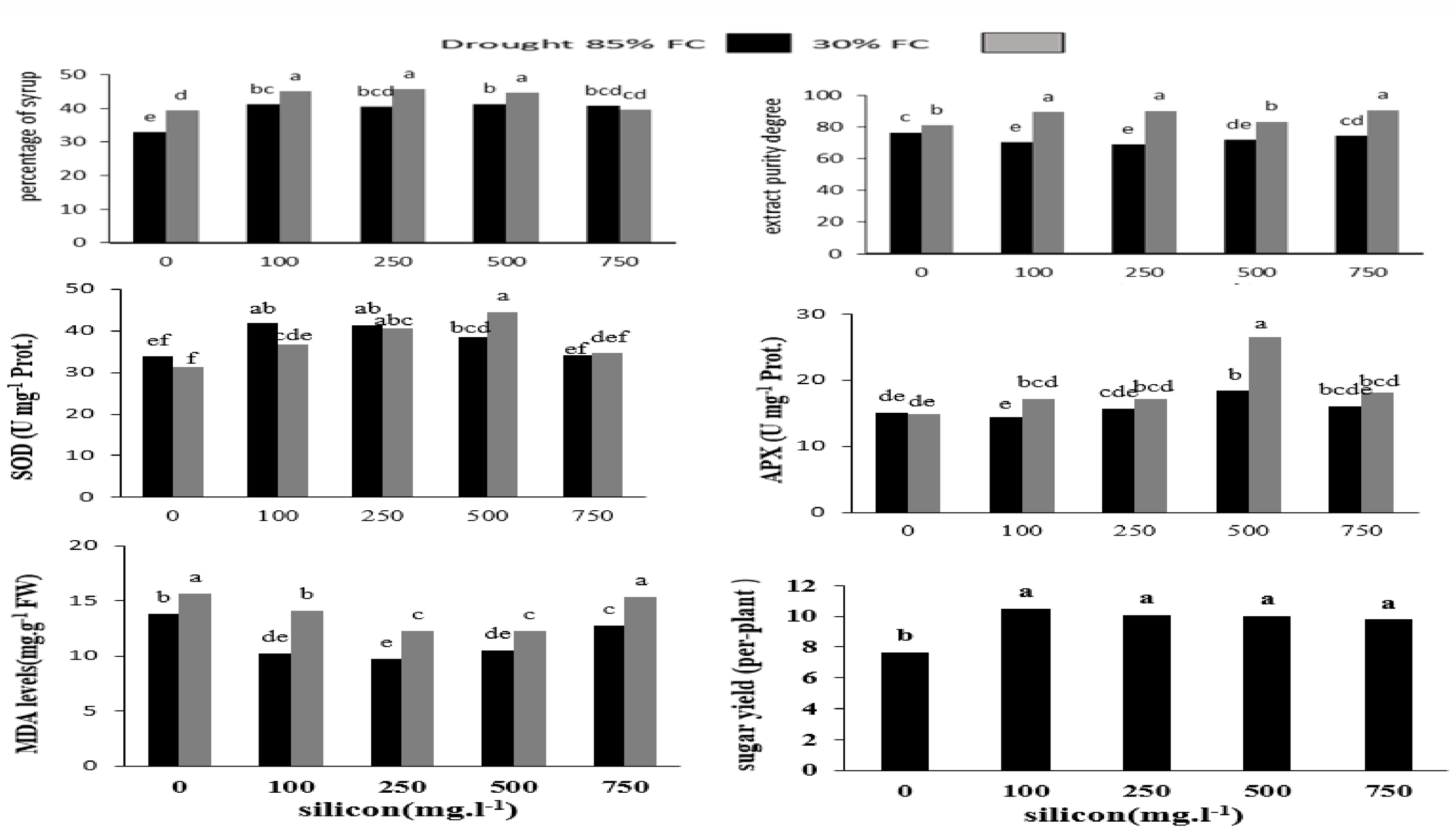
Results and discussion

Drought stress (30% FC) significantly intensified oxidative damage and reduced juice quality in sugarcane. Compared with the control (85% FC), drought markedly increased malondialdehyde (MDA) content, indicating enhanced ROS-induced membrane lipid peroxidation. Activities of catalase (CAT) and ascorbate peroxidase (APX) were significantly affected by both drought stress and foliar potassium silicate application, whereas superoxide dismutase (SOD) activity remained unchanged, suggesting a constitutive role of SOD in the CP69-1062 cultivar under water deficit.

Foliar potassium silicate effectively alleviated drought-induced stress responses. As summarized in **Figure 1**, moderate silicon application reduced MDA accumulation while enhancing antioxidant capacity and improving technological juice traits under drought conditions. The 250 mg L^{-1} potassium silicate treatment produced the most consistent improvement, simultaneously enhancing antioxidant performance, juice purity, and sugar yield per plant. This response indicates that moderate foliar Si + K application optimizes redox balance, carbon partitioning toward sucrose, and juice extractability without inducing osmotic stress.

In contrast, higher silicon doses (500 and 750 mg L^{-1}) provided limited additional benefits. Their reduced effectiveness suggests that excessive foliar silicate may transiently increase osmotic pressure at the leaf surface, slightly constraining sucrose loading and juice extraction efficiency. Overall, the results demonstrate that technological sugar traits and physiological tolerance peak at moderate foliar silicon supply rather than at maximum application rates.

Figure 1. Integrated response of sugarcane to drought stress and foliar potassium silicate application, showing the optimal effect of 250 mg L^{-1} on oxidative stress mitigation and juice quality under severe water limitation.



References

Singh, R.K., et al. (2023). Drought-induced oxidative stress alters catalase and ascorbate peroxidase activity in commercial sugarcane genotypes. *Journal of Plant Physiology*, 289, 154045.

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