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Rhizosphere enzyme activities in sorghum under limited resource availability in sub-Saharan Africa

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Abstract

Multiple nutrient deficiencies coupled with water limitation pose significant challenges to agriculture and food security in sub-Saharan Africa. Identifying high-yielding crop varieties adapted to multiple resource limitations could enhance crop productivity and conserve natural resources. Sorghum, the second most important crop in sub-Saharan Africa, is a drought-tolerant species with highly adaptive rhizosphere traits, such as extracellular enzyme activities, which are not yet well understood. Identifying sorghum varieties that can maintain high soil enzyme activity during droughts could improve food security in the region.

To investigate this, we conducted a field experiment in Siaya, Kenya, using three sorghum genotypes: the landrace Makueni local (Mkl), the open-pollinated Gadam (Gd), and the hybrid IESH varieties. Rhizosphere samples were collected from depths of 0–30 cm (d1) and 30–60 cm (d2) under well-watered and drought conditions, with four field replicates for each treatment. Rhizosphere enzyme activities of N-acetyl- -D-glucosaminidase (Chitinase), Leucine aminopeptidase (LaP), and Acid phosphatase (AcdP) were evaluated for all treatments.

Our findings revealed that in the rhizosphere of Mkl, the chitinase enzyme system changed under drought, likely because microorganisms produced different chitinase enzyme systems under drought stress. The well-watered Makueni genotype exhibited acid phosphatase with lower substrate affinity (high Km) in the topsoil compared to the subsoils, and the effect became stronger when the topsoil dried out during the drought, resulting in increased substrate affinity.

Overall, soil enzyme activities were influenced by both drought and crop genotype, with limited loss of activity in the topsoil during drought. Despite the relatively high drought resistance of these critical rhizosphere functions, the volume of soil connected to the rhizosphere was low in the dried-out topsoil. Enhanced nutrient mining for subsoil was not observed, suggesting the potential for improving rhizosphere traits to enhance drought tolerance in breeding programmes. This study highlights the importance of understanding key rhizosphere traits, specifically enzyme activity, for future food security in sub-Saharan Africa.

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