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Contrasting root and rhizosheath strategies of crop genotypes under drought stress and varying soil texture

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Abstract

How do crop genotypes modulate root traits and rhizosheath formation in response to drought and soil texture, and do these responses reflect region-specific adaptive strategies? To address this question, we investigated the root system architecture and rhizosheath development of three major crops - maize, cowpea, and soybean, grown under controlled conditions in two soil textures (sandy loam and silt loam) and two moisture regimes (well-watered vs. severe drought). The study included six African maize genotypes (bred for drought-prone environments), three cowpea genotypes, three soybean genotypes, and six German maize genotypes (three landraces and three hybrids). Rhizosheath, defined as the adhering soil to the root system when roots are removed from the soil, was collected and analysed for its dry mass and carbon content. Root and shoot traits were quantified via high-resolution scanning (Epson Perfection V850 Pro), with image analysis conducted using WinRHIZO to measure total root length, surface area, root diameter, shoot length, and shoot diameter. Results revealed clear genotype- and origin-specific strategies. Drought stress reduced total root length and surface area across all crops but consistently increased rhizosheath mass per unit root, indicating a compensatory mechanism to enhance soil-root water connectivity. African maize genotypes, particularly T2B-SR and DT STR-Y SYN 14, maintained greater root system and invested more in rhizosheath formation under drought, especially in sandy soils, highlighting a conservative yet adaptive response shaped by arid environments. In contrast, German genotypes such as Alpenfex and Benedictio KWS displayed stronger root and rhizosheath traits under well-watered conditions, suggesting a more acquisitive strategy less tuned to drought resilience. Cowpea genotypes generally outperformed soybean in both root development and rhizosheath formation across all treatments, indicating superior functional plasticity. Differences across soil textures further emphasised the moderating role of physical soil properties in shaping root-soil interactions and drought responses. Our findings underscore the importance of tailoring root trait selection to environmental context and reveal how region-specific breeding histories shape root phenotypes and their contribution to drought resilience.

Keywords: Drought, Genotype, Rhizosheath, Root, Soil

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