4.2 Regulatory effects of moderate water stress on polysaccharide synthesis and accumulation

Moderate water stress appears to promote polysaccharide-related carbon reallocation in *D. officinale*, although severe or combined stress impairs growth and quality. Recent work on the Danxia cultivar showed that harsh environments characterized by intense heat and limited rainfall were associated with substantial accumulation of bioactive polysaccharides, and that abiotic stress enhanced soluble sugar accumulation by transcriptionally activating sucrose synthase genes (Liu et al., 2025). Among these genes, *DoSUS2* responded strongly to drought and ABA, and its heterologous expression enhanced drought tolerance, soluble sugar accumulation, and ROS scavenging capacity, supporting a mechanism in which stress-induced sucrose turnover increases osmotic protection and precursor supply for polysaccharide synthesis. Consistent with this, dehydration increased soluble sugar content in leaves, and cold stress increased soluble sugars in both leaves and stems, while acid invertase genes were implicated in stress-responsive sucrose hydrolysis and osmotic homeostasis (Liu et al., 2024).

The beneficial effect is conditional, because genotype and stress intensity matter. Comparative drought analysis showed that the drought-tolerant genotype maintained stronger antioxidant capacity, with higher proline, APX, and CAT under intensifying drought, whereas the drought-sensitive genotype showed more severe repression of photosynthesis-related genes (Huang et al., 2023). Under combined heat–drought stress, *D. officinale* showed marked genotype-dependent differences in morphology, antioxidative capacity, polysaccharide accumulation, and transcriptome response, and dual stress induced glycosyltransferase genes that likely support stress adaptation (Figure 2) (Gao et al., 2026). Additional mechanistic evidence shows that drought-related transcription factors can directly regulate mannan biosynthesis: *DoMYB75* activates *DoCSLA* genes and improves drought tolerance, and *DoDof7* promotes polysaccharide biosynthesis under combined heat-drought stress by activating *DoGMPP2* and increasing mannose content (He et al., 2026; Yang et al., 2026). Together with evidence that droughted strains differ in intracellular water utilization, nutrient transport, and metabolic capacity, these findings indicate that moderate stress promotes accumulation, but excessive stress shifts the balance toward injury and growth suppression (Luo et al., 2024).

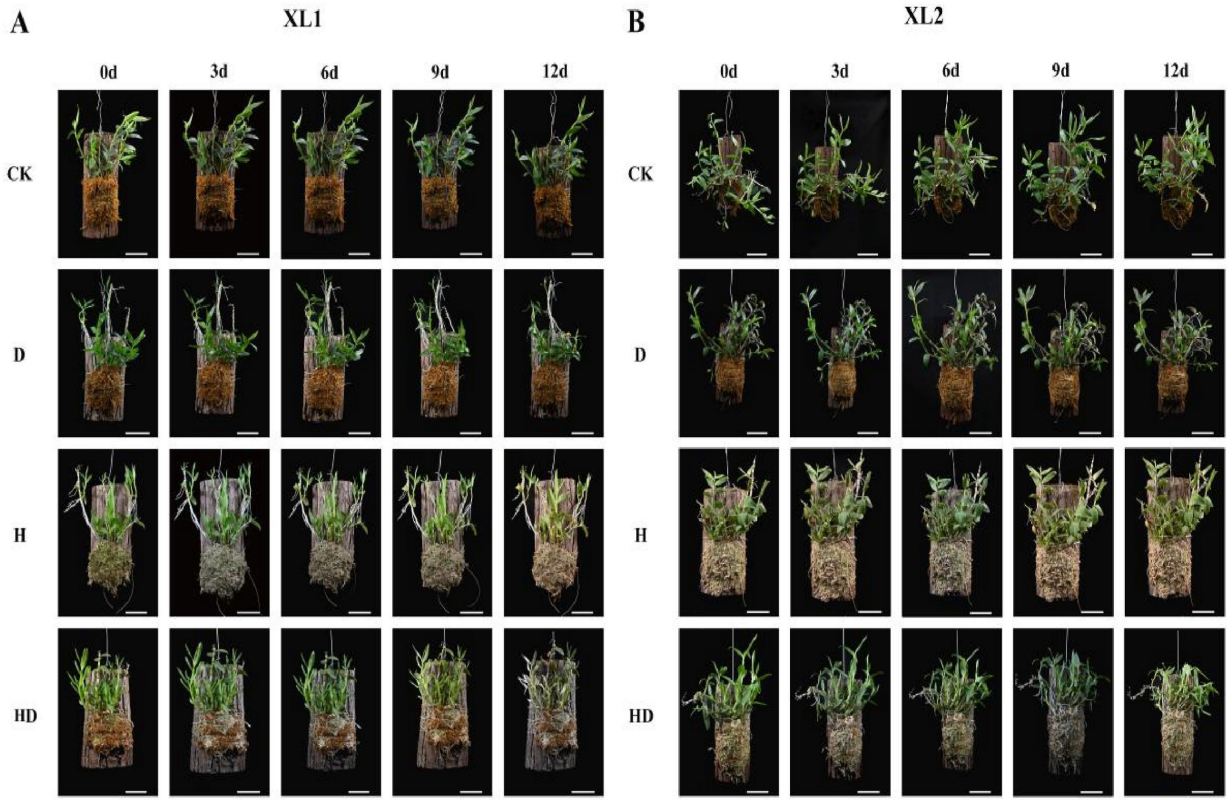


Figure 2 Phenotypic changes of *D. officinale* XL1 (A) and XL2 (B) under different treatments (Adopted from Gao et al., 2026)

Image caption: CK: Control group; D: Drought treatment; H: High temperature treatment; HD: High temperature and drought composite stress; the scale is 5 cm (Adopted from Gao et al., 2026)