

from primarily stomatal limitation to combined stomatal and non-stomatal inhibition of photosynthesis. Water relations are impaired in parallel with photosynthesis, because declining leaf hydration, reduced water uptake relative to transpiration demand, and membrane injury all constrain physiological stability under drought. Even so, *Chrysanthemum* shows meaningful adaptive variation: tolerant genotypes or related species maintain better water status, less membrane damage, stronger antioxidative protection, and less compromised photosynthesis than sensitive materials.

For sustainable *Chrysanthemum* production, the main implication is that water-saving management should reduce unnecessary irrigation while avoiding severe stress that causes visible quality loss, depressed growth, and lower marketability. Moderate or monitored deficit appears more useful than uncontrolled drying, because *Chrysanthemum* can recover rapidly from cyclical water shortage and, in some systems, moderate deficit improves adaptation and post-production performance. Production strategies should also combine irrigation control with physiological protection and genotype choice. Exogenous melatonin and brassinolide both improved relative water content, photosynthetic performance, antioxidant capacity, and biochemical homeostasis under drought, while grafting onto *Artemisia annua* helped maintain gas exchange, photosynthesis-related gene expression, and Rubisco activity. At the cultivar level, multivariate screening now supports the use of chlorophyll traits, relative water content, membrane stability, canopy temperature depression, fluorescence, biomass, and reproductive traits as practical indicators for selecting drought-resilient production materials.

Future research should move from single-trait descriptions toward integrated multi-omics and phenomics frameworks that connect drought physiology with underlying genes, proteins, metabolites, and high-throughput phenotypes across developmental stages and environments. This need is especially pressing in *Chrysanthemum* because current omics applications remain relatively early, full-genome resources are still limiting, and large-population phenotyping under environmental variation remains one of the major bottlenecks for breeding progress. A second priority is to translate genetic discovery into usable breeding tools for drought-tolerant cultivars with stable photosynthesis and efficient water use. Association mapping, multi-locus GWAS, and integrative linkage mapping have already identified favorable alleles, pre-bred tolerant cultivars, colocalized loci, and validated candidate genes, but these resources still need functional validation and deployment in cultivar development. More broadly, future experiments should compare mild, moderate, and severe drought with rewatering phases, because stress intensity-dependent designs are better suited to linking dynamic physiological responses with transcriptomic regulation and to defining agronomically useful tolerance rather than survival alone.

Acknowledgments

I extend my sincere gratitude to the anonymous reviewers for their valuable and insightful comments, which have greatly strengthened this paper.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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