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*Editorial*

# Drought Stress in Horticultural Plants

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Drought stress is one of the main factors limiting horticultural crops, especially in environments such as the Mediterranean basin, which is often characterized by sub-optimal water availability. Global changes will determine the increase in semi-arid conditions, so all horticultural crops will have to cope with water scarcity. Appropriate plant selection and new cultivation methods, especially strategies of deficit irrigation, are crucial in improving crop cultivation performance.

This Special Issue, entitled "Drought Stress in Horticultural Plants", comprises 11 innovative publications, which could enrich our knowledge about the mechanisms of plant to drought stress.

The plants that overcome drought stress develop different morphological, physiological, and biochemical mechanisms. Yang et al. [1] provide a review that focuses on the molecular mechanisms, and in particular on the main drought stress signals and signal transduction pathways in plants, as well as the functional and regulatory genes related to drought stress. The authors summarized the above aspects to provide valuable background knowledge and a theoretical basis for future agriculture, forestry breeding, and cultivation.

Climate change is often cited as one of the future challenges facing the agricultural sector because it significantly impacts both the agricultural sector and food security. The incidence of extreme weather conditions, such as flooding, drought, heat or frost, among others, is becoming more frequent, placing plants under stressful conditions. Another review article written by Giordano et al. [2], focused its attention on the plants' defense mechanisms and the involved morpho-physiological, biochemical, and molecular changes in the responses of ornamental plants to deficit irrigation. Drought stress tolerance can be reached through the selection of species tolerant to drought stress or by increasing the tolerance of sensitive species. In particular, this study analyzed the little-known response of ornamental plants to water stress conditions, as this is an agricultural sector that is constantly growing. From the different species analyzed in this manuscript, it was shown that both sensitive and tolerant plants have innate defense mechanisms, which include morphological changes (increase in leaf thickness, stomata density reduction and reduction in plant growth), physiological changes (restoration of osmotic balance and the closure of stomata), and synthesis of antioxidant molecules and enzymes. The drought-stress response also includes hormonal activity, transcription factors, and the activation of specific genes.

Among the experimental articles, Ferreira et al. [3] evaluated the ecophysiological parameters and the productivity of *Vigna unguiculata* (L.) Walp in response to water deficiency during the reproductive phase. Over the course of this study, the limit value could be established as a threshold water potential (−0.88 MPa) from which the water scarcity has negative effects on the cowpea grown under the climatic conditions of northeastern Pará.

Duarte et al. [4] analyzed how water stress level estimation is possible with good accuracy on the whole canopy, using majority voting at the tuber differentiation and maximum rate of tuberization phenological stages; the use of machine learning algorithms



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allows us to determine which regions in the spectral signature of the leaves are more influential to better estimate water stress from remote sensing using images in the visible (400–700 nm) and near-infrared (NIR) (700–1000 nm) bands. The results could lead to the use of more specific normalized water indices for water stress detection and estimation in potato crops by using these machine learning algorithms. This work is an important base for further research considering actual potato crop field conditions and cultural practices.

Bedding plants play an important role in public parks and private gardens. Very frequently, particularly in the Mediterranean area, these plants can suffer from drought stress because they are not always adequately watered. Romano and Toscano [5] analyzed the morphological, physiological, and enzymatic responses of *Zinnia elegans* L. subjected to different drought-stress levels. This study showed that the species response was different in relation to their stress levels. With light deficit irrigation, the plants could perform as well as fully irrigated plants. With medium deficit irrigation, the mechanisms were not always suitable to overcome drought stress. With severe deficit irrigation, the strategies adopted by the plants were not able to resist drought stress (e.g., stomatal closure, photosynthesis reduction, increase in water use efficiency and increase in enzyme activity and proline content).

The Mediterranean environment is characterized by high summer temperatures often associated with a shortage and poor quality of irrigation water. The presence of simultaneous stresses (drought and saline aerosol) has a cumulative negative effect on plant growth and survival. Toscano et al. [6] wanted to analyze the effects of drought and aerosol stresses on two species (*Callistemon citrinus* (Curtis) Skeels and *Viburnum tinus* L. 'Lucidum'). The interaction between the two stress conditions was found to be additive for almost all the physiological parameters, resulting in enhanced damage on plants under stress combination. The overall data suggested that *Viburnum* was more tolerant compared to *Callistemon* under the experimental conditions studied.

Hessini et al. [7] investigated the limits of tolerance to water deficit of the Damask rose and identified the main physiological and biochemical mechanisms that are linked to drought resistance. An integrated approach combining biochemical and physiological studies revealed new insights into the mechanisms and processes involved in *Rosa damascena* Mill. var. *trigentipetala* drought adaptation. In particular, under water-deficit conditions, the contents of biomolecules were positively correlated with antioxidant and inhibitory enzyme activities (LOX, AChE). These results suggest adequate protection against oxidative damage, and, thus, adaptation to water limitation. Water deficit can successfully enhance health-promoting phytochemicals in roses, which could be manipulated through agricultural techniques and screening programs to develop drought-tolerant genotypes.

In Asia, the mung bean is a nutritionally and economically important legume crop. This crop is sensitive to water scarcity in the different stages of development of its growth period, but the information regarding this is rather scarce. Ariharasutharsan et al. [8] imposed water stress on two mung bean cultivars, VRM(Gg)1 and CO6 during the flowering stage, evaluating physiological, biochemical, and transcriptional changes. Transcriptional analysis of photosynthesis, antioxidants, and drought-sensitive genes showed that VRM(Gg)1 increased transcripts more than CO6 under drought stress. Increased transcripts of drought-responsive genes indicate that VRM(Gg)1 showed a better genetic basis against drought stress than CO6. These results help us understand the mung bean response to drought stress and will contribute to the development of genotypes with increased drought tolerance using naturally occurring genetic variants.

The exploration and conservation of genetic diversity among plant accessions are important for the management of plant genetic resources. Forty-six tomato accessions from Jordan were collected by Makhadmeh et al. [9] and evaluated for their performance and morphophysiology, as well as undergoing molecular characterization to detect genetic diversity. The accessions were also subjected to two levels of water stress. Drought stress negatively affected several traits, revealing a wide range of variations among tomato accessions. The results provide new insight into the use of informative molecular markers to elucidate such a large genetic variation discovered in this collection.

Nemeskéri et al. [10], analyzed the use of plant growth-promoting rhizobacteria (PGPR) to promote tolerance to drought stress in tomato cultivars. Drought-tolerant PGPR may support plant development under limited water supply conditions when the plant's water demand is not completely satisfied under rain-fed conditions or when the availability of irrigation water is limited. The authors analyzed the effects of two inoculation treatments compared to control plants without artificial inoculation and three irrigation levels. In particular, they measured the chlorophyll a fluorescence, leaf chlorophyll content (SPAD value), canopy temperature, and yield. Different effects resulted according to the growth stage and in relation to the irrigation levels. Based on the results, the authors recommend the application of the PGPR given the positive effects observes on physiological processes, leading to a higher marketable yield, particularly under water shortage.

Li et al. [11] analyzed the difference in drought tolerance of seven common lily varieties based on morphological and physiological markers. The results showed differences in the morphological indices of leaves and anatomical structures in these varieties. Drought reduced chlorophyll content, inhibited net photosynthesis and increased enzyme activity, malondialdehyde, proline, soluble sugar, and soluble protein. The structure of lily leaves can therefore be used as one of the indices for classifying drought resistance. Genetic diversity analysis and functional annotations of genes associated with the SSR information obtained in this study provide valuable information on the most suitable genotype that can be implemented in plant breeding programs and future molecular analysis to differentiate the drought resistance of flower varieties.

Drought stress must be continuously investigated through multidisciplinary approaches in order to obtain valuable information about the mechanisms involved in plant stress responses, leading to the identification of agronomic solutions to mitigate stressful effects. Moreover, the study of plant response mechanisms, and particularly the genes and the signal transduction involved in stress tolerance, will help the breeder in the selection of drought-tolerant plants, the identification of suitable genotypes, and the adoption of specific management strategies in drought-prone environments.

Overall, these papers provide insights into new research directions within this field, covering the horticultural and ornamental species of interest. In the future, further research will be focused on finding new approaches and species, with a particular interest in maintaining plant productivity and food quality.

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