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Editorial

Plant Responses to Stress and Environmental Stimulus

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Plants respond to diverse environmental stimuli such as light, nutrients, temperature, and oxygen, which shape their growth and fate. When these stimuli are suboptimal for adequate plant growth, they cause stress. This Special Issue aimed to collect research articles providing evidence about plant responses to stresses and environmental stimuli, as well as some methodological papers describing new models or methodologies for plant phenotyping.

One type of environmental stress, often overlooked, is low temperatures at night. Rajametov et al. [1] studied the effect of low night temperatures on diverse growth and productivity parameters of thirty-nine *Capsicum annuum* L. accessions, including chili and bell fruit varieties, as a means to assist in the identification of low-temperature-tolerant cultivars to assist breeding programs. Using 10 °C as the night-low temperature and 15 °C as a control, the authors found that low temperature reduced plant height; the number of flowers; fruit weight, length, and diameter; and the number of seeds per fruit in all accessions. However, a few parameters, such as stem diameter and length of main axis, were differentially affected in the different accessions. By performing correlations, principal component, and hierarchical cluster analysis, the authors observed that the group of best-performing accessions was mainly discriminated by its positive influence on most reproductive traits, such as number of fruits, fruit length, fruit diameter and fruit fresh weight. The authors suggested these parameters to be critical to identify night-low-temperature-tolerant genotypes in breeding programs. Finally, the authors identified bell and chili pepper accessions with contrasting performances in low temperatures [1].

Aiming to understand the mechanisms involved in saline stress tolerance in rice (*Oryza sativa* L.), Jahan et al. [2] analyzed the transcriptomic response to saline stress in rice seedlings of elite mega-hybrid rice (LYP9) and its parents (PA64s and 93-11). The authors found that the mega-hybrid LYP9 outperformed the parental lines in terms of salt stress tolerance (100 mM NaCl). The transcriptomic response to salt of these genotypes varied over time, initially (7 days) mainly relating to photosynthesis, but later (14 days) relating to hydrogen peroxide metabolic processes and cell wall organization. In addition, the authors found that the transcription factors belonging to the bHLH family were the most abundant among the differentially expressed genes, suggesting that this family of transcription factors may play a prominent role in salt stress tolerance.

In another study on rice, Ahmad et al. [3] evaluated the performance of 2030 japonica rice accessions, based on six agronomic traits, under lowland and upland conditions, to identify drought-tolerant genotypes. With these traits, they determined a drought-resistant grade (DRG) score that was used to classify the accessions, 10% of them being classified as drought-tolerant. Based on the drought-resistant grade, 42 elite genotypes, including upland and lowland genotypes, were selected. These genotypes may be an essential source of material for rice-breeding programs, or could even be used as such by producers, in areas susceptible to drought conditions.

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Under drought conditions and other abiotic stress conditions, reactive oxygen species are over-produced. Ascorbate and glutathione play a relevant role as soluble antioxidants to prevent oxidative damage caused by excessive ROS [4]. In this Special Issue, Hoang et al. [5] characterized arabidopsis ascorbate- (*vtc2-4* and *vtc5-2*) and glutathione-(*cad2-1*) deficient mutants under abiotic stress. These mutants had a reduced sensitivity to ABA during germination and a lower germination rate under osmotic and salt stress. Moreover, the glutathione-deficient mutants showed lower tolerance to osmotic, salt, oxidative, and cadmium stress according to leaf area and root growth parameters. However, the ascorbate-deficient mutants showed, in some traits such as primary root length, number of lateral roots, and leaf area, a better performance than the wild type in some stress conditions. Under more severe stress, the ascorbate deficiency resulted in poorer performance in all stress conditions tested. This study evidences that ascorbate and glutathione are not antioxidants with redundant functions.

Given the importance of root architecture responses under drought stress, Urbanavičiūtė et al. [6] tested the root system diversity in six durum wheat genotypes with contrasting performance under drought. Even though a small number of genotypes were used, the authors found a large variability among them in terms of development, distribution, and architecture of the root system when subjected to drought. Interestingly, even the drought-tolerant genotypes showed contrasting strategies in response to drought. The authors concluded that high-throughput scanners are a valuable tool to identify interesting root traits in response to drought and speed up the selection of genotypes for plant breeding programs.

Stomatal conductance is one of the most important physiological responses to drought. Thus, stomatal conductance can be very informative of the capability of different genotypes to respond to drought. However, monitoring stomatal conductance during drought imposition can be a tedious and laborious activity. Simondi et al. [7] developed a mathematical model to predict stomatal conductance and water consumption kinetics with low sampling requirements. In particular, the authors developed this model using soybean plants in controlled conditions, but the approach they used can be reproduced in other conditions and plant species to determine the parameters B and k that feed the model in the newer conditions, in order to simplify the monitoring of stomatal conductance and water consumption.

Also in drought conditions, Berriel et al. [8] studied crop performance indexes, determined through isotopic analysis, in four legumes used as summer cover crops, *Crotalaria juncea*, *Crotalaria spectabilis*, *Crotalaria ochroleuca*, and *Cajanus cajan*. Based on the analysis of the parameters used as crop performance indexes, *C. cajan* was the most promising legume to be used as a cover crop among the four cover crops tested. Furthermore, the authors proposed the ratio between fixed nitrogen and transpired water, and the ratio between fixed nitrogen and ^{13}C isotopic discrimination, as good indicators of drought tolerance in fixing legumes.

Kulczycki et al. [9] also studied the effect of drought and its combination with sulfur fertilization on growth and yield parameters in maize and wheat. In these plants, in the absence of sulfur fertilization, moderate drought (45% FWC, relative to 60% FWC in control) had a small impact on grain yield, whereas a more severe drought condition (30%) significantly affected grain yield. Interestingly, the authors showed that in these crops, sulfur fertilization only had a positive impact in the absence of severe drought. These results show that using fertilizers in the context of drought may not be recommended, as it may not have beneficial impacts on growth-related parameters. Therefore, the investment in applying fertilizers will not pay off in terms of productivity. From a methodological point of view, this study also evidences that works intended to show the effect of mineral fertilization on growth-related parameters need to ensure the absence of drought episodes that can modify the response of plants to the nutrients attenuating the positive effects of fertilization.

However, in a different context, a similar message is obtained from the work reported by Signorelli et al. [10], who evaluated the effect of soil water content on bud burst rate using grapevine single node cuttings. The authors showed that soil water content (% of field capacity) significantly affects bud burst rate, concluding that soil water content has to be controlled to assess bud burst in perennial plants. Alternatively, when it is impossible to monitor water content during the assay, the authors recommend using a high soil water content to avoid the effect of water availability on bud burst rate. The manuscript has a methodological scope and illustrates a protocol to determine field capacity and monitor it. This protocol is helpful for works researching in the field of drought stress.

Although water restrictions are generally detrimental to plant growth, excessive irrigation can also be detrimental, especially for plants domesticated in arid regions. This is the case with olive trees, which were domesticated in the Eastern Mediterranean but now grow in more humid environments such as the one found in Rio de la Plata (South America), and where irrigation practices are very common. Conde et al. [11] compared the effect of full irrigation (supplying the water equivalent to the average of 100% evapotranspiration), partial irrigation (equivalent to 50% evapotranspiration), and water deprivation on fruit yield, oil content, and other productivity-related parameters, in two cultivars, Arbequina and Frantoio. The authors found that irrigation resulted in a significant increase in fruit weight and pulp/pit ratio but did not reduce the oil content in either cultivar. On the other hand, water restriction induced the content of polyphenols in the fruits in both cultivars, revealing a possible management practice by limiting water availability to improve olive oil quality without affecting oil productivity.

Another work dealing with agronomical management practices in tree corps was presented by Severino et al. [12], who studied pre- and post-harvest management of sunburn in apples (Granny Smith) under neotropical climate conditions. In multiple seasons, the authors evaluated the effect of sunburn protectors, white nets (20% translucent), black nets (35 and 50% translucent), and control without a netting system or sunburn protector applications. The authors found that the black net-50% treatment had the most positive effect on preventing sunburns, whereas the use of sunburn protectors did not affect any parameter tested in the neotropical climate of Uruguay. Importantly, the netting did not affect growth and leaf carbon assimilation, meaning that it can be recommended as a management practice for apples susceptible to sunburn such as Granny Smith.

Other environmental stimuli may be due to the presence of microbes in the surrounding environment of plants. These microbes can be beneficial or detrimental to plant growth, and understanding these possible interactions is relevant to proposing environmentally friendly strategies to promote plant growth and quality. In this sense, some studies have evaluated arbuscular mycorrhiza fungi (AMF) and seaweed extracts (SWE) as biofertilizers, however, little is known about the interaction of these biofertilizers. Rasouli et al. [13] studied the effect of these biofertilizers, separately and in combination, on plant growth and antioxidant capacity of lettuce plants. The authors found that the use of *Glomus mosseae* (20 g pot^{-1}) as AMF and *Ascophyllum nodosum* (0.5, 1.5, and 3.0 g pot^{-1}) as SWE had positive effects on plant growth. Moreover, the combination of these biofertilizers had the most positive results on plant growth and total antioxidant capacity, a property that can be indicative of crop quality.

Plants themselves produce compounds that can affect other plant growth. This is the case with walnut, which produces high amounts of juglone, a phenolic compound that can be toxic or growth-stunting to other plants. Medic et al. [14] evaluated the effect of pure juglone and walnut leaf extracts on the plant growth of four different crop species, *Beta vulgaris* L., *Brassica rapa* L. var. japonica, *Lactuca sativa* L., and *Valerianella locusta* Laterr. The authors found that beetroot and lettuce were less susceptible to juglone and other allelochemicals than turnip and mache, which presented lower yield and reduced quality. This research is useful to understand what crops can be grown in soils where walnuts were grown, particularly in the early years post-planting the new crop.

Together, these manuscripts help us to understand the multiple variables affecting crop productivity and quality, and the magnitude of the consequences of the different variables (such as water, salt, sunlight, temperature, microbes, and even other plant compounds). In some of these cases, the studies have proposed better agronomical management practices to avoid the effect of possible stressors, and in others, it is likely that the information generated will assist other studies to translate the basic knowledge into applicable knowledge for the agronomic field.

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