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Water Deficit and Water Stress in Plants Focused Fruits and Vegetables: A Mini review

Mini review

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Abstract

Water deficit and water stress are terms that are sometimes used interchangeably, when their meaning is very different from the physiological point of view in plants. A plant can be in conditions of water deficit and not be in a state of stress, due to its greater tolerance to drought. Since of this perspective, a brief analysis of water deficit and water stress in plants is the aim of this report.

Introduction

Water deficit is a condition of deficit of soil moisture in relation to its amount of usable humidity in the soil, which corresponds to the difference between the field capacity (FC) and the permanent wilting point (PWP) [1]. While water stress is when the plant shows a physiological step of compensation of chemical processes as a way of survival in the step of a critical state of water deficit, which can lead to permanent wilting [2].

In 2021, the United Nations declared it as the international year of fruits and vegetables, spotlighting their basic role in human nutrition and food security, as well as the importance to improve the sustainable production of these crops [3]. These plant species are the most common for the healthy nutrition and include a varied group of plant foods with important energy and nutrient and fiber content [4,5]. Furthermore, these agri-food crops are a source of phytochemicals with antioxidant activity, and the processes for obtaining these products, as well as its effectiveness, mechanisms, and application methods, are still being studied [6,7].

Physiological Processes as Adaptation to Water Deficit and Water Stress

Metabolic and photosynthetic reactions predominantly occur in an aqueous medium, making the limited availability of water in a plant's environment lead to unfavorable responses, impacting morphology, anatomy, and physiological processes under water deficit to induce water stress conditions [8]. Water is transported within plants through three distinct routes: apoplastic, via cell walls without crossing cell membranes, transmembrane (entering cells), and symplastic (through plasmodesmata communicating between partitions) [9]. Plant's water status is often expressed through relative water content (RWC), which represents the amount needed for total saturation and reflects the water balance [10]. Transpiration, the process through which plants lose a significant amount of water, mainly occurs through stomata, modified epidermal cells surrounded by guard cells [11]. Stomata, acting as hydraulically directed valves, regulate moisture loss by altering pore openings. Beyond controlling transpiration, stomata serve as the entry route for CO_2 during photosynthesis [12,13]. Various factors influence transpiration rates and stomatal activity, including vapor pressure deficit, light quality and quantity, environmental CO_2, air contaminants, leaf temperature, and soil water content [14,15]. The initiation of stomatal closure, according to Hernández et al. (2013), is signaled by the roots and dependent on soil water content.

Transpiration becomes a necessary secondary process for photosynthesis during the day when the vapor pressure deficit is higher. The combination of transpiration and low soil water availability significantly affects plants, with stomatal closure mediated by abscisic acid to prevent water loss. Each plant species has a specific response threshold to water potential and factors influencing stomatal opening [9, 14].

Water stress, induced by global climate change and intense drought periods, adversely affects plant development, crop growth, and productivity. Understanding genetic and physiological mechanisms that enable plants to tolerate water deficit becomes crucial for designing efficient cropping systems in water-limited regions. Plants employ adaptive strategies during water stress, with C4 and CAM plants exhibiting anatomical and metabolic differences to reduce water loss, while C3 plants may experience reduced photosynthetic advantages in drought conditions [15]. Symptoms of water deficit in plants include delayed growth, restricted CO_2 diffusion, decreased photosynthesis, and accelerated leaf senescence [10].

Water Efficiency Use in Plants

The concept of available water pertains to the amount of water within the soil falling within an acceptable range between the field capacity and the permanent wilting point. The closer the soil is to the PWP, the more challenging it becomes for the plant to access water [16]. Efficient water use (EWU) is considered a physiological parameter that demonstrates tolerance to water deficit in various productive species, thereby aiding in the development of plant improvement programs. It is crucial to note that plant dry matter production is closely linked to soil water availability [17]. Consequently, there is a pressing need to identify new genotypes with higher EWU, as it signifies the relationship between accumulated plant dry matter and transpired water, as emphasized by the Inter-American Institute for Cooperation on Agriculture [18].

Conclusion

A better understanding of the response behavior of plants to water stress induced by a water deficit will allow the generation of technology for agri-food production in regions with low rainfall due to frequent droughts in arid areas.

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