Environmental stress in crops

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EDITORIAL

Environmental stress in crops: Effects and responses during reproduction

Environmental stresses experienced during reproductive development cause drastic yield reductions in crop plants. Much of the literature has, however, focused on the stress responses of plant vegetative tissues. Although stresses experienced during the vegetative stage of plant development can affect crop yields, the reproductive stage is the most stress-sensitive phase of the crop growth cycle, which directly determines crop productivity. In particular, the efficient operation of photosynthesis and assimilate partitioning during the early reproductive stages plays a crucial role in dry matter accumulation and reproductive organ formation. Several morpho-physiological traits that improve plant vegetative growth have been used to enhance crop stress tolerance. However, vegetative traits do not necessarily improve stress tolerance at the reproductive stage, nor do they ensure higher grain yields during the terminal stage of plant growth under stress conditions. In addition, there is a poor correlation between stress tolerance at the seedling/vegetative stage and that observed at the reproductive stage, suggesting that separate sets of genes are involved in the stress tolerance during reproduction.

The identification of the reproductive stage-specific target traits and dissection of physiological and molecular responses of crop reproductive tissues to environmental stresses (either applied individually or in combination) are critical steps towards improving the grain yield under unfavorable environmental conditions. This information is essential for the development of stress-tolerant crop cultivars and global food security. Additionally, exploiting the natural molecular genetic variations in crop species for reproductive stage stress tolerance is of paramount importance for assisting plant breeders in their efforts to identify stress tolerant and high-yielding cultivars.

This Special Issue encompasses reviews and research articles that contribute towards and further our current understanding of plant reproductive stage stress tolerance. The comprehensive review articles contained in this Special Issue offer a synthesis of current knowledge, together with critical analysis of the current literature. They provide novel and wide-ranging insights into the topic. The research articles provide new information concerning the genetic and physiological mechanisms underlying plant reproductive fitness and productivity under various environmental conditions.

The review by Jeger (2023) provides a comprehensive and unifying description of term 'tolerance', which is defined as the ability of the host plant to mitigate the effects of infection on reproductive and survival fitness. This tolerance is robust, regardless of the pathogen load. This compelling review highlights the need for more intensive studies of disease tolerance at the reproductive stage. Jeger (2023) argues that it is important to define the interactions and host responses to biotic and abiotic stresses more clearly. Similarly, this article considers whether virus infection can reduce the severity of different abiotic stresses, as well as providing an understanding of the role of abiotic stress tolerance in reducing vulnerability to plant pathogens. Finally, Jeger (2023) emphasizes the need for more field studies on tolerance, together with the use of mathematical models for the development of disease management strategies.

The review article by Van Haeften et al., (2023) provides an expert evaluation of the impact of various abiotic stresses on reproductive growth and productivity in mungbean from a physiological perspective. Van Haeften et al., (2023) consider the traits that confer adaptation and reproductive fitness, emphasizing the need for greater application of new biotechnological tools that will accelerate the development of future climate smart mungbean crop. Furthermore, Van Haeften et al., (2023) argue that limitations on the number of genotypes available, as well as the lack of field studies and detailed experimental information constitute major hurdles in achieving mungbean reproductive resilience.

Heat stress causes detrimental effects on the reproductive development of numerous crop species by impairing pollen development and seed set. Smith et al., (2023) provide a wealth of new data concerning the deleterious effects of heat stress on both the early and late anther developmental stages of sorghum (*Sorghum bicolor* (L.) Moench), resulting in decrease in grain yield. The analysis of the pollen viability reported in this study shows that the booting stage is more susceptible to the duration of heat stress than the stage of pollen mother cell development. These findings implicate heat-induced effects of auxin on apical and basal tiller formation at the two stages of reproductive phase. These effects may protect grain yields in crops experiencing heat stress.

Genetic diversity is the backbone of global food security. It affords the possibility that a plant species can adapt to various environmental stresses. The review by Shokat et al., (2023) provides a comprehensive overview of the potential of genetic variation and pre-breeding traits found in in a wide-ranging population of bread wheat (*Triticum aestivum* L.) genotypes, to improve flowering stage drought and heat stress tolerance. They explore the potential of a range of physiological parameters related to eco-physiology, antioxidant and carbohydrate metabolism, osmoprotection, and endogenous phytohormone levels, together with novel genes, in predicting reproductive stage-specific yield-related traits in plants experiencing drought and heat stress. Shokat et al., (2023) propose that the availability of diverse wheat genetic resources, together with the identified pre-breeding traits, may be effectively exploited in breeding wheat cultivars with high resilience to adverse environmental conditions.

In addition to genetic resources, genomic resources are crucial for crop improvement. Advances in genomic technologies have enabled generation of new genomic resources which may be utilized in crop improvement programs to secure future global food security. Pruthi et al., (2023) have identified several quantitative trait loci (QTLs) and candidate genes associated with rice salt tolerance at the flowering stage. These were found to be different from those associated with seedling stage salt tolerance, suggesting that distinct pathways of genetic control underpin salt tolerance at these developmental stages in rice. This finding necessitates the stacking of different QTLs/genes for the further improvement of salt tolerance at both developmental stages. Notably, Pruthi et al., (2023) also identified some introgression lines with enhanced salt tolerance at both the seedling and flowering stages. The application of state-of-the-art approaches such as whole genome sequencing, transcriptomics, and metabolomics, will lead to a deeper understanding of salt tolerance mechanisms at both stages in these rice lines.

Collectively, the review and research articles that comprise this Special Issue provide new and useful information concerning the effects of environmental stresses on reproductive fitness in crops. They offer a wealth of valuable expert insights into the reproductive stage-specific target traits, physiological and molecular responses to stress, as well as the genomic resources, and natural genetic variations in crop species and their wild relatives. This information is invaluable in assisting plant breeding strategies designed to accelerate the genetic improvement of crops through technologies such as marker-assisted selection, high-throughput phenotyping, genome editing and genomic selection. This Special Issue provides a wealth of useful information that will assist in the development of crop cultivars that are more resilient to stress at the reproductive phase, thus safeguarding crop yields.

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DATA AVAILABILITY STATEMENT

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