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Significance of Ear to Wheat under Heat Stress

SD Pradeep[1] and Raktim Mitra[2]

[1]Research Scholar, Department of Botany and Plant Physiology, CCSHAU, Hisar, 125004, Haryana, India.

[2] Research Scholar, Division of plant physiology, ICAR-Indian Agricultural Research Institute, New Delhi, 110012, India

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Introduction

Wheat (*Triticum aestivum* L.) is among the world's most extensively cultivated plant. One of the main effects of climate change that is of great concern worldwide is the rise in global temperature. Global warming poses a significant challenge in achieving high productivity of wheat (Pradeep *et al.*, 2022). Wheat crops are significantly impacted by high temperatures starting from the early emergence stage. Wheat seedlings exposed to heat stress, even over a short time, may experience a reduction in shoot and root length, biomass, membrane stability and chlorophyll content. Root growth and tillering are reduced followed by heading and maturity enhancement under heat stress. At temperatures above the threshold level, photosynthesis is a highly delicate physiological mechanism. Further to this, pollen viability is also reduced leading to higher unfertilized flowers. A lower photosynthetic rate has been observed under heat stress and this was mainly due to thylakoid membranes damage, changes in the composition of lipids in the thylakoid membrane, ROS production and stomatal and non stomatal limitations.

Importance of ear

The ear is a reproductive organ of the wheat plant and its morpho physiological traits are positively correlated with yield. During grain filling, the contribution of the wheat ear to yield is significant under abiotic stress conditions (Sanchez-Bragado *et al.*, 2020). Photosynthesisrelated parameters of the ear such as rubisco, chlorophyll content, stomatal conductance and fluorescence is moderately affected by drought stress compared to leaf photosynthesis (Sanchez-Bragado *et al.*, 2020). Due to the proximity of the ear bracts and the green pericarp of the developing grain, CO_2 emitted during the respiration of the grain endosperm can be fixed by these two structures rather than the leaves. Along with this, awns also have better assimilatory ability for CO_2 (Tambussi *et al.*, 2007). Glumes have anatomical

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structures to facilitate photosynthesis. Awns also display better energy dissipation efficiency through the xanthophyll cycle and nonphotochemical quenching (NPQ) pathway, indicating higher antioxidant capacity. All these together contribute to higher integrity of thylakoid membrane, higher photosynthetic capability, delayed senescence and heat stability of glumes at later stages of grain filling (Kong *et al.*, 2015).

Additionally, Vicente *et al.* (2018) found that ears with higher intrinsic water use efficiency (WUE) had lower transpiration rates, which was substantiated by lower ^{13}C values. The ear functions as a buffer, contributing more under abiotic stress (22%–45%) and less under non stress situations (13%–33%).An increase in transcript levels of antioxidant enzymes (Vicente *et al.*, 2018), low levels of ROS (Kong *et al.*, 2015) and increased expression of dehydrinsconfirm higher stress tolerance of the ear and so its importance as a contributor to grain yield under stressful environmental conditions. Maydup *et al.* (2014) and Sanchez-Bragado *et al.* (2015) showed genetic variation in CO_2 uptake through ear photosynthesis and its contribution to yield (2014).All ear parts like glumes, lemmas, and awns can perform photosynthesis (Hu *et al.*, 2019; Tam bussi *et al.*, 2007). Using herbicides that prevent photosynthesis, such as DCMU (3-(3,4-dichlorophenyl)-1,1-dimethylurea) and ear shading method, the photosynthetic contribution of the ear was 45% &60% respectively depending on the method used.

Important Characteristics of Ear

- Photosynthetically active ear parts such as glumes, awns lemma, grain pericarp
- High levels of radiation interception because of its apical position in canopy
- Delayed senescence compared with leaves
- High water use efficiency
- Osmotic adjustment
- Refixation of CO_2 respired by grains
- More tolerant to drought and heat

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Awn is an appendage of the lemma of spikelet. The most significant photosynthetic tissues after the heading are ear components like glumes and awns. Chlorophyll is present in awns and glumes and thus they are photo synthetically active. When awns were present, ear showed higher intrinsic water use efficiency and photosynthetic capacity under stress conditions, indicating that awn photosynthesis provide pivotal contribution in stress conditions, when leaf photosynthesis is adversely impacted. Awns continue to work for a longer time throughout the grain-filling period. However, the role of awns in filling grains is ambiguous and contentious; it has been described as positive, partially positive, neutral, and negative.

Conclusions

The wheat's ability to withstand heat stress is the product of numerous interconnected pathways, reactions, and defense mechanisms that take place throughout the course of the plant's lifecycle. Understanding and enhancing wheat's thermo tolerance to heat stress can be done by investigating the variability and causes of physiological processes that are connected to greater yield or yield stability under heat stress. The majority of wheat research has focused on leaf photosynthesis and post-an thesis stem reserve mobilization under abiotic stresses. However, recent wheat research has revealed the role of ear and ear-related physiological features in conferring yield stability, particularly under abiotic stress situations.

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