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EFFECT OF HIGH TEMPERATURE STRESS IN WHEAT CROP

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Introduction

Temperature across the world is continuously increasing at the rate of 0.15–0.17 °C in each decade. It is effect agricultural crop productivity. Therefore, thermo tolerance strategies are needed to have sustainability in crop yield under higher temperature.

The range of optimum temperature for wheat growth at different crop growth stages i.e. heading, anthesis, and grain filling duration is 16 ± 2.3 °C, 23 ± 1.75 °C, and 26 ± 1.53 °C, respectively. The high temperature adversely affects the crop phenology, growth, and development. The pre-anthesis high temperature retards the pollen viability, seed formation, and embryo development. The post-anthesis high temperature declines the starch granules accumulation, stem reserve carbohydrates, and translocation of photosynthates into grains. A high temperature above 40 °C inhibits the photosynthesis by damaging the photosystem-II, electron transport chain, and photosystem-I.

Crop productivity depends on biotic (diseases and insect pest) and abiotic (heat, drought, and salinity) factors (Hussain *et al* 2013). Among the abiotic stresses, the higher temperature is a major concern influencing crop growth and development. The global temperature roughly increased by 1.5 °C with the same accelerating trend in all regions from the 1970s, as reported by the intergovernmental panel of climatic change and was predicted to increase 2.5–5.8 °C until the 2100s (IPCC Climate Change, 2014). The global average temperature annually increased by 0.04–0.07 °C and 0.15–0.17 °C per decade since the 1880s and 1970s, respectively according to the National Oceanic and Atmospheric Administration (NOAA, 2018). Therefore, global warming characterized by an extreme temperature possesses the challenge to improve the yield potential of crops. High temperature influences the wheat productivity in tropical, subtropical, arid and semi-arid regions of the world.

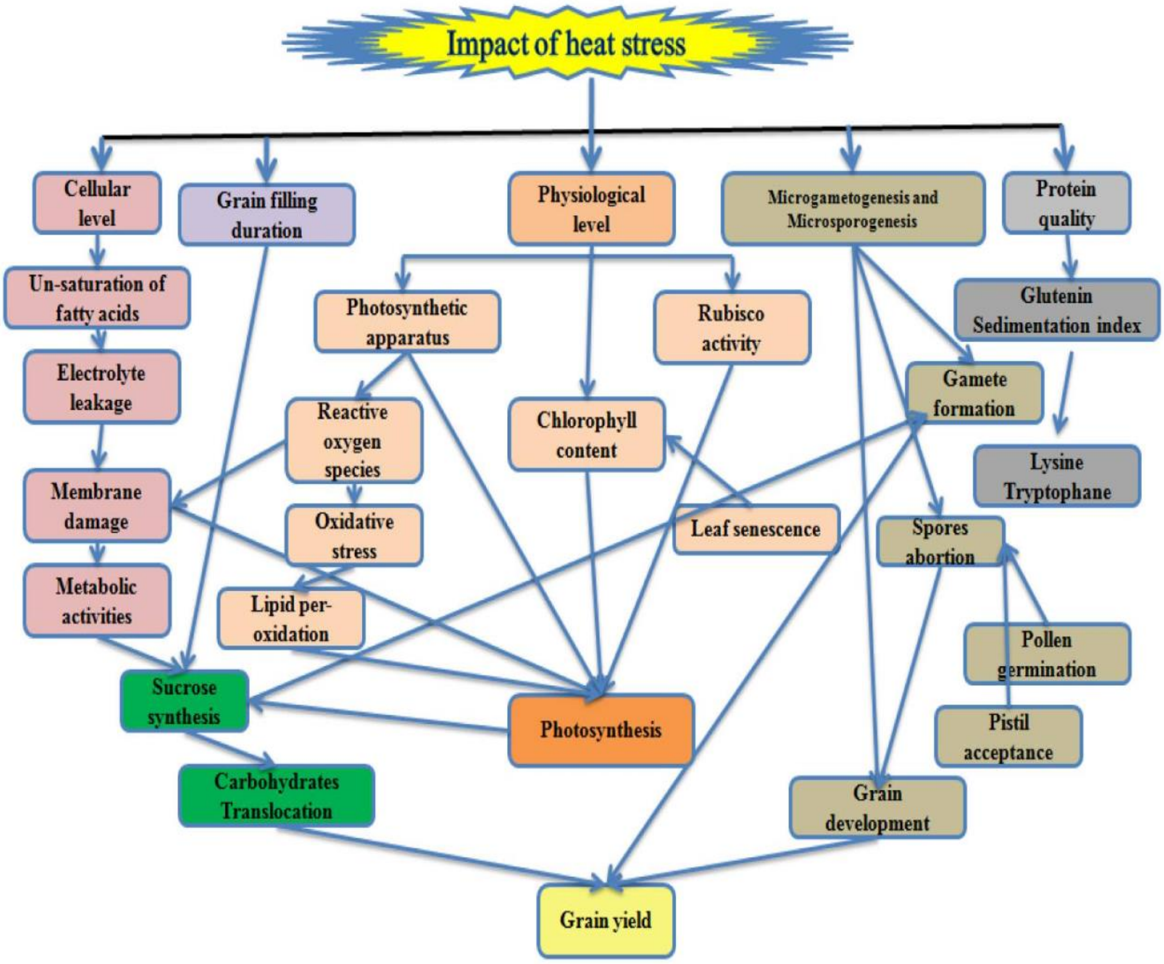
The optimum temperature for wheat growth and development:

The high temperature in the tropical region is an inevitable constraint for wheat during germination and early growth stages, whereas in the Mediterranean region, the reproductive stage is highly sensitive. A high temperature of 3–4 °C above the optimum temperature at grain filling reduces 10–50% of the wheat yield in Asia with the current production technology and varieties. Each degree increase in the temperature at the grain filling duration reduces 6% of wheat yield globally (Asseng *et al* 2015) and 3–17% in South Asia including India and Pakistan (Lobell *et al* 2008).

Impact and Tolerance strategies of high temperature:

1. Effect on wheat morphology: In various crops, including wheat, HS negatively influence the seed germination and plant establishment. High temperature (45°C) has negative impact on embryonic cells, followed by improper germination and emergence which leads to poor crop stand. High temperature affects the survivability of the productive tiller, which result in decrease in yield. HS in wheat result in decrease grain yield and tiller number. Heat Stress causes decrease in root growth which ultimately affects the crop production. The effect of Heat stress is highly significant during reproductive phase.

2. Effect on wheat physiology: Photosynthesis is most important physiological process in plant which is highly influenced by high temperature. Stroma and thylakoid lamellae are most sensitive to heat stress in wheat. High temperature (~ 40°C) results in permanent alternation of RuBisCO, Rubisco Activase and Photosystem II. Upon exposure of wheat in Heat Stress condition, the RuBisCO enzyme was found to be deactivated. Rubisco activase breakdown under heat stress cause decrease in photosynthetic capacity.



(Source: khan *et al* 2021)

Crop Management practices:

Agronomic practices including seed priming, organic mulches, inorganic fertilizers, and timely sowing with recommended management practices mitigate the heat stress in wheat. Wheat seed priming in the aerated solution of $CaCl_2$ (1.2%) for 12 h improves the germination, growth, leaf area index, chlorophyll content, assimilation rate, and grain yield (Pask *et al* 2014, Wajid *et al* 2018). Mulching with rice husk conserves water, improves water use efficiency, maintains the water status in soil, and slows down the release of nitrogen for plant uptake (Rummana *et al* 2018 Humphreys *et al* 2016).

(a) (b)

Fig.1: Impact of heat stress (forced maturity) in wheat crop

The application of inorganic fertilizers viz., nitrogen, and potassium maintain the chlorophyll content, osmoregulation, cytokinin biosynthesis, protein stability, redox homeostasis, and photosynthesis at high temperature. Zinc improves the superoxide dismutase activity, membrane integrity, chlorophyll content, chlorophyll florescence, and kernel growth at high temperature. The silicon application at 10 mg/kg of soil at heading improves the osmotic potential (26%), photosynthetic rate (21%), catalase activity (38%), superoxide dismutase activity (35%), stomatal conductance (20%), and transpiration rate (32%) in wheat under high temperature (Fahad *et al*, 2017) .

The photosynthetic product is necessary to be translocated to different plant parts for its growth and development. The rate of assimilate translocation from source to sink is reduced under high temperature stress caused by decrease in membrane stability.

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