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Editorial

# Climate Induced Heat Stress: A Big Constraint of Wheat Production in the Subtropics

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Wheat is the top most cereal crop in the world which is facing heat stress due to climatic changes. Raising temperature and imitating climate change negatively affect the growth and development of wheat plant which results fatal loss of productivity. The concentration of $CO_2$ and temperature are increasing day by day beyond the optimum level and winter duration suitable for wheat production is declining. Different estimates of meterologists show that the global temperature will increase by 2.5ºC to 4.5ºC by 21$^{st}$ century due to rising concentration of green house gases. If we want to make wheat adapted to this changing climatic condition we must know how climate change is affecting the production of wheat and how interaction is happening between changing climate and wheat production. New researches have assessed the effect of global temperature increase on the production of wheat. The global population will increase upto 12 billion by the year of 2050 (FAO). On the other hand, according to FAO (Food and Agriculture Organization) demand for wheat will be increased by 60% on the next few decades. But increasing temperature due to climate change is creating a barrier to global wheat production.

Heat stress is one of the major abiotic stresses providing as a constraint to the production of wheat. Wheat production is mainly affected in the sub tropical region due to an increasing rate of temperature. Heat stress breaks the total morphological, physiological, biochemical and genetic systems of wheat plant causing an ultimate reduction of grain yield. Main effect of heat stress has been found mostly at the reproductive stage of wheat as it is the most vulnerable stage to heat stress. Temperature above 32ºC during anthesis period may causes pollen sterility. As a result the yield of wheat reduces which causes a mass reduction in total production.

Food safety and nutritional security will be exacerbated by climate induced high temperatures, droughts and reduced water availability in most agricultural crops environments, particularly in developing countries of the world. Growth and development of plant take up numerous biochemical reactions that are responsive to temperature. Heat stress alone or in permutation with drought is a widespread limitation during flowering and grain filling stages in many cereals of tropics and subtropics. Heat stress in combination with drought is becoming an increasingly severe constraint on wheat yield and quality in many regions of the world. It is one of the major abiotic stresses affecting the growth and yield related characters of wheat. In the year of 2017-18 the total wheat production all over the world was 763.19 million metric tones according to USDA (United States Department of Agriculture). But the total production of wheat in the year of 2018-19 is 732.87 million metric tones which mean a reduction in production by 30.32 million metric tones. This is happening only because of the changing climate and shortening the winter duration as well as terminal temperature stress. China is at the first ranking wheat producing country followed by India, Russia and the United States (according to FAOSTAT). However, in China, wheat production is likely to be negatively affected by increasing global temperature. Here temperature is the only one critical variable that affects wheat production. Wheat production of Russia was forecasted at 72.0 million metric tones for the year 2018-19 whereas the record of the year 2017-18 was 85.0 million metric tones based on USDA report. From many publications it has been found that each 1ºC temperature increase will cause around 10% reduction of world wheat production.

It is one of the major abiotic stresses affecting the growth and yield related characters of wheat. Heat stress can cause significant decrease in floral buds and flowers abortion and affects grain yield. The most sensitive phenological stages of wheat plants to heat stresses are pollination and fertilization. Climate induced heat stress causes damage to protein synthesis process and oxidative damage to membranes of wheat plant. Such damages limit the growth of wheat plant resulting poor grain quality and reduced yield. Heat stress during grain filling period is a major climatic constraint causing reduction in grain yield of wheat. It has found in many researches that the catalytic activity of Rubisco enzyme increases with increasing temperature and it's ability to bind with oxygen inspite of binding with CO2 reduces the net photosynthetic rate. Photosynthetic rate of wheat plant usually declines above 30ºC temperature. The economic yield greatly reduces due to reduction in source and sink activity of wheat plant under climate induced heat stress. Grain weight which is considered as one of the major yield contributors and grain number per spike have found to be reduced due to the exposure of floral initiation and spikelet development stage to heat stress thus adversely affecting maximum yield potential of wheat. Seed germination, seedling growth, cell turgidity and water use efficiency of wheat plant significantly reduces by heat stress. Heat stress disturbs the cellular functions by producing ROS (Reactive Oxygen Species) which leads to oxydative stress. Leaf senescence, photosynthetic enzymes deactivation, reduction in photoassimilate translocation and grain filling duration are also the results of climate induced heat stress which in turn reduces the total productivity of wheat. Greater heat tolerance is observed where less damage occurs in a plant process due to high tissue temperature. Development of thermo-tolerant wheat varieties is imperative towards the improvement of wheat yield.

Climate is not in human control. But it can be adopted different management techniques and effective approaches toward mitigating the effect of climate induced heat stress to make sustainable wheat production. Screening of available germplasms of wheat along with different advanced technologies like genomics study, marker assisted selection, mapping quantitative trait loci etc can be applied to develop wheat varieties against climate induced heat stress in order to retaining sustainable wheat production throughout the world. However, a proper knowledge of heat stress tolerance features and molecular characterization is needed for applying various techniques successfully. The ultimate success in heat stress management depends on the combined efforts of plant breeders, molecular biologist and plant physiologist. Currently various strategies have been adapted to develop thermo-tolerance in wheat varieties. The morphological, physiological, biochemical and molecular mechanisms of heat tolerance in wheat can be studied based on different parameters such as canopy temperature depression, leaf senescence, grain filling duration, grain yield, photosynthesis, chlorophyll content, membrane thermo stability, translocation of photo-assimilates, starch synthesis, antioxidant response, protein synthesis and omics approaches. Microarray technology has recently become a powerful tool for the systematic analysis of expression of large numbers of genes induced or repressed by heat treatment.

Climate induced threats can be tackled by (i) adoption of climate alleviation tools in agricultural activities; (ii) bringing back native minor food crops such as millets, oats, barley, pulse and root crops; (iii) development of heat and drought tolerant cultivars; and (iv) increase investment in agricultural research; (v) positive government policy. Indigenous crops have inherent potential and traits to cope with adverse climatic conditions. Hence, diversifying the crops should be a prime framework of the climate-smart agriculture to meet the global food safety and nutritional security. Therefore, the adverse effects of climate change on agricultural production need to be attended by multidisciplinary approaches through strong research collaboration and public-private partnership.

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