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A Review on Strong Impacts of Thermal Stress on Plants Physiology, Agricultural Yield; and Timely Adaptation in Plants to Heat Stress

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A REVIEW ON STRONG IMPACTS OF THERMAL STRESS ON PLANTS PHYSIOLOGY, AGRICULTURAL YIELD; AND TIMELY ADAPTATION IN PLANTS TO HEAT STRESS

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ABSTRACT

In this review, we checked the harsh influence of high temperature or heat stress on plant metabolism and crop yield. Plants can bear a minimum range of temperature; temperature more than this optimum range comes in the term of heat stress. Climate changes increase the number and severity of heat waves that reduced the development of plants and resulted in the death of the entire plant. Heat stress is a major stressful environment that destroys plant growth, biochemical reactions, and the yield of crops across the world. High-temperature influences many physiological and chemical reactions in plants. HS is now a big deal for crop production and the essential goal of agriculture is to maintain a high yield of crops. A plant lives in the conditions of high temperature based on its capacity to receive the HT stimulus, generate and change the signal, and then initiate physiological and biochemical changes. The plants show physiological and biochemical responses to heat the stress, is an active area of research. To deal with HT, different molecular techniques are in progress. After thoroughly reviewed of the different discoveries on plants' responses, adaptation, and forbearance to HT at the cellular, organelles, and entire plant levels, this article described several approaches that could be taken to increase thermo- forbearance in plants.

Keywords: Abiotic stress; heat stress; heat shock proteins; oxidative stress; stress signaling.

INTRODUCTION

Our world is facing numerous changes with time, but out of all these changes, the sudden variations in the atmospheric temperature are the most detrimental. It is investigated that the temperature of our universe is increasing at the rate of 0.2 % after every hundred years. If the situation remains the same, then life on earth will be endangered by the 2100 (IPCC, 2007). This continually increasing temperature stress is very harmful to all the forms of life including plants, animals, and other living substances. Plants are more particularly affected by the increasing temperature. After all, they cannot migrate to suitable areas because they are motionless. Heat stress, to some extent, is bearable for the plants because they show a response to each kind of stress including heat stress by regulating many physical and biological processes. They transmit signals to the entire body for modifications in the metabolic pathways. Heat stress has one of the fatal consequences which are the production of a large amount of ROS, also called reactive oxygen species. ROS causes several oxidative abiotic stresses (Hasanuzzaman et al., 2012).

Stress is commonly outlined because the increase in temperature on the far side of threshold levels for an excessive amount of time can cause irreversible distress to plant growth and development. Generally, a brief elevation in temperature, sometimes 10-15^{o}C on the top of close, is taken into account heat stress. Temperature more than the margin affects the crop growth, and development and extremely affects the yield, and also coldness affects the speed of seed germination. Almost it happens in a particular climate zone depending on the chance and amount of temperature. According to some researchers, it is believed that all the time temperatures don't have an equal impact on the plant growth and development independently, which means the diurnal temperature may be a higher predictor of plant response to very high temperatures, (Gunthardt Goerg, 2005). Plants show a response to HT by producing an excessive amount of solutes and minerals, the advantage of this adaptation is that the cell maintains its turgidity, and cellular damage is prevented (Valliyodan et al., 2016). Direct injuries embody Protein impairment, coagulation, and enhanced Degree Celsius. This rise in temperature has caught the attention of researchers, government people, and scientists because that temperature is influencing either direct or indirect way world population. In such devastating situations, the world's food resources must increase more than 75 % to meet the demand of the increasing population. By 2055, there will be trillion people to be fed (Stratonovitch and Semenov, 2015). HS decreases the crop's productivity. Lets we take the example of wheat and suppose that each 2-degree increase in warmth pressure, the world production. (*Triticum Aestivum*) will decrease to more than 12 %. However, Hs harm crop production. Increased temperature has other beneficial effects on productivity in older regions (Challinor et al.2014). As plants are non-motile, they are more commonly impacted by HS (Lobell and field 2007: Hatfield and prueger 2015). HS very greatly influenced the plant activity, including germination of seeds, growth and development, photosynthesis and reproduction that lessens the yield and development of plants. For obtaining good yields under stressful conditions, particular management of field choices can be implemented. The environment for the growth of crops and agricultural practices in the past 10,000 years is rapidly changing, just because of human-induced practices in the field (IPCC, 2007b). If mitigation measures are not taken to lessen the carbon frequency of the world economy and the gradual greenhouse gas emission, then world's temperature is expected to increase continuously.

Effect of HS on Growth

Various environmental stresses stop plants development, and it elaborates that high temperature is surely a major concern. Synchronal agriculture comes in front of big environmental stress all over the world. Due to the high increase in population rate and forceful alterations within the climate, the whole world's food resources are in danger (Lesk et al., 2016). Different morphological, chemical, and metabolic changes due to high temperatures affect the growth and maturation of plants (Wahid et al., 2007). Nowadays, heat stress caused by an increase in atmospheric temperature is an important ecological barrier for the production of crops worldwide. This severe condition causes alternations in cultivation periods, which can alter the dispersal of agricultural yields (Porter, 2005). The high environmental temperature could affect the structure and function of proteins and associated enzymes. It may harshly impact the yield at the cellular level (Smertenko et al., 1997). All these conditions support aerobic destruction, which become a critical limiting factor for plant production.

Through all aspects, this short-time experience to heat stress throughout the seed germination may end up in hastened filling of seeds and can eventually lead to devaluation within productivity. At this point, we have tendency to check out the essential comebacks of plants to aridity and warmth pressure besides the government choices which might be

accommodated to reduce the deleterious effects of those abiotic pressures. Poor development, plant emanation, irregular seedlings, bad phonogram intensity and reduced complex body parts are basic effects resulted from high temperature in numerous trichophytes. Through the induction of abcisic acid, plant can support germination even under high environmental temperature (Lesk et al., 2016). The productivity of wheat was extremely restricted that cause necrobiosis because of extremely high temperature. Plant length, range of cultivation and total biomass were lowered in rice vascular plant because of high temperature (Hall, 2001). The size of cell and its rate of expansion is also reduced because the high temperature stress decreases the water content of the cell. High temperature could alter the whole phonologic period by lowering the existence. Slightly increase in temperature up to 1 or 2 degree more than the than optimum level leads to a decrease in the filling time of grains and have negative impact on yield of cereal. Because of accumulation of proteins, plant shows necrobiosis in particular cells or tissues that occur in just a few minutes or seconds, at terribly high temperature. Instead ordinary heat stress for enlarged amount cause moderately death; each sorts of destruction will cause peeling of leaves, dropping of flowers and fruits, or may be the destruction of whole plant.

Impact of HS on Yield:

High temperature has negative impact on all crops and plants. It influences each and every aspect of the metabolism of plants. But the impact of HS that is more harmful is on the crop yield. Our world population is booming day by day, in order to feed such a huge population; we have to expand our food resources. But unfortunately, whole world is facing global warming problem that in some respect has its impact on the world crop yield. AS a result, we are losing our food resources. HS and drought cause maximum reduction in the number and yield of crops. However, the damage done by the HT depends on the stage of growth of crops, its time period and most important on the severity of the HS. It is a well-known fact that the reproductive stage is most widely vulnerable to the damage done by heat stress. Wheat is a crop of temperate region. So, the impact of HS is harsher on Wheat. High temperature of both the air and soil reduces not only the growth of shoots but also the growth of roots. For the spoiling of crops soil temperature is responsible more than the air temperature. The yield of crops, no doubt, depends on the successful growth of the flower, germination of seeds, and other such factors. Pollination is the process involved in fertilization of plants. Due to heat stress, it is also influenced. The severity of the heat stress can be detected from such fact that a plant susceptible to HS losses its grain size to about 50% as compared to the unaffected plant (Bheemanahalli et al, 2020). It is carefully declared by the researchers and the farmers that a single hot day having temperature more than the optimal temperature for the crop production can lead to a prominent reduction in the production of grain size. Several plants growth phases like flowering, seed germination, grain filling and abscission of leaves are also affected by HS.

There is no doubt that two major types of stresses result in low crop yield,

1) Heat stress
2) Drought.

Whenever any one of the above-mentioned stress occurs, then the crop yield will reduce to a minimum (Fahad et al., 2017). The problem of heat stress is a major hindrance in the yield of crops in tropical countries. But it is not a big deal in temperate countries, because in these countries due to cold weather conditions, heat stress is a plus point for the crops.

Molecular, Cellular, and Physiological Impact of Thermal Stress in Plants

I am convinced in the natural surroundings of plants, there are a lot of stresses in the form of heat, low availability of moisture, and dormancy of seed pressure. No doubt, in some situations, the HS becomes extra stress of water shortage and high amount of salt pressure, it is very essential to search out the freelance act and organic values of the higher degree of temperature on boost the implications of combined abiotic stress. Heat sensitivity, the plant's temperature differs with the phase of growth of the plant thermal stress to some level affects all somatic and fruitful phases.

"Varied physiological lesions square measures discovered at higher temperatures, like foliage and stalk burns, leaf aging and falling, hang-up of the shoot and root development or ovary hurt, that lands up in so a decline in plant efficiency", (Vollenweider and Goerg, 2005). In numerous situations, the look of plant changes and relatively the hypocotyls and petioles extend similar to the morphological reply of gloom dodging. When exposed to the HS, every mechanism of the plant's body shows a response at the cellular level. The network of the cellular system is completely changed." Likewise bodily structure and work of different cellular membranes are also badly damaged ", (Weis and berry, 1988).

The world population is increasing. So, the rate of fuel consumption is also increasing. The harmful gases emitted from the fuel burning are increasing the warmth pressure in the atmosphere. "During the last 250 years, greenhouse gas and paraffin absorption among the atmosphere unit of measurement enhance by 30 minutes and 100 and fiftieth" (Friedlingstein et al., 2010).

The increase in inefficient house gases is the most important logic for heating of the world climate. Throughout now, heat stress has become the main important issue that decreases the production of crops and food security all around the world." The rise of temperature affects the growth of local crop production." (Lobell et al., 2011; Abdelrahman et al., 2017)

This high-level increase in the world temperature is a major concern for the scientists because life on earth is badly affected directly and indirectly only because of temperature. "Despite the fact, world food security has to be compelled to magnify by quite seventieth to satisfy the wants of ever-growing community that will increase to nine billion humans by the year 2050", (Aaronovitch and Semenov 2015). Heat Stroke or heat stress extremely affects and decreases the yield of agriculture. "For example: suppose that heat stress or heat stroke decrease production of wheat, international potency by quite half dozen June 1944 for every degree rises the heat" (Asseng et al., 2015).

"Surely, there is a negative impact of HS on overall crop production, but the increased temperature in cooled regions has fruitful effects on productivity", (Challinor et al., 2017). Plants are immobile organisms, they cannot move in favorable places or conditions, so the functions of plants are heavily hindered by HT. Heat stress considerably affects the activities of plants badly during seed germination, growth, development, activity, leading to serious impacts on plant growth.

Plant Responses to Heat Stress

The amount of water available to the plants is very important for their response to heat stress. Heat stress results in water loss from the stomata because plants try to cool themselves by transpiration, so plants face the problem of dehydration. Due to the low availability of water, the photosynthetic activity of the plants is also reduced. So, in such condition's plants respond to heat stress by carrying out some physical, chemical, and physiological changes. "During the exposure of plants to high-temperature stress, plants regulate the expression of heat-absorbing proteins called 'Heat shock proteins 'and they also

control all the factors involved in the synthesis of these proteins called 'Heat shock transcription factors," (Zhao et al., 2016). HSFs play a very important role because it shows a response to several heat stresses or other abiotic stresses by producing and then regulating the Hsps. In the subsequent response to heat stress in plants, near about 5 % of the plant's enzyme named transcriptome enhances up to more than twofold with the help of Hsps (Saidi et al., 2011). The oxidative stress response also results because of the production of ROSc when there is a problem of heat stress (Potters et al., 2007). The membrane lipids and pigments peroxidation decrease the permeability of the membrane, which is the symbol of damage done at the cellular level when species of activated oxygen are generated under heat stress (Xu et al., 2006). This damage done by the HS can be inhibited by regulating the heat shock protein's response in plants. Proteotoxic pressure can also be lessened by the metabolic pathway of heat shock proteins, if the proteotoxic stress is not normalized then it destroys the entire cellular response of the plant's body.

CONCLUSION

Because of its effects on growth, biochemical reactions, and crop yield, Heat stress has become a major problem for the production of crops across the entire world. The negative or the positive impact of heat stress depends on the chances of an event occurring and the period during which this stress lasts. The world's surrounding temperature is increased because of the release of greenhouse gases which results in heat stress and warming of the universe. For important agricultural plants, there is a need to understand the adaptations and processes being adopted by plants to overcome this problem of HS. The plants' responses to HT have been studied deeply but still, there is a need to understand the thermo-tolerance mechanism in plants. The clear definition of the role played by the temperature is being complicated by the seasonal and day-to-day change of temperature of the world, just for the reason that the response to various temperatures is determined by different abilities of plants to adapt to different weather schemes. Among the different developmental stages and also across or among different species, plant response to HS varies.

To remain safe from all above-mentioned damages done by HS, plants produce various metabolites such as antioxidant, heat shock proteins, heat stress transcriptional etc. The mechanisms activated in response to heat stress or any other abiotic stress in plants emphasizes on the thorough physiology or molecular study. For the development of stress tolerant plants, there is a need of understanding the signaling pathways and expression of specific genes in response to HT. Different molecular studies that reveal the response and the extent of tolerance in plants will make the way for producing by genetic engineering such verities of plants that are resistant to that stress. It will surely improve the yield of important types of crops that are our main staples for food. If there is proper training of our formers about the timing of sowing of seeds of different crops at the suitable period then the harsh effects of the climate like HS or HT can be prevented. IN this review, we conclude that selection of variants and the proper timing and environmental conditions can be helpful for reducing the damage done by abiotic particularly heat stress.

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