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EFFECT OF HIGH TEMPERATURE ON CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

A popular crop, chickpea offer healthy nourishment to the world rising population. Among pulses, chickpea (Cicer arietinum L.) is first grain legume crop to be domesticated by human commonly known as "Bengal gram or gram". The chickpea changes how it grows in response to climate change. When the harvest season is about to expire, the crop frequently encounters moisture stress (terminal drought). If sowing is delayed, the crop can suffer heat stress during the reproductive period. A significant factor in yield loss in chickpea during the reproductive stage is high temperature. High temperature is one of the most significant abiotic constraints to chickpea growth and yield under a wide range of conditions. Climate change is now widely recognized as an inescapable occurrence and one of the most difficult concerns that mankind will face in the future. According to climate research and present production patterns, existing chickpea growing regions are under threat from rising temperatures. High temperatures have a detrimental effect on photosynthesis, respiration, membrane stability, fertilization, fruit maturity, seed quality, nutrient absorption, protoplasmic movement, material transport, hormone and primary and secondary metabolite levels. Heat tolerance is a complex trait. An effective and simple screening method with well-defined traits for selecting heat-tolerant genotypes in chickpea under field conditions is necessary for practical and economically viable breeding techniques for heat tolerance.

Keywords: *Growth, Heat, Stress and Temperature.*

Introduction

Chickpea (*Cicer arietinum* L.) is the most important pulse crop and mostly grown under rainfed conditions. Chickpea is considered as healthy vegetarian food due to its beneficial nutritional profile. Chickpeas are categorized into two distinct types: the small-seeded desi 'with a brown-coloured seed coat' and the large-seeded 'cream or beige-coloured kabuli'. Chickpea seed has prime significance for human food and animal feed because it contains 17–31% protein and biological activity of protein ranged from 52 to 78%. The global chickpea area is about 14.84 million hectares with production of 15.08 million tonnes with an average yield of 1,016 kg/ha (FAOSTAT, 2020). The most important chickpea growing countries are India, Pakistan, Turkey, Iran, Mexico, Myanmar, Ethiopia, Australia and Canada. In India, chickpea is cultivated on an area of 9.85 million hectares with production of 11.99 million tonnes and productivity of 1217 kg/ha (Anonymous, 2021). Major chickpea producing states in the country are Madhya Pradesh, Rajasthan, Maharastra, Uttar Pradesh, Karnataka, Chattisgarh, Andhra Pradesh, Gujarat and Jharkhand. Chickpea contains vitamins and minerals like as Ca, Mg, Zn, K, Fe and P (Jukanti *et al*., 2012) and is also free from anti-nutritional factors which make it nutritionally more valuable and thereby increasing consumer preference for this legume. Chickpea production is limited by various abiotic stresses (cold, heat, drought, salt, etc.). However, the Mediterranean's winter-sown chickpea suffers cold stress during the vegetative stage. Chickpea has high-temperature stress throughout the reproductive and pod-filling stages in late-sown conditions, which results in significant production losses. Low and high temperatures both have an adverse effect on pollen viability, pollen germination on the stigma, and pollen tube growth, which leads to insufficient pod formation. Using agronomic, phenological, morphological and physiological parameters, high temperature stress has been investigated in a wide range of crops including wheat (Sharma *et al*., 2005) and rice (Weerakoon *et al*., 2008), whereas only limited research has been done in chickpea (Wahid *et al*., 2007). Peas, lentils, chickpeas, and faba beans are examples of cool season pulse crops, which are generally more heat sensitive than warm season pulse crops (cowpea, soybean, groundnut, pigeon pea, and mung bean).

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Chickpeas are mostly grown in arid and semi-arid regions of India. At their terminal phases, particularly during the active pod filling stage, they are subjected to significant temperature stress. Delays in sowing cause the post-anthesis phase to be exposed to high temperatures, drastically reducing the potential yield. At temperatures of 30°C at 50% flowering and >30°C for 3–4 days at 100% blooming, yield loss has been reported (Summerfield *et al*., 1984). Such circumstances, according to Rheenen *et al*. (1997), shorten the period of flowering and pod filling, which causes significant yield losses. The average global temperature will increase by 0.3°C every decade, rising to 1 and 3°C over current levels by 2025 and 2100, respectively (Jones *et al*., 1999). By causing the threshold temperature for the start of the season and crop maturity to reach sooner, rising temperatures may change the geographic distribution and growing season of agricultural crops. It is possible that a catastrophic collapse of cellular organisation causes severe cellular damage and may be cell death to occur at very high temperatures in a short period of time (Schoffl *et al*., 1999).

Effect of High Temperature/ Heat Stress

All aspects of chickpea growth, phenology and development are impacted by excessive heat stress, including biomass, flowering time, pod number, days to maturity, seed weight, grain yield, and a host of physiological and developmental processes in plants (Devasirvatham *et al*., 2013 and Kaushal *et al*., 2013). The effects of heat stress on chickpea plants at various phases of growth and development are detailed here.

Effect of high temperature on germination, pollen viability and vegetative growth of chickpea

As a result of high temperature, chickpea seeds do not germinate beyond 45°C (Singh and Dhaliwal, 1972 and Ibrahim, 2011), seedling development is impaired (Kaushal *et al*., 2013) and seedlings can potentially die as a result of high temperatures (Singh and Dhaliwal, 1972). (Kaushal *et al*., 2011). Under heat stress condition, genotypes had low pollen viability percentage than normal sown chickpea (Kumar *et al*. 2017). Studies conducted in a controlled setting found that growing at 35/25°C significantly increased biomass in both tolerant and sensitive genotypes, but growing at 40/30°C significantly decreased biomass at maturity in all genotypes, more so in the sensitive genotypes (Kumar *et al*., 2013).

Effect of high temperature on reproductive growth of chickpea

All phenological stage of chickpeas are affected by heat stress, however the reproductive stage is thought to be more sensitive to temperature extremes than the vegetative stage (Sita *et al*., 2017). Broadly speaking, heat stress during reproduction reduced flower number, increased flower abortion, altered anther loculem number, pollen sterility with poor pollen germination, decreased stigma receptivity, decreased fertilisation, decreased stigma remobilization, decreased ovary abnormalities, decreased seed number, weight, and yield are all effects of reduced flower number (Devasirvatham *et al*., 2013 and Kaushal *et al.,* 2013). By causing physiological anomalies, pre-anthesis exposure of chickpea to heat stress (35/20°C) decreased anther growth, pollen output, and fertility (Devasirvatham *et al*., 2013).

High-temperature stress post-anthesis has been linked to poor pollen germination, pollen tube development and fertilization, and the loss of stigma receptivity, which lowers seed quantity, seed weight, and seed output (Kaushal *et al.,* 2013 and Kumar *et al*., 2013) (Summerfield *et al*., 1984; Wang *et al*., 2006). Chickpea stigma function and pollen fertility suffer at temperatures over 45 °C (Devasirvatham *et al*., 2015). Heat stress increased oxidative stress and decreased leaf photosynthesis, which decreased the amount of soluble carbohydrates and ATP in the pistil and prevented nutrients from being transported from the style to the pollen tube, inhibiting the growth of the pollen tube and the development of the ovary (Kumar *et al*., 2013).

Effect of high temperature on physiology of chickpea

Heat sensitivity can be determined by a number of essential physiological characteristics, such as chlorophyll content, photosynthetic rate, and the integrity of the leaf tissue membrane (Hasanuzzaman *et al*., 2013). Compared to other legumes, chickpea is substantially more susceptible to high temperatures (50°C for 48 hours) in terms of membrane stability and photosystem II performance (Srinivasan *et al*., 1996). By injuring the chloroplasts and causing heat stress (35/16°C for 10 days), Wang *et al*. (2006) found that chickpea leaves begin to senesce. Chlorosis resulted from heat stress (>32/20°C during reproductive stage), which decreased the chlorophyll content in chickpea leaves; this loss may have been brought on by photooxidative stress or suppression of chlorophyll production (Guo *et al.,* 2006). In a heat-sensitive chickpea genotype, heat stress (above 32/20°C during reproductive stage) resulted in more leaf damage than in a heat-tolerant genotype, likely as a result of a greater reduction in leaf water status (as RLWC), a potential decline in stomatal conductance, and a restriction in root hydraulic conductivity (Kaushal *et al*., 2013). With rising temperatures, chickpea transpiration efficiency dropped (Singh *et al.,* 1972). Chickpea's quantum yieldor photosystem II (PSI) activity was unaffected at 35°C, but at 46°C (during pod filling), there was a notable decline that resulted in irreparable harm to photosynthetic systems (Basu *et al*., 2009). In a similar vein, Srinivasan et al. (1996) found substantial PS damage in chickpea after 48 hours at 50°C. When temperatures exceeded 35°C during the reproductive stage, photosynthesis, electron flow, and metabolic pathways were reduced, which resulted in smaller grains (Kaushal *et al.,* 2013; Awasthi *et al*., 2014 and Redden *et al.,* 2014).

Conclusion and future perspective

Current global climate change trends have resulted in recurrent periods of frequent high temperature, presenting a threat to plant development and productivity in a variety of crops, including chickpea. Because of their indeterminate growth habit, chickpea plants will continue to blossom and develop pods if the temperature stays favorable, and this time may be extended by introducing cold tolerance into chickpea. Chickpea, on the other hand, is predicted to endure higher terminal temperatures in warmer climes, particularly in spring-sown locations, therefore high temperature resistant chickpea must be created for these places to ensure continued productivity under global warming. Drought tolerance should be included in both cold and heat tolerant cultivars so that dual tolerance chickpeas have additional protection against drought damage in addition to cold or heat stress. The physiological processes of heat, as well as drought and cold, are not entirely known. Furthermore, heat-tolerant genotypes must be tested to see if they set pods under cold stress by submitting them to LT in a controlled setting and assessing their reproductive function and pod set. In various chickpea producing locales, terminal drought generally corresponds with terminal heat stress, hence the creation of heat and drought resistant chickpea cultivars is sought. The incorporation of multiple landraces and a crop gene pool containing "adaptive characteristics" might improve the robustness of chickpea genotypes in harsh climates. Future research should focus on producing designer chickpea cultivars that can withstand stress situation, such as heat, in order to increase heat stress tolerance while maintaining good agronomic performance. The use of genomics/transcriptomics/resequencing in combination with reference genome sequences in chickpea is expected to improve our understanding of heat stress tolerance, which will aid in the development of single- or multiple stress tolerant high-yielding chickpea cultivars suited to specific climatic niches in the near future.

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