



High Temperature Significance of Anthocyanins Accumulation Stress Responses in Chickpea (*Cicer arietinum* L.)

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Abstract – A field experiment was carried to evaluate the chickpea genotypes for high temperature tolerance. High temperature stress was imposed by delaying sowing dates *i.e.* normal and late sowing date. Under late sown conditions, high temperature was experienced by crop starting from flowering stage to maturity. A significant variability was recorded in growth and yield. The late sown high temperature stress condition significantly reduced the crop yield parameters. The plants grown under high temperature conditions were observed for various morphological changes such as stunted growth, chlorosis, leaf tip burning, accumulation of anthocyanins and forced maturity. Under late sown conditions in genotype ICCV 92944 anthocyanins accumulation was observed in the basal part of the stem, branches and leaves while under normal sown conditions no such accumulation occurred, whereas in HC 5 there was no pigment accumulation was observed even under stress and normal conditions. The accumulation of anthocyanin has a positive relation with high yield in ICCV 92944. Under such conditions, accumulation of these pigments may be the reason in response to high temperature tolerance leads to the induction of antioxidant defense system.

Keywords – Anthocyanin, Antioxidant Defense, High Temperature Stress, Tolerance, Yield.

I. INTRODUCTION

High temperature stress is becoming the major concern for plant scientists worldwide due to the changing climate. Atmospheric temperature is expected to increase in future due to potential climatic changes. By the end of the 21st Century, the earth's climate is predicted to warm by an average of 2-4°C [1], due to both anthropogenic and natural factors [2]. The seriousness of high temperature stress depends on its timing, duration and intensity on crops. Chickpea (*Cicer arietinum* L.) is the most important legume crop of the arid and semi-arid zones of India. It's grown as low input crop under conserved soil moisture and generally experiences terminal high temperature stress of various duration and intensity during reproductive phase. Short periods (10 day) of high temperatures ($\geq 35^{\circ}\text{C}$) during early flowering and pod development of chickpea are known to cause significant reduction in pod number, seed set and grain yield [3, 4]. The precise mechanism of reduction in the biomass and grain yield under high temperature stress is still unknown. No information is available regarding the effect of high temperature stress on accumulation of anthocyanin pigment in chickpea, the species known to have for wide range of adaptability under high temperature condition.

Anthocyanins often appear transiently at specific developmental stages and may be induced by a number of environmental factors [4, 5]. The subsequent production and localization of anthocyanins in root, stem and especially leaf tissues may allow the plant to develop resistance to a number of environmental stresses. This article showed that the high temperature causes the induction of anthocyanins and their proposed importance in ameliorating temperature stress.

II. MATERIAL AND METHODS

The present study was carried out to understand the tolerance mechanism based on visual observations of anthocyanin pigment in relation to their yield potential in two chickpea genotypes, namely, ICCV 92944 and HC 5 differing in sensitive to high temperature. The experiment was conducted in the research area of CCS Haryana Agricultural University, Hisar, 125004, Haryana. High temperature stress was given by manipulation of sowing dates *i.e.* normal sown (NS) (11th November, 2011) and late sown (LS) (16th December, 2011) during *rabi* season of the year 2011-12. The observations were recorded as the temperature rises above 35°C at reproductive stage (end of March) and yield data plant⁻¹ recorded at harvest.

III. RESULTS AND DISCUSSION

Leaf light absorption depends on leaf pigment composition which may vary under the influence of environmental factors within a species. The leaf anthocyanin accumulation in non reproductive parts in two chickpea genotypes differed when they were grown at different dates of sowing. Induction of anthocyanins by high temperatures has received less attention than photo induction, even though the evidence for this process is seen in our studies in both two genotypes. It was apparent from these visual observations that the ICCV 92944 genotype was able to minimize heat stress injury to the leaf tissues to a greater extent than the HC 5 genotype. In ICCV 92944, accumulated anthocyanins in the basal part of the stem, branches and leaves was observed (Figure 1C&D) under late sown condition, while no such accumulation occurred in under normal sown condition (Figure 1A&B). In genotype HC 5, there was no anthocyanin pigment accumulated on leaf and stem under both normal and late sown conditions (Figure 2). Generally, high temperature reduces grain yield by reducing the crop cycle. This

indicates that developmental stages of chickpea were reduced due to high temperature. Our findings showed that high temperature decreased seed yield (Table 1) in LS as compared to NS, but percent reduction was lower (21.09) in ICCV 92944 as compared to HC 5 (43.03). Under LS condition maximum seed yield *i.e.* 19.94 g plant⁻¹ was noticed in ICCV 92944 than (12.18 g plant⁻¹) HC 5 (Table 1). What adaptive advantages do leaf tissues containing high levels of anthocyanin have over those tissues with lower levels? More grain yield in ICCV 92944 was due to accumulation of anthocyanin under LS condition that in turn may induce better antioxidant defense mechanism under high temperature (>35°C) [6, 7, 8].

In conclusion, the modulation of leaf anthocyanin content by high temperature as an effective indicator for tolerance mechanism in chickpea and is correlated with the yield potential of respective genotypes. Based on above physiological trait, genotype ICCV 92944 was identified as high temperature tolerant and can be used further for crop improvement programme of Plant Breeding. In future line of work, the quantification of anthocyanin in chickpea genotypes is required to better modulation of the mechanism of high temperature tolerance.

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Table 1. Yield per plant of chickpea under normal sown (NS) and late sown (LS) sown conditions

Genotypes	Yield plant ⁻¹ (g)		
	NS	LS	Mean
ICCV 92944	25.27	19.94 (21.09)*	22.60
HC 5	21.38	12.18 (43.03)	16.80
Mean	23.32	16.10	

Yield plant⁻¹ CD at 5% level was; Genotypes (G) = 0.81, Temperature (T) = 0.81, G × T = 1.14

*Values in parentheses indicate per cent decrease over respective NS.



Fig. 1. A comparison in visual observation of anthocyanin accumulation in chickpea genotype ICCV 92944. No accumulation in leaves (A) and stems (B) under normal sown (NS). But anthocyanin accumulated in leaves (C) and stem (D) under late sown (LS) conditions



Fig. 2. There was no anthocyanin accumulation in chickpea genotype HC 5 under NS and LS conditions.