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Effect of moisture stress on total chlorophyll content of cotton

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Abstract
The present investigation was conducted during *kharif* season of 2018-19 at the experimental field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). There were two different conditions were maintained, one set was grown in field condition (non-stress) in randomized block design and another set of genotype in pot was placed under rainout shelter (water stress condition). The seeds of ten cotton (*Gossypium hirsutum*) genotypes viz., AKH-09-5, AKH-2012-8, AKH-1301, AKH-1302, NH-545, AKH-9916, AKH-8828, PKV Rajat and NH-615 were sown in both conditions in three replications. The study was aimed to determine the influence of water stress on cotton physiology including total chlorophyll content. Under control condition pot culture was maintained with desired quantity of irrigation up to initiation of bolls. Water stress was imposed at initiation of bolls (75 DAS) for 12 days to every genotype and replication wise. Second stress was imposed 12 days after first stress. Genotypes under water stress condition was sown in 90 earthen pots with five holes of 2.5 cm deep. The observation for chlorophyll content was recorded at 90, 60 and 120 DAS. In the conducted experiment some of the *G. hirsutum* genotypes showed highest total chlorophyll content at the initial stage of plant growth and gradually it decreased afterwards during boll development stage in both conditions. Moisture stress adversely affected the content of chlorophyll pigment of genotypes after imposition of water stress which was tested under control condition (stress condition).

Keywords: Cotton, *Gossypium hirsutum*, total chlorophyll content, moisture stress

Introduction
Cotton, a semi-xerophyte, is grown in tropical & sub-tropical conditions. The optimum temperature for vegetative growth is 21-27 ºC and it can tolerate temperature to the extent of 43 ºC. It is estimated that one third of world population has been in area where the water sources are poor. About 95 to 97 percent area is under rainfed cultivation. Most of the times erratic rainfall with uneven distribution occurs. Therefore, cotton crop has to face the water stress at flowering and boll development stage. Chlorophyll is an essential component of plant and plays a key role in growth and development by the process of photosynthesis (Rahdari *et al*., 2012) [11]. Moisture stress produced changes in photosynthetic pigments and components (Anjum *et al.* 2003) [1], damaged photosynthetic apparatus and reduced activities of calvin cycle enzymes, which are important causes of reduced crop yield (Monakhova *et. al*. 2002) [9]. Drought reduces the plant growth by influencing various physiological as well as biochemical functions such as photosynthesis, chlorophyll synthesis, nutrient metabolism, ion uptake and translocation, respiration, and carbohydrates metabolism (Farooq *et al.*, 2009; Li *et al.* 2011) [5, 8]. Stomata closing in response to moisture stress results in a reduction in leaf photosynthetic capacity resulting in chloroplast dehydration and decreased CO_2 diffusion into the leaf (Zhang *et al.* 2017) [12]. A severe water deficit situation can lead to the decrease in chlorophyll content, protein content, and soluble sugar level, have also been reported in plants under drought stress (Bandurska *et al*., 2010; Kazama *et al.*, 2014) [3, 7].

Material and Methodology
The experiment was carried out on the experimental field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola located at 304.415 meter altitude, 20º30’ N latitude and 72º02’ longitude during *Kharif* season of during *Kharif* season of 2018-19. Ten genotypes of *G. hirsutum* AKH-09-5, AKH-2012-8, AKH-1301, AKH-1302, NH-545, AKH-9916, AKH-8828, PKV Rajat and NH-615 were tested.

A] water stress condition
Pot culture with desired quantity irrigation up to initiation of bolls was given. Water stress was imposed at initiation of bolls (75 DAS) for 12 days for every genotype and replication wise.
Second stress was imposed 12 days after first stress. 90 earthen pots of 18×17×10 inch were maintained for water stress condition (3 pots per genotypes per replications). Five holes of 2.5 cm deep around the periphery was made in each pots and two seeds was sown per hill. After germination seedlings was thinned and maintained one plant per hill, thus there was three seedlings per pot was maintained. 120 polybags were sown as separate set for root parameter and dry matter production studies.

B] Non stress condition
Genotype in field condition with three replications at spacing of 60cm×30cm.

Estimation of Chlorophyll Content (mg/g fresh wt.)
Leaf chlorophyll content was estimated at 60, 90 and 120 DAS by following Hiscox and Israelstam (1979). In this method, 100 mg of fresh leaf tissue was weighed and incubated in 7.0 ml dimethyl sulfoxide (DMSO) at 65 °C for 2 hr. At the end of the incubation period, supernatant was decanted and the volume was made up to 10.0 ml with DMSO. The absorbance of the extract was read at 645, 652 and 663 nm in a spectrophotometer using DMSO as blank.
The chlorophyll content was calculated by the equation as given below:

$$\text{Total Chlorophyll (mg/g fresh wt.)} = 20.2 (A645) + 8.02 (A663) \times \frac{v}{1000 \times W}$$

Where,
A = absorbance at specific wavelengths,
v = final volume of chlorophyll extract,
W = fresh weight of sample.

Result and Discussion
Total leaf chlorophyll content as influenced due to water stress and non-water stress condition showed statistically significant differences among different cotton genotypes. At 60 DAS genotype AKH-2012-8 (2.14 mg/g fr.wt.) was significantly noted higher for total chlorophyll content among all genotypes followed by AKH-9916 (2.1 mg/g fr.wt.) and AKH-1301 (1.93 mg/g fr.wt.) under non stress condition. Under stress AKH-8828 (2.4 mg/g fr.wt.) was significantly highest followed by AKH-9916 (2.16 mg/g fr.wt.). During initial stages of crop growth total chlorophyll content was maintained by genotypes of both stress and non-stress conditions rather some genotypes showed better chlorophyll content under control condition. Later on it gradually initiated to decrease in stress condition after the imposition of water stress on pots.
Genotypes of field condition (Non-Stress) had more chlorophyll content when compared with stress condition. At 90 DAS, NH-545 and AKH-9916 (2.26 mg/g fr.wt.) were noted significantly higher total chlorophyll content over mean value followed by AKH-2012-8 (2.23 mg/g fr.wt.). At 120 DAS it was reduced in all genotypes and NH-545(1.96 mg/g fr.wt.) and AKH-9916 (1.9 mg/g fr.wt.) retained highest chlorophyll content at 120 DAS also.
Chlorophyll content of *G. hirsutum* was reduced in pot culture at 90 and 120 DAS (stress imposed at 75 DAS). At 90 DAS, under stress condition all genotypes declined its content of total chlorophyll. Among ten tested genotypes AKH-9916 (2 mg/g fr.wt.) recorded significantly higher chlorophyll content and remained at par with AKH-8828 (1.86 mg/g fr.wt.). Total chlorophyll content determines the photosynthetic capacity of the cotton genotypes and influences the rate of photosynthesis, dry matter production and the yield. Under drought conditions, a decline in chlorophyll pigments have been reported, making plant vulnerable to die (Astorga *et al*, 2010) [2].
At 120 DAS it decreased more due to both imposition of water stress and crop age, it had been continuously reduced up to the harvest of crop. Genotype AKH-9916 (1.76 mg/g fr.wt.) and AKH-1301 (1.54 mg/g fr.wt.) maintained its chlorophyll contained and showed the tolerance towards the water stress. The property of chlorophyll stability was found to be correlated with drought resistance and hence it is criteria for measuring drought tolerance Chetti *et al.* (2002) [4]. Among all 10 genotypes AKH-09-5 (1.01 mg/g fr.wt.) was more affected by moisture stress and had lowest chlorophyll content. Chlorophyll content was significantly decreased in the cotton under water stressed condition compared to well-watered condition but the difference was less and these findings are in agreement with findings of Muhammad *et al.* (2011) [10]. The variation in the chlorophyll content may be due to availability of water whether due to stress or non-stress condition and partly due to varietal performance.

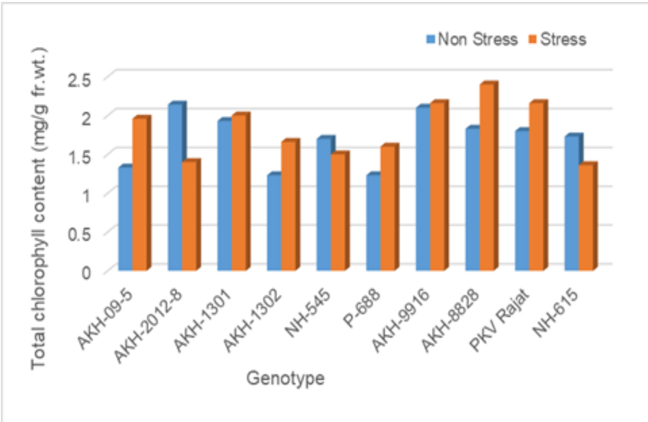

Fig 1: Performance of different cotton genotypes in water stress and non-stress condition in relation to total chlorophyll content (mg/g fr.wt.) 60 DAS

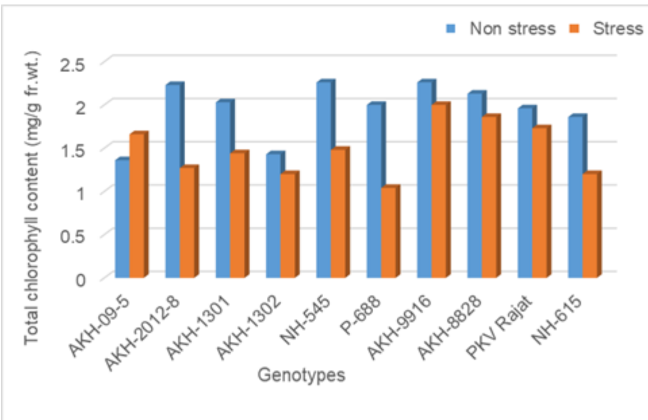

Fig 2: Performance of different cotton genotypes in water stress and non-stress condition in relation to total chlorophyll content (mg/g fr.wt.) 90 DAS

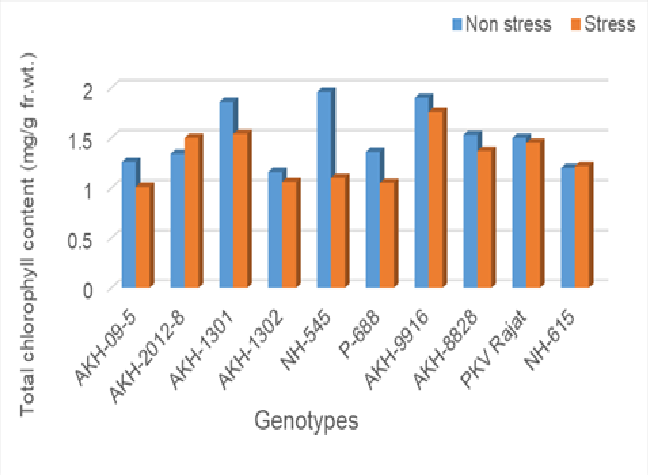

Fig 3: Performance of different cotton genotypes in water stress and non-stress condition in relation to total chlorophyll content (mg/g fr.wt.) 120 DAS

Conclusions

The experiment revealed that total chlorophyll content of tested genotypes for moisture stress was reduced after the imposition of water stress on control condition (pot culture). Set of genotypes tested under field condition had more chlorophyll content than the stressed genotypes. Plant with enough environmental and moisture condition habitually reduced their chlorophyll content during the later stages of growth. But stressed genotypes were started destruction of chlorophyll pigments at vegetative stage of growth. Deficiency of water adversely affected the synthesis of different biomolecules such as chlorophyll pigments of plant which was also recorded for lower seed cotton yield.

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