ADAPTATION OF COTTON TO DIFFERENT WATERING REGIMES

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Abstract

Many physiological functions and morphological properties determining yield of cotton plant may inhibited by different water regimes. The aim of the present study was to investigate morpho-physiological adaptation of cotton plants to different irrigation regimes. For this purpose, a pot experiment was conducted under fully controlled growth chamber. Cotton plants (*Gossypium hirsutum* L.) were exposed three irrigation regimes. Plants were irrigated when water holding capacity reach 20%, 40% and 60% to field capacity in I20, I40 and I60 treatments respectively. Physiological parameters such as transpiration, canopy temperature depression (CTD) and SPAD values and morphological parameters such as adaxial and abaxial stomatal density were determined. Lowest transpiration found in I20 treatments than I40 and I60 treatments. SPAD value remained lower level in I20 treatment whereas higher in I60 treatments during different irrigation regimes. Stomatal density was higher in adaxial surface than abaxial surface of leaves. On the other hand, increasing stoma number per unit leaf area in adaxial surface with lower irrigation frequency was recorded. Our results suggested that cotton plants adapt to different water regimes via regulating transpiring organs and their functions.

Key words: Cotton, water regime, SPAD, CTD, stomatal density, irrigation frequency

Increasing in global food requirement forces enlarge agricultural land all over the world. However, global climate change is still a major limiting factor for the future agriculture production. Among many consequences of climate change, drought is a major detrimental factor for crop production. Novel water management strategies need to be improved for irrigated crops such as cotton in water limited environments. Increased irrigation frequency is one of the common methods to maximize irrigation use efficiency. However, limited irrigation due to increased frequency may lead cotton plants to face with temporary water stress condition.

Cotton is a widely grown industrial crop. It has a critical importance as the main raw material of weaving and clothing industry. Additionally it is widely used for producing oil and animal feed. The production and consumption of cotton is increasing day by day due to rise in human population (Gündüz *et al*, 2003). However, environmental influences like global warming still constraint the plant production in a large part of the world. One of the most significant indicators of the global warming is drought. Thus, drought is still seen as a major challenge for the future of agriculture. The magnitude of drought stress may vary from year to year. Also this effect is strongly correlated with the rainfall regimes and the air temperatures (Soltani *et al*, 2001; Dalil and Golezani, 2012). This study aimed to investigate the adaptation of cotton plants to different irrigation frequencies. In this direction the physiologic and morphologic adaptations of cotton plants were monitored, in case of irrigating the plants with same amount of water in different irrigation frequencies.

MATERIAL AND METHOD

The commercial cotton cultivar named MAY P 06 was used as plant material. The pots used in this study were 10 cm height and 5 cm width and made of incorruptible plastic. The bottom parts of the pots were isolated via a plastic cover to avoid of water leaking. The pots were filled with a mixture consisted of one part sand and three parts peat. Four seeds for each pots were sown into the pots in 12th April 2015. Than healthiest one plant was selected from every pot and other three were removed. Then all pots were fertilized with 15-15-15 compound fertilizer as 10 kg N/da for every pot. The trial was conducted under fully controlled conditions. Growing conditions were 25 C^{o} day-night temperature with 12 hours dark and 12 hours daylight and under 40-50% relative humidity. The trial was conducted in randomized plots design with four replications. Irrigation frequencies were

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used as a single factor and three different irrigation frequencies with the same amount of water were applied to the pots. The soil water content was regulated via gravimetrically. The pots were completed to 60% of WHC via irrigation when they reach fewer than 20%, 40% and 60% of WHC for first (I20), second (I40) and third (I60) irrigation treatments. During the treatment 4 traits were measured as transpiration rate, stoma density on abaxial and adaxial surfaces of the leaves, canopy temperature deficit (CTD) and SPAD value.

Transpiration rates of the pots were recorded daily by gravimetric way. An empty pot (just filled with sand-peat mixture) was placed near the other pots to calculate the evaporation. Since the evapotranspiration occurred in the pots with plant, the transpiration could be easily calculated by removing the evaporation value from the evapotranspiration value.

For stoma density, the 5th leaf of each plant was used. Transparent nail polish was applied to the abaxial (underface) and the adaxial (upper surface) part of the leaves. Than the plaster tape was sticked to the surfaces after the nail polish was dried. Than the stoma prints obtained on the plaster tapes were captured under the microscope and stoma numbers were counted.

Canopy Temperature Depression values were calculated by following formula.

$$CTD= t_c - t_a$$

Where the t_c is the leaf temperature value obtained from the forth leaf of the plants by taking three different measurements via the infrared thermometer, while the t_a is the ambient temperature measured by TINYTAG.

SPAD value of the plants were determined via KONICA Spadmeter. Daily measurements were done at the forth leaves of the cotton plants.

RESULTS AND DISCUSSIONS

The transpiration rates of three different irrigation frequency applications can be seen at *figure 1*. The cotton plants in I60 irrigation treatment had 15 g/day average transpiration rate and the daily transpiration rates varied from 8 to 15 g (*figure 1*). The average transpiration rates were observed as 13g and 7g for I40 and I20 treatments respectively. Additionally daily transpirations varied from 3 to 21 g for I40 treatment, while it varied from 0 to 24 for I20 treatment (*figure 1*). The transpiration amount of three treatments continued close to each other at the beginning of the experiment. But the transpiration almost stopped in I20 treatment. However, the transpiration rate climbed to normal level after the irrigation applied 10th day (*figure 1*). Highest transpiration was observed for I60 treatment, while lowest transpiration values obtained from I20 treatment. This indicates that, the transpiration rates increase as the irrigation frequency increases.

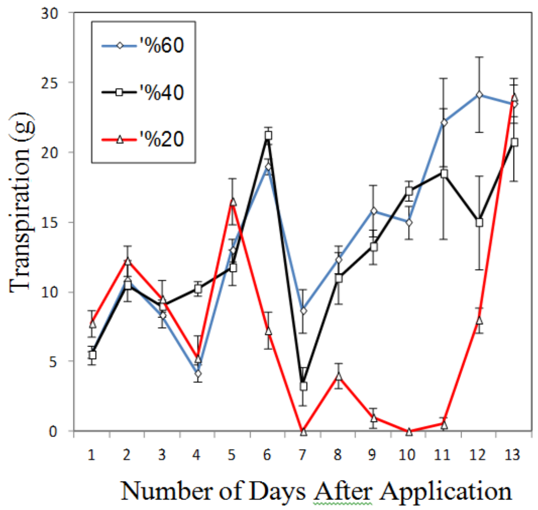

Figure 1 **The effects of three different irrigation frequencies to transpiration rates of cotton plants**

The SPAD values are shown in *figure 2*. *figure 2* shows that, all three treatments have the SPAD values from 32 to 40. The average SPAD values for I60, I40 and I20 treatments were 35.8, 36.8 and 37.0 respectively. The most frequently irrigated plant group (I60 treatment) always had lower SPAD values than those of the other groups. I20 treatment showed highest SPAD values until 10th day, however this increase was stopped after this day. Increase in leaf surface area and decrease in chlorophyll density could be the cause of this situation. Hence, it can be said that the greenness of the leaves decreases as the irrigation frequency increases. Çekiç (2007) reported that it was possible to observe an increase in chlorophyll density due to decreasing in leaf surface area under drought conditions.

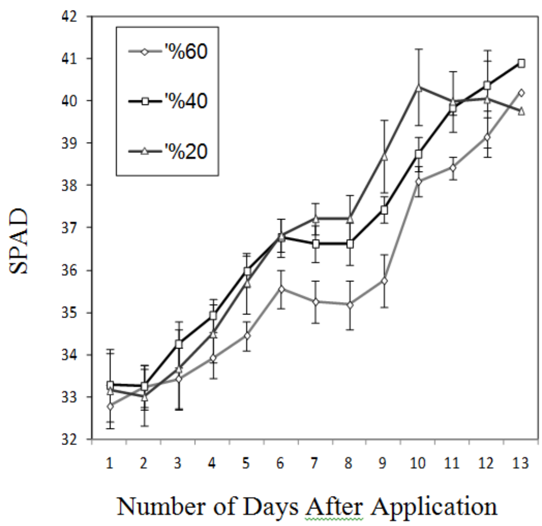

Figure 2 **The effects of three different irrigation frequencies to chlorophyll contents (SPAD) of cotton plants**

CTD is accepted as one of the most important drought indicator for the plants (Dejonge *et al*., 2015). When the CTD values were examined, it was shown that the CTD values of three treatment varied from 4.2 to 8.2 and maximum average CTD was obtained as 5.6 from I60 treatment, while minimum value was measured as 4.6 from I20 treatment (*figure 3*). In I40 treatment average CTD value was recorded as 5.0 (Figure 3). It can be interpreted as the CTD values proportional to the transpiration rates. Three treatments had shown almost same CTD values in the first 5 days of the application. However significant decline was observed in I20 treatment since the sixth day of the trial. The I20 treatment exhibiting the lowest transpiration rate had also the lowest CTD values. Belko *et al*. (2012), reported higher transpiration values in higher transpiring plants. But the CTD values of this treatment increased after 10th day of the trial (*figure 3*).

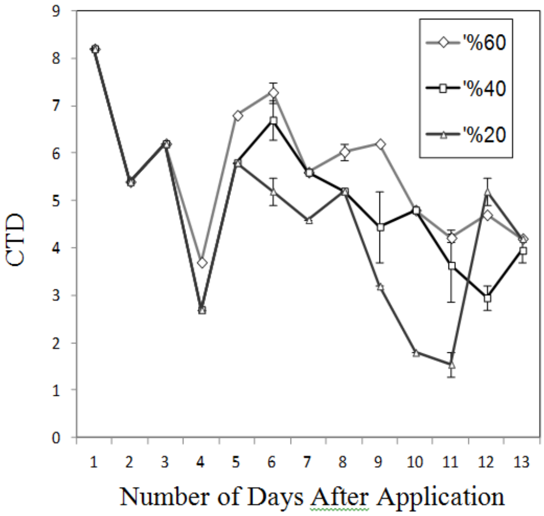

Figure 3 **The effects of three different irrigation frequencies to canopy temperature depression (CTD) of cotton plant**

Adaxial and abaxial stoma densities of three different irrigation frequencies are exhibited in *figure 4*. When the stoma density values from abaxial surface of the leaves was investigated, it was seen that stoma densities were found 2.3, 2.0 and 2.8 for I60, I40 and I20 treatments respectively (*figure 4*). The differences between the treatments were found insignificant for the abaxial surfaces. However, significant differences were detected between three treatments for the stoma densities on adaxial surfaces (*figure 4*). The stoma density of I60 treatment varied from 12 to 16 and average value was found as 13.3. Additionally, for I40 treatment the stoma densities changed from 7 to 11 and the average was 9.6. Lastly, the abaxial stoma density of I20 treatment varied from 6 to 9 and average was 7.8. The stoma density of I20 treatment was found statistically higher than those of other two treatments. Besides, there was no significant difference between 40% and 60% treatments in terms of abaxial stoma density.

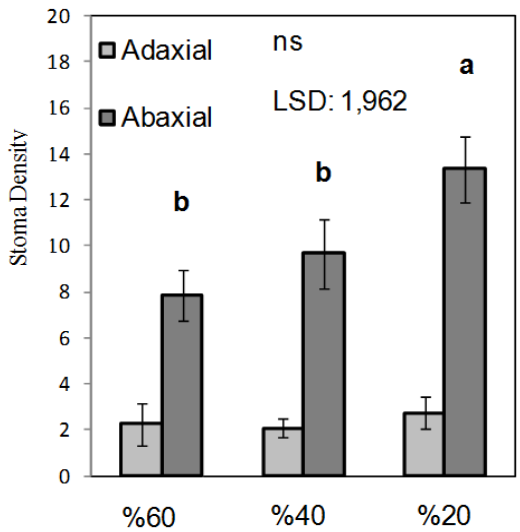

Figure 4 **The effects of three different irrigation frequencies to abaxial and adaxial stoma density of cotton plant**

CONCLUSIONS

In conclusion, we may suggest that regulated deficient irrigation caused decrease on photosynthetic activities. Our results suggested that cotton plants subjected to lower irrigation frequency narrow their leaves to reduce transpiration. This response is a common adaptation of a plant subjected to water stress. On the other hand, increasing stoma number per unit leaf area in adaxial surface with lower irrigation frequency was found. This result could not reveal as an increase in transpiring organs under lower irrigation frequency but a consequence of narrowing leaves under water deficit condition. Our results suggested that cotton plants adapt to different water frequency via regulating transpiring organs and their functions as water stress conditions. Therefore we may suggest that determining irrigation frequency in cotton production should be considered as a main factor rather than irrigation amount.

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