INTERNATIONAL JOURNAL OF COTTON RESEARCH AND TECHNOLOGY
Research Manuscript
EISSN= 2707-5281
www.sciplatform.com

# The Effects of drought stress on physiological properties of cotton (*G. Hirsutum* L.)

**Remzi Ekinci*, Sema Basbag**
Field Crops Department, Faculty of Agriculture, Dicle University, Diyarbakir, Turkey.

| Author's Contribution | **Ekinci, R:** wrote the manuscript and collected the data, **S. Basbag:** collected the reference and performed data analysis. |
|---|---|
| Article History | *Corresponding email address: remzi.ekinci@dicle.edu.tr<br>**Received: 28 August 2020, Revised: 19 September 2020, Accepted: 18 October 2020, Published Online: 31 October 2020** |
|  | **ABSTRACT** **Digital Object Identifier (DOI): https://doi.org/10.33865/IJCRT.002.01.0365** |

As cotton is a product that is grown by irrigating during the summer and rainfall periods, global warming and the drought stress associated with it affect the cotton cultivation negatively. The aim of this study was to investigate the effects of different field capacity saturation degrees (FCSD) on some physiological properties of cotton cultivars. The study was carried out in Dicle University Faculty of Agriculture in the experimental area in 2014-2015 with 3 replications according to the split plot design. The experiment was arranged in a split- plots design with three replications. Main plots were different FCSD (100%, 80%, 60%, and 40%) and sub plots were cotton varieties (Stoneville-453, GW-Teks, and Deltaopal). Leaf temperature (˚C), leaf stoma conductivity (mmol $m^{-2}$ $s^{-1}$) (leaf photosynthesis yield (μmol $m^{-2}$ $s^{-1}$), leaf SPAD value, canopy temperature (˚C) and seed cotton yield (g.per $plant^{-1}$) properties were investigated in this study. Physiological adverse effects of cotton plant in limited irrigation conditions were determined. Although linear regression was determined between deficit irrigation conditions and leaf temperature, canopy temperature, leaf SPAD value, quadratic regression was detected between leaf stomatal conductivity, leaf photosynthesis yield and seed cotton yield.

**Key word**: Cotton, drought, physiological properties, stress.

**INTRODUCTION:** There has been a decrease in the amount of precipitation and irregularity along with climate change in recent years. This shows that drought will be even more problematic in agricultural production in the future. It is predicted that climate zones will shift with the effect of global climate change. In addition, Turkey's influence will remain a hotter and drier climate, cannot adapt to the climate, the flora and fauna will disappear, this change is expected to alter the pattern of agricultural products (Türkes *et al.*, 2000). The world's temperature will rise by 4 °C by 2100; this increase can be as high as 8-9°C is noted in Turkey (Tarakcioglu, 2008). Irrigation requires increasing yield in the region due to inadequate precipitation during the growing season of cotton. The global climate change and the drought have become a major problem in agricultural production. Global warming and the resulting drought stress adversely affect cotton farming both in our country and in the world. Therefore, it is of great importance to investigate how drought stress causes a change in the micro ecology, morphology and physiology of the cotton plant. It is importance to understand the occurrence of drought and the extent of the damage and to take some necessary measures to prevent the damage caused by drought and will increase in the future. In addition, understanding the change caused by drought on the cotton plant is important in future cotton breeding studies.

**OBJECTIVES:** This study was carried out in order to contribute to scientific and practical applications in the studies to be carried out in order to less effect the production in water stress in cotton production.

**MATERIALS AND METHODS:** The study was carried out in with 3 replications according to the split plot design in Dicle University Faculty of Agriculture experimental area in 2014-2015. The main parcel is arranged as different field capacity saturation degree (FCSD) (%) (100%, 80%, 60%, 40%) obtained from different irrigation water amount and the sub parcel is arranged as cotton varieties (ST-453 (Stoneville-453), GW-Teks, and Deltaopal). Diyarbakir province has a hard land climate. The summers are very hot, the winters are cold, but the cold is not as severe as in Eastern Anatolia. The hottest month average is 31ºC and the coldest month average is 1.8ºC. The highest temperature to date was 46.2ºC (21 July 1937) and the lowest temperature was -24.2ºC (11th January 1933). Approximately 2% of the average annual precipitation is 496 $mm^2$, falls in summer. Average relative humidity occurs mostly in December and January (77%) and minimum (20%) in July and August. Delta T Profile Probe Tube was placed between the middle 2 rows of each plot in order to determine soil moisture level before the first irrigation. A profile was opened from a point representing the trial site, and distorted and undisturbed soil samples were taken in 30 cm layers up to 90 cm. Soil samples, using the analysis methods specified by Tüzüner and Rural Affairs (1990); field capacity, wilting point, volume weight, soil structure, soil reaction, total salt, organic matter, lime, available phosphorus and potassium were analysed (table1).

| Depth | Structure | saturation with water | field capacity | wilting point, | Volume weight |
|---|---|---|---|---|---|
| 90 cm | clay-loam | 62% | 41.52% | 11.88% | 1.35 g/$cm^3$ |
| **pH** | **Salt** | **Lime Content** | **$P_2O_5$** | **$K_2O$** | **Organic Matter** |
| 7.87 | 1.064 ds/m | 30.4% | 4.4% | 2.5% | 1.8% |

Table1. Soil analyses of experimental area.

Fertilization was applied as 160 kg $ha^{-1}$ N and 70 kg $ha^{-1}$ $P_2O_5$ pure fertilizer to the experimental area. Drip irrigation method made with irrigation. The first irrigation was made to all parcels when irrigation to the level of soil field capacity was reduced to

35%. Plant water consumption was calculated by Moisture (Beyce *et al.*, 1972). Soil moisture measurements were carried out before and after irrigation by Delta T Profile Probe. Soil moisture changes are given in figure 1. In the Study were

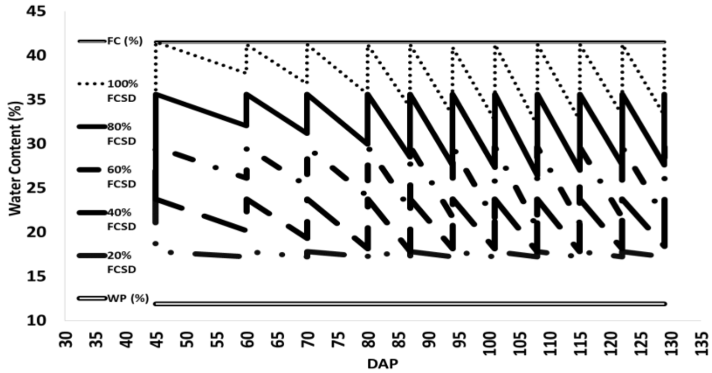


Figure 1: Soil moisture changes before and after irrigation with Delta T Profile Probe (FC: Field capacity (42%); WP: Wilting point (11%); FCDS: Field capacity saturation degrees; DAP: Day after Planting).

Reduction Method which is related to water balance equality investigated leaf temperature (◦C) (infrared thermometer), canopy temperature (FLIR E60 thermal imager) (˚C), leaf stoma conductivity (mmol $m^{-2}$ $s^{-1}$) (Delta-T Model AP-4 porometer), SPAD values (Minolta SPAD-502 Chlorophyll-Meter), leaf photosynthesis yield (µmol $m^{-2}$ $s^{-1}$) (EARS-PPM Plant Photosynthesis System), and cotton seed yield (g $plant^{-1}$). Physiological observations were taken from 3 plants which were marked from each parcel between 10: 00-11: 30 in the morning 90 days after of planting date. The values obtained for each trait were analysed statistically using JMP 5.0 (Copyright © 1989-2002 SAS Institute Inc.) statistical package program in the study. The results were analysed by F test, correlation and regression analysis. Means were grouped according to LSD test.

**RESULTS AND DISCUSSION:** Mean values of leaf temperature (˚C), canopy temperature (˚C), leaf stomatal conductivity (mmol $m^{-2}$ $s^{-1}$) of the investigated traits are given in table 1 and Mean values of leaf SPAD value, leaf photosynthesis yield (µmol $m^{-2}$ $s^{-1}$), and seed cotton yield (g $plant^{-1}$) of the investigated traits are given in table 2.

| Varieties | FCSD (%) | Leaf temperature (◦C) 2014 | 2015 | Means | | Canopy temperature (◦C) 2014 | 2015 | Means | | Leaf stoma conductivity (mmol $m^{-2}$ $s^{-1}$) 2014 | 2015 | Means |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deltaopal | 20% | 48.14 | 45.12 | 46.63 | | 56.33 | 53.16 | 54.74 | | 664.86 | 615.49 | 640.17fgh |
| | 40% | 44.23 | 41.79 | 43.01 | | 50.59 | 48.04 | 49.32 | | 673.88 | 708.90 | 691.39fg |
| | 60% | 43.94 | 41.70 | 42.82 | | 45.58 | 43.25 | 44.41 | | 1318.90 | 1642.90 | 1480.90de |
| | 80% | 33.22 | 31.47 | 32.34 | | 33.35 | 31.54 | 32.44 | | 2579.49 | 2316.93 | 2448.21b |
| | 100% | 29.03 | 28.28 | 28.66 | | 24.78 | 24.02 | 24.40 | | 1722.78 | 2101.65 | 1912.22c |
| ST-453 | 20% | 46.65 | 44.30 | 45.47 | | 54.90 | 52.44 | 53.67 | | 522.46 | 442.47 | 482.47h |
| | 40% | 44.70 | 42.45 | 43.57 | | 51.25 | 48.89 | 50.07 | | 535.95 | 502.34 | 519.14gh |
| | 60% | 43.57 | 41.49 | 42.53 | | 45.31 | 43.14 | 44.23 | | 1131.31 | 1463.33 | 1297.32e |
| | 80% | 31.03 | 29.64 | 30.33 | | 28.70 | 29.62 | 29.16 | | 2276.03 | 3058.13 | 2667.08a |
| | 100% | 29.15 | 29.63 | 29.39 | | 24.89 | 25.44 | 25.17 | | 1812.38 | 2140.19 | 1976.29c |
| GW-Teks | 20% | 48.69 | 46.86 | 47.78 | | 56.75 | 54.86 | 55.81 | | 646.60 | 639.24 | 642.92fgh |
| | 40% | 48.81 | 46.17 | 47.49 | | 55.36 | 52.60 | 53.98 | | 787.65 | 888.05 | 837.85f |
| | 60% | 45.61 | 43.21 | 44.41 | | 47.27 | 44.76 | 46.02 | | 1518.55 | 1499.63 | 1509.09d |
| | 80% | 34.78 | 33.19 | 33.98 | | 34.93 | 33.26 | 34.10 | | 2454.15 | 2425.50 | 2439.82b |
| | 100% | 32.72 | 31.58 | 32.15 | | 28.59 | 27.42 | 28.01 | | 1771.78 | 2161.34 | 1966.56c |
| Deltaopal | | 39.71 | 37.67 | 38.69 | b | 42.13 | 40.00 | 41.06 | b | 1391.98 | 1477.17ab | 1434.58 |
| ST-453 | | 42.12 | 40.20 | 38.26 | b | 41.01 | 39.90 | 40.45 | c | 1255.63 | 1521.29a | 1388.46 |
| GW-Teks | | 39.02 | 37.50 | 41.16 | a | 44.58 | 42.58 | 43.58 | a | 1435.75 | 1522.75a | 1479.25 |
| Means | 20% | 47.83 | 45.43 | 46.63 | a | 55.99 | 53.48 | 54.74 | a | 611.31g | 565.73g | 588.52d |
| | 40% | 45.91 | 43.47 | 44.69 | b | 52.40 | 49.85 | 51.12 | b | 665.83g | 699.76g | 682.79d |
| | 60% | 44.37 | 42.13 | 43.25 | c | 46.05 | 43.72 | 44.88 | c | 1322.92f | 1535.29e | 1429.10c |
| | 80% | 33.01 | 31.43 | 32.22 | d | 32.33 | 31.47 | 31.90 | d | 2436.56b | 2600.18a | 2518.37a |
| | 100% | 30.30 | 29.83 | 30.06 | e | 26.09 | 25.63 | 25.86 | e | 1768.98d | 2134.39c | 1951.69b |
| Means | | 40.28 a | 38.46 b | 39.37 | | 42.57 | 40.83b | 41.70 | | 1361.12b | 1507.07a | 1434.10 |

Table 2: Mean values of leaf temperature, canopy temperature, and leaf stoma conductivity.

**Leaf temperature (˚C):** The leaf temperatures of cotton varieties used as materials varied between 38.26 ˚C (ST-453) and 41.16 ˚C (GW-Teks) (table 1). The leaf temperature values of all cotton varieties are highly affected by different FCSDs, and there is a linear relationship between FCSD and leaf temperature properties in all cotton varieties. A negative correlation ($r=-0.89$, $p<0.001$) between FCSD and leaf temperature. When all varieties were taken into account, $y=-0.2745x+56.775$ ($R^2=0.79$) regression/change equation was obtained (figure 2). The leaf temperature of the cotton plant is highly affected in arid and extreme irrigation conditions. It was determined that leaf temperature was very close to the varieties and amount of water used. Excessive leaf temperature

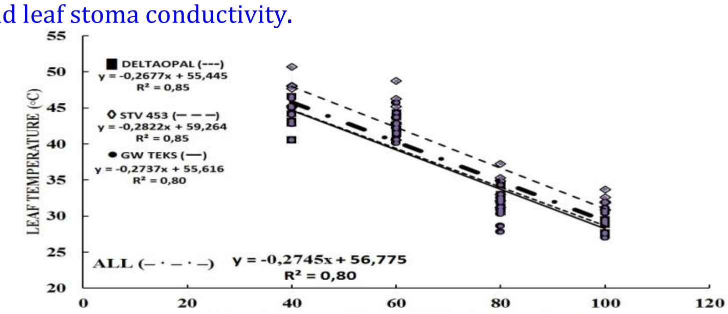


Figure 2: The relationship between leaf temperature and FCSD.

increases are of great importance in terms of leaf viability and functions. Extremely high drought stress can cause irreversible damage to the plant with prolonged persistence. The fact that the leaf temperature is a very easily and practically measurable and verifiable feature reveals that it can be used in plant stress studies. Our results coincide with Jackson (1982) and Zia-Khan *et al.* (2015).

**Canopy temperature (◦C):** The canopy temperatures of different cotton varieties varied between 40.45 ˚C and 43.58 ˚C (table 1). In all cultivars, it was found that canopy temperature values were highly influenced by different FCSDs, and there was a linear relationship between FCSD and canopy temperature characteristics in all cotton varieties. A negative correlation ($r=-0.89$, $p<0.001$) between FCSD and canopy temperature supports these results. When all varieties were taken into account, it was found that $y=-0.4439x + 69.516$ ($R^2=0.92$) regression equation. Drought stress on cotton plant development affects the leaf temperature of the plant. If there is not enough moisture in the soil, the canopy temperature of the plant will increase. The change in canopy temperature is not only related to drought stress but also to the level of temperature stress (figure 3). Our findings are similar to those of Mahan *et al.* (2005), Conaty *et al.* (2012) and Köken *et al.* (2016).

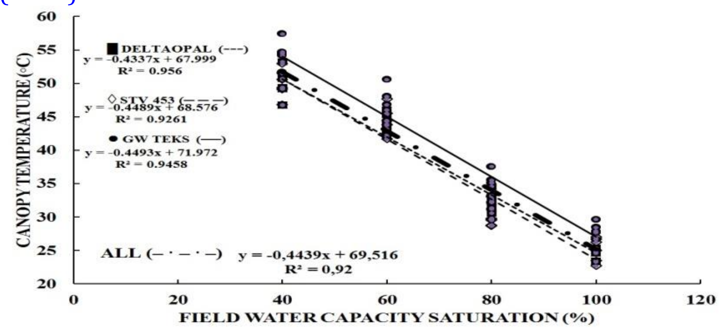


Figure 3: The relationship between canopy temperature and FCSD

**Leaf stoma conductivity (mmol m⁻².s⁻¹):** Cotton varieties, leaf stomatal conductivity, 442.47 mmol $m^{-2}$ $s^{-1}$ and 3058.13 mmol $m^{-2}$ $s^{-1}$ varied between table 1. It is seen that the stoma conductivity values of all varieties are highly affected by different FCSDs and there is a quadratic relationship between FCSD and stoma conductivity property in all cotton varieties. A positive correlation ($r=+0.79$, $p<0.001$) between FCSD. When all varieties were taken into account, it was found that $y=-0.772x^2+132.17x-3457.1$ ($R^2=0.84$) regression equation (figure 4). The highest stoma conductivity value is obtained, the FCSD value is 85%; the highest stoma conductivity values were found to be 2200 mmol $m^{-2}$ $s^{-1}$. Stomatal conductivity is one of the most important parameters affecting the respiration and photosynthesis of cotton plant. However, there are many factors that affect this parameter. A similar result was reported by Zia-Khan *et al.* (2015) and Köken *et al.* (2016).

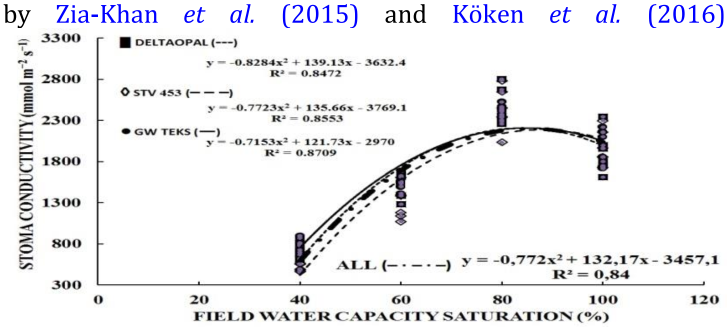


Figure 4: The relationship between stoma conductivity and FCSD.

**Leaf SPAD value:** The leaf SPAD values of cotton varieties ranged between 47.29 and 49.35 (table 2). It is seen that leaf SPAD values of all cultivars are highly affected by different FCSDs, and there is a linear relationship between FCSD and leaf SPAD properties in all cotton varieties. A negative correlation ($r = -0.95$, $p <0.001$) between FCSD and leaf SPAD supports this result. When all varieties were taken into account, it was found that $y=-0.6404x+88.465$ ($R^2=0.91$) regression equation the chlorophyll content of the leaves is of great importance in the development of cotton plants (figure 5). The differences in the chlorophyll content of the existing stresses in both plant nutrition and growing ecology of the plant and the fact that this feature is clearly understood under drought stress conditions, being easy to detect and demonstrating that this feature can be used in next studies. A similar result was reported by Bauerle *et al.* (2004) and Köken *et al.* (2016).

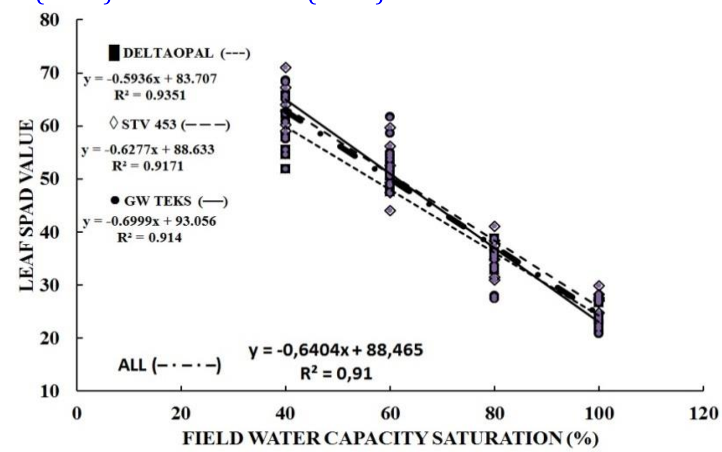


Figure 5. The relationship between leaf SPAD value and FCSD

**Leaf photosynthetic efficiency (μmol m⁻²s⁻¹):** Cotton varieties photosynthetic efficiency values ranged from 569.46 μmol $m^{-2}$ $s^{-1}$ (2014) to 630.53 μmol $m^{-2}$ $s^{-1}$ (2015), (figure 6). It

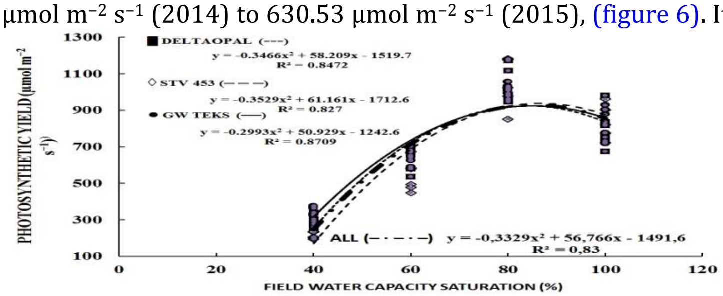


Figure 6. The relationship between photosynthetic yield and FCSD.

was determined, photosynthesis yield values of all cultivars were affected by different FCSDs and quadratic regression was found between FCSD and photosynthesis yield properties. A positive correlation ($r=+0.78$, $p<0.001$) between FCSD and photosynthesis yield was supported by this result. When all varieties were taken into consideration, was obtained that $y=-0.3329x^2+56.766x–1491.6$ ($R^2 = 0.83$) regression. The highest photosynthesis yield value was obtained 85% FCSD. The photosynthesis yield has an important role in the physiological development of cotton plant. These results are in agreement with those of Bauerle *et al.* (2004) and Köken *et al.* (2016).

**Seed cotton yield (gr):** Seed cotton yield of the varieties ranged from 12.24 g. to 56.99 g. (table 2). It is seen that seed cotton yields are affected by different FCSDs and quadratic regression between FCSD and seed cotton yields. In addition, a

positive correlation (r=+0.84, p <0.001) between FCSD and cotton yield values supports this result. Considering all the varieties used as material $y=-0.1472x^2+25.739x-645.11$ ($R^2$ = 0.91) regression equation is obtained, the highest seed cotton yields obtained FCSD value is 87%; the highest seed cotton yield was found to be 50.41 g (figure 7). Water has an important role in the development of cotton plant. Under dry conditions, the growth, development and morphological structure of cotton plant deteriorates and yield decreases significantly. These results are in agreement with those of Başal and Aydın (2006).

| Varieties | FCSD (%) | Leaf SPAD Value | | | | Yield of Leaf Photosynthesis (µmol $m^{-2}$ $s^{-1}$) | | | Cotton Yield Yield (g.$plant^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2014 | 2015 | Means | | 2014 | 2015 | Means | 2014 | 2015 | Means |
| **Deltaopal** | 20% | 70.23 | 65.43 | 67.83 | | 278.16 | 257.51 | 267.83 | 15.54 | 15.74 | 15.64 |
| | 40% | 59.80 | 56.33 | 58.06 | | 281.94 | 296.59 | 289.26 | 16.35 | 18.03 | 17.19 |
| | 60% | 52.96 | 49.79 | 51.38 | | 551.80 | 687.35 | 619.58 | 31.82 | 39.73 | 35.78 |
| | 80% | 36.54 | 34.12 | 35.33 | | 1079.21 | 969.35 | 1024.28 | 52.59 | 50.40 | 51.50 |
| | 100% | 24.05 | 23.62 | 23.84 | | 720.78 | 879.29 | 800.03 | 46.21 | 45.56 | 45.88 |
| **ST-453** | 20% | 66.01 | 64.25 | 65.13 | | 218.58 | 185.12 | 201.85 | 18.06 | 17.22 | 17.64 |
| | 40% | 65.94 | 62.16 | 64.05 | | 224.23 | 210.17 | 217.20 | 19.44 | 21.74 | 20.59 |
| | 60% | 53.23 | 49.86 | 51.55 | | 473.32 | 612.22 | 542.77 | 35.44 | 35.00 | 35.22 |
| | 80% | 36.68 | 34.71 | 35.70 | | 952.24 | 1279.46 | 1115.85 | 56.99 | 55.13 | 56.06 |
| | 100% | 28.04 | 26.93 | 27.49 | | 758.26 | 895.41 | 826.84 | 47.00 | 46.48 | 46.74 |
| **GW-Teks** | 20% | 72.22 | 68.78 | 70.50 | | 270.53 | 267.44 | 268.98 | 13.20 | 12.24 | 12.72 |
| | 40% | 65.88 | 62.60 | 64.24 | | 329.54 | 371.54 | 350.54 | 14.00 | 13.78 | 13.89 |
| | 60% | 56.14 | 53.15 | 54.64 | | 635.33 | 627.42 | 631.37 | 28.44 | 36.84 | 32.64 |
| | 80% | 33.24 | 31.51 | 32.37 | | 1026.76 | 1014.78 | 1020.77 | 53.30 | 50.61 | 51.96 |
| | 100% | 23.99 | 26.02 | 25.00 | | 741.28 | 904.26 | 822.77 | 48.02 | 46.06 | 47.04 |
| Deltaopal | | 48.72 | 45.86 | 47.29 | b | 582.38 | 618.02 | 600.20 | 32.50 | 33.89 | 33.32 b |
| ST-453 | | 49.98 | 47.58 | 48.78 | a | 525.33 | 636.48 | 580.90 | 35.39 | 35.11 | 35.25 a |
| GW-Teks | | 50.29 | 48.41 | 49.35 | a | 600.69 | 637.09 | 618.89 | 31.39 | 31.91 | 31.65 b |
| **Means** | 20% | 69.49 | 66.15 | 67.82 | a | 255.76 | 236.69 | 246.22d | 15.60 | 15.07 | 15.33 d |
| | 40% | 63.87 | 60.36 | 62.12 | b | 278.57 | 292.77 | 285.67d | 16.60 | 17.85 | 17.22 d |
| | 60% | 54.11 | 50.93 | 52.52 | c | 553.48 | 642.33 | 597.91c | 31.90 | 37.19 | 34.55 c |
| | 80% | 35.49 | 33.45 | 34.47 | d | 1019.40 | 1087.86 | 1053.63a | 54.29 | 52.05 | 53.17 a |
| | 100% | 25.36 | 25.52 | 25.44 | e | 740.11 | 892.99 | 816.55b | 47.08 | 46.03 | 46.55 b |
| **Means** | | **49.66a** | **47.28b** | **48.47** | | **569.46b** | **630.53a** | **599.99** | 33.09 | 33.64 | **33.37** |

Table 3: Leaf SPAD value, leaf photosynthesis yield and cotton mass yield average values of properties

**Seed cotton yield (gr):** Seed cotton yield of the varieties ranged from 12.24 g. to 56.99 g. (table 2). It is seen that seed cotton yields are affected by different FCSDs and quadratic regression between FCSD and seed cotton yields. In addition, a positive correlation (r=+0.84, p <0.001) between FCSD and cotton yield values supports this result. Considering all the varieties used as material $y=-0.1472x^2+25.739x-645.11$ ($R^2$ = 0.91) regression equation is obtained, the highest seed cotton yields obtained FCSD value is 87%; the highest seed cotton yield was found to be 50.41 g (figure 7). Water has an important role in the development of cotton plant. Under dry conditions, the growth, development and morphological structure of cotton plant deteriorates and yield decreases significantly. These results are in agreement with those of Başal and Aydın (2006), Sezener *et al.* (2015) and Niu *et al.* (2018).

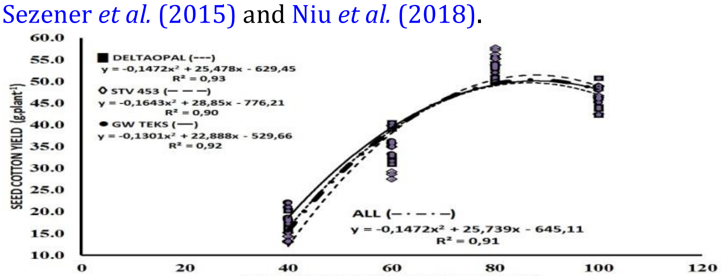


Figure 7: The relationship between seed cotton yield and FCSD.

**CONCLUSIONS:** Drought stress, as in many other plants, showed important results in terms of physiological properties examined in cotton. Although there was a negative correlation between drought stress and leaf temperature, canopy temperature and leaf SPAD values, there was a positive correlation between drought stress and leaf stoma conductivity, leaf photosynthesis yield and seed cotton yield. The most suitable FCSD values in terms of leaf stoma conductivity, leaf photosynthesis yield and seed cotton yield were 85%, 85%, 87%, respectively. In the study were found to be important and practical to properties such as leaf temperature, canopy temperature, leaf SPAD value, leaf stoma conductivity, leaf photosynthesis yield and cotton mass yield properties to determine the performance of genotypes under drought stress conditions.

**ACKNOWLEDGEMENTS:** This research has been supported by Dicle University Scientific Research Projects Coordination Unit. Project Number: 13-ZF-30, 2013. We would like to thank Dicle University for financial support.

**REFERENCES:** Başal, H. and Ü. Aydın, 2006. Water stress in cotton (*Gossypium hirsutum* L.). Ege Üniversitesi Ziraat Fakültesi Dergisi, 43(3): 101-111.

Bauerle, W. L., D. J. Weston, J. D. Bowden, J. B. Dudley and J. E. Toler, 2004. Leaf absorptance of photosynthetically active radiation in relation to chlorophyll meter estimates among woody plant species. Scientia horticulturae, 101(1-2): 169-178.

Beyce, O., K. Madanoglu and C. Ayla, 1972. Some irrigated crops grown in the consumption of water in turkey. Central soil water research institute publications. Publication number: 15, Ankara.

Conaty, W., J. Burke, J. Mahan, J. Neilsen and B. Sutton, 2012. Determining the optimum plant temperature of cotton physiology and yield to improve plant-based irrigation scheduling. Crop science, 52(4): 1828-1836.

Jackson, R. D., 1982. Canopy temperature and crop water stress. In: Advances in irrigation. Elsevier: pp: 43-85.

Köken, Ġ., U. Çakaloğullari, D. Ġġtġplġler and Ö. TATAR, 2016. Adaptation of cotton to different watering regimes. Agronomy series of scientific research, 59(2): 1-17.

Mahan, J. R., J. J. Burke, D. F. Wanjura and D. R. Upchurch, 2005. Determination of temperature and time thresholds for biotic irrigation of peanut on the southern high plains of texas. Irrigation Science, 23(4): 145-152.

Niu, J., S. Zhang, S. Liu, H. Ma, J. Chen, Q. Shen, C. Ge, X. Zhang, C. Pang and X. Zhao, 2018. The compensation effects of physiology and yield in cotton after drought stress. Journal of plant physiology, 224: 30-48.

Sezener, V., H. Basal, C. Peynircioglu, T. Gurbuz and K. Kizilkaya, 2015. Screening of cotton cultivars for drought tolerance under field conditions. Turkish journal field crops, 20(2): 223-232.

Tarakcioglu, I., 2008. Organic cotton and textile industry. stanbul Chamber of Commerce Publications, Publication No: 2008-7. İstanbul.

Türkes, M., U. M. Sumer and G. C. Nisan, 2000. Global climate change and its possible effects, ministry of environment, united nations framework convention on climate change seminar notes Istanbul Chamber of Industry, 7-24, Ankara.

Tüzüner, A. J. M. o. A., Forestry and G. D. o. R. S. Rural Affairs, Ankara, 1990. Soil and water analysis laboratories handbook.

Zia-Khan, S., W. Spreer, Y. Pengnian, X. Zhao, H. Othmanli, X. He and J. Müller, 2015. Effect of dust deposition on stomatal conductance and leaf temperature of cotton in Northwest China. Water, 7(1): 116-131.