International Journal of
Agriculture, Environment and Food Sciences

JAEFS

e-ISSN : 2618-5946

DOI: 10.31015/jaefs.2020.1.12

www.jaefs.com

Research Article

Int J Agric Environ Food Sci 4 (1): 107-113 (2020)

Response of certain tomato (*Solanum lycopersicum*) genotypes to drought stress in terms of yield and quality in Sırnak

Yelderem Akhoundnejad[1,*]

[1]Department of Horticulture, Faculty of Agriculture, University of Sırnak,73300 Sırnak, Turkey

[*]Corresponding Author: yakhoundnejad@sirnak.edu.tr

Abstract

In the present study, threelocal tomato genotypes:Yarbasi, Tepekoyu andFereng (*Solanum lycopersicum*); and one commercial tomato variety: Kamenta F_1, were subjected to dry stress (100%, 50%, 25%) through controlled irrigation after the first flowering of the tomato plant. The experiment was carried out with four replicates,and with eightplants per replicate. A statistically significant difference was observed between drought stress administered and the methods of administration compared to the control plants only in the drought stress administered in the amount of chlorophyll. The total yield of the Fereng tomato genotype indicated that both stresses were less affected by 50% and 25% drought stress. It carried out to be significantly reduced (50% and 25%) in both dry stresses.

Keywords: Tomato, Drought stress, Yield, Chlorophyll

Introduction

The tomatooriginates in South America, althoughit has become one of the most important fruits all around the worldin terms of production and consumption, and Turkey is no exception in this regard. In recent years, the yield of tomatoes in Turkey has increased as a result ofdevelopments in seed production and technological advances (Ertürk, 2015).

Due to global warming, the duration and severity of ecosystems in the current state (drought and temperature) is increasing worldwide (Trenberth et al., 2014). Drought and salt stress responses have been reported to have decreasedin melonproduction in connection to such parameters as plant height, stem diameter, number of leaves and leaf area (Kuşvuran, 2010). In a study examining the relationship between the morphological, physiological and biochemical responses of different tomato, eggplant and melon genotypes to drought,it was reported that effective criteria exist for the measurement of tolerance to drought stress based on the scale value, plant age weight, leaf area, leaf water potential and stomatal conductance intomato, eggplant and melon genotypes (Kiran et al., 2015).

In a study of 55 tomato genotypes carried out by Daşgan et al., the samples were classified as tolerant, moderately tolerant or sensitive to drought and salinity. In addition, dry weight, plant total leaf area, stomatal conductance, leaf osmotic potential, leaf water potential, different concentrations in the green parts and root, and the membrane injury index were reported to be the best parameters (Daşgan et al., 2018).

In the present study, physiological and morphological measurements were made of the responsesof the different tomato genotypes to drought stress under the climate and soil conditions of Şırnak. The aim in this regard was (1) to investigate the reactions of certain physiological and morphological parameters of tomatoes under two different drought conditions, and (2), toidentify the relationshipbetween the physiological and morphological analysisresults and the measuredtomato findings. The present study will not only help provide an under-

Cite this article as:
Akhoundnejad, Y. (2020). Response of certain tomato (*Solanum lycopersicum*) genotypes to drought stress in terms of yield and quality in Sırnak. Int. J. Agric. Environ. Food Sci., 4(1), 107-113.
DOI: https://doi.org/10.31015/jaefs.2020.1.12
ORCID: [1]0000-0002-1435-864X
Received: 21 October 2019 **Accepted:** 24 February 2020 **Published Online:** 15 March 2020
Year: 2020 **Volume:** 4 **Issue:** 1 (March) **Pages:** 107-113
Available online at : http://www.jaefs.com - http://dergipark.gov.tr/jaefs

standing of the drought-stressed physiological mechanisms of tomato plants, but will also serve as a guide for future breeding studies involving tomatoes.

Materials and Method

In the present study, three local genotypes (Yarbasi, Tepekoyu, Fereng) and one commercial variety (Kamenta) of tomato were selected for analysis. The experiment was carried out in the research area of the Sırnak University Faculty of Agriculture, Department of Horticulture. Seeds were sown in viols on March 15, 2019 in a 2:1 peat and perlitesoil, and theseedlings were planted on April 15, in 120 cm rows at 50 cm centers. The plants were harvestedon 31 August, with three replications and eightplantsper repetition. The drought stress application was started 30 days after the planting of the seedlings.

For the experiment, the amount of water given to the plants and the time of irrigation were realized 3 times a week in three different irrigation applications. The water was applied to the plants in line with the evaporation values read daily from the evaporation boiler (Class Apan). In the study, 16 mm branded drip irrigation laterals were positioned at 50 cm centers with a flow rate of 2 L h^{-1}forthe irrigation system. Temperature, humidity and precipitation data was obtained from the Şırnak Regional Metrology Directorate (fig. 1,2), and thetotal amount of water per plant per soil during production was determined (Table 1). The amount of irrigation water given to the plants in the experiment was determined through the following formula:

IR =A* E pan *kcp * P

in which:

IR = Amount of Water Spent (m^3) A= Parcel size (da)

E (pan)=Evaporation (mm) kcp = Number of floors of tomato plant (0.80)

P = Flora % P = Crown width of tomato plant (cm) Row spacing $^{-1}$(cm)

Table 1. Total irrigation water applied to tomato plants in different applications (Liter Plant $^{-1}$)

Application	Before stress (15.04.2019–15.05.2019)	Afterstress (16.05.2019–30.08.2019)	Rainfall *	Total amount of water used
100%	43.6 L	265.62 L	151 L	455.22 L
50%	43.6 L	132.81 L	151 L	327.41 L
25%	43.6 L	66.40 L	151 L	261 L

*Rainfall dates: (01.04.2011–30.04.2011) 97 L-(01.05.2011–31.05.2011) 49L(01.06.2011–30.06.2011) 4L-(01.07.2011–31.07.2011) 1 L

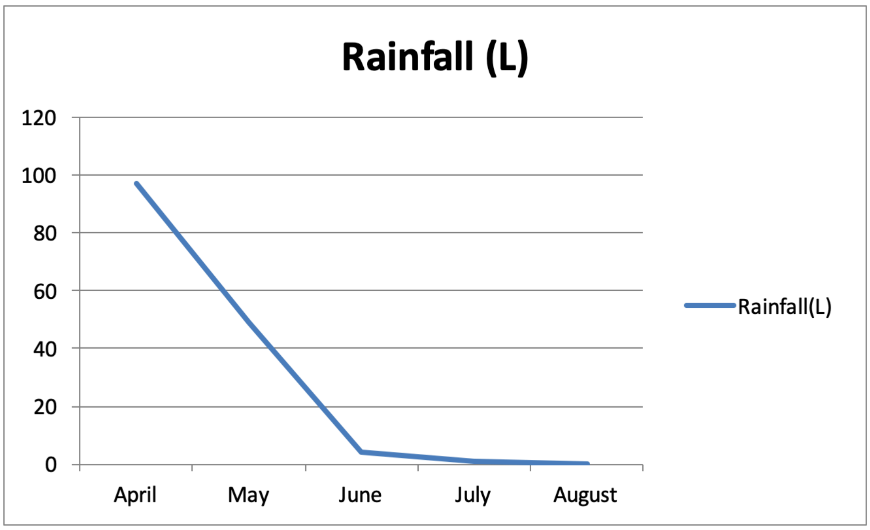

Figure 1. Rainfall values recorded during the experiment

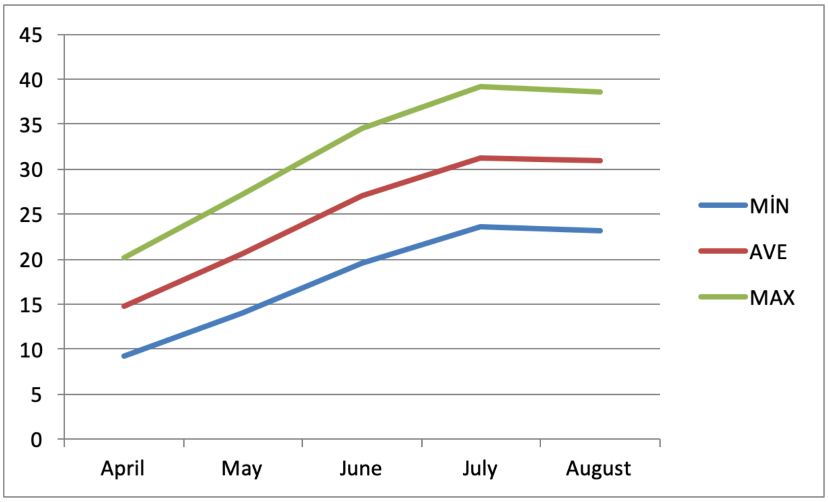

Figure 2. Maximum, medium and minimum temperature values recorded during the experiment

In the present study, the fruit length (mm), fruit diameter (mm), fruit wall thickness (mm), chlorophyll content of tomato leaf, TSS (%), number of fruit (pieces fruit-1), fruit weight (g), total yield (kg HA^{-1}) produced with different irrigation amounts (100% (Control), 50%, 25%) were measured.

The experiment was established carried outin accordance with the experiment design. The data was analyzed using the JMP software package. The differences between the mean values of the investigated properties was determined through an $LSD_{(0.05)}$ test.

Results and discussion

The average values of the different tomato genotypes and the percentage change in values were examined. Thefruit length values corresponding to 100%, 50% and 25% irrigation applicationwere respectively 61.02 (mm) 58.36 (mm) and 56.56 (mm), while theaverage changes were determined as -4.62 at 50% irrigation and -12.13 at 25% irrigation. Table 2 shows that the different drought stress applications are affected according to their own control in tomato genotypes fruit size. Accordingly, when the average values are examined, fruit length is found to decrease by an average of -4.62% in a 50% irrigation application. In the 25% irrigation application, fruit length was found to decreaseby -12.13% as an average among all genotypes (Table 2).An analysis of the data in Table 2 reveals that while fruit length under drought stress was affected most in the Tepekoyu and Fereng genotypes at 50% irrigation, the genotype was the least and most affected genotype at 25% irrigation. The fruit diameter of the studied Tepekoyu tomato genotypewas 67.00 mm in the control sampleand also 67.00 mm in the 50% irrigation application, meaning no-difference between the samples under 50% irrigation and the controls (Table 3). In the study by Daşgan et al. (2009) comparing 50%-restricted PRD open and closed systems and full irrigation open and closed systems in greenhouse hydroponic cucumber cultivation, the effect of the different applications on fruit diameter was reported to be insignificant.Drought and salt stress conditions have been reported to decrease such parameters as plant height, stem diameter, number of leaves and leaf area in melons (Kuşvuran, 2010). The samples most affected by drought stress at 50% and 25% irrigation were the Fereng and Yarbasi genotypes, whereas the most affected genotypes under 50% and 25% irrigation drought stress were the Drape and Kamenta genotypes (Table 4).

Among the studied tomato genotypes, it was found that the mean BRIXvalue was 6.37 in the control, 6.78 in the 50% irrigation and 6.63 in 25% irrigation samples. It can thus be concluded that the ratio of BRIX increases as the level of aridity increases. In an examination of the BRIX values, the highest value was found to be 7.33 in the 25% irrigation sample and the lowest value was 5.53 in the 100% irrigation. Ergun (1994) stated that it is inversely proportional to the water supplied through irrigation (Table 5). In the present study, the tomato fruit weight 50% irrigation% change rate -24.84% genotypes most affecting genotype was Yarbasi and the least affected genotype was Fereng genotype% -11.31% change. For the 25% of the irrigation rate% -36.29% of the most affecting genotype was the Yarbasi, and the least affecting genotype was Ferenge % -24.24% was determined (Table 6). It has been determined that water stress applied to tomato crops causesa drop in both yield and fruit weight (Sanchez Rodriguez et al., 2010; Alp and Kabay, 2017).

Table 2. Tomato genotypes examined under different drought stresses and the effects on fruit length (mm) values and percentages % change according to control

Genotype	100 % irrigation Control (mm)	50% irrigation (mm)	25% irrigation (mm)	50%irrigation %change according to control	25%irrigation %change according to control
Yarbasi	80.91±2.12 a	77.63±2.13 a	74.76±1.54a	-4.05	-7.60
Tepekoyu	64.34±4.79 b	65.26± 0.44 b	52.26±2.65ab	1.43	-18.77
Fereng	52.51± 3.53 c	44.72± 3.18 c	41.43± 2.25 b	-14.83	-21.10
Kamenta	46.33±2.65 c	45.85±2.08 c	57.78±0.57ab	-1.03	-1.03
Mean	61.02	58.36	56.56	-4.62	-12.13
$LSD_{0.05}$	7.29	3.46	4.23	-	-

Table 3. Tomato genotypes examined under different drought stressesand the effects on fruit diameter (mm) values and percentages % change according to control

Genotype	100 % irrigation Control (mm)	50% irrigation (mm)	25% irrigation (mm)	50%irrigation %change according to control	25%irrigation %change according to control
Yarbasi	59.00±1.00b	55.13±0.67b	56.49±1.20b	-6.56	-4.25
Tepekoyu	67.00±1.00a	67.00± 0.69a	61.83±0.80a	0.00	-7.72
Fereng	41.18±0.40c	40.14±0.83c	36.66±0.87c	-2.53	-10.98
Kamenta	35.26±0.58d	33.36±0.71d	33.99±0.62d	-5.39	-3.60
Mean	50.61	48.90	47.16	-3.62	-6.64
$LSD_{0.05}$	1.27	1.26	2.03	-	-

Table 4. Tomato genotypes examined under different drought stressesand the effects on fruit wall thickness (mm)values and percentages % change according to control

Genotype	100 % irrigation Control (mm)	50% irrigation (mm)	25% irrigation (mm)	%50 irrigation %change according to control	%25 irrigation %change according to control
Yarbasi	3.38± 1.00 b	3.06±0.67 c	3.22±1.20b	-9.47	-4.73
Tepekoyu	2.55± 1.00 c	2.38±0.69 d	2.35±0.80 c	-6.67	-7.84
Fereng	3.39± 0.40 b	3.26±0.83 b	3.14±0.87 b	-3.83	-7.37
Kamenta	5.60± 0.58 a	5.23±0.71 a	4.69±0.62 a	-6.61	-16.25
Mean	3.73	3.48	3.35	-6.64	-9.05
$LSD_{0.05}$	0.28	0.19	0.28	-	-

Table 5. Tomato genotypes examined under different drought stressesand the effects on BRIX values and percentages % change according to control

Genotype	100 % irrigation Control	50% irrigation	25% irrigation	50%irrigation %change according to control	25%irrigation %change according to control
Yarbasi	5.53±0.45	6.24±0.08 c	6.64±0.10	12.84	20.07
Tepekoyu	6.66±0.15	6.80±0.005 b	6.62±0.24	2.10	-0.60
Fereng	6.43±0.25	6.91±0.08 b	6.74±0.32	7.47	4.82
Kamenta	6.85±0.27	7.19±0.24 a	7.33±0.10	4.96	7.01
Mean	6.37	6.78	6.63	6.84	7.83
$LSD_{0.05}$	ns	0.22	ns	-	-

ns: not significant

Table 6. Tomato genotypes examined under different drought stressesand the effects on fruit weight (per fruit -1)values and percentages % change according to control

Genotype	w100 % irrigation Control (per fruit $^{-1}$)	50% irrigation (per fruit $^{-1}$)	25% irrigation (per fruit $^{-1}$)	50%irrigation %change according to control	25% irrigation %change according to control
Yarbasi	206.66±3.51a	155.33±1.15a	131.66±9.01a	-24.84	-36.29
Tepekoyu	150.66±5.13b	132.35±10.06b	111.00±3.06b	-12.15	-26.32
Fereng	144.33±6.65b	128.00±5.19 b	109.35±7.76b	-11.31	-24.24
Kamenta	108.66±1.15c	94.00 ±5.29 c	83.66±5.03 c	-13.49	-23.01
Mean	152.57	127.42	108.91	-15.45	-27.46
LSD $_{0.05}$	9.66	13.40	15.46	-	-

An analysis of the average fruit yield values reveals the mean number of fruit in the 50% irrigation application to be 30.25 according to their controls, and 31.00 in 25% irrigation application, as an average of all genotypes (Table 7). Accordingly, the number of tomatoes and fruits increased under both drought stresses as an average of all genotypes when compared to the controls. Generally, as the drought stress of tomato plants is increased, fertilization takes place, continuing the generation of tomatoes, and so the number of fruit increases. It has been found previously in the tomato study of Akhoundnejad (2011),the watermelon study of Karipçin et al. (2008) and the pepper study of Berenyi (1971) that the application of water stress in the cultivation of tomato, pepper and watermelon reduced both the number of flowers and fruit,and that the fruits remain small.

Table 7. Tomato genotypes examined under different drought stressesand the effects on fruit(Plant number-1)values and percentages % change according to control

Genotype	100 % irrigation Control (Plant number^{-1})	50% irrigation (Plant number^{-1})	25% irrigation (Plant number^{-1})	50%irrigation %change according to control	25%irrigation %change according to control
Yarbasi	25±1.00 c	28±1.52 b	24±1.73 b	12.00	-4.00
Tepekoyu	23±1.52 c	27±1.52 b	31±0.5 a	17.39	34.78
Fereng	34±2.51 a	38±0.57 a	34±1.00 a	11.76	0.00
Kamenta	30±2.08 b	28±1.00 b	35±1.00 a	-6.67	16.67
Mean	28	30.25	31	8.62	11.86
LSD $_{0.05}$	2.13	2.30	ns	-	-

ns: not significant

When the average values of the tomato genotypes in the study andthe % change, 100%, 50% and 25% total yield values in irrigation applications, respectively 75,440.25 (plant ha^{-1}) 58,384.25 (plant ha^{-1}) and 48,562.50 (plant ha^{-1}), and considering the% change averages, a decrease of -22.32 was noted in the 50% irrigation samples and of -35.15 in the 25% irrigation samples was determined. It can be understood from Table 9 that the total yield of the different tomato genotypes under different drought stress applications differs from that of the controls. An analysis of the mean values reveals that the total yield from the Fereng genotype subjected to 50% and 25% irrigation reduction was found to be the least affected,at -3.52% and -12.33%, respectively; while the 50% and 25% irrigated Tepekoyu genotype was found to be the most affected, with values of -33.97% and -45.98% (Table 9). Previous studies have found total yield and fruit weight to decrease as drought stress is increased in different melon genotypes (Akhoundnejad and Dasgan, 2019). It has further been reported that a decrease in yield in field crops may be related to the continuation of chlorophyll loss during grain filling, and that different physiological mechanisms in the plant can help determine temperature tolerances under field conditions (Reynolds et al.,2001).

Conclusion

In this study of drought sensitive and tolerant tomato genotypes in the Sırnak province, significant differences were found in fruit size, fruit number, fruit diameter, total yield, chlorophyll content, fruit weight, and tolerant and sensitive varieties. In the present study, the Fereng genotype was found to be stress tolerant in terms of total yield values under 50% and 25% drought stress conditions. It was concluded from the study that the parameters applied to determine the effects of drought stress on tomato genotypes under the conditions in Şırnak are appropriate for the selection of genotypes tolerant to drought stress, and may also be considered in breeding programs in the future for the development of an exclusive line.

Table 8. Tomato genotypes examined under different drought stresses and the effects on chlorophyll (%)values and percentages % change according to control

Genotype	100 % irrigation Control (%)	50% irrigation (%)	25% irrigation (%)	50%irrigation %change according to control	25%irrigation %change according to control
Yarbasi	65.63±2.22b	51.63±0.83c	45.22±2.74b	-21.33	-31.10
Tepekoyu	65.22±1.51b	56.48±0.78c	44.45±1.04b	-13.40	-31.85
Fereng	71.78±0.87a	67.54±0.91a	52.57±0.84a	-5.91	-26.76
Kamenta	68.61±1.29ab	51.48±1.04c	51.78±1.46a	-24.97	-24.53
Mean	67.81	56.78	67.81	-16.40	-28.56
$LSD_{0.05}$	0.45	0.19	2.25	-	-

Table 9. Tomato genotypes examined under different drought stressesand the effects on total yieldvalues (plant ha^{-1}) and percentages % change according to control

Genotype	100 % irrigation Control (plant ha^{-1})	50% irrigation (plant ha^{-1})	25% irrigation (plant ha^{-1})	%50 irrigation %change according to control	%25 irrigation %change according to control
Yarbasi	85630±3356a	64857±2641a	51290±2179b	-24.26	-40.10
Tepekoyu	76568±1208b	50556±856b	41361±1877c	-33.97	-45.98
Fereng	70043±1717c	67580±882 a	61410±1349a	-3.52	-12.33
Kamenta	69520±946c	50380±796 b	40189±1895c	-27.53	-42.19
Mean	75440.25	58384.25	48562.5	-22.32	-35.15
$LSD_{0.05}$	3372	3020	2098	-	-

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

References

Akhoundnejad, Y., Dasgan, H.Y. (2019). Effect of different irrigation levels on physiological performance of some drought tolerant melon (Cucumis melo L.) genotypes. Applied Ecology and Environmental Research, 17(4):9997-10012 [Google Scholar]

Akhoundnejad, Y. (2011). Determination of the field performance of some selected tomato genotypes against drought stress. Cukurova University, Institute of Science and Technology, Master Thesis, Code No: 4126, Page 111.

Altunlu, H. (2011). The effects of grafting against drought stresse in tomatoes. Ege University, Institute of Science and Technology, PhD Thesis.

Alp, Y., Kabay, T. (2017). The effect of drought stress on plant development in some native and commercial tomato genotypes. Yüzüncü Yıl University Journal of Agricultural Sciences, 27(3): 387-395.

Berenyi, M. (1971). Some results of studies on fruit set in Capsicums. Zoldsegtermesztesi kullntezet Bulletje, 6, 83-95.

Dasgan, H.Y., Bayram, M., Kusvuran, S., AydonerCoban, G., Akhoundnejad, Y. (2018). Screening of tomatoes for their resistance to salinity and drought stress. Journal of Biology, Agriculture and Healthcare, Vol.8, No.24. [Google Scholar]

Daşgan, H.Y., Kuşvuran, Ş., Kırda, C. (2009). Effects of partial root region dryness in soilless greenhouse. TUBİTAK 1050566 No. Project Final Report.

Ergün, S. (1994). "Yalova Çorbacı-12" Investigation of the effects of different irrigation applications on yield and quality of pepper cultivar". Atatürk Horticultural Center Research Institute-Yalova, Research and Studies Publication No. 43.

Ertürk, Y.E., Çirka, M. (2015). Tomato production and marketing in Turkey and North Eastern Anatolia Region, YYU J AGR Sci, 25(1):84-97 [Google Scholar]

Karipçin, M.Z. (2009). Determination of drought tolerance on wild and domestic watermelon genotypes. Cukurova University, Institute of Science and Technology, PhD Thesis.Page259.

Kevin, E.T., Aiguo, D., Gerard, V.D.S., Philip, D. Jones., J.B., Keith, R.B., Justin, S. (2014). Global warming and changes in drought. Nature Climate Change, volume 4, 17–22 [Google Scholar]

Kıran, S., Kuşvuran, Ş., Özkay, F., Ellialtıoğlu, Ş. (2015). Determination of relationship among different parameters for evaluated drought resistance in tomatoes, eggplant and melon genotypes. Nevsehir Journal of Science and Technology, volume 4, (2), 25-20 [Google Scholar]

Kuşvuran, Ş. (2010). Relationships between physiological mechanisms of tolerances to drought and salinity in melons. Cukurova University. Institute of Science and Technology, PhD Thesis, 4126, Page 356.

Reynolds, M.P., Nagarajan, S., Razzaque, M.A., Ageeb, O.A.A. (2001). Heat tolerance. Application of physiology in wheat breeding. Mexico, DF, CIMMYT.

Sanchez-Rodriguez, E., Rubio-Wilhelmi, M., Cervilla, L.M., Blasco, B., Rios, J.J., Rosales, M.A., Ruiz, J.M. (2010). Genotypic differences in some physiological parameters symptomatic for oxidative stress under moderate drought in tomato plants. Plant Science, 178(1): 30-40. [Google Scholar]