Physiological Performance of Some High Temperature Tolerant Tomato Genotypes

Yelderem Akhoundnejad (Corresponding author)
Sirnak University Faculty of Agriculture Depatment of Horticulture, 73300 Idil / Sirnak, Turkey
E-mail: yakhoundnejad@sirnak.edu.tr

H. Yildiz Dasgan
Cukurova University Faculty of Agriculture Depatment of Horticulture, 01330, Adana, Turkey

Abstract
This study was conducted for determining high temperature tolerance in tomato genotypes. First year, 131 genotypes tomatoes were used, second year, 20 genotypes from the first year with endurance to higher temperature, also 2 sensitive and 2 trade varieties were used. Two testing fields were established in 2 different periods in the summer to study control and high temperature of genotypes. During the testing period, these are the measured, analyzed and examined parameters in plants and fruits: 0-5 scale evaluation of visual damage of high temperature stress on green night to plant, leaf stoma conductance, membrane damage on leaf cells, leaf water potential, leaf osmotic potential, leaf temperature, leaf area index, K and Ca concentrations in leaf and fruit According to the results tomato genotypes were sorted from highest to lowest levels for their stress tolerance.

Keywords: Solanum lycopersicum, high temperature, tolerance, stress physiology, stomatal conductance, water potential, membrane injury, K and Ca.

1. Introduction

Plant growth and productivity are significantly depended on environmental factors and world agriculture will be affected by climate changes (Kandlikar and Risbey 2000). Effects of global warming on agricultural productivity indicate that high temperature (HT) will have detrimental effects in many developing countries (Mendelsohn and Dinar 1999). In tropical and subtropical regions heat stress may become a major limiting factor for crop production. High temperature (HT) stress has been reported as one of the most important causes of change in plant morphology, physiology and biochemical aspects, which reduces plant growth and development in many crops, including tomato. In tomato, physiological parameters such as seed germination, seedling and vegetative growth, flowering, fruit set, and fruit ripening are adversely affected at the temperature above 35 ^{0}C (Thomas and Prasad 2003; Wahid et al. 2007). The researchers reported that reproductive development was affected by high temperature stress more than vegetative development (Sato et al. 2002; Abdelmageed et al. 2003). HT limited flower bud initiation and development and resulted in abortion of the flowers and reduction in yield of many crops (Peet et al. 1998; Sato et al. 2000; Cross et al. 2003; Young et al. 2004). HT tolerant tomato genotypes provide valuable tool for improving new cultivars. The selection of crops or species tolerant to HT stress would be the best and the easiest strategy for increasing fruit set at HT in tomato (Warner and Erwin 2005). Local populations are the valuable source of heat-tolerant genes for tomato genetic improvement. Plant breeders have been interested in developing new cultivars with higher yielding and resistance to pests and diseases, tolerance of drought, salinity and other abiotic stresses. This caused to narrow genetic base of landraces. Diversity within cultivated plants has been replaced by genetic uniformity of new cultivars. Plant breeders need the genetic diversity of genes found in wild and landraces to be able todevelop new cultivars of crop plants in the future; therefore evaluation and conservation of the landraces is important (Ford-Lloyd 2003). Several methods have been used to evaluate variation in heat tolerance of genotypes. It has been reported that in evaluating individual flowers of either crop plants or landraces for tolerance to high temperature it is critical to observe whether the fruit set is seeded or seedless (Sato et al. 2002). Evaluating genotypes through the fate of flower development for heat tolerance is an important technique because these processes are directly related to yield.

2.Material and methods

And in the second experiment of the first year, by studying the temperature values for long years of the region for enabling to time the vegetative and generative developments of tomato genotypes in the period corresponding to high temperature intervals in the region, the seeds were sown at alter date, namely on 15th April 2014. As the sowing date of the second experiment was preferred, date 38 days later from the first experiment. The measurements were made 70 days later between 24th – 26th July 2014 in tomato genotypes exposed to high temperatures of the region in the period of May-June-July.

Table 1. genotaypes tomatoin the first year

genotaype G*		genotaype G*		genotaype G*		genotaype G*		genotaypes	G*	genotaypes	G*
s No	name	s No	name	s No	name	s No	name	No	name	No	name
Tom-1	AG 2134	Tom-23	1071-31	Tom-46	- Fe 68	Tom-142	TR 37277	Tom-172	TR 52263	Tom-213	Mardin-Nusaybin
Tom-2	SC 2121	Tom-24	1071-32	Tom-47	Red Cherry-Large	Tom-143	TR 40351	Tom-173	TR 52361	Tom-214	Elazğı iri kiraz 2013
Tom-3	Urbana	Tom-25	1071-22	Tom-48	Super Sweet-	Tom-144	TR 40359	Tom-174	TR 52376	Tom-215	Diyarbakır- Lice
Tom-4	İnvictus	Tom-26	1009-6	Tom-106	Karaduvar,	Tom-145	TR 40361	Tom-175	TR 52377	Tom-216	Diyarbakır Yöresel
Tom-5	Pearson	Tom-27	1009-16	Tom-108	Pakmor,	Tom-146	TR 40363	Tom-176	TR 52414	Tom-217	Erdemli-local
Tom-6	Rio Fuego	Tom-28	1009-8	Tom-109	68x71 (1999),	Tom-147	TR 40395	Tom-177	TR 52428	Tom-218	Siverek - Keçiburcu
Tom-7	WC 156	Tom-29	1009-18	Tom-110	71x68 (1999),	Tom-149	TR 40478	Tom-179	TR 43484	Tom-219	Domates Akşehir
Tom-8	68 VF 26	Tom-30	1009-9	Tom-111	Tridora, RHT 1	Tom-150	TR 49449	Tom-199	Trabzon	Tom-220	CLN1466EA
Tom-9	Falcon	Tom-31	1048-34	Tom-112	Mieulignon T1	Tom-151	TR 49644	Tom-200-1	Pozantı	Tom-221	CLN1621F
Tom-10	H 2274	Tom-32	1048-16	Tom-113	Romitel, RHT 3	Tom-152	TR 49646	Tom-200-2	Es-24F	Tom-222	CL5915-206D4
Tom-11	Cambell 37	Tom-33	1048-21	Tom-114	Lignon S5,	Tom-157	TR 48932	Tom-201-A	Red top VF	Tom-223	CL5915-206D4
Tom-12	Rio Grande	Tom-34	1048-27	Tom-115	Lignon S2,	Tom-161	TR 55711	Tom-201-B	kirkizistan	Tom-224	CLN2413D
Tom-13	Arizona	Tom-35	1048-28	Tom-116	Lignon S1	Tom-162	TR 68513	Tom-202	H-1706	Tom-225	CLN3126A-7
Tom-14	Cambell 33	Tom-36	51/2	Tom-117	VF 6203,	Tom-163	TR 68516	Tom-204	Koral	Tom-226	CLN3241H-27
Tom-15	T-2 İmproved	Tom-37	194	Tom-118	ACE VF 55	Tom-164	TR 68517	Tom-205	İ-40	Tom-227	CLN3212C
Tom-16	Super Marmande	Tom-38	17	Tom-119	Adana Yerli,	Tom-165	TR 62573	Tom-206	Siverek Yerli	Tom-228	CLN2026D
Tom-17	Super 6. H. E. S. 58	Tom-39	370	Tom-120	Birecik Yerli	Tom-166	TR 61658	Tom-207	Konya Yerli, Talha	Tom-229	CLN3125L
Tom-18	Lignon C. 19.18	Tom-40	227/1	Tom-121	Lignon S3	Tom-167	TR 61697	Tom-208	Kızıltepe Yerli, Lokman	Tom-230	CLN3125O
Tom-19	Roza	Tom-41	FER	Tom-122	Lignon C.8.6	Tom-168	TR 61796	Tom-209	13-Beyköy	Tom-231	CLN3078A
Tom-20	1071-33	Tom-43	Fer	Tom-123	Lignon C.8.6	Tom-169	TR 61870	Tom-210	Kırgızistan Beef	Tom-232	CLN3078C
Tom-21	1071-34	Tom-44	pimpinellifolium	Tom-139	TR 47820	Tom-170	TR 63233	Tom-211	Kırgızistan Sarı	Tom-233	CLN3078G-AV
Tom-22	1071-35	Tom-45	L. hirsitum	Tom-140	TR 47865	Tom-171	TR 66330	Tom-212	İspanya-Madrid		

*Genotaypes

Second Year Experiments

In the second year of the study, 20 most long lasting tomato genotypes out of 131 tomato genotypes, which were studied control and high temperature stress in the first year experiments, were chosen. By adding 2 representative sensitive genotypes, one of which was F_1 hybrid, and the other one of which was standard open pollinated to them, total 24 tomato genotypes were used for the second year experiments. In the second year control and stress experiments, their physiological parameters were taken. The first experiment of the first year was started in 20th February with the sowing of seeds. The measurements were 2 times between 16th – 20th June 2015 and 15th – 20th July 2015 when the physiological observations and severe temperatures were started, and when the plants were 70 and 90 days old.

Table 2. genotaypes tomato in the second year

No	Resistant genotypes	Genotypes name	No	Resistant genotypes	Genotypes name
1	Tom-12	Rio Grande	14	Tom-173	TR 52361
2	Tom-14	Cambell 33	15	Tom-201-B	kirkizistan
3	Tom-19	Roza	16	Tom-211	Kırgızistan Sarı
4	Tom-20	1071-33	17	Tom-225	CLN3126A-7
5	Tom-26	1009-6	18	Tom-230	CLN3125O
6	Tom-40	227/1	19	Tom-232	CLN3078C
7	Tom-47	Red Cherry-Large	20	Tom-233	CLN3078G-AV
8	Tom-108	Pakmor,		**Sensitive genotypes**	
9	Tom-111	Tridora, RHT 1	21	Tom-175	TR 52377
10	Tom-114	Lignon S5,	22	Tom-116	Lignon S1
11	Tom-115	Lignon S2,		**Instance species**	
12	Tom-119	Adana Yerli,	23	Hazera 5656 F1	Hazera 5656 F1
13	Tom-165	TR 62573	24	Tom-10	H 2274

According to the total grades 24 tomato genotypes were arranged from the one which took the highest grade to the one which took the lowest grade (Table 3).

In the experiment, the monthly minimum, average and maximum temperature and air relative humidity values for years 2014 and 2015 are shown in Figure 1, Figure 2, Figure 3 and Figure 4 respectively.

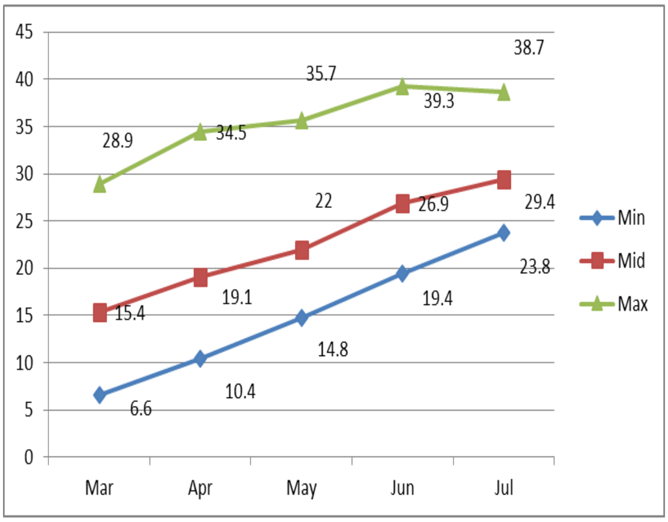

Figure 1. 2014 spring-summer period recorded During Trial min, max, mid Temprearature values (^{o}C)

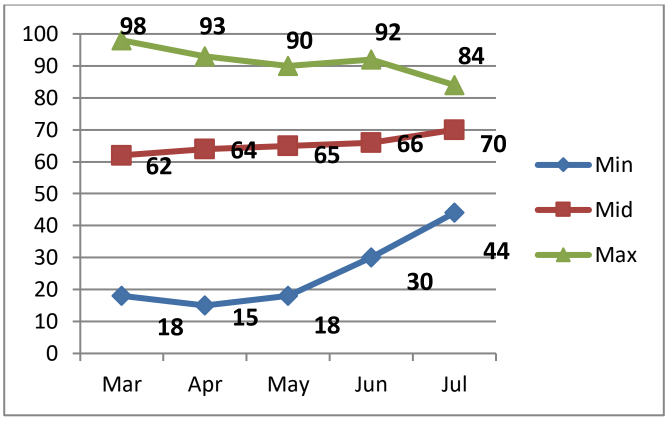

Figure 2. 2014 spring-summer period recorded during trial min,max,mid Monthly air relative humidity values (%)

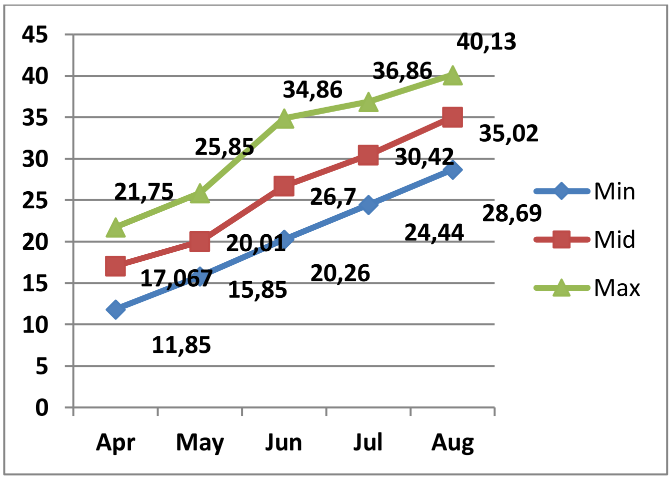

Figure 2. 2015 spring-summer period recorded recorded during trial min, max, mid Temperature values (ºC)

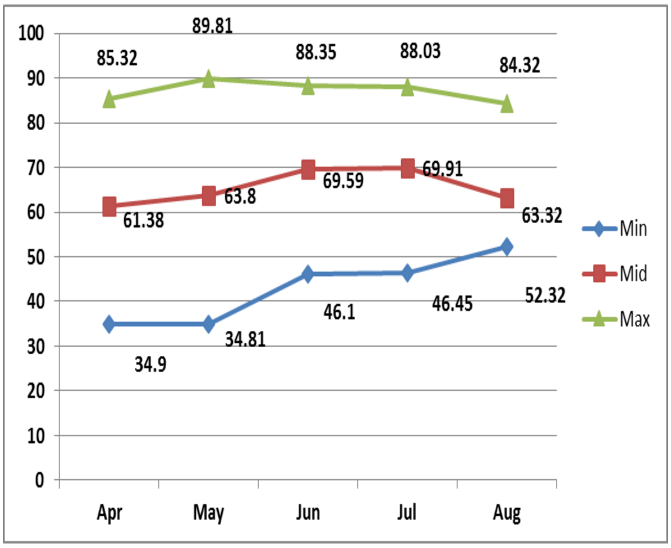

Figure 4. 2015 spring-summer period recorded during trial min,max,mid Monthly air relative humidity values (%)

First Year Experiment and parameter a series shown below were examined.
1.0-5 Scale Evaluation 2. Green light fresh 3. Dried weights 4. leaf temperature
5. leaf area index (LAI) 6. Total fruit weight 7. Total fruit count 8. Mean fruit weight

Table 3. At the end of the first year experiments, the changes of tomato genotypes under "high temperature stress" were calculated and compared with the controls,

Parameters	Point
0-5 Scale Evaluation	15
Green light fresh	10
Dried weights	15
leaf temperature	15
leaf area index (LAI)	15
Total fruit weight	15
Total fruit count	10
Mean fruit weight	5
Total	**100**

And for the other second experiment of the second year, a period of time, which was 38 days later from the first experiment, was chosen as the sowing date. The measurements were made 2 times. The experiment randomized blocks were arranged in 4 repetitions in the experiment design and I such a way there would be 10 plants in each prepetition. While sowing tomatoes, the row interval and the intrarow were arranged 120 cm and 50 cm respectively. In this case, the intensive of sowing became 1666 plants/minute.

Parameters Measured and Analyses Made in the Plants in the Second Year Experiment,

Scale Evaluation (Daşgan and et. al, 2010)
The points were given between 0-5 according to the degree of damaging of the plants from high temperature stress.

Leaf Area Index (m2/m2)
The leaf area index of the plant canopy was measured over the living plants in the field.

Determination of Leaf Water Potential (MPa)
By taking Soilmoisture brand portable pressure ring to the field during the experiments, water potential in the plants' 4th leaves as from their growing ends was determined in MPa.

Determination of Leaf Osmotic Potential (MPa)
The 3rd leaves from 3 plants of each genotype in every repetition were used for this purpose. 1 g sample was taken by weighing from the leaves and homogenized by adding 19 g distilled water and kept at -20 ^{o}C. When the measurement would be made, the samples solved were passed through a filter of 0.45 µm in precision. 50 µl were taken from the samples obtained after the process of filtration was read on the basis of freezing point through Knauer brand k-7400 model osmometer device. The values wererecorded in mOsmol. During calculation, these values were converted into MPa unit.

Determination of leaf stoma conductance (mmol m-2 s-1)
During the experiments, by using Delta T Devices brand AP4 model portable porometer, the gas passing from stomas in 3rd-4th leaves as from their growing ends was recorded.

Damaging of Membrane in Leaf Cells (%)

4th leaves of 3 plants as from their tops in every repetition were used for this purpose. It was calculated with the measuring of the electrolyte giving out from the cell (Fan and Blake, 1994; Dlugokecka). After the leaf discs were waited for 4 hours within de-ionized water, EC was measured. After the same discs were waited for 10 minutes at 100ºC, EC value was re-measured.

Membrane Damaging Index = (Lt – Lc / 1-Lc) x 100

Here, Lt: EC of the leaf in the dryness stress before sterilizing in an autoclave device;

Lc: EC of the leaf in the dryness stress before sterilizing in an autoclave device

Potassium and Calcium Concentration in Fruit (µg / g dry weight or %)

The fruit samplings were made from tomato genotypes in every repetition. These fruits which were washes, dried and ground, 200 mg was taken from the samples so ground was burned in the ash furnace at 550ºC for a period of 5 hours. The ash which occurred after the process of burning was solved with 33% HCl acid and filtered through a blue band leaching paper. The samples so filtered were diluted at the rate of 1/10 with 3.3% HCl acid. In the examinations made on the diluted samples through Varian brand FS220 model Atomic Absorption Spectrophotometer device, the concentrations of K and Ca elements were determined.

Determination of Leaf Temperature (ºC)

The leaf temperatures were determined in the 3rd-4th leaves as from their growing ends in ºC with the help of an infrared thermometer and recorded accordingly.

Table 4. At the end of the second year, the changes of tomato genotypes under high temperature stress were calculated according to the controls; the parameters used in scaling made weighted upon them and the points which they gained according to the level of importance.

Parameters	Point
leaf water potential	9
leaf osmotic potential	9
leaf stoma conductance	16
leaf temperature	14
membrane damage on leaf cells	10
Ca concentrations in leaf	6
K concentrations in leaf	6
Ca concentrations fruit	6
Kconcentrations fruit	6
leaf area index	12
0-5 scale	6
Total	100

Doing weighting rating changes in the studied parameters of the tomato genotypes which were growed with High Temperature stress against the ones which were growed without High Temperature stress were calculated. With these rates of change, a “ weighting rating” method improved. While weighting rating, the parameters which were used, and the points the parameters took according to the level of importance were selected to as : 0-5 scale evaluation of visual damage of high temperature stress on green night to plant 6 point , leaf stoma conductance 16 points , membrane damage on leaf cells 10 points, leaf water potential 9 points , leaf osmotic potential 9 points, leaf temperature 12 points, leaf area index 12 points, K concentrations in leaf 6 points , Ca concentrations in leaf 6 points, K concentrations in fruit 6 points, Ca concentrations fruit 6 points, the changes of the parameters entering the weighting rating, acording to control were averaged in both High Temperature stress applications. These avareges were multipliedwith the grade that the parameters took in the weighting heighting. After multiplied with each parameters grade, all parameters were collected. According to the total grades, 24 tomato genotypes were arranged from the one which took the highest grade to the one which took the lowest grade (Table 8).

3. Results

The leaf temperature values recorded the control and high temperature stress application of 131 different tomato genotypes in the first year experiments are shown in the Table. While average leaf temperature value of the control plants was recording as 25.07 ºC, it can be said that this situation has an effect decreasing transpiration because the plants under high temperature stress generally tend to close the leaf stomas, and therefore the leaf temperature tends to increasing in the stress plants. The leaf area index values as recorded in the tomato genotype's control and high temperature stress applications are indicated in the (Table 5).

Table 5. Of the first year tomato genotypes under the control conditions and high temperature stress application; leaf temperature, leaf area index, Green Component Fresh Weight, Green Component Dry Weight, Scale, Total Output of Fruit, Total Number of Fruit, Average Fruit Weight values and rate of change in % according to the control.

parametre	Control		High Temperature stress		change compared to control (%)
leaf temperature (ºC)	mean	25.07	mean	29.43	18.03
leaf area index (m^2/m^2)	mean	5.26	mean	4.06	-21.49
Green Component Fresh Weight (g/ plant)	mean	1922	mean	1474	-18.14
Green Component Dry Weight (g/ plant)	mean	197.08	mean	87.04	-53.49
Scale	-		mean	3,04	-
Total Output of Fruit (g/ plant)	Mean	357	mean	264	-25.50
Total Number of Fruit (number per /plant)	Mean	8.34	mean	6.08	-21.46
Average Fruit Weight (g)	mean	53.35	mean	50.46	2.90

As expected that the high temperature stress is associated with the control in the plants, it has decreased the tomatoes' leaf area. And the reason of this is thought to result from that the growth of the plants slows down under the high temperature stress conditions. Together with that the slowing down of the growth of the plants under the high temperature stress conditions, it can be seen that there are also some decreases in the number of leaves. The tomato plants were pulled up when their experiment periods were completed, and the plants' green component fresh weights were weighed and recorded accordingly. The tomato plants were pulled up when their experiment periods were completed, and the plants' green component dried weights were weighed and recorded accordingly. By looking at the plants' symptoms in green component, the points between 0 and 50 were given. In this scale, it is evaluated 0 to be the best and 5 to be the worst (Table 7). Any scale evaluation was not made for the control plants. At the abiotic stress studies which were made at tomato (Daşgan, et al, 2002), at pepper (Aktaş, et al, 2006), at beans (Daşgan and Koç, 2009), and at melon (Kuşvuran, 2010), they have reported that it has been observed that there are significant variations among the genotypes in terms of the scale values, and that the scale evaluation is also of importance apart from other morphological and physiological parameters.

Table 6. After the process of weighed scaling of the rates of change of the parameters recorded in the tomato genotypes grown under high temperature stress in the first year experiment according to the control was completed, the aligning towards the genotype taking the lowest point from the genotype taking the highest point.

*G.N	1th	*G.N	2th	*G.N	3th	*G.N	4th
Tom-225	**4558**	**Tom-162**	**-1733**	**Tom-151**	**-2313**	**Tom-224**	**-2814**
Tom-165	**3496**	**Tom-172**	**-1763**	**Tom-29**	**-2335**	**Tom-109**	**-2833**
Tom-173	**3354**	**Tom-27**	**-1766**	**Tom-204**	**-2348**	**Tom-157**	**-2836**
Tom-114	2075	**Tom-143**	-1834	**Tom-13**	-2360	**Tom-122**	-2856
Tom-115	1999	**Tom-121**	-1838	**Tom-11**	-2371	**Tom-118**	-2873
Tom-119	1922	**Tom-46**	-1841	**Tom-176**	-2377	**Tom-117**	-2887
Tom-47	1743	**Tom-210**	-1910	**Tom-34**	-2415	**Tom-145**	-2888
Tom-233	1548	**Tom-144**	-1943	**Tom-152**	-2437	**Tom-208**	-2892
Tom-111	1486	**Tom200-2**	-1950	**Tom-113**	-2457	**Tom-179**	-2902
Tom-174	1393	**Tom-227**	-1951	**Tom-8**	-2460	**Tom-21**	-2912
Tom-19	252	**Tom-221**	-1963	**Tom-110**	-2468	**Tom-214**	-2917
Tom-108	153	**Tom-30**	-1980	**Tom-18**	-2471	**Tom-220**	-2927
Tom-232	5	**Tom-3**	-1987	**Tom-164**	-2474	**Tom-212**	-2934
Tom-40	-169	**Tom-17**	-1997	**Tom-170**	-2490	**Tom-169**	-2944
Tom-223	-255	**Tom-171**	-2010	**Tom-20**	-2519	**Tom-48**	-2949
Tom-230	-265	**Tom-218**	-2060	**Tom-207**	-2522	**Tom-231**	-2949
Tom201B	-482	**Tom-229**	-2060	**Tom-226**	-2528	**Tom-9**	-2952
Tom-211	-615	**Tom-37**	-2070	**Tom-28**	-2557	**Tom-215**	-3012
Tom-26	-896	**Tom-219**	-2071	**Tom-163**	-2591	**Tom-32**	-3039
Tom-161	-935	**Tom-43**	-2080	**Tom-22**	-2596	**Tom-168**	-3074
Tom-14	-940	**Tom200-1**	-2081	**Tom-2**	-2625	**Tom-140**	-3132
Tom-228	-998	**Tom-6**	-2089	**Tom-146**	-2632	**Tom-147**	-3146
Tom-177	-1020	**Tom-35**	-2095	**Tom-106**	-2639	**Tom-16**	-3295
Tom-10	-1035	**Tom-31**	-2117	**Tom-45**	-2650	**Tom-142**	-3297
Tom-199	-1143	**Tom-33**	-2123	**Tom-216**	-2654	**Tom-36**	-3301
Tom-206	-1195	**Tom-24**	-2145	**Tom-222**	-2655	**Tom-44**	-3485
Tom-202	-1411	**Tom-38**	-2183	**Tom-4**	-2703	**Tom-213**	-3503
Tom-39	-1501	**Tom-123**	-2188	**Tom-15**	-2704	**Tom-120**	-3517
Tom-112	-1551	**Tom-41**	-2212	**Tom-23**	-2735	**Tom-217**	-3578
Tom-205	-1586	**Tom-149**	-2220	**Tom-139**	-2738	**Tom-166**	-3603
Tom-12	-1616	**Tom-150**	-2231	**Tom-25**	-2745	**Tom-116**	-3736
Tom-5	-1646	**Tom-209**	-2234	**Tom-167**	-2757	**Tom-175**	-3921
Tom201A	-1655	**Tom-1**	-2295	**Tom-7**	-2759	-	-

***G.N (**Genotypes Number)

Table 7. In the applications of the second year tomato genotypes' rates in different periods of time under the control conditions and temperature stress conditions; 0-5 scale evaluation of visual damage of high temperature stress on green night to plant.

Genotype No.	High Temperature stress
Tom-10	0.43 m
Tom-12	3.70 d
Tom-14	3.08 e
Tom-19	2.75 f
Tom-20	3.00 e
Tom-26	1.18 l
Tom-40	4.00 b
Tom-47	1.80 i
Tom-108	3.75 cd
Tom-111	3.10 e
Tom-114	3.80 cd
Tom-115	2.08 h
Tom-116	4.03 ab
Tom-119	3.10 e
Tom-165	2.08 h
Tom-173	3.85 c
Tom-175	4.15 a
Tom-201B	2.05 h
Tom-211	2.43 g
Tom-225	2.80 f
Tom-230	1.43 k
Tom-232	2.83 f
Tom-233	2.05 h
F15656	1.63 j
Mean	**2.71**
LSD$_{0.05}$	0.13

In the second year, the overall average value of leaf area index under high temperature of tomato genotypes tested has been 3.92m2 / m2 and the average of control plants has been 5.30m2 / m2.Decrease in leaf area indices has occurred as 24.46% according to control of tomato genotypes under high temperature stress.Leaf area index values and plant green component are directly proportional. And the overall average value of leaf temperature under high temperature of tomato genotypes tested has been 33,77 ^{0}C and the average of control plants has been 29,45 ^{0}C.İncrease in leaf temperature indices has occurred as 14,79 % according to control of tomato genotypes under high temperature stres (Table 8). Cornic and Ghashgaie have investigated the leaf temperature in their experimentation with beans and it is found that the stomata are opened with a decrease in leaf temperature (Cornic and Ghashgaie 1991).

Table 8. In the applications of the second year tomato genotypes' rates in different periods of time under the control conditions and temperature stress conditions; Leaf Temperature, Leaf Area Index, rate of Changes in % according to the control.

Genotype No.	Control Leaf Temperature (ºC)	Control Leaf Area Index (m^2/m^2)	High Temperature stress Leaf Temperature (ºC)	High Temperature stress Leaf Area Index (m^2/m^2)	Change compared to control (%) Leaf Temperature	Change compared to control (%) Leaf Area Index
Tom-10	28.89 j-l	6.13 d	32.90 g-ı	4.02 h-k	13.88	-34.42
Tom-12	29.48 g-ı	7.58 a	31.36 l	3.29 lm	6.38	-56.60
Tom-14	28.80 k-m	4.13 ıj	34.08 cd	3.08 mn	18.33	-25.42
Tom-19	29.11 ı-k	3.84 kl	34.50 c	3.82 ı-k	18.52	-0.52
Tom-20	30.23 c	5.42 f	32.41 ıj	4.04 h-j	7.21	-25.46
Tom-26	27.34 n	6.18 d	32.20 j-k	5.68 a	17.78	-8.09
Tom-40	29.14 ı-k	4.55 h	37.24 a	4.09 g-ı	27.80	-10.11
Tom-47	29.80 d-g	7.45 a	35.48 b	4.22 f-h	19.06	-43.36
Tom-108	28.64 lm	5.26 f	33.73 d-f	3.76 j-k	17.77	-28.52
Tom-111	31.71 a	5.36 f	31.74 kl	4.35 e-g	0.09	-18.84
Tom-114	30.11 cd	5.42 f	33.71 d-f	3.72 k	11.96	-31.37
Tom-115	28.56 lm	4.65 h	33.90 c-e	3.84 ı-k	18.70	-17.42
Tom-116	30.13 cd	4.89 g	33.83 d-e	4.48 d-f	12.28	-8.38
Tom-119	28.55 lm	7.03 b	34.04 cd	5.14 b	19.23	-26.88
Tom-165	30.05 c-e	4.21 ı	33.00 g-ı	3.18 l-n	9.82	-24.47
Tom-173	29.30 hı	4.64 h	34.08 cd	4.14 c-e	16.31	-2.11
Tom-175	30.18 cd	6.51 c	35.34 b	4.87 bc	17.10	-25.19
Tom-201B	29.59 f-h	6.21 d	34.34 cd	2.91 n-o	16.05	-53.14
Tom-211	29.90 c-f	6.16 d	32.59 h-j	4.25 f-h	9.00	-31.01
Tom-225	31.23 b	3.95 j-l	35.70 b	3.39 l	14.31	-14.18
Tom-230	28.66 lm	3.78 l	33.09 f-h	3.31 l-m	15.46	-12.43
Tom-232	29.73 e-g	4.02 ı-k	32.74 g-j	2.49 p	10.12	-38.06
Tom-233	29.25 h-j	3.99 j-l	35.23 b	2.76 op	20.44	-30.83
F15656	28.43 m	5.87 e	33.36 e-g	4.68 cd	17.34	-20.27
Mean	**29.45**	**5.30**	**33.77**	**3.92**	**14,79**	**-24.46**
$LSD_{0.05}$	0.38	0.21	0.64	0.30		

In the second year, the overall average value of leaf osmotic potential under high temperature of tomato genotypes tested has been 3,47 Mpa and the average of control plants has been -2,44 Mpa. İncrease in leaf osmotic potential has occurred as 36,59% according to control of tomato genotypes under high temperature stres. And the overall average value of leaf water potential under high temperature of tomato genotypes tested has been -0.64 Mpa and the average of control plants has been -0,31 Mpa. İncrease in leaf water potential has occurred as 11,19 % according to control of tomato genotypes under high temperature stres (Table 9). Xu et al. (2009) have determined that the osmotic potential of leaves in control applications has been higher than in stress application.Ghebrehiwot et al. (2008) have investigated the effect of smoke-water and smoke-isolated butenolithin on Eragrostis spectabilistohum sprouting and seedling growth in different temperatures, light conditions and osmotic potentials.The average leaf water potential of tomato genotypes at high temperature in the experiment has been -0.64 MPa, while the average of control plants has been -0.31 MPa.As the negative MPa value in leaf water potential moves away from zero, the amount of water in the leaves decreases as much as. Karipin et al. (2009) have found that the increase in water stress conditions has resulted in a decrease in leaf water potential, thus leaf water potential increases as stress increases.The results of this study have shown parallelism to our study.Morales et al. (2004) have stated that high temperature stress has resulted in a decrease in plant leaf water potential by preventing the plant growth.

Table 9. In the applications of the second year tomato genotypes' rates in different periods of time under the control conditions and temperature stress conditions; leaf water potential, Leaf Osmotic Potential, rate of Changes in % according to the control.

Genotype No.	Control Leaf Osmotic Potential (MPa)	Control leaf water potential (MPa)	High Temperature stress Leaf Osmotic Potential (MPa)	High Temperature stress leaf water potential (MPa)	Change compared to control (%) Leaf Osmotic Potential	Change compared to control (%) leaf water potential
Tom-10	-2.33 b-f	-0.30 g	-3.23 b-d	-0.64 hı	38.63	113.63
Tom-12	-2.51 g-k	-0.34 h	-3.27 d	-0.79 l	30.28	132.19
Tom-14	-2.43 d-j	-0.31 g	-2.97 a	-0.72 k	22.22	129.15
Tom-19	-2.86 m	-0.25 de	-3.04 a	-0.56 ef	6.29	124.81
Tom-20	-2.33 b-f	-0.37 ı	-3.09 ab	-0.71 k	32.62	92.49
Tom-26	-2.17 ab	-0.47 m	-3.31 de	-0.60 gh	52.53	27.47
Tom-40	-2.60 j-l	-0.31 g	-3.31 de	-0.59 fg	27.31	93.99
Tom-47	-2.11 a	-0.45 l	-3.08 a	-0.69 jk	45.97	54.63
Tom-108	-2.43 d-j	-0.39 j	-3,01 a	-0.64 hı	23.87	41.41
Tom-111	-2.22 a-c	-0.47 lm	-3.25 cd	-0.66 ıj	46.40	63.62
Tom-114	-2.70 lm	-0.27 f	-3.57 fg	-0.52 c-e	32.22	91.62
Tom-115	-2.50 f-k	-0.34 h	-3.27 d	-0.88 n	30.80	157.97
Tom-116	-2.27 a-d	-0.34 h	-3,62 g	-0.85 mn	59.47	152.13
Tom-119	-2.57 ı-l	-0.43 k	-3.98 j	-0.83 lm	54.86	94.15
Tom-165	-2.46 e-k	-0.21 b	-3.81 h	-0.49 bc	54.88	135.11
Tom-173	-2.50 f-k	-0.27 ef	-3.26 d	-0.47 ab	30.40	72.98
Tom-175	-2.32 b-f	-0.28 f	-3.98 i	-0.79 l	71.55	186.81
Tom-201B	-2.35 c-g	-0.21 b	-3.48 fg	-0.51 b-d	48.09	143.68
Tom-211	-2.34 b-g	-0.17 a	-3.26 d	-0.43 a	39.32	160.93
Tom-225	-2.61 kl	-0.28 f	-3.43 e-f	-0.53 c-e	31.42	90.04
Tom-230	-2.41 d-ı	-0.24 cd	-2.95 a	-0.54 de	22.41	126.56
Tom-232	-2.60 j-l	-0.25 cd	-3.10 a-c	-0.52 k	19.23	108.11
Tom-233	-2.54 h-l	-0.23 bc	-3.26 d	-0.55 ıj	28.35	139.35
F15656	-2.37 c-h	-0.24 cd	-3.06 a	-0.48 b	29.11	99.50
Mean	**-2.44**	**-0.31**	**-3.47**	**-0.64**	**36.59**	**115.19**
LSD$_{0.05}$	0.17	0.019	0.15	0.041		

4. Discussion

The most important factor restricting the high temperature vegetative production is abiotic stress factor. The increase occurring in hot regions together with the global climatic change has been threatening agriculture and agricultural lands. When leaf stoma conductivity, membrane damaging in leaves, K and Ca concentrations in leaves and fruits, leaf osmotic potential and parameters were studied, while the variations were observed among the genotypes as a result of the both dryness stresses, it was seen that the changes were more important according their own controls. In the second year, the overall average value of Ca concentrations in leaf under high temperature of tomato genotypes tested has been 5,37 % and the average of control plants has been 6,24 %. Decrease in Ca concentrations in leaf has occurred as 11,22 % according to control of tomato genotypes under high temperature stres. And the overall average value of Ca concentrations in fruit under high temperature of tomato genotypes tested has been 0,29 % and the average of control plants has been 0,34 %. Decrease in Ca concentrations in fruit has occurred as 14,72 % according to control of tomato genotypes under high temperature stres The best performers in terms of Ca concentrations in leaf have been selected by taking into account the % change rates of the tomato genotypes in the experiment in comparison to their control in high temperature stress application.These genotypes are respectively; Tom115 (33.97%), Tom14 (30.11%), and the most affected genotypes from the percentage change in the high temperatures stress compared to control have been Tom175 (-40.00%), Tom173 (-39.97%) and Tom165 (-38.19%).Genotypes that have been affected reasonably according to the percentage changes have been Tom26 (-25.34%), Tom108 (-28.24%), F15656 (-29.47%), Tom119 (-29.74%) and Tom165 (-38.19%). The best performers in terms of Ca concentrations in fruit have been selected by taking into account the % change rates of the tomato genotypes in the experiment in comparison to their control in high temperature stress application.These genotypes are respectively; Tom14 (% 10.71), Tom225 (% 10.34),Tom19 (% (10.34), Tom26 (% 3.45), and the most affected genotypes from the percentage change in the high temperatures stress compared to control have been Tom12 (% -47.73), Tom20 (% -37.93), Tom211 (% -31.43). Genotypes that have been affected reasonably according to the percentage changes have been Tom119 (% -18.75),Tom175 (% -23.81),Tom108 (% -23.53),Tom10 (% -25.00), (Table 10).

In the second year, the overall average value of K concentrations in leaf under high temperature of tomato genotypes tested has been 2,32 % and the average of control plants has been2,64 %. Decrease in K concentrations in leaf has occurred as 8,58 % according to control of tomato genotypes under high temperature stres. And the overall average value of K concentrations in fruit under high temperature of tomato genotypes tested has been 2,85 % and the average of control plants has been 3,40 %. Decrease in K concentrations in fruit has occurred as 15,86 % according to control of tomato genotypes under high temperature stres. control in high temperature stress application.These genotypes are respectively; Tom12 (% 7.25),Tom225 (% 5.71),Tom233 (% 2.78),Tom19 (% 2.28), and the most affected genotypes from the percentage change in the high temperatures stress compared to control have been Tom108 (% -25.71), Tom 114 (% -29.72) veTom111 (% -21.72). Genotypes that have been affected reasonably according to the percentage changes have been Tom211 (% -7.43),Tom173 (% -9.70), F15656 (% -10.48), Tom119 (% -10.97). And the best performers in terms of K concentrations in fruit have been selected by taking into account the % change rates of the tomato genotypes in the experiment in comparison to their control in high temperature stress application.These genotypes are respectively; Tom173 (% -3.88), Tom119 (% -6.75),Tom116 (% -8.02), Tom201B (% -9.26),and the most affected genotypes from the percentage change in the high temperatures stress compared to control have been Tom232 (% -26.83), Tom 26 (% -24.93) ve Tom111 (% -23.36). Genotypes that have been affected reasonably according to the percentage changes have been Tom175 (% -15.27),Tom40 (% -16.16),Tom211 (% -16.14),Tom14 (% -17.44), (Table 11).

Table 10. In the applications of the second year tomato genotypes' rates in different periods of time under the control conditions and temperature stress conditions; Calcium (Ca) Concentration in Leaf, Calcium (Ca) Concentration in Fruit, rate of Changes in % according to the control

Genotype No.	Control (Ca) Concentration in Leaf (%)	Control (Ca) Concentration in Fruit (%)	High Temperature stress (Ca) Concentration in Leaf (%)	High Temperature stress (Ca) Concentration in Fruit (%)	Change compared to control (%) (Ca) Concentration in Leaf	Change compared to control (%) (Ca) Concentration in Fruit
Tom-10	4.45 k-l	0.32 h-m	5.78 d-e	0.24 g-h	29.89	-25.00
Tom-12	3.76 m	0.44 a	4.58 h-j	0.23 h-i	21.81	-47.73
Tom-14	4.35 l	0.28 m	5.66 d-e	0.31 a-d	30.11	10.71
Tom-19	5.53 g-i	0.29 k-m	5.69 d-e	0.32 a-b	2.89	10.34
Tom-20	3.61 m	0.29 j-m	3.74 k-l	0.18 i	3.60	-37.93
Tom-26	6.55 d-e	0.29 k-m	4.89 f-i	0.30 a-f	-25.34	3.45
Tom-40	6.18 e-f	0.29 l-m	5.20 e-h	0.25 f-h	-15.86	-13.79
Tom-47	6.76 d	0.30 i-m	6.72 b-c	0.26 c-h	-0.59	-13.33
Tom-108	6.94 c-d	0.34 f-k	4.98 f-h	0.26 e-h	-28.24	-23.53
Tom-111	8.43 a	0.34 e-k	8.76 a	0.30 a-f	3.91	-11.76
Tom-114	6.94 c-d	0.35 e-j	6.20 c-d	0.32 a-b	-10.66	-8.57
Tom-115	5.21 h-j	0.34 f-k	6.98 b	0.29 b-g	33.97	-14.71
Tom-116	4.99 i-k	0.32 g-l	3.96 j-l	0.23 g-i	-20.64	-28.13
Tom-119	5.75 f-h	0.32 i-m	4.04 j-l	0.26 d-h	-29.74	-18.75
Tom-165	6.86 c-d	0.31 i-m	4.24 i-k	0.30 a-f	-38.19	-3.23
Tom-173	5.93 f-g	0.38 c-g	3.56 l	0.34 a	-39.97	-10.53
Tom-175	6.80 d	0.42 a-c	4.08 j-l	0.32 a-c	-40.00	-23.81
Tom-201B	6.69 d-e	0.39 b-e	5.24 e-g	0.32 a-b	-21.67	-17.95
Tom-211	4.67 j-l	0.35 d-i	3.78 k-l	0.24 f-h	-19.06	-31.43
Tom-225	8.49 a	0.29 j-m	5.56 d-f	0.32 a-b	-34.51	10.34
Tom-230	7.39 b-c	0.39 b-d	6.64 b-c	0.35 a	-10.15	-10.26
Tom-232	7.02 c-d	0.36 c-h	6.50 b-c	0.33 a-b	-7.41	-8.33
Tom-233	8.89 a	0.38 b-f	6.76 b-c	0.33 a-b	-23.96	-13.16
F15656	7.67 b	0.42 a-b	5.41 e-g	0.31 a-f	-29.47	-26.19
Mean	**6.24**	**0,34**	**5.37**	**0,29**	**-11.22**	**-14.72**
LSD$_{0.05}$	0.56	0,048	0.65	0,057		

Table 11. In the applications of the second year tomato genotypes' rates in different periods of time under the control conditions and temperature stress conditions; Potassium (K) Concentration in Leaf, Potassium (K) Concentration in Fruit, rate of Changes in % according to the control.

Genotype No.	Control (K) Concentration in Leaf (%)	Control (K) Concentration in Fruit (%)	High Temperature stress (K)Concentration in Leaf (%)	High Temperature stress (K)Concentration in Fruit (%)	Change compared to control (%) Concentration in Leaf	Change compared to control (%) Concentration in Fruit
Tom-10	3.12 a-b	3.89 a	2.67 d-e	3.06 a-d	-14.42	-21,34
Tom-12	2.07 j	3.57 a-f	2.22 f-i	2.89 b-f	7.25	-19,05
Tom-14	2.65 e-g	3.44 b-h	2.22 f-i	2.84 c-f	-16.23	-17,44
Tom-19	2.19 i-j	3.34 c-h	2.24 f-i	2.59 f	2.28	-22,46
Tom-20	2.74 d-f	3.03 h	2.37 f	2.69 d-f	-13.50	-11,22
Tom-26	2.77 d-f	3.61 a-e	2.71 c-e	2.71 d-f	-2.17	-24,93
Tom-40	2.46 g-h	3.28 d-h	2.38 f	2.75 d-f	-3.25	-16,16
Tom-47	2.48 g-h	3.56 a-f	2.03 i-j	3.03 a-e	-18.15	-14,89
Tom-108	3.15 a-b	3.67 a-d	2.34 f-g	2.86 b-f	-25.71	-22,07
Tom-111	2.44 g-i	3.81 a-b	1.91 j	2.92 b-f	-21.72	-23,36
Tom-114	2.86 c-e	3.66 a-d	2.01 g-j	2.86 c-f	-29.72	-21,86
Tom-115	2.63 e-g	3.07 g-h	2.32 f-h	2.62 f	-11.79	-14,66
Tom-116	3.10 a-c	3.49 a-g	3.12 a	3.21 a-c	0.65	-8,02
Tom-119	3.10 a-c	3.26 d-h	2.76 b-d	3.04 a-e	-10.97	-6,75
Tom-165	3.16 a-b	3.74 a-c	2.81 b-d	3.35 a	-11.08	-10,43
Tom-173	3.30 a-b	3.39 b-h	2.98 a-c	3.26 a-b	-9.70	-3,83
Tom-175	2.99 b-d	3.34 c-h	2.95 a-d	2.83 c-f	-1.34	-15,27
Tom-201B	2.58 f-g	3.24 d-h	2.43 e-f	2.94 b-f	-5.81	-9,26
Tom-211	3.23 a-b	3.16 f-h	2.99 a-b	2.65 e-f	-7.43	-16,14
Tom-225	2.10 j	3.03 h	2.22 f-i	2.61 f	5.71	-13,86
Tom-230	2.07 j	3.40 b-h	1.93 j	2.69 d-f	-6.76	-20,88
Tom-232	2.10 j	3.28 d-h	2.01 i-j	2.40 b-f	-4.29	-26,83
Tom-233	1.80 k	3.17 e-h	1.85 j	2.87 b-f	2.78	-9,46
F15656	2.29 h-j	3.09 g-h	2.05 h-j	2.77 d-f	-10.48	-10,36
Mean	**2.64**	**3,40**	**2.32**	**2,85**	**-8.58**	**-15.86**
LSD$_{0.05}$	0.26	0.39	0.28	0.44		

In the second year, the overall average value of membrane damage on leaf cells under high temperature of tomato genotypes tested has been 20,54 % and the average of control plants has been 13,97 %. İncrease in membrane damage on leaf cells has occurred as 44,70 % according to control of tomato genotypes under high temperature stres. And the overall average value of leaf stoma conductance under high temperature of tomato genotypes tested has been 174 mmol/m^2/s and the average of control plants has been 536 mmol/m^2/s. Decrease in leaf stoma conductance has occurred as 66 % according to control of tomato genotypes under high temperature stres (Table 12). Mathieu et al have reported that under high-temperature stress conditions, it can be seen decreases in leaf numbers together with slowing down of plant growth, and the greater the total number of leaves and hence the greater the surface area, the greater the amount of water lost through transpiration, for this reason, plants are trying to prevent water loss by keeping their stomata as closed as possible under high temperature stress and pulling the transpiration to a minimum with shrinkage of leaf areas (Mathieu et al 2014). Vermeulen et al have found that when the stomata are closed, the temperature of the leaves has increased, when the leaf temperature has decreased, stomata are opened and under these conditions, the photosynthesis continues its normal functioning (Vermeulen et al 2007). Katarzania et al. (2010) have stated that the membrane damage in stress conditions is increased in the study conducted by Kuşvuran (2010).Genping et al. (1996) have emphasized that corn plants have increased cell damage under high temperature stress conditions.Talve Shannor (1983) has found that the membrane damage at higher temperatures in tomato plants has been greater in his study. Zhou et al. (2015) have reported that in high temperature stress of tomato plant, the stoma conductance has decreased with respect to the control, the main cause is the decrease of transpiration and deficiency in accumulation of CO2.

Table 12. In the applications of the second year tomato genotypes' rates in different periods of time under the control conditions and temperature stress conditions; leaf stoma conductivity, leave water potential, Damaging of Membrane in Leaf Cells, rate of Changes in % according to the control.

Genotype No.	Control Damaging of Membrane (%)	Control leaf stoma conductivity (mmol/m2/s)	High Temperature stress Damaging of Membrane (%)	High Temperature Stress leaf stoma conductivity (mmol/m2/s)	Change compared to control (%) Damaging of Membrane	Change compared to control (%)leaf stoma conductivity
Tom-10	12.36 d-f	454.63 k	18.83 e-g	300.13 c	52,35	-33.98
Tom-12	12.27 e-f	496.75 ı	20.68 c-g	183.50 e	68,54	-63.06
Tom-14	13.48 c-f	537.75 gh	19.89 e-g	90.50 lm	47,55	-83.17
Tom-19	15.03 a-d	798.88 a	18.70 e-g	403.63 ab	24,42	-49.48
Tom-20	16.73 a	612.13 d	25.33 b	72.50 n	51,40	-88.16
Tom-26	15.51 a-c	772.13 ab	20.75 c-g	413.25 a	33,78	-46.48
Tom-40	14.15 a-f	591.63 de	17.99 fg	113.88 ıj	27,14	-80.75
Tom-47	13.05 c-f	460.75 jk	17.60 g	125.13 hı	34,87	-72.84
Tom-108	13.44 c-f	515.63 hı	21.82 b-f	291.50 c	62,35	-43.47
Tom-111	12.88 c-f	593.00 de	17.89 fg	96.50 kl	38,90	-83.73
Tom-114	14.58 a-f	416.75 l	17.86 fg	160.38 f	22,50	-61.52
Tom-115	14.14 a-f	341.63 m	20.58 c-g	107.88 jk	45,54	-68.42
Tom-116	12.47 d-f	320.00 mn	24.53 bc	83.13 mn	96,71	-74.02
Tom-119	11.99 f	654.13 c	22.01 b-f	111.50 j	83,57	-82.95
Tom-165	15.53 a-c	487.63 ıj	17.65 g	101.50 j-l	13,65	-79.19
Tom-173	14.77 a-e	558.00 fg	20.36 d-g	205.38 d	37,85	-63.19
Tom-175	14.65 a-f	297.25 n	22.50 b-e	108.88 jk	53,58	-63.37
Tom-201B	13.94 b-f	307.25 n	24.14 b-d	126.75 h	73,17	-58.75
Tom-211	16.47 ab	665.75 c	17.47 g	140.13 g	6,07	-78.95
Tom-225	15.48 a-c	239.63 o	30.78 a	92.38 lm	98,84	-61.45
Tom-230	13.47 c-f	575.50 ef	19.42 e-g	124.75 h-ı	44,17	-78.32
Tom-232	11.99 f	595.00 de	20.28 d-g	194.38 de	69,14	-67.33
Tom-233	13.45 c-f	571.63 ef	17.05 g	152.75 f	26,77	-73.28
F15656	13.49 c-f	760.88 b	18.84 e-g	398.00 b	39,66	-47.69
Mean	**13,97**	**526.01**	**20,54**	**174.93**	**44,70**	**-66,81**
LSD$_{0.05}$	2.73	30.7	4,15	12.3		

5. CONCLUSION

In this, the water using efficiency parameters were also determinant. In our works to continue hereinafter, the selection of tomato genotypes will be made, through 10 tomato genotypes and one representative spices which are the most tolerant and the fruit feature of which is the most suitable to develop the commercial spices, all which are selected to repeat the “dryness performance in land” for the third time, the experiment will be repeated. After the 2nd prepetition land experiment which we need for reinforcing the tolerance levels of the genotypes to less high temperature stress, the becoming prominent of the hopeful lines will be clarified much more.

Table 13. After the process of weighed scaling the rates of change of the physiological parameters of the tomato genotypes grown under high temperature stress as recorded and measured in the experiment according to the control was completed, the aligning towards the genotype taking the lowest point from the genotype taking the highest point.

Genotypes No	Weighting Rating Parameters
Tom-115	1059.47
Tom-119	366.03
Tom-19	168.13
Tom-14	-123.27
Tom-173	-227.08
F15656	-277.2
Tom-225	-290.07
Tom-233	-354.13
Tom-26	-430.96
Tom-165	-519.36
Tom-10	-606.04
Tom-232	-610.48
Tom-47	-618.27
Tom-114	-637.26
Tom-230	-679.01
Tom-12	-681.86
Tom-111	-733.48
Tom-40	-800.06
Tom-20	-889.45
Tom-116	-965.97
Tom-211	-969.68
Tom-175	-984.02
Tom-108	-1013.01
Tom-201B	-1190.86

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