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Grain Yield and Some Physiological Traits Associated with Heat Tolerance in Bread Wheat (*Triticum aestivum* L.) Genotypes

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ABSTRACT

This research was carried out in the experimental fields of Department of Field Crops, Faculty of Agriculture, the University of Namık Kemal in 2014-2015. In the study, totally 30 bread wheat (*Triticum aestivum* L.) genotypes (15 cultivars; early, medium-early and late-maturing; 10 lines are tolerant to the heat-temperature stress which were provided by CIMMYT-International Maize and Wheat Improvement Center), 5 lines (were taken from the same university's wheat breeding program which was collaborated by the CIMMYT) were used as an experimental material. The experiment was adjusted in a split-plot design with 3 replicates. Sowing dates (Normal (NS ≈ November 09, 2014) and Late sowing (LS ≈ January 09, 2015)) were constituted the main plots, and the genotypes constituted the sub-plots. These physiological traits ((membrane thermostability (MT), canopy temperature (CT), leaf chlorophyll content (LCC) and stomatal conductance (SC)) were measured at the LS stage due to giving much more correct, logical and meaningful results, but grain yield (GY) was fixed for all the sowing dates. Obtained findings are: The GY was varied between (4.35-6.34 t ha^{-1}) for genotypes; the MT was changed between (10.58-66.25%); the CT was realized between (17.67-22.00 ^{o}C); the LCC was varied between (38.30-53.30 SPAD) and the SC was changed between (25.20-166.80 mmol m^{-2} s^{-1}). It was observed that most of the CIMMYT originated genotypes are tolerant to high-temperature stress and most of the wheats that are grown in Thrace Region are negatively affected by the high-temperature stress.

Keywords: Heat tolerance; Canopy temperature; Chlorophyll content; Membrane thermostability; Stomatal conductance

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1. Introduction

Bread wheat (*Triticum aestivum* L.) is one of the oldest and most important staple foods of the world agriculture because of its high adaptation ability, stress-tolerant genotypes, easy transportation and storage. It has expanded in quite different ecologies, undergoes many restrictive abiotic stress factors. Abiotic stress factors negatively influence the growing and grain yield by causing morphological, physiological, biochemical and molecular changes (Wang et al 2001). The stress factors such as high temperatures, salinity, and drought which occurred as a result of global climate change that has been highly felt in recent years influence plant yield quite a lot (Mathur & Jajoo 2014).

The abiotic stress conditions such as high-temperature stress are being threatened to agriculture and agricultural fields in many regions in the world

(Wang et al 2003). In addition, cultivated many plants grow well between (15-45 °C) temperature limits, and in outside of these limits their growth, development, metabolism, quality and quantity, etc. are highly (negatively) affected depending on regions. However, under high-temperature conditions, heading or flowering of plants may be negatively influenced, abnormalities such as pollen viability reduce, flower shedding happens, respiration, photosynthesis, fertilization evens decreases, and finally all of them stop (Balla et al 2011). Besides, Kirby et al (1985) and Longnecker et al (1993) stated that plants react differently to high-temperature stress in different phenological periods, and their development and survival durations depend on genotype, growing duration, cultivation technique applications and especially the temperature of the region in which they grow.

The researches revealed that the yield decrease which is caused by high-temperature stress in the development process of wheat is related to the decrease in the number and weight of grains per spike (Hays et al 2007). Reynolds et al (1994) explained that high-temperature stress in temperate environments is an important restrictive factor in heading and grain filling periods. Balla et al (2011) identified that high temperature is the most effective factor at the early embryo development stage in bread wheat. The reductive effects of high temperature on grain yield were revealed by Bluementhal et al (1995) and Wardlaw et al (2002). Kosina et al (2007) stated that high temperatures at heading and grain filling stages caused significant decreases in grain size and weight. Mentioned researchers' studies of wheat's tolerance to high-temperature stress, to know the physiological traits of genotypes which they use to resistance high-temperature stress will increase the effectiveness of breeding programs in the improvement of new high-temperature tolerant genotypes. Reynolds et al (2001) manifested that the LCC of bread wheat and high photosynthesis rate, stay-green duration, CT, MT and SC are physiological traits that are related to wheat's tolerance to the high-temperature stress.

The aim of this study is to identify the effects of high-temperature stress on the grain yield and selected physiological traits and to detect and use them as selection criteria for the high-temperature tolerant wheat breeding programs as genitor.

2. Material and Methods

2.1. Experimental site and growing conditions

This research was conducted out at the University of Tekirdağ Namık Kemal, Faculty of Agriculture, Department of Field Crops, Tekirdağ, Turkey in the 2014-2015. Geographically, Tekirdağ district locates at latitude 40^o 36'-40^o 31' and longitude 26^o 43'-28^o 08'and asl is 10 m. The mean temperature, total rainfall and relative humidity in the 2014-2015 with long-term means are presented in Table 1. As seen in Table 1, the mean temperature in November 2014 and July 2015 is 13.1 ^{o}C and the long-term annual mean value since this period is 12.7 ^{o}C. While the total temperature is 915.4 ^{o}C during a heading-maturation stage in the NS; in the LS, total temperature becomes 1084.8 ^{o}C during the heading-maturation stage. The difference between the total temperature in a heading-maturation stage in the NS and in a heading-maturation stage in the LS is 169.4 ^{o}C. Likewise, while the total rainfall is 62.1 mm during a heading-maturation stage in the NS, in the LS total rainfall becomes 88.6 mm during the heading-maturation stage. The difference between the total rainfall in a heading-maturation stage in the NS and in a heading-maturation stage in the LS is 26.5 mm.

According to soil analysis results, experimental area's soil was clay-loam, slightly acidic (pH 6.5), limeless, and poor (1.08%) in the organic matter.

2.2. Experimental materials and design

Thirty bread wheat (*Triticum aestivum* L.) genotypes were used as experimental material in this study. They are (15) registered cultivars (Namely, Nota, Kate A1, Basribey, Gelibolu, Esperia, Saraybosna, Syrena, Flamura 85, Krasunia, Dropia, Tina, Golia, Tekirdağ, Pehlivan and Yubileynaya 100) with different phenological and agronomical traits (such as early maturing, medium-early maturing and late

Table 1- Some meteorological parameters during the 2014-2015

Months	*Mean temp. (°C)*	*Rainfall (mm)*	*Humidity (%)*	*Long-Term*		
				Mean temp. (°C)	*Rainfall (mm)*	*Humidity (%)*
November-2014	11.2	35.2	85.2	11.3	62.5	84.0
December-2014	9.3	80.3	89.1	7.2	82.5	83.6
January-2015	5.8	61.5	81.9	5.2	62.1	84.0
February-2015	6.5	90.3	86.0	5.7	64.9	81.4
March-2015	8.5	29.4	81.9	8.0	57.4	80.7
April-2015	11.4	60.1	74.3	12.2	41.5	78.2
May-2015	18.6	1.4	76.3	17.6	33.8	75.1
June-2015	21.3	58.4	73.3	22.2	35.0	72.6
July-2015	24.9	0.5	70.6	25.0	26.7	69.6
Total	-	417.1	-	-	466.4	-
Mean	13.1	-	79.8	12.7	-	78.8
Total temperature is 915.4 °C and total rainfall is 62.1 mm during a heading-maturity stage under the NS conditions.						
Total temperature is 1084.8 °C and total rainfall is 88.6 mm during a heading-maturity stage under the LS conditions.						

Source, Tekirdağ meteorology station

maturing); (10) lines obtained from the Heat Tolerance Nursery (HTN) of CIMMYT (International Maize and Wheat Improvement Center-Mexico) collection which are known as tolerant to the heat-temperature stress (CIMMYT-HTN 2014/15-1, CIMMYT-HTN 2014/15-2, CIMMYT-HTN 2014/15-3, CIMMYT-HTN 2014/15-4, CIMMYT-HTN 2014/15-5, CIMMYT-HTN 2014/15-6, CIMMYT-HTN 2014/15-7, CIMMYT-HTN 2014/15-8, CIMMYT-HTN 2014/15-9 and CIMMYT-HTN 2014/15-10) and (5) lines are (CIMMYT-HTN 2013/14-4464, CIMMYT-HTN 2013/14-4488, CIMMYT-HTN 2013/14-4489, CIMMYT-HTN 2013/14-4490 and CIMMYT-HTN 2013/14-4492). Except them, Basribey bread wheat was used as a standard "tolerant" cultivar to the high-temperature stress in this study.

On the other hand, to be able to synchronize of growth stages, the experiment was arranged in a split-plot design with 3 replicates at two sowing dates (Normal sowing date ≈ 09 November 2014 and Late sowing time date ≈ 09 January 2015). Sowing dates were adjusted as main plots and genotypes were allotted as subplots. Sowing procedure was done in 1.2 m x 5 m plots, consisted of 6 rows spaced 20 cm apart. The seeding rate was arranged as 500 seeds m^{-2} and 20.20.0 composed fertilizer was used which include 50 kg ha^{-1} pure nitrogen (N) and 50 kg ha^{-1} pure phosphor (P_2O_5) was with the sowing. In addition to this, 60 kg ha^{-1} pure N as urea fertilizer (46% N) at the tillering stage and 50 kg ha^{-1} pure N as ammonium nitrate fertilizer (33% N) at the stem elongation stage were also given. Moreover, chemical control method was applied between tillering and stems elongation stages in spring considering the maturation condition and density of the prevalent weeds such as ryegrass (*Lolium multiflorum*), creeping thistle (*Cirsium arvense*), finger speedwell (*Veronica triphyllos*), wild mustard (*Sinapis arvensis*). All plots were harvested with a HEGE-160 combine harvester on the July 2015 during the maturity.

2.3. Measurement of grain yield and physiological traits

Grain Yield (t ha^{-1}): After 0.5 m pieces were cut from the beginnings and endings of the plots at the maturity (Zadoks Growth Stage (ZGS) 93; Zadoks et al 1974), and obtained values were transformed into t ha^{-1}. In addition, all the physiological traits presented below were a measured at the post-anthesis periods of the plants (ZGS 69; Zadoks et at 1974).

Membrane Thermostability (MT-%): It was fixed as (%) in the fully-developed flag leaves according to Reynolds et al (2001).

Canopy Temperature (CT- °C): It was measured with a portable infrared thermometer (Extech Mini IR Thermometer Modell 42500) as °C (Reynolds et al 2001). It was taken as two measurements per plot during the day between (11:00h to 14:00h).

Leaf Chlorophyll Content (LCC-SPAD): It was measured with "Konica Minolta SPAD-502 Plus" portable chlorophyll meter in the fully-developed flag leaves and determined as "SPAD value" (Pask et al 2012). It was taken three averages of five leaves per plot, and they were done from 11:00h to 14:00h.

Stomatal Conductance (SC-mmol m^{-2} s^{-1}): It was measured with a portable leaf porometer (Decagon SC-1 Leaf Porometer) and determined as mmol m^{-2} s^{-1} by calculating the average (Pask et al 2012). It was taken three readings on different, randomly chosen leaves from each plot. Readings were done from 11:00h to 14:00h.

2.4. Statistical analysis

All the data obtained from this experiment were subjected to variance analysis (ANOVA) using MSTAT-C statistical software, and mean values were compared using Duncan's Multiple Range Test (Steel & Torrie 1960).

3. Results and Discussion

In the experiment, obtained data for the GY were combined and analyzed to compare the GY performance of bread wheat genotypes under the NS and LS (heat-temperature stress). Whereas, the physiological traits associated with heat tolerance mechanisms which MT, CT, LCC and SC were determined under the LS conditions (Table 3).

Grain yield (t ha^{-1}): The effect of sowing date for the GY was not statistically significant, but genotype and sowing date x genotype interaction was statistically significant ($P \leq 0.01$) in terms of the GY (Table 2). Although the difference between sowing dates for the GY was not statistically significant, the mean of GY which was determined as 5.76 t ha^{-1} in the NS, decreased around 7.8% in the LS and was determined as 5.31 t ha^{-1}. It was taken more rainfall in the LS than NS during heading-maturity stages. However, as it can be understood from Table 1, plants were exposed 169.4 °C higher temperature during heading-maturity stages in the LS comparing to the NS. This situation caused stress, early senescence and decrease in grain filling stage. Thus, in the LS, the lower GY (5.31 t ha^{-1}) was obtained with the influence of high-temperature stress. Similarly, Mohammadi et al (2004) found out that the high-temperature stress at the post-anthesis stage of wheat decreases the grain filling duration, and the grain and head weight, but it does not influence of grain number per spike. Din et al (2010) discovered that the GY decreased 53.75% at the LS conditions. Modhej et al (2015) revealed that the high-temperature stress occurred at the LS conditions as decreases in the GY 30%, and 1000 grain weight.

In the research, the mean of the GY (for the genotypes) varied between 4.35 to 6.34 t ha^{-1}. The highest GY was obtained from CIMMYT-HTN 2014/15-5 (6.34 t ha^{-1}). It was followed by Basribey (6.22 t ha^{-1}), CIMMYT-HTN 2014/15-1 (6.21 t ha^{-1}), CIMMYT-HTN 2014/15-4 (6.20 t ha^{-1}) and Nota (6.19 t ha^{-1}), but the lowest GY was observed in CIMMYT-HTN 2014/15-7 (4.35 t ha^{-1}) and it was followed by CIMMYT-HTN 2014/15-10 (4.43 t ha^{-1}) (Table 2). In the research, it has been realized that the lines obtained from the CIMMYT and having high heat tolerance have high the GY.

The highest GY in the NS was obtained from CIMMYT-HTN 2013/14-4492 (6.87 t ha^{-1}). It was followed by CIMMYT-HTN 2013/14-4489 (6.85 t ha^{-1}), Nota (6.76 t ha^{-1}), CIMMYT-HTN 2014/15-5 (6.73 t ha^{-1}), CIMMYT-HTN 2013/14-4488 (6.63 t ha^{-1}), Basribey (6.46 t ha^{-1}), Yubileynaya 100 (6.39 t ha^{-1}), Tina and Flamura 85 (6.09 t ha^{-1}), and CIMMYT-HTN 2013/14-4490 (6.06 t ha^{-1}) (Table 2). The GY performances of bread wheat genotypes which were used for the LS date, they were exposed to high-temperature stress at the post-anthesis stage were lower than normal sowing date. The genotype

Table 2- Mean values and statistically significance groups for the GY (t ha^{-1})

Genotype	*Sowing date*		*Change rate (%)*	*Mean*
	N	*L*		
CIMMYT-HTN 2014/15-1	6.37 a-f	6.06 a-ı	-4.87	6.21 ab
CIMMYT-HTN 2013/14-4489	6.85 a	5.19 j-t	-24.23	6.02 a-d
CIMMYT-HTN 2014/15-5	6.73 abc	5.95 b-j	-11.59	6.34 a
CIMMYT-HTN 2013/14-4492	6.87 a	5.26 ı-t	-23.44	6.06 abc
CIMMYT-HTN 2014/15-8	5.63 e-o	3.88 w	-31.08	4.75 hıj
Basribey	6.46 a-e	5.99 b-j	-7.28	6.22 ab
CIMMYT-HTN 2014/15-4	6.27 a-g	6.14 a-h	-2.07	6.20 ab
CIMMYT-HTN 2014/15-6	5.46 g-s	5.36 h-t	-1.83	5.41 efg
Esperia	5.29 h-t	5.66 e-n	6.99	5.47 d-g
CIMMYT-HTN 2013/14-4488	6.63 a-d	5.06 k-u	-23.68	5.84 a-f
CIMMYT-HTN 2013/14-4490	6.06 a-ı	5.91 c-j	-2.48	5.98 a-e
Syrena	5.04 k-u	5.55 f-r	10.12	5.29 fgh
CIMMYT-HTN 2014/15-2	5.93 b-j	5.87 d-k	-1.01	5.90 a-e
CIMMYT-HTN 2014/15-9	5.72 e-n	5.64 e-o	-1.40	5.68 b-f
Krasunia	5.65 e-n	5.56 f-q	-1.59	5.60 c-f
Nota	6.76 ab	5.62 e-p	-16.86	6.19 ab
Gelibolu	5.83 d-m	4.74 q-v	-18.70	5.28 fgh
Tina	6.09 a-ı	4.71 r-v	-22.76	5.40 efg
Dropia	4.65 s-v	5.02 l-u	7.96	4.83 hıj
CIMMYT-HTN 2014/15-7	4.67 s-v	4.03 vw	-13.70	4.35 j
CIMMYT-HTN 2013/14-4464	5.62 e-p	5.95 b-j	5.87	5.78 a-f
Yubileynaya 100	6.39 a-f	5.38 e-n	-15.80	5.88 a-e
Kate A1	5.94 b-j	5.53 f-v	-6.90	5.73 b-f
Saraybosna	5.00 m-u	4.72 q-v	-5.60	4.86 hıj
CIMMYT-HTN 2014/15-10	4.59 t-w	4.28 uvw	-6.75	4.43 ıj
CIMMYT-HTN 2014/15-3	5.15 j-t	5.89 c-k	14.37	5.52 c-f
Golia	4.78 p-v	5.14 j-t	7.53	4.96 ghı
Tekirdağ	4.87 n-u	4.79 o-v	1.64	4.83 hıj
Pehlivan	5.53 f-r	5.64 e-o	1.99	5.58 c-f
Flamura-85	6.09 a-ı	4.94 n-u	-18.88	5.51 c-f
Mean	5.76	5.31	-7.81	
MSE	17.86148			

GY, grain yield; MSE, mean squared error; N, normal; L, late

that had the highest GY in the LS date was CIMMYT-HTN 2014/15-4 (6.14 t ha^{-1}). This line was followed by CIMMYT-HTN 2014/15-1 (6.06 t ha^{-1}), Basribey (5.99 t ha^{-1}), CIMMYT-HTN 2013/14-4464 (5.95 t ha^{-1}), CIMMYT-HTN 2013/14-4490 (5.91 t ha^{-1}), CIMMYT-HTN 2014/15-3 (5.89 t ha^{-1}), CIMMYT-HTN 2014/15-2 (5.87 t ha^{-1}) (Table 2). Basribey cultivar and CIMMYT-HTN 2014/15-5, CIMMYT-HTN 2014/15-4, CIMMYT-HTN 2013/14-4490 were the highest GY both in NS and LS (Table 2).

Membrane thermostability (MT-%): There were significant differences (P≤0.01) among the mean of bread wheat cultivars for the MT (Table 3). That is one of the methods that are recommended in the

Table 3- Means and significance groups of genotypes' some examined traits

Genotype	*MT (%)*	*CT (°C)*	*LCC (SPAD)*	*SC (mmol $m^{-2} s^{-1}$)*
Nota	50.270 e	20.000 a-d	43.233 efg	58.133 b-g
Kate A1	44.670 h	19.333 b-e	48.867 a-f	79.200 bcd
Basribey	39.960 m	20.667 ab	44.367 c-g	72.500 b-f
Gelibolu	30.930 uv	21.000 ab	46.367 a-f	32.733 efg
Esperia	20.000 A	20.667 ab	50.233 a-e	93.500 bc
Saraybosna	33.670 t	20.667 ab	53.000 ab	166.800 a
Syrena	49.530 f	20.000 a-d	48.633 a-f	33.133 efg
Flamura 85	30.930 uv	20.000 a-d	49.667 a-e	55.000 b-g
Krasunia	35.000 s	22.000 a	49.367 a-e	95.633 ab
Dropia	37.130 o	21.000 ab	50.733 a-d	78.300 b-e
Tina	26.660 y	20.000 a-d	50.233 a-e	64.100 b-g
Golia	31.040 u	21.333 ab	47.300 a-f	32.733 efg
Tekirdağ	10.580 B	21.000 ab	45.667 c-g	93.933 bc
Pehlivan	42.830 i	20.333 abc	41.833 fg	38.000 d-g
Yubileynaya 100	54.230 d	21.000 ab	50.900 a-d	55.633 b-g
CIMMYT-HTN 2014/15-1	44.590 h	20.333 abc	49.367 a-e	61.567 b-g
CIMMYT-HTN 2014/15-2	66.250 a	19.333 b-e	49.367 a-e	56.600 b-g
CIMMYT-HTN 2014/15-3	37.380 n	20.000 a-d	45.500 c-g	55.900 b-g
CIMMYT-HTN 2014/15-4	40.970 l	19.333 b-e	46.100 b-f	33.400 efg
CIMMYT-HTN 2014/15-5	58.010 b	17.667 e	48.733 a-f	46.133 d-g
CIMMYT-HTN 2014/15-6	50.300 e	19.333 b-e	51.467 ac	39.533 d-g
CIMMYT-HTN 2014/15-7	46.110 g	19.333 b-e	49.800 a-e	52.667 b-g
CIMMYT-HTN 2014/15-8	43.010 i	18.000 de	44.333 c-g	51.167 c-g
CIMMYT-HTN 2014/15-9	56.820 c	17.667 e	38.300 g	79.100 bcd
CIMMYT-HTN 2014/15-10	36.660 p	18.333 cde	53.300 a	28.767 fg
CIMMYT-HTN 2013/14-4464	23.960 z	20.667 ab	45.700 c-f	43.633 d-g
CIMMYT-HTN 2013/14-4488	26.890 y	20.333 abc	44.033 d-g	55.433 b-g
CIMMYT-HTN 2013/14-4489	30.670 v	21.000 ab	48.700 a-f	78.500 bcd
CIMMYT-HTN 2013/14-4490	35.670 r	21.000 ab	47.600 a-f	43.867 d-g
CIMMYT-HTN 2013/14 4492	41.730 k	21.000 ab	50.333 a-e	71.267 b-g
MSE	0.022	1.292	12.820	466.613

MT, membrane thermostability; CT, canopy temperature; LCC, leaf chlorophyll content (LCC); SC, stomatal conductance (SC); MSE, mean squared error

tolerant plant selection to stress condition(s). The method used for the identification of membrane permeability depends on the principle of the determination of the number of ions that leak into the apoplastic fluid from cytoplasm as a result of function disorder in cell membrane caused by injury (Gusta et al 2003). The study revealed that the MT increased in stress conditions, which means that the genotypes with lower cell injury are more tolerant to heat stress conditions.

In this study, mean MT values had a large variation between 10.580 to 66.250% (Table 3). This might be a result of different genetic structures of the genotypes used in the research. The highest MT value was detected in CIMMYT-HTN 2014/ 15-2 (66.250%). It was followed by CIMMYT-

HTN 2014/15-5, CIMMYT-HTN 2014/15-9 and Yubileynaya 100 (58.010%, 58.200% and 54.230%, respectively). It can be said that the heat-temperature stress tolerance of these genotypes for the MT values is higher than others. In the study, the lowest MT value was taken from Tekirdağ (10.580%) and Esperia (20.000%) cultivars. Our findings on genotypes have similar with the reports of Sikder et al (1999), Blum et al (2001), Hasan et al (2007), Yıldırım et al (2009), Khan et al (2013) and Khan et al (2015) who revealed that the MT of wheat genotypes that are exposed to high-temperature stress caused by LS which depends on the genotype.

Canopy temperature (CT- °C): In the variance analysis made for the CT, differences between the genotypes have been found as $P \leq 0.01$ significant (Table 3). The high CT causes the increase in respiration of the plants and consequently decreases the net photosynthesis rate. For this reason, the genotypes which have the lower CT under the same ecological conditions are advantageous considering plant development.

The CT in all genotypes was varied between (17.667 °C to 22.000 °C) (Table 3). Accordingly, differences occur that reach to 4.333 °C between CT of the wheat genotypes that grown under the same ecological conditions. This can be a result of different reactions of tested genotypes to the high-temperature stress caused by late sowing. Similar to our findings, Ray & Ahmad (2015) revealed that CTs of wheat genotypes at the post-anthesis stage are different. Also, the researchers revealed that CT can be used as a selection criterion under the high-temperature stress conditions.

In our study, it was found that CIMMYT-HTN 2014/15-9 and CIMMYT-HTN 2014/15-5 (17.667 °C) had the lowest CT among bread wheat genotypes. These lines were followed by CIMMYT-HTN 2014/15-8 (18.000 °C), CIMMYT-HTN 2014/15-10 (18.333 °C), CIMMYT-HTN 2014/15-7, CIMMYT-HTN 2014/15-6, CIMMYT-HTN 2014/15-4, CIMMYT-HTN 2014/15-2 and Kate A-1 (19.333 °C). The results revealed that the CIMMYT origin genotypes have the lower CT and more tolerant to the high temperatures. Our findings in accordance with Sikder & Paul (2010) who are found that high heat tolerant wheats have the lower CT than those of the sensitive. On the other hand, the highest CT was measured in Krasunia (22.000 °C), Golia (21.333 °C), Dropia (21.000 °C), Tekirdağ (21.000 °C), CIMMYT-HTN 2013/14-4490 (21.000 °C), CIMMYT-HTN 2013/14-4492 (21.000 °C), CIMMYT-HTN 2013/14-4489 (21.000 °C), Yubileynaya 100 (21.000 °C) and Gelibolu (21.000 °C). In the light of these results, it was realized that Krasunia, Dropia, Tekirdağ, Gelibolu, Esperia cultivars' CT were affected by high temperatures. Besides, CIMMYT-HTN 2013/14-4490, CIMMYT-HTN 2013/14-4492, CIMMYT-HTN 2013/14-4489 and CIMMYT-HTN 2013/14-4464 lines are believed to have a lower tolerance in terms of the CT.

Leaf chlorophyll content (LCC-SPAD): The mean of the LCC differences of the genotypes which are exposed to heat stress in late sowing were determined as $P \leq 0.01$ significant (Table 3). The LCC values were changed between (38.300 to 53.300 SPAD) and had been a large variation (Table 3). This might be a result of different genetic structures of the wheat genotypes used in the research. Similar to our findings, Javed et al (2014) revealed that the LCC of cultivars in high-temperature stress were significantly different. In our study, the highest LCC was detected in CIMMYT-HTN 2014/15-10 (53.300 SPAD). It was followed by Saraybosna (53.000 SPAD), CIMMYT-HTN 2014/15-6 (51.467 SPAD), Yubileynaya 100 (50.990 SPAD) and Dropia (50.773 SPAD). These results revealed that CIMMYT origin lines which are known to be tolerant to the high-temperature since they have the high LCC. Our findings are similar to the findings of Reynolds et al (1996), Nawaz et al (2013) and Feng et al (2014). The lowest LCC among the genotypes was found in CIMMYT-HTN 2014/15-9 with (38.300 SPAD). It was followed by Pehlivan (41.833 SPAD) and Nota (43.233 SPAD). In a general evaluation considering the LCC of other genotypes, it was observed that some lines which are known to be tolerant to the high-temperature(s) (CIMMYT-HTN 2013/14-4488, CIMMYT-HTN 2014/15-8, CIMMYT-HTN 2014/15-3 and CIMMYT-HTN 2013/14-4464) had the very low LCC (44.033, 44.333, 45.500, 45.700 SPAD, respectively) (Table 3). On the other hand, it can be mentioned that there was not a certain correlation between the LCC and high-temperature stress and this trait depends on genotype, ecology, and their interactions and used growing techniques.

Stomatal conductance (SC- mmol m^{-2} s^{-1}): The SC is known as a physiological selection criterion used in estimating gas exchange such as CO_2 absorption thoroughly to the leaves and water loss with transpiration depending on stomata pore (Pask et al 2012). Munjal & Rana (2003) revealed that the low of CT and high SC during the grain filling period of bread wheat genotypes under the high-temperature(s) can be basic morpho-physiological criteria for the high GY. According to the results of variance analysis in the study, the difference between the genotypes has been statistically ($P \leq 0.01$) found significant for the SC (Table 3). The SC in the bread wheats was shown a large variation between (25.200 to 166.800 mmol m^{-2} s^{-1}). This variation shows that bread wheat genotypes do not respond equally to heat- temperature stress in terms of the SC. The highest SC values were detected in Saraybosna (166.800 mmol m^{-2} s^{-1}), Krasunia (95.633 mmol m^{-2} s^{-1}), Tekirdağ (93.933 mmol m^{-2} s^{-1}), Esperia (93.500 mmol m^{-2} s^{-1}) cultivars (Table 3). Golia cultivar (25.200 mmol m^{-2} s^{-1}) had the lowest stomatal conductance. This cultivar was followed by CIMMYT-HTN 2014/15-10 (28.767 mmol m^{-2} s^{-1}), Gelibolu (32.733 mmol m^{-2} s^{-1}), Syrena with (33.133 mmol m^{-2} s^{-1}) and CIMMYT-HTN 2014/15-4 (33.400 mmol m^{-2} s^{-1}). It has been realized that the flag leaf SC values of tested genotypes were found as low during the post-anthesis period. This may be caused by the senescence of flag leaves in the post-anthesis period in which measurements have been made. Similar to our findings, Bahar et al (2009) reported that SC value of durum wheats' (*Triticum durum* Desf.) 294 mmol m^{-2} s^{-1} at the early milk stage, and it decreased to 225 mmol m^{-2} s^{-1} at the end of the milk stage and to 167 mmol m^{-2} s^{-1} at the early dough stage, and this resulted from senescence of flag leaf after anthesis.

4. Conclusions

As a summary, Dropia, Nota, CIMMYT-HTN 2014/15-2, CIMMYT-HTN 2014/15-6, CIMMYT-HTN 2014/15-10 were found as prominent for all investigated traits, except for the GY. It is possible that to use of these genotypes as genitor(s) or progenitor(s) in the wheat breeding programs for the heat-temperature stress tolerance. The (5) genotypes (Basribey, CIMMYT-HTN 2013/14-4490, CIMMYT-HTN 2014/15-1, CIMMYT-HTN 2014/15-4, CIMMYT-HTN 2014/15-5, respectively) were higher in terms of the GY at the NS and LS. On the other hand, these genotypes were found as the prominent for the examined heat tolerance parameters. In order to develop the heat tolerant and to get higher of the GY, a comprehensive wheat breeding program can be suggested which includes multiple crossing among them with the selection method considered for the heat tolerance, yield and yield components like the physiological parameters such as MT, CT, LCC and SC against to the high-temperature stress in wheat.

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