Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2020, Vol. 4 (1), 136-147
https://doi.org/10.29329/ijiaar.2020.238.14

Original article

Effect of Canopy Temperature at Different Growth Stage on Yield Component in Bread Wheat (*Triticum aestivum* L.) Genotypes under Rainfed Condition

İrfan Öztürk *

Department of Wheat and Barley Breeding, Trakya Agricultural Research Institute, University of Trakya, Edirne, Turkey

Abstract

Bread wheat is the widely growing cereal crops in Trakia region and various environment conditions reducing grain yield. The aim of this research was to determine the effects of canopy temperature at different growth stages in bread wheat genotypes on yield and yield component under rainfed conditions. Research was carried out at Trakya Region, Turkey, in 2017-2018 growing years at 4 locations with 25 genotypes in randomized completely blocks design with 4 replications. Canopy temperature, chlorophyll content, days of heading, grain yield, plant height, peduncle length, spike length, number of spike per square meter, number of spike per spike, number of kernel per spike, and spike weight and also, relationship among these characters were investigated. For determining canopy temperature of the genotypes data was taken at four different plant growth stages (Z41, Z55, Z60 and Z70). The analysis of variance revealed highly significant differences among the genotypes for grain yield, plant height, days of heading, chlorophyll content, number of spike per square meter, peduncle length, spike length, number of spike per spike, number of kernel per spike and spike weight. Mean grain yield of the genotypes was 616.1 kg da^{-1}, and the highest yields were obtained in G21 line with 680.7 kg da^{-1} and followed by cultivar Köprü (677.6 kg da^{-1}). Correlation coefficients based on the investigated parameters were determined by Pearson's correlation analysis. Grain yield was negatively slightly correlated with canopy temperature at booting stage (Z41) and negatively significantly correlated at Z51 growth stage (r=-0.534**). A significant positive correlation was determined between grain yield and chlorophyll content at Z55 growth stage (r=0.600**). It was found significant positive correlation between grain yield and number of spike per square meter (r=0.416*) and, peduncle length (r=0.469*). A negative correlation was observed between chlorophyll content with canopy temperature at Z41 (r=0.595**), and Z55 (r=0.586**) growth stages. A moderate negative correlation was found between spikelet number per spike with canopy temperature at Z61, and at Z70. The correlations among physiological parameters revealed that canopy temperature and chlorophyll content were positively associated with grain yield; hence these components can be used as reliable selection criteria to improve grain yield in wheat. Thus estimation of correlation analysis among yield and yield components and, physiological parameters may provide effective selection criteria to improve bread wheat grain yield.

Keywords: Bread wheat, genotypes, yield components, physiological parameters.

Received: 23 November 2019 * **Accepted:** 17 March 2020 * **DOI:** https://doi.org/10.29329/ijiaar.2020.238.14

* **Corresponding author:**

İrfan Öztürk, Department of Wheat and Barley Breeding, Trakya Agricultural Research Institute, University of Trakya, Edirne, Turkey.
Email: ozturkirfan62@yahoo.com

INTRODUCTION

Wheat is grown under a wide range of environmental conditions where climatic factors such as temperature and moisture combined with agronomic inputs such as fertilizer exert diverse effects on plant growth and metabolism. The manifestation of those effects in the developing kernel impacts the value of the crop by influencing yield, grain characteristics and flour quality. Within the kernel, complex programs of gene expression control physiological and biochemical processes, including cell division, water uptake and kernel expansion, accumulation of starch and protein, maturation and desiccation. A better understanding of the genetic program of grain development and the influence of specific environmental variables on that program is required to minimize the effects of environment on yield and quality (Altenbach et al., 2003). Canopy temperature depression (CTD) measured with an infrared thermometer was significantly positively correlated with performance at the international sites when measured between 1200 and 1600 hours, after full canopy establishment. The correlation of CTD with yield was not affected by the irrigation status of the crop under well-watered conditions. The possible use of these traits in selection for yield under hot conditions is discussed (Reynolds et al., 1994). Periods at such high temperature occur frequently during grain filling in both Mediterranean and continental climates, and such extremes may be more frequent throughout Europe in future climates of warmer mean temperatures (Barrow and Hulme, 1996). The duration of grain filling in cereals is determined principally by temperature (Slafer and Rawson, 1994; Wheeler et al., 1996). In wheat, high temperatures (>31 °C) after anthesis can decrease the rate of grain-filling (Randall and Moss, 1990; Stone et al., 1995; Wardlaw and Moncur 1995), while high temperatures imposed before anthesis can also decrease yield (Wardlaw et al., 1989; Tashiro and Wardlaw, 1990; Hunt et al., 1991). The effect of short periods of exposure to high temperatures (>31 °C) on wheat grain yields are thought to be equivalent to a 2-3 °C warming in the seasonal mean temperature (Wheeler et al., 1996). Also, up to a 23% reduction in grain yield has been reported from as little as 4 d exposure to very high temperatures (Randall and Moss, 1990; Hawker and Jenner, 1993; Stone and Nicolas, 1994). In winter wheat, high temperature episodes occurring near to anthesis can reduce the number of grains per ear and the subsequent rate of increase in harvest index, resulting in smaller grain yields (Wheeler et al., 1996). The response of roots to high temperature may also be important since transpiration cooling, which can limit the effects of thermal stress, depends on evaporation and the supply of water to the leaf from the soil. Any effects of thermal stress on the morphology and physiology of the root system may influence water movement through the plant (Mahan, McMichael and Wanjura, 1995). Drought stress reduces grain yield of wheat through negative affecting the yield components, such as number of plants per unit area, number of spikes and grains per plant, or unit area and single grain weight, which are determined at different stages of plant development (Francia et al., 2013; Hossain et al., 2012; Farooq et al., 2009). Water deficiency and higher temperature in different stages of plant growth can have different effects on physiological, agronomic and morphological traits in bread wheat. The current study examined the response of yield,

yield components, and other physiological traits of the canopy temperature occurring in bread wheat plants at four different developmental stages. Therefore, the objective of the study was to investigate whether the canopy temperature at various plant development phase and effects on yield and other agronomical and physiological characters in bread wheat genotypes.

Material and Methods

The research was carried out at Trakia Region, Turkey, during 2017-2018 growing years at 4 locations under rainfed condition. The experiment was conducted with 25 genotypes in randomized completely blocks design (RCBD) with 4 replications. Each plot was 6 meter long and had 6 rows, spaced 0.17 meters apart. A seed rate of 500 seeds per square meter was used. Sowings of the experiment were performed by using a plot drill.

Table 1. The climatic value of the 2017-2018 growing year in Edirne location

Months	Rainfall (mm)	Relative Humidity (%)	Temperature (ºC)		
			Min.	Max.	Mean
September 2017	34.2	57.8	6.8	35.9	21.3
October 2017	135.2	77.1	3.8	27.8	13.6
November 2017	71.6	75.7	-2.1	27.4	9.5
December 2017	119.6	85.1	-4.2	20.8	7.4
January 2018	55.6	88.1	-5.2	15.1	4.3
February 2018	101.8	89.5	-5.4	16.1	5.7
March 2018	145.6	88.8	-11.0	20.2	8.9
April 2018	3.0	61.3	2.6	31.7	16.6
May 2018	18.8	64.0	9.2	31.1	20.3
June 2018	148.4	66.4	11.7	34.8	22.6
Total/Mean	833.8	75.4	-11	35.9	13.0

Data recorded for chlorophyll content and canopy temperature (Jackson et al., 1981; Fisher, 2001; Reynolds et al., 2001; Guttierrez-Rodriguez et al., 2004; Babar et al., 2006). For determining canopy temperature of the genotypes data was taken at four different plant growth stages; early booting stage (Z41), heading stage (Z55), flowering stage (Z61) and grain filling stage (Z70). In the research; chlorophyll content (Babar et al, 2006) was measured at heading stage (Z55). Agronomic characters such as; grain yield (kg da^{-1}), plant height (cm), peduncle length (cm), spike length (cm), days of heading, number of spike per square meter, number of spike per spike, number of kernel per spike, and spike weight (g) and also relationship among these parameters were investigated.

To evaluate significant differences between genotypes, the analysis of variance (ANOVA) was performed. The differences between genotype means of parameters were tested by the L.S.D test. Letter groupings were generated by using a 5% level of significance. Data were analyzed statistically for analysis of variance the method described by Gomez and Gomez (1984). The significance of differences among means was compared by using L.S.D (5%) test (Kalaycı, 2005). Correlation coefficients among all parameters were evaluated based on the means of all genotypes. Also, regression graphs are used to predict adaptability and relationship of the characters of genotypes.

Results and Discussion

The analysis of variance revealed highly significant differences among the bread wheat genotypes for grain yield, plant height, peduncle length, spike length, number of spike per square meter, number of spike per spike, and number of kernel per spike. Grain yield is the mainly objective of the cereals crops. Combined analysis of variance across four locations revealed highly significant variation among genotypes for grain yield (Table 1). The mean grain yield of the genotypes was 616.1 kg da^{-1}, and the highest yields were obtained in G21, and cultivar Köprü with 680.7 kg da^{-1}, and 677.6 kg da^{-1}, respectively. Plant height is another important trait in wheat genotypes. Plant height for lodging resistant is one of the important characters for bread wheat production Trakya region. G27 had the highest plant height with 110.3 cm, while the shortest plant height recorded for G8 (81.3 cm). There is a significant variation among the genotypes for plant height, as they all expected to have a reasonable resistant to lodging. This trait was identified to be highly controlled genetically, while environment condition of wheat growing has an influence on this phenomenon (Pinera-Chavez et al., 2016). Peduncle length as another important trait among the genotypes studied. G27 had the highest value of 37.94 cm, while the shortest peduncle recorded for G9 (22.87 cm). There is a significant variation among the genotypes for peduncle length. Based on yield component length of spike is an important trait tends to be different among the genotypes. Genotypes G17 had the highest value of 10.95 cm, while the shortest spike length for G18 (8.42 cm). There is a significant variation among the genotypes for spike length (Table 1).

Table 1. The mean grain yield and agronomic parameters of genotypes in 2017-2018

No	Genotypes	GY	PH	PL	SL	SNM	SNS	KNS
1	Pehlivan	628.5 ±151.1	107.5^{ab}	35.47^{b}	8.83$^{ı-m}$	495.3^{a}	18.3^{ef}	32.6^{k}
2	G2	571.1±184.9	96.8^{e-h}	31.00^{def}	10.10^{b-e}	408.0^{b-f}	18.5^{ef}	53.1^{a}
3	G3	659.1±183.7	92.0^{hı}	32.20^{cde}	9.11^{g-m}	373.0^{e-h}	19.3^{de}	39.4^{e-k}
4	G4	624.4±177.2	92.5^{ghı}	32.60^{cde}	9.06^{g-m}	463.0^{ab}	18.3^{ef}	36.9^{g-k}
5	Selimiye	612.0±170.1	97.0^{e-h}	32.96^{cd}	8.89^{h-m}	465.3^{ab}	18.5^{ef}	34.4^{ıjk}
6	G6	643.0±196.6	92.0^{hı}	30.48^{efg}	9.18^{f-m}	401.5^{c-f}	18.5^{ef}	35.3^{h-k}
7	G7	569.6±188.5	99.0^{def}	23.68^{kl}	9.32^{e-l}	330.0^{hıj}	20.7^{a-d}	47.7^{a-e}
8	G8	585.8±144.8	81.3^{j}	28.39^{ghı}	9.55^{d-j}	398.8^{c-g}	19.9^{b-e}	46.7^{a-f}
9	G9	476.3±160.8	90.8^{ı}	22.87^{l}	9.84^{b-g}	309.3^{ıj}	18.8^{ef}	42.4$^{c-ı}$
10	Gelibolu	642.8±178.2	97.8^{d-g}	29.45$^{f-ı}$	8.78^{j-m}	433.0^{bcd}	18.5^{ef}	41.8^{c-j}
11	G11	567.1±165.1	99.5^{def}	27.37^{ıj}	9.09^{g-m}	392.0^{c-g}	17.3^{f}	38.3^{f-k}
12	G12	587.5±181.4	107.8^{ab}	31.42^{c-f}	8.48^{lm}	399.5^{c-g}	19.2^{de}	36.5^{g-k}
13	G13	596.6±215.4	94.3$^{f-ı}$	27.42^{ıj}	9.71^{c-h}	413.0^{b-e}	21.2^{abc}	48.5^{a-d}
14	G14	584.8±216.1	110.3^{a}	27.39^{ıj}	8.66^{lm}	367.5$^{e-ı}$	19.6^{b-e}	43.2^{b-h}
15	Saban	630.2±150.8	94.3$^{f-ı}$	30.31^{e-h}	9.51^{e-k}	451.0^{abc}	18.3^{ef}	40.1^{d-k}
16	G16	655.2±208.8	100.3^{cde}	32.10^{cde}	10.56^{abc}	350.3^{f-j}	21.7^{a}	45.6^{a-f}
17	G17	657.5±187.7	99.3^{def}	32.24^{cde}	10.95^{a}	361.0^{e-j}	22.3^{a}	51.1^{ab}
18	G18	602.1±182.0	108.0^{a}	28.66^{ghı}	8.42^{m}	407.3^{b-f}	18.3^{ef}	33.7^{jk}
19	G19	638.0±171.7	93.0^{ghı}	25.97^{jk}	8.97^{h-m}	368.3$^{e-ı}$	18.4^{ef}	48.0^{a-d}
20	Köprü	677.6±206.2	97.5^{d-g}	31.10^{def}	8.66^{klm}	382.3^{d-h}	19.5^{cde}	43.9^{b-g}
21	G21	680.7±216.4	105.5^{abc}	33.64^{bc}	10.58^{ab}	303.3^{j}	21.3^{ab}	46.4^{a-f}
22	G22	606.1±183.4	93.0^{ghı}	32.01^{cde}	9.67$^{d-ı}$	374.3^{d-h}	19.0^{def}	45.0^{a-g}
23	G23	595.3±188.2	96.3^{e-h}	28.12^{hıj}	10.10^{b-e}	413.5^{b-e}	21.6^{a}	49.5^{abc}
24	G24	652.0±235.9	102.5^{bcd}	37.94^{a}	10.01^{b-f}	373.0^{e-h}	17.3^{f}	49.9^{abc}
25	G25	658.4±188.9	95.8$^{e-ı}$	32.81^{cd}	10.36^{a-d}	340.0^{g-j}	17.4^{f}	39.3^{e-k}
Mean		616.1	97.7	30.30	9.5	390.9	19.3	42.8
CV (%)		7.3	3.8	4.6	5.3	10.8	5.2	12.1
LSD (0.05)		31.10	5.29	2.30	0.84	59.52	1.68	8.46
F		16.01**	12.25**	18.01**	5.68**	5.03**	5.70**	3.89**

Note: Significance at *: $P<0.05$; **: $P<0.01$; GY: Grain yield (kg da^{-1}), PH: Plant height (cm), PL: Peduncle length (cm), SL: Spike length (cm), SNM: Spike number per square meter, SNS: Spikelet number per spike, KNS: Kernel number per spike

The number of spike per square meter of wheat genotypes were studied under rainfed condition and it was found significant difference among genotypes (Table 1). The maximum number of spike was noted in cultivar Pehlivan (495.3), followed by Selimiye, G4, and Saban cultivar. Genotypes G21 and G9 produced minimum number of spike per square meter. Under rainfed condition the number of spikelet per spike in different wheat genotypes during the years 2017-2018 were studied and very highly significant difference were found among the genotypes (Table 1). G7 showed maximum numbers (22.3), non-significantly followed by G16 (21.7) and G23 (21.6). Genotypes G11 and G24 showed significantly minimum (17.3) number of spikelet per spike. The numbers of grains per spike of wheat genotypes were investigated under rainfed condition and it was found significant difference among genotypes. The maximum number of grains was noted in genotypes G2 (53.1), significantly followed by G17 (51.1). Cultivar Pehlivan produced minimum (32.6) number of grains per spike of wheat. Genotypes G18 (33.7), Selimiye (34.4) and G6 (35.3) produced minimum number of grains per spike (Table 1).

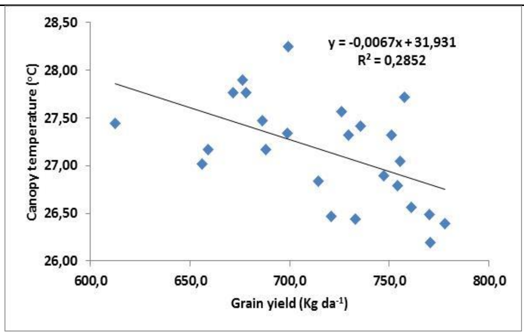
Table 2. The mean physiological parameters of the genotypes in 2017-2018

No	**Genotypes**	**CT (Z41)**	**CT (Z55)**	**CT (Z61)**	**CT (Z70)**	**SPAD (Z55)**	**DH**	**SW**
1	Pehlivan	18.78^{b-e}	26.20^{g}	31.50^{a-f}	31.73^{ab}	48.1^{a-e}	113.8^{de}	1.96^{de}
2	G2	20.43^{a}	27.90^{ab}	32.23^{abc}	32.33^{ab}	45.4^{efg}	111.5^{f}	2.49^{a-d}
3	G3	18.58^{b-e}	27.33^{a-f}	32.10^{a-d}	32.05^{ab}	48.5^{a-e}	113.8^{de}	2.22^{b-e}
4	G4	18.28^{cde}	26.58^{d-g}	31.70^{a-e}	31.35^{ab}	50.6^{a}	113.5^{e}	2.30^{a-e}
5	Selimiye	19.25^{a-d}	27.35^{a-f}	31.80^{a-e}	32.43^{ab}	48.5^{a-e}	111.8^{f}	1.82^{e}
6	G6	18.55^{b-e}	26.90^{b-g}	30.88^{c-f}	32.30^{ab}	49.8^{abc}	113.8^{de}	2.10^{cde}
7	G7	18.00^{de}	27.18^{b-g}	31.08^{b-f}	31.18^{b}	47.2^{a-f}	117.8^{a}	2.11^{cde}
8	G8	18.60^{b-e}	27.18^{b-g}	32.40^{ab}	31.28^{ab}	46.2^{b-g}	114.8^{cde}	2.71^{ab}
9	G9	20.05^{ab}	27.45^{a-f}	31.23^{b-f}	31.98^{ab}	42.6^{g}	118.0^{a}	2.43^{a-d}
10	Gelibolu	18.15^{cde}	26.80^{c-g}	30.83^{c-f}	31.73^{ab}	49.8^{a-d}	110.8^{f}	2.13^{cde}
11	G11	19.60^{abc}	27.48^{a-e}	31.90^{a-e}	32.28^{ab}	48.5^{a-e}	113.8^{de}	2.09^{cde}
12	G12	17.85^{de}	27.78^{abc}	31.23^{b-f}	32.25^{ab}	46.1^{d-g}	117.8^{a}	1.99^{de}
13	G13	19.40^{a-d}	27.43^{a-f}	32.73^{a}	31.80^{ab}	44.3^{fg}	115.8^{bc}	2.61^{abc}
14	G14	18.43^{cde}	27.03^{b-g}	31.05^{b-f}	31.08^{b}	47.2^{a-f}	118.0^{a}	2.44^{a-d}
15	Saban	18.58^{b-e}	27.73^{abc}	31.60^{a-f}	32.63^{a}	49.9^{ab}	110.8^{f}	2.06^{de}
16	G16	18.25^{cde}	26.85^{b-g}	31.45^{a-f}	31.35^{ab}	48.3^{a-e}	115.3^{cd}	2.71^{ab}
17	G17	18.83^{b-e}	26.48^{efg}	30.15^{f}	31.53^{ab}	48.9^{a-e}	114.5^{cde}	2.79^{a}
18	G18	19.03^{a-e}	27.58^{a-d}	31.55^{a-f}	32.58^{a}	46.1^{c-g}	117.3^{ab}	1.81^{e}
19	G19	19.43^{a-d}	27.33^{a-f}	31.83^{a-e}	31.95^{ab}	45.7^{efg}	114.3^{cde}	2.62^{abc}
20	Köprü	17.58^{e}	26.40^{fg}	31.25^{a-f}	31.98^{ab}	50.0^{a}	114.5^{cde}	2.63^{abc}
21	G21	18.80^{b-e}	26.50^{efg}	30.43^{ef}	31.60^{ab}	47.3^{a-f}	110.8^{f}	2.45^{a-d}
22	G22	19.13^{a-e}	27.78^{abc}	31.55^{a-f}	32.25^{ab}	45.9^{efg}	108.3^{g}	2.23^{b-e}
23	G23	19.05^{a-e}	27.05^{b-g}	30.65^{def}	32.25^{ab}	47.5^{a-f}	114.0^{de}	2.61^{abc}
24	G24	18.43^{cde}	26.45^{efg}	31.78^{a-e}	32.15^{ab}	50.7^{a}	114.3^{cde}	2.71^{ab}
25	G25	18.85^{a-e}	28.25^{a}	32.10^{a-d}	32.33^{ab}	45.7^{efg}	108.5^{g}	1.95^{de}
Mean		18.7	27.2	31.5	31.9	47.5	113.8	2.31
CV (%)		5.9	2.8	3.3	3.1	5.5	1.1	13.8
LSD (0.05)		1.57	1.05	1.47	1.37	3.70	1.71	0.52
F		1.39ns	1.98*	1.38ns	0.83ns	2.43**	20.4**	2.60**

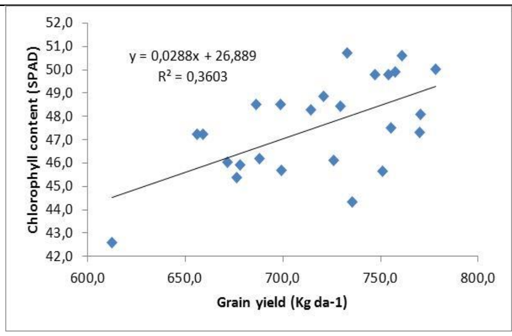
Note: Significance at *: P<0.05; **: P<0.01; CT: Canopy temperature (ºC), SPAD: Chlorophyll content, DH: days of heading, SW: Spike weight (g)

Yields are likely to continue to increase, although possibly at a slower rate than in the past few decades. Increases in wheat yields in rainfed environments have been achieved during most of this century through the use of conventional breeding methods. A physiological approach may increase the rate of yield improvement in a number of ways (Reynolds et al., 2001). Canopy temperature and chlorophyll content could be used as selection physiological parameters for yield under various drought stress conditions (Öztürk and Korkut, 2018). In the study, canopy temperature (CT), chlorophyll content (SPAD), days of heading (DH), spike weight (SW) and relationship among these characters were investigated. For determining canopy temperature of the genotypes data was taken at four different plant growth stages (Z41, Z55, Z61 and Z70). The analysis of variance revealed highly significant differences among the bread wheat genotypes for CT at Z55, chlorophyll content (SPAD), days of heading, and spike weight (Table 2). There was no significant difference among genotypes for canopy temperature except at Z55 growth phase due to experiment carried out under rainfed condition. The mean canopy temperature at Z55 was 25.6 ^{o}C, minimum was 26.20 ^{o}C and maximum 28.25 ^{o}C. The lowest canopy temperature was measured in cultivar Pehlivan at Z55 growth stage. Chlorophyll content of the genotypes was scaled at heading stage (Z55). There was significant difference among genotypes, G24 and G7 lines had higher chlorophyll content than other genotypes (Table 2).

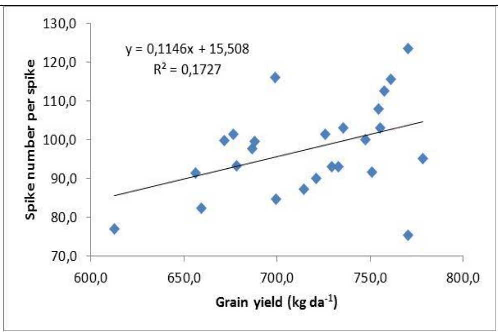
In case of days to heading, it was found that the mean and range values were larger among genotypes. The larger range values (108.3 days for G22, and 118 days for G9 and G14) suggested that the character have wider variations including early as well as late maturing genotypes. The maximum spike weight was determined in genotype G17 (2.79 g), and followed by G4, G8 and G16. Genotypes G18 and Selimiye was produced minimum spike weight (Table 2). Present study revealed that grain yield of winter bread wheat genotypes under rainfed conditions can be improved by selecting the genotypes having more spike number per square meter, peduncle length, and chlorophyll content among the yield components and physiological parameters which were analyzed.



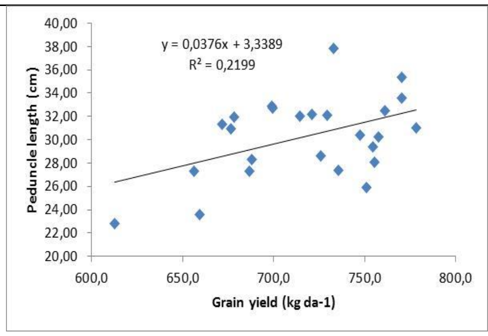
Grain yield and CT at Z55



Grain yield and SPAD at Z55



Grain yield and spike number per spike



Grain yield and peduncle length

Figure 1. Relationship between grain yield and some physiological parameters

Grain yield and agro-physiological parameter such as canopy temperature and chlorophyll content compared and it was found various associations. In this research as it expected there was positively relation between chlorophyll content with grain yield at Z55 (R^2=0.36) growth phase. It was found slightly positive relation between grain yield with spike number per spike, and peduncle length. These results showed that genotypes has higher grain yield which have higher chlorophyll content and lower canopy temperature (Figure 1).

Table 3. Correlation coefficients among physiological parameters and agronomic characters

Parameters	**GY**	**CT (Z41)**	**CT (Z55)**	**CT (Z61)**	**CT (Z70)**	**SPAD (Z55)**
CT (Z41)	-0.333					
CT (Z55)	-0.534**	0.440*				
CT (Z61)	-0.138	0.324	0.478*			
CT (Z70)	0.091	0.359	0.525**	0.204		
SPAD (Z55)	0.600**	-0.595**	-0.586**	-0.283	-0.046	
DH	-0.340	-0.156	-0.177	-0.103	-0.363	-0.222
PH	0.047	-0.217	-0.216	-0.388	-0.024	0.113
SNM	0.416*	-0.046	-0.110	0.252	0.243	0.386
PL	0.469*	-0.261	-0.340	0.007	0.169	0.533**
SL	-0.043	0.282	-0.032	-0.157	-0.122	-0.130
SNS	0.055	-0.159	-0.303	-0.422*	-0.508**	-0.123
KNS	-0.101	0.200	-0.069	-0.056	-0.302	-0.197
SW	0.078	0.035	-0.389	-0.071	-0.463*	-0.037

Note: Significance at *: P<0.05; **: P<0.01; GY: Grain yield (kg da^{-1}), CT: Canopy temperature, SPAD: Chlorophyll content, DH: days of heading, PH: Plant height (cm), SNM: Spike number per square meter, PL: Peduncle length (cm), SL: Spike length (cm), SNS: Spikelet number per spike, KNS: Kernel number per spike, SW: Spike weight (g)

Correlation coefficients based on the investigated parameters were determined by Pearson's correlation analysis (Table 3, 4). Grain yield was negatively slightly correlated with canopy temperature at booting stage (Z41) and negatively significantly correlated at Z51 growth stage (r=-0.534**). There was no relation between CT and grain yield at Z70 plant stage. A significant positive correlation was determined between grain yield and chlorophyll content at Z55 growth stage (r=0.600**). It was found significant positive correlation between grain yield and number of spike per square meter (r=0.416*) and, peduncle length (r=0.469*). A negative correlation was observed between chlorophyll content with canopy temperature at Z41 (r=0.595**), and Z55 (r=0.586**) growth stages. A moderate negative correlation was found between spikelet number per spike with canopy temperature at Z61, and at Z70. There was slightly negative relation between canopy temperatures at Z70 with spike weight (Table 3). It was found highly significant positive correlation between spike length with spikelet number per spike (r=0.479*), kernel number per spike (r=0.631**), and spike weight (r=0.534**). Spikelet number per spike was significantly positively correlated with kernel number per spike (r=0.518**), and spike weight (r=0.548**) (Table 4).

Table 4. Correlation coefficients among yield component and agronomic characters

Parameters	**DH**	**PH**	**SNM**	**PL**	**SL**	**SNS**	**KNS**
PH	0.261						
SNM	-0.171	-0.001					
PL	-0.486*	0.260	0.294				
SL	-0.309	-0.196	-0.478*	0.193			
SNS	0.262	0.030	-0.322	-0.162	0.479*		
KNS	-0.002	-0.206	-0.467*	-0.156	0.631**	0.518**	
SW	0.182	-0.258	-0.373	-0.047	0.534**	0.548**	0.820**

Note: Significance at *: P<0.05; **: P<0.01; DH: days of heading, PH: Plant height (cm), SNM: Spike number per square meter, PL: Peduncle length (cm), SL: Spike length (cm), SNS: Spikelet number per spike, KNS: Kernel number per spike, SW: Spike weight (g)

Conclusion

Genetic variability is very essential for the success of any wheat breeding programs. Grain yield is the mainly objective of the cereals crops. Increases in wheat yields in rainfed environments have been achieved during most of this century through the use of conventional breeding methods. A physiological approach may increase the rate of yield improvement in a number of ways. In the study wide variation among tested genotypes was observed for different parameters. The analysis of variance revealed highly significant differences among the genotypes for investigated parameters. The highest yields were obtained in G21 line and followed by cultivar Köprü. Correlation coefficients based on the investigated parameters were done and grain yield was negatively slightly correlated with canopy temperature at booting stage (Z41) and negatively significantly correlated at Z55 growth stage. A significant positive correlation was determined between grain yield and chlorophyll content at Z55 growth stage. It was found significant positive correlation between grain yield and number of spike per square meter and, peduncle length. A negative correlation was observed between chlorophyll content with canopy temperature at Z41, and Z55 growth stages. A moderate negative correlation was found between spikelet number per spike with canopy temperature at Z61, and at Z70. The correlations among physiological parameters revealed that canopy temperature were negatively and chlorophyll content were positively associated with grain yield; hence these components can be used as reliable selection criteria to improve grain yield in wheat under limited rainfed and higher temperature (<30^{o}C) condition. Thus estimation of correlation analysis among yield and yield components and, physiological parameters may provide effective selection criteria to improve bread wheat grain yield. According to result of the study showed that genotypes has higher grain yield which have higher chlorophyll content and lower canopy temperature under rainfed condition.

REFERENCES

Altenbach, S.B., F.M. DuPont, K.M. Kothari, R. Chan, E.L. Johnson and D. Lieu (2003). Temperature, Water and Fertilizer Influence the Timing of Key Events During Grain Development in a US Spring Wheat. Journal of Cereal Science. 37(2003) 9-20. doi:10.1006/jcrs.2002.0483, available online at http://www.idealibrary.com on

Babar, M.A., M.P. Reynolds, M. van Ginkel, A.R. Klatt, W.R. Raun and M.L. Stone (2006). Spectral Reflectance to Estimate Genetic Variation for In-Season Biomass, Leaf Chlorophyll, and Canopy Temperature in Wheat. Crop Breeding and Genetics. Crop Sci., 46, 1046-1057.

Barrow, E.M., and M. Hulme (1996). Changing probabilities of daily temperature extremes in the UK related to future global warming and changes in climate variability. Climate Res., 6, 21-31.

Farooq, M., A. Wahid, N. Kobayashi, D. Fujita and S.M.A. Basra (2009). Plant drought stress: effects, mechanisms and management. Agronomy for Sustainable Development, 29, 185, 2009.

Fischer, R.A. (2001). Selektion Traits for Improving Yield Potantial. Application of Physiology in Wheat Breeding. Chapter-13, p. 148-159. International Maize and Wheat Improvement Center, CIMMYT. Mexico.

Francia, E., A. Tondelli, F. Rizza, F.W. Badeck, W.T.B.Thomas, I. van Eeuwijk Romagosa, A.M. Stanca and N. Pecchioni (2013). Determinants of barley grain yield in drought-prone Mediterranean environments. Italian J. Agron., 8 (1), 1.

Gomez, K. A., and A. A. Gomez (1984). Statistical Procedures for Agricultural Research. 2nd Ed. John Willey and Sons, Inc. New York. 641.

Hawker, J.S. and C. F. Jenner (1993). High temperature affects the activity of enzymes in the committed pathway of starch synthesis in developing wheat endosperm. Austral. J. Plant Physiol., 20, 197-209.

Hossain, A., J.A. Teixeira da Silva, M.V. Lozovskaya, V.P. Zvolinsky and V.I. Mukhortov (2012). High temperature combined with drought affect rainfed spring wheat and barley in southeastern Russia: Yield, relative performance and heat susceptibility index. J. Plant Breed. Crop Sci., 4 (11), 184.

Hunt, L.A., G. van der Poorten and S. Pararajasingham (1991). Postanthesis temperature effects on duration and rate of grain-filling in some winter and spring wheat. Can. J. Plant Sci., 71, 609-617.

Jackson, R. D., S.B. Idso, R.J. Reginato and P.J. Pinter (1981). Canopy Temperature as a Crop Water Stress Indicator. Water Resour. Res., 17, 4, 1133-1138.

Mahan, J.R., B.L. Mc.Michael and D. F. Wanjura (1995). Methods of reducing the adverse effects of temperature stress on plants: a review. Environ. Exp. Bot., 35, 251-258.

Pinera-Chavez, F., P. Berry, M. Foulkes, G. Molero and M. Reynolds (2016). Avoiding lodging in irrigated spring wheat. II. Genetic variation of stem and root structural properties. Field Crop Res., 196, P: 64-74.

Randall, P.J. and H.J. Moss (1990). Some effects of temperature regime during Grain-filling on wheat quality. Austral. J. Agric. Res., 41, 603-617.

Reynolds, M. P., M. Balota, M. I. B. Delgado, I. Amani and R.A. Fischer (1994). Physiological and Morphological Traits Associated With Spring Wheat Yield Under Hot, Irrigated Conditions. Austral. J. Plant Physiol., 21 (6), 717-730.

Reynolds, M.P., S. Nagarajan, M.A. Razzaque and O.A.A. Ageeb (2001). Heat Tolerance. Application of Physiology in Wheat Breeding, Chapter 10, p.124-135. International Maize and Wheat Improvement Center, CIMMYT. Mexico.

Reynolds, M.P., J.I. Ortiz-Monasterio and A. Mc. Nab, (eds) (2001). Application of Physiology in Wheat Breeding, Mexico, D.F., CIMMYT.

Slafer, G.A. and H.M. Rawson (1994). Sensitivity of wheat phasic development to major environmental factors: a re-examination of some assumptions made by physiologists and modellers. Austral. J. Plant Physiol., 21, 393-426.

Stone, P. J., R. Savin, I.F. Wardlaw and M. E. Nicolas (1995). The influence of recovery temperature on the effects of a brief heat shock on wheat I. Grain growth. Austral. J. Plant Physiol., 22, 945-954.

Stone, P. J., and M. E. Nicolas (1994). Wheat cultivars vary widely in their responses of grain yield and quality to short periods of post-anthesis heat stress. Austral. J. Plant Physiol., 21, 887-900.

Tashiro, T. and I.F. Wardlaw (1990). The response to high temperature shock and humidity changes prior to and during the early stages of grain development in wheat. Austral. J. Plant Physiol., 17, 551-561.

Öztürk, İ., and Z. K. Korkut (2018). Effect of Drought Stress Condition on Different Plant Growth Stages on Some Physiological Traits in Bread Wheat (Triticum aestivum L.) Genotypes. Turkish J. Agrıc. Nat. Sci., 5(4), 375-385.

Wardlaw, I.F., I.A. Dawson, P. Munibi and R. Fewster (1989). The tolerance of wheat to high temperatures during reproductive growth. II. Survey procedures and general response patterns. Austral. J. Agric. Res., 40, 1-13.

Wardlaw, I. F., and L. Moncur (1995). The response of wheat to high temperature following anthesis. I. The rate and duration of kernel filling. Austral. J. Plant Physiol., 22, 391-397.

Wheeler, T.R., T.D. Hong, R.H. Ellis, G. R. Batts, J.I.L. Morison and P. Hadley (1996). The duration and rate of grain growth and harvest index of wheat (*Triticum aestivum*) in response to temperature and CO_2. J. Exp. Bot., 47, 623-630.

Zadoks, J., T. Chang and C. Konzak (1974). A decimal code for the growth stages of cereals. Weed Res., 14, 415-421.