ÇOMÜ Zir. Fak. Derg. (COMU J. Agric. Fac.)
2023: 11 (1): 66-74
ISSN: 2147–8384 / e-ISSN: 2564–6826
doi: 10.33202/comuagri.1193015

Research Article

Evaluation of Physiological and Yield Traits of Some Bread Wheat Varieties (*Triticum aestivum* L.) Grown in Different Environments

Ali Erkul[1*] **Feride Öncan Sümer**[2] **Aydın Ünay**[2]

[1] Aydın Adnan Menderes University, Vocational College of Sultanhisar, 09470, Aydın-Türkiye
[2] Aydın Adnan Menderes University, Faculty of Agriculture, Department of Field Crops, Aydın-Türkiye
*Sorumlu yazar: aerkul@adu.edu.tr

Received Date: 21.10.2022 Accepted Date: 17.04.2023

Abstract

This study aimed to evaluate the performance of some bread wheat varieties in different environments, and to reveal the relationships between some physiological parameters and yield and yield components. Three bread wheat varieties, (Namely, Basribey 95, Alibey, and Kaşifbey 95), were used as plant materials. Field experiments were conducted during the 2009-2010 and 2010-2011 growing seasons in Aydın and Menemen locations. The experimental layout was a RCBD with three replications at each location and year. In the study, canopy temperature depression (CTD), chlorophyll content (CC), stomatal conductance (SC), grain yield (GY), plant height (PH), spike number per square meter (S/m^2), thousand kernel weight (TKW), test weight (TW), grain number per spike (G/S), single spike yield (SSY), number of days to heading (DHE), were examined. CTD in ZGS 65 had a decisive role in gaining high grain yield. Also, CC in ZGS 65 and ZGS 71 might be defined as an important physiological traits. On the other hand, the contribution of the SC parameter determined in ZGS 55, ZGS 65 and ZGS 71 to the yield depends on the environment. Those parameters could be selection criteria for high-yield wheat breeding due to positive and significant correlations with grain yield.

Keywords: bread wheat (*Triticum aestivum* L), canopy temperature depression, stomatal conductance, chlorophyll content

Farklı Çevrelerde Yetiştirilen Bazı Ekmeklik Buğday Çeşitlerinin (*Triticum aestivum* L.) Fizyolojik ve Verim Özelliklerinin Değerlendirilmesi

Öz

Bu çalışmada, farklı çevrelerde bazı ekmeklik buğday çeşitlerinin performansını değerlendirmek ve bazı fizyolojik parametreler ile verim ve verim öğeleri arasındaki ilişkileri ortaya koymak amaçlanmıştır. Araştırmada üç ekmeklik buğday çeşidi (Basribey 95, Alibey ve Kaşifbey 95) bitki materyali olarak kullanılmıştır. Tarla denemesi 2009-2010 ve 2010-2011 yetiştirme sezonunda, Aydın ve Menemen lokasyonlarında yürütülmüştür. Deneme her bir lokasyon ve yılda tesadüf blokları deneme deseninde üç tekrarlamalı olarak gerçekleştirilmiştir. Denemede, kanopi sıcaklık toleransı (KST), klorofil içeriği (KLİ), stoma iletkenliği (STİ), tane verimi (TV), bitki boyu (BB), metrekarede başak sayısı (BS/m^2), bin tane ağırlığı (BTA), hektolitre ağırlığı (Hl), başakta tane sayısı (BTS), tek başak verimi (TBV) ve başaklanma gün sayısı (BGS) belirlenmiştir. ZGS 65 gelişme dönemindeki KST'nin yüksek tane verimi elde etmede belirleyici olduğu; ZGS 65 ve ZGS 71 gelişme dönemlerindeki KLİ'nin önemli bir fizyolojik karakter olarak tanımlanabileceği; ZGS 55, ZGS 65 ve ZGS 71 gelişme dönemlerindeki STİ parametresinin verime katkısının çevreye göre farklılık gösterebileceği; verimle olan olumlu ve önemli ilişki göstermesinden dolayı bu fizyolojik parametrelerden çeşit ıslah programlarında yararlanılabileceği görüşüne ulaşılmıştır.

Anahtar Kelimeler: ekmeklik buğday (*Triticum aestivum* L), kanopi sıcaklık toleransı, stoma iletkenliği, klorofil içeriği

Introduction

Bread wheat is the most important cultivated plant in Turkey as in the whole world. Cultivation areas and production were 217 million hectares and 189 million tons in the world, respectively (FAOSTAT, 2021). Turkey produces approximately 20 million tons of wheat in an area of 7.3 million hectares. The coastal area of the Aegean region, İzmir and Aydın provinces, have high productivity potential for wheat varieties with spring type (Ünsal and Geren, 2008). The different environmental conditions have affected the wheat yield (Hagos and Abay, 2013, Tsenov et al., 2014; Öztürk, 2022). The effects of environmental factors on the filling period with the greatest need for assimilation affects the photosynthesis process are very important (Kumari et al., 2007).

The CTD has been used as a physiological traits in many research, and is expressed as the difference between air temperature and canopy temperature. If it is lower than the air temperature, the CTD is positive (Balota et al., 2007). In addition, this parameter has been used safely in breeding studies due to its inherent high genetic correlation (r = 0.86) and its inheritability (Reynolds et al., 1998; Reynolds et al., 2001). Genotypes having cooler canopies (higher CTD) showed longer grain filling periods and consequently maintained less reduction of TKW under heat stress conditions (Ray and Ahmed, 2015). The CTD is influenced by biological and environmental factors such as soil water status, air temperature, relative humidity, continuous radiation, wind, evapotranspiration, cloudiness, plant transmission system, and plant metabolism. It has been reported that the CTD should be measured under cool and humid conditions where this parameter will not be useful and therefore the air is warm, windless, cloudless, and low in the proportional nematode (ie, high water vapor temperature) (Amani et al., 1996, Reynolds et al., 2001). The CTD can be measured quickly and easily with an infrared thermometer in wheat trial parcels. Bahar et al., (2005) have shown that CTD has positive relations with GY, SSY, and G/S, and that this parameter can be used as a selection criterion in breeding programs.

The second parameter is the SC. The CTD is a very suitable parameter in the selection of superior genotypes in physiological care in environments with low temperature tolerance and hot and proportional humidity. However, in environments with highly proportional noodles, the cooling effect of the leaves exposed to the leaves is neglected and the genotypic difference cannot be detected correctly. However, leaves open their stomata to permit CO_2 uptake, and differences in CO_2 uptake result from differences in SC (Reynolds et al., 2001). Stomatal conductivity refers to the ratio of CO_2 entering the leaf for photosynthesis to the amount of water vapor released from the leaf (Jones, 1987). The low SC has been reported to improve water use efficiency (WUE) in wheat (*Triticum spp.*) (Gay, 1994, Condon et al., 1990). Rebetzke et al., 2001, found large genetic differences in SC in the populations they studied. SC can be measured rapidly with a porometer (Rawson and Hulse, 1996). It has been reported that canopy can be used in combination with these two features because of temperature tolerance and SC related to each other and grain yield (Reynolds et al., 2001).

Another physiological parameter is the CC. It has been reported that the rate of photosynthesis and the amount of chlorophyll in leaves are positively correlated with yield (Reynolds et al., 1994). It has been reported that high CC and high SC are related to temperature tolerance and that these two traits can be inherited (Skovmand et al., 2001).

This study aimed to evaluate the performance of some bread wheat varieties in different environments, and to reveal the relationships between some physiological parameters and yield and yield components.

Material and Methods

Three bread wheat varieties (Namely, Basribey 95, Alibey and Kaşifbey 95) were used as materials in the research. The study was conducted at two locations (Menemen; 27º 4'E, 38º 36'N, asl 30 m and Aydın; 27º 51'E, 37º 51'N, asl 50 m) during the 2010 and 2011 years. The experimental layout was a RCBD with three replications at each location and year. The plot area was 8 square meters (1.6 x 5 m). The sowing density was 450 seeds m^{-2}. The experiment was carried out on November 11, 2009, and November 12, 2010, in the Aydın location and on 01.09.2010 and 12.05.2010 in the Menemen location. Nitrogen (160 kg ha^{-1}) and phosphorus (80 kg ha^{-1}) were applied to experimental plots. In both locations, irrigation was applied to all plots at two times.

The CTD, SC, and CC measurements were taken at three different periods of the Zadoks Growth Scale (ZGS) by (Zadoks et al., 1974); ZGS 55; (50% of spike visible, mid heading) ZGS 65; (50% of spikes are flowering, mid flowering) ZGS 71; (kernels watery ripe, clear liquid). The CTD was measured at 11:00 am and 15:00 pm using an infrared thermometer (Model 910). CTD measurements techniques were made by Reynolds et al. 1998. The CTD values were calculated as follows given by Balota et al., (2007); The CTD = Ta-Tc. Where, Ta: Air temperature, Tc: Canopy temperature. The CTD is positive when the canopy is cooler than the air. Abbreviations: CTD1: ZGS 55, CTD2: ZGS 65, CTD3: ZGS 71. SC (mmol $m^{-2}s^{-1}$) was measured by a self-calibrated diffusion porometer (Decagon SC-1 Leaf Porometer) between 11:00 am and 16:00 pm. Measurements were taken on five flag leaves per plot. Abbreviations: SC1: ZGS 55, SC2: ZGS 65, SC3: ZGS 71. CC measurements were made on 15 flag leaves with a chlorophyll meter (SPAD 502). Abbreviations: CC1: ZGS 55, CC2: ZGS 65, CC3: ZGS 71. GY was determined from 4.8 square meters plot area. In addition, PH, S/m^2, TKW, TW, G/S, SSY, and DHE were measured. Analysis of variance was applied for investigated traits according to factorial design with pooled data. Mean comparisons for all characters were made according to the Duncan test by SPSS statistical software. Phenotypic correlations between investigated traits were also examined (Steel and Torrie, 1980). The monthly average temperature and total precipitation values of the locations were given in Figure 1.

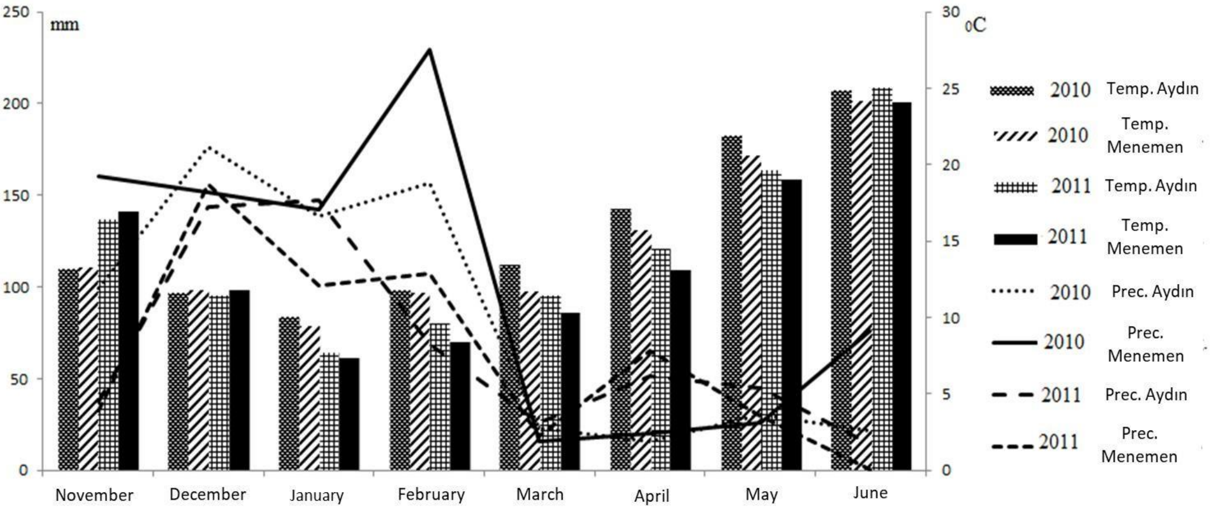

Fig 1. Monthly average temperature and total precipitation values for Aydın and Menemen locations

Results and Discussion

The results of variance analysis of the investigated traits are given in Table 1.

Table 1. Results of variance analysis of the investigated traits

		Mean of squares								
SOV	DF	CTD1	CTD2	CTD3	CC1	CC2	CC3	SC1	SC2	SC3
Environment	3	**	**	**	**	**	**	**	**	**
Variety	2	ns	ns	ns	ns	ns	ns	ns	ns	*
Env. x Var.	6	ns	*	ns	ns	**	**	ns	ns	ns

*,** significant at p< 0.05 and 0.01 respectively. ns:non-significant. Abbreviations: SOV: Source of variation, CTD: Canopy temperature depression, CC: Chlorophyll content, SC: Stomatal conductance, PH: Plant height, S/m^2: Spike number per square meter, GY: Grain yield, TKW: Thousand kernel weight, TW: Test weight, G/S: Grain number per spike, SSY: Single spike yield, DHE: Number of days to heading

Table 1. Continued

		Mean of squares							
SOV	DF	PH	S/m^2	GY	TKW	TW	G/S	SSY	DHE
Environment	3	**	**	**	**	**	**	**	**
Variety	2	ns	ns	**	ns	**	ns	ns	**
Env. x Var.	6	**	**	**	ns	**	*	**	ns

*,** significant at p< 0.05 and 0.01 respectively. ns:non-significant. Abbreviations: SOV: Source of variation, CTD: Canopy temperature depression, CC: Chlorophyll content, SC: Stomatal conductance, PH: Plant height, S/m^2: Spike number per square meter, GY: Grain yield, TKW: Thousand kernel weight, TW: Test weight, G/S: Grain number per spike, SSY: Single spike yield, DHE: Number of days to heading

Environment x variety was found significant for physiological parameters such as CTD2, CC2, and CC3 and yield and yield components such as PH, S/m^2, GY, TW, G/S and SSY. In examining all traits, the differences between environments were significant. For SC3, GY, TW and DHE, the differences between varieties were significant (Table 1).

Mean values of investigated traits in environment x variety interaction are presented in Table 2. The highest (3.60 °C) and the lowest (-2.17 °C) CTD2 values were founded in the 2011 year of Menemen and 2011 year of Aydın location from a variety of Alibey respectively (Table 2). Canopy temperature values varied from -0.22 °C to 9.1 °C in several studies (Golestani and Assad, 1998; Reynolds et. al, 1998; Ayeneh et. al., 2002; Bahar *et. al.*, 2005; Kumari et. al., 2007; Karimizadeh et. al., 2011; Ray and Ahmed, 2015; Al-Ghzawi et. al., 2018). The CTD2 measured in all varieties during the flowering period were found high in the second year of the Menemen location. This is because there is more rainfall in the second year of the Menemen location. As a result, in the second year of Menemen's location, SSY and the GY increased.

The highest (61.31%) and the lowest (51.62%) CC2 values were taken from Kaşifbey 95 variety in different locations and years. Similarly, the highest (58.97%) and the lowest (21.12%) CC3 values were taken from Kaşifbey 95 variety in different locations and years (Table 2). In other studies, chlorophyll values were varied from 38.5% to 75% (Reynolds *et al.*, 1998; Ayeneh et al., 2002; Babar et al., 2006; Karimizadeh et al., 2011; Al-Ghzawi et. al., 2018). In the first year of the Menemen location, the difference between CC2 and CC3 values in all varieties was found to be significant. There was chlorophyll loss compared to other locations and years. Thus, it can be stated as a description of the decrease in GY with TKW and SSY. Similarly, Reynolds *et al.*, (2001) reported that the decrease in the yield of wheat was related to the continuation of chlorophyll loss during the grain-filling period.

Table 2. Mean values of investigated traits in environment x variety interaction

Parameter	Variety	2010 Aydın	2010 Menemen	2011 Aydın	2011 Menemen
	Basribey95	1.28b*	2.62a	-0.43b	3.40a
CTD2	Alibey	1.22b	2.75a	-2.17c	3.60a
	Kaşifbey95	1.62a	2.29ab	-0.22b	3.53a
	Basribey95	56.51a	54.51a	59.65a	54.37a
CC2	Alibey	57.40a	54.96a	58.92b	54.67a
	Kaşifbey95	55.83a	51.62b	61.31a	54.86a
	Basribey95	46.85a	22.25b	57.60a	52.97a
CC3	Alibey	41.23b	31.40a	57.18a	52.91a
	Kaşifbey95	44.56a	21.12b	58.97a	53.85a
	Basribey95	99.8a	83.3b	116.6a	95.5b
PH	Alibey	94.8a	85.4b	116.8a	93.1b
	Kaşifbey95	88.4b	93.5a	112.7a	104.9a
	Basribey95	515a	477a	729a	737a
S/m^2	Alibey	480a	519a	717a	682a
	Kaşifbey95	560a	475a	653a	558b
	Basribey95	5380 a	4890 a	6690a	8180a
GY	Alibey	4630 b	4430 a	4350b	7200a
	Kaşifbey95	4590 b	3100 b	6690a	7480a
	Basribey95	48.7a	32.9a	31.9a	40.2a
TKW	Alibey	38.0b	33.3a	37.0a	38.7a
	Kaşifbey95	38.2b	25.9b	31.0a	39.2a
	Basribey95	80.2a	71.1a	76.4a	77.9a
TW	Alibey	72.8c	71.9a	72.8b	79.0a
	Kaşifbey95	76.6b	63.7b	70.5b	76.8a
	Basribey95	47.5a	55.9a	42.1a	55.3b
G/S	Alibey	45.1a	60.5a	35.6b	58.1b
	Kaşifbey95	44.9a	55.3a	47.1a	68.1a
	Basribey95	2.19a	1.74a	1.81a	2.13b
SSY	Alibey	1.60b	1.95a	1.65a	2.27b
	Kaşifbey95	1.53b	1.41b	1.90a	2.76a

*:Means followed by the same letter are not significantly different at the 5% probability level.
CTD: Canopy temperature depression, CC: Chlorophyll content, PH: Plant height, S/m^2: Spike number per square meter, GY: Grain yield, TKW: Thousand kernel weight, TW: Test weight, G/S: Grain number per spike, SSY: Single spike yield.

The highest value for PH (116.8 cm) was observed in the Alibey variety in Aydın in the second year, and the lowest value (83.3 cm) was observed in Basribey 95 variety in the Menemen location in the first year (Table 2). Different PH values were reported by Yüce et al., (2001) between 91.3 cm to 111.2 cm and by Erkul et al., (2005) between 70.5 cm and 117.2 cm.

The highest value (717) in terms of the S/m^2 was found in the second year in the Menemen location from the Basribey 95, and the lowest value (475) in the Menemen location in the first year of Kaşifbey 95 (Table 2). Different values for this trait between 299.8 and 560 have been reported by several researchers (Demir et al., 1997; Dokuyucu et al., 1997; Çığ and Ülker, 2003).

In terms of GY, the highest GY (8180 kg ha^{-1}) was obtained from Basribey 95 in the Menemen location in the second year. The lowest GY (3100 kg ha^{-1}) was obtained from Kaşifbey 95 variety in the Menemen location in the first year (Table 2). Erkul *et al.*, (2005) reported that the GY varied between 2922 kg ha^{-1} and 8615 kg ha^{-1}. Similar findings have been reported by several authors (Akıncı et al., 2001; Yüce et al., 2001; Genç et al., 2003).

When TKWs of the bread wheat varieties were examined, the highest TKW (48.7 g) was found in Basribey 95 variety in the first year in the Aydın location, and the lowest TKW (25.9 g) was determined in Kaşifbey 95 variety in the first year in the Menemen location (Table 2).

The highest value in terms of TW (80.2 kg/hl) was found in Basribey 95 variety in the first year in the Aydın location, and the lowest value (63.7 kg/hl) was determined in Kaşifbey 95 variety in the Menemen location in the first year (Table 2). The limits of variation in TW were determined by Şener et al., (1997) between 68.8 kg/hl and 83.1 kg/hl, by Dokuyucu *et al.*, (1999) between 80.3 kg/hl and 84.4 kg/hl, by Toklu et al., (1999) between 74.3 kg/hl and 81 kg/hl, by Karatopak and Dinçer (1999) between 72.6 kg/hl and 81.3 kg/hl.

The G/S values in the wheat varieties discussed in the study are given in Table 2. The highest G/S value (68.1) was determined in Kaşifbey 95 variety in the second year in the Menemen location, and the lowest G/S value (35.6) was determined in the Alibey variety in Aydın in the second year. The limits of variation in G/S were explained by Şener et al., (1997) between 41.4 and 56.4, by Dokuyucu et al., (1997) between 44.9 and 56.3, by Dokuyucu et al., (1999) between 34 and 54, by Çığ and Ülker (2003) between 23.3 and 50.4.

The highest SSY (2.76 g) was obtained from Kaşifbey 95 variety in the second year in the Menemen location, and the lowest SSY (1.41 g) was obtained from the Kaşifbey in the first year in the Menemen location (Table 2). Dokuyucu *et al.*, (1997), Dokuyucu et al., (1999) and Okur et al., (2003) have been reported similar findings in their studies.

Mean values of CTD1, CTD3, CC1, SC1, SC2, and SC3 in different environments are given in Table 3. CTD1 values measured during the period of ZGS 55 ranged from -0.76 ^{o}C to 3.18 ^{o}C in various locations and years. CTD3 values measured at the stage of ZGS 71 varied from 0.77 ^{o}C to 2.29 ^{o}C in different environments. CC values determined during the period of ZGS 55 ranged from 54.10% to 62.89% in mentioned environments (Table 3).

Table 3. Mean values of CTD1, CTD3, CC1, SC1, SC2, and SC3 in different environments

Parameter	2010 Aydın	2010 Menemen	2011 Aydın	2011 Menemen
CTD 1	1.27 B*	2.81 A	-0.76 C	3.18 A
CTD 3	2.04 A	1.43 A	0.77 B	2.29 A
CC 1	62.89 A	54.10 B	62.28 A	60.14 A
SC 1	97.56 B	100.00 B	178.60 A	147.13 A
SC 2	274.22B	297.70 B	307.69 B	401.55 A
SC 3	306.99B	311.44 B	170.94 C	494.08 A

*:Means followed by the same letter are not significantly different at the 5% probability level.
CTD: Canopy temperature depression, CC: Chlorophyll content, SC: Stomatal conductance.

SC values related to three of Zadok's growth periods ranged between 97.56 mmol $m^{-2}s^{-1}$ and 494.08 mmol $m^{-2}s^{-1}$ (Table 3). This agrees with the results explained by Fischer et. al., (1998). On the contrary, Bahar et. al., (2011) declared more highest SC values (between 505 mmol $m^{-2}s^{-1}$ and 1003 $m^{-2}s^{-1}$).

Correlations

Correlation coefficients of investigated traits are presented in Table 4. Although negative and significant correlation coefficients were found between CTD1, CTD2, SC3 and PH, positive and significant correlation coefficients were determined between CC1, CC2, CC3, SC1, and PH (Table 4). This means that canopy temperature depression increases in the parcels with high plant sizes. On the other hand, high CC in all three periods affected the PH positively.

Table 4. Correlation coefficients of investigated traits

	PH	S/m^2	GY	TKW	TW	G/S	SSY	DHE
CTD1	-0.781**	-0.688**	0.086	-0.086	-0.284	0.251	0.253	-0.597**
CTD2	-0.743**	-0.399*	0.278	0.181	0.219	0.665**	0.467**	-0.366*
CTD3	-0.178	-0.119	0.419**	0.397*	0.491**	-0.022	0.627**	0.242
CC1	0.559**	0.307	0.353*	0.412*	0.479**	-0.419**	0.185	0.941**
CC2	0.681**	0.442**	0.276	0.105	0.190	-0.521**	0.044	0.622**
CC3	0.729**	0.738**	0.644**	0.328	0.576**	-0.288	0.382*	0.834**
SC1	0.675**	0.705**	0.395*	-0.141	0.158	-0.233	0.186	0.383*
SC2	0.070	0.341*	0.383*	0.013	0.201	0.303	0.377*	0.037
SC3	-0.468**	0.043	0.367*	0.336*	0.395*	0.535**	0.414*	-0.170

*,** Significant at $p < 0.05$ and 0.01 respectively. Abbreviations: CTD: Canopy temperature depression, CC: Chlorophyll content, SC: Stomatal conductance, PH: Plant height, S/m^2: Spike number per square meter, GY: Grain yield, TKW: Thousand kernel weight, TW: Test weight, G/S: Grain number per spike, SSY: Single spike yield, DHE: Number of days to heading.

Similar to the interpretation of PH can be made between the CTD and S/m^2. CTD was significantly adversely affected by high S/m^2. Similarly, CC was found to be significantly positive in the parcels where the S/m^2 was high. In the first two periods, SC was higher in parcels with higher spike numbers. When TKW and TW are evaluated together; there were positive and significant effects of late CTD and SC and early CC. Negative and significant correlation coefficients were found between the G/S and early CC. In the same period, considering the correlations with TKW and TW, it can be said that the CC increases the yield over the grain weight (Table 4).

Positive correlation coefficients were determined between the GY, and SSY and evaluated physiological parameters. The correlation coefficient with GY was positive and significant for CTD3, CC1, CC3, SC1, SC2, and SC3 (Table 4). It could be concluded that high values of the CTD, CC and SC were found to affect the yield positively. Similarly, Royo et al., (2002), Bahar et al., (2008) ve Guendouz et al., (2012) determined positive correlation coefficients between GY and the CTD and stated that the CTD could be an effective method for testing high temperature and drought-tolerant genotypes. On the other hand, the found positive and significant correlation coefficients between SPAD values measuring the CC and the GY were consistent with other researchers' results (Islam et al., 2014; Monostori et al., 2016). Fischer et al., (1998) revealed that they found positive and significant relationships between yield and the CTD, photosynthesis ratio and stomatal conductivity in their study. Besides, Bahar et al., (2009) found no significant correlations between SC and yield in early and late milk and late maturation periods, but found positive and significant correlation coefficients with the G/S. In our study, the positive and significant correlation coefficients between GY and SC in all three periods indicate that this traits can be used for the estimation of yield in physiological studies.

Conclusion

In this study, based on the physiological parameters evaluated, the CTD in ZGS 65 was a decisive role in gaining high GY. Also, CC in ZGS 65 and ZGS 71 can be defined as important physiological traits. On the other hand, the contribution of SC parameters determined in ZGS 55, ZGS 65 and ZGS 71 to the yield depends on the environment. Those parameters could be selection criteria in breeding programs for high yield due to positive and significant correlations with GY.

Acknowledgements

The authors are grateful to Wheat Department of Agean Agriculture Research Institute, especially Chief Rıza ÜNSAL, Dr. Hatice GEREN and İsmail SEVİM. This research was supported through the Project No: SUMYO-10001 by Adnan Menderes University.

Authors' Contributions

The authors declare that they have contributed equally to the article.

Conflicts of Interest Statement

The authors declare that they have no conflict of interest.

References

Akıncı, C., Yıldırım, M., Sönmez, N., 2001. Diyarbakır sulu koşullarina uygun ekmeklik buğday çeşit ve hatlarının belirlenmesi. Türkiye 4. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 69-74. 17-21 Eylül, Tekirdağ.

Al-Ghzawi, A., Khalaf, Y., Al-Ajlouni, Z.I., Al-Quraan, N.A., Musallam, I., Hani, NB., 2018. The effect of supplemental irrigation on canopy temperature depression, chlorophyll content, and water use efficiency in three wheat (Triticum aestivum L. and T. Durum desf.) varieties grown in dry regions of Jordan. Agriculture. 8(5): 67.

Amani, I., Fischer, R.A., Reynolds, M.P, 1996. Evaluation of canopy temperature as a screening tool for heat tolerance in spring wheat. J.Agron.Crop Sci.176:119-129.

Ayeneh, A., M., Van Ginkel, M.P., Reynolds, K.A, 2002. Comparison of laf, spike, peduncle and canopy temperature depression in wheat under heat stress. Field Crops Research. 79: 173-184.

Babar, M.A, Reynolds, M.P., Ginkel, M.V, Klatt, A.R, Raun, W.R, Stone, M.L, 2006. Spectral reflectance to estimate genetic variation for in-season biomass, leaf chlorophyll, and canopy temperature in wheat. Crop Sci. 46:1046-1057.

Bahar, B., Barutçular, C., Yıldırım, M., Genç, İ., 2005. Buğdayda bitki topluluğu sıcaklığı düşüşünün verim ve verim unsurları ile ilişkisi. Türkiye 5. Tarla Bitkileri Kongresi. Bildiriler Cilt: 2. 665-668. 5-9 Eylül, Antalya.

Bahar, B., Yıldırım, M., Genç, İ., 2008. Effect of canopy temperature depression on grain yield and yield components in bread and durum wheat. Not. Bot. Hort. Agrobot. Cluj. 36 (1): 34-37.

Bahar, B., Barutçular, C., Yıldırım, M., 2009. Relationships between stomatal conductance and yield components in spring durum wheat under mediterranean conditions. Not. Bot. Hort. Agrobot. Cluj. 37 (2):45-48.

Bahar, B., Yıldırım, M., Yücel, C., 2011. Heat and drought resistance criteria in spring bread wheat (*Triticum aestivum* L.): Morpho-physiological parameters for heat tolerance. Scientific Research and Essays. 6(10): 2212-2220.

Balota, M., Payne, AWA., Evett, S.R., Lazar, M.D., 2007. Canopy temperature depression sampling to assess grain yield and genotypic differentiation in winter wheat. Crop Sci. 47:1518-1529.

Condon, A.G., Farquar, G.D., Richards, R.A., 1990. Genotypic variation in carbon isotope discrimination and transpiration efficiency in wheat. Aust. J. Plant Physiol. 17:9-22.

Çığ, F., Ülker, M., 2003. Yeni tescil edilen bazı ekmeklik ve makarnalık buğday çeşitlerinin Van koşullarında verim ve verim öğelerinin belirlenmesi. Türkiye 5. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 431-435. 13-17 Ekim, Diyarbakır.

Demir, İ., Turgut, İ., Yüce, S., Konak, C., Sever, C., Tosun, M., 1997. Ege Bölgesinde farklı lokasyonlarda yetiştirilen ekmeklik buğdayların verim ve bazı verim öğeleri üzerinde bir araştırma. Türkiye 2. Tarla Bitkileri Kongresi. Bildiriler: s. 11-15. 22-25 Eylül, Samsun.

Dokuyucu, T., Akkaya, A., Nacar, A., İspir, B., 1997. Kahramanmaraş koşullarında bazı ekmeklik buğdayların verim, verim unsurları ve fenolojik özelliklerinin incelenmesi. Türkiye 2. Tarla Bitkileri Kongresi. Bildiriler: s.16-20. 22-25 Eylül, Samsun.

Dokuyucu, T., Cesurer, L., Akkaya, A., 1999. Bazı ekmeklik buğday (T*riticum aestivum* L.) genotiplerinin Kahramanmaraş koşullarında verim ve verim unsurlarının incelenmesi. Türkiye 3. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 127-132. 15-20 Kasım 1999, Adana.

Erkul, A., Konak, C., Turgut, İ., Öncan, F., 2005. Büyük Menderes Havzasına uyumlu ekmeklik buğday çeşitlerinin geliştirilmesi. Türkiye 6. Tarla Bitkileri Kongresi. Cilt: 2. 669-674. 5-9 Eylül, Antalya.

Faostat, 2021. Food and Agriculture Organization of the United Nations (FAO). FAOSTAT Database. http://faostat.fao.org/ (entered on 14th September 2022).

Fischer, R.A, D., Rees, K.D., Sayre, Z.M., Lu, AG., Condon, A., Saavedra, L., 1998. Wheat yield progress is associated with higher stomatal conductance and photosynthetic rate and cooler canopies. Crop Sci. 38:1467-1475.

Gay, A.P., 1994. Breeding for leaf water conductance, its heritability and its effect on water use in *Lolium perenne*. Aspects of Applied Biology-Efficiency of Water Use in Crop Systems. 38:41-46.

Genç, İ., Yağbasanlar, T., Özkan, H., Yıldırım, M., Yücel, C., Özer, S., Bahar B., Altıntaş, S., Topal, M., 2003. Çukurova koşullarına uygun buğday ıslah çalışmaları. Türkiye 5. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 41-46. 13-17 Ekim, Diyarbakır.

Golestani, A.S., Assad, M.T., 1998. Evaluation of four screening techniques for drought resistance and their relationship to yield reduction ratio in wheat. Euphytica 103:293-299.

Guendouz, A., Guessoum, S., Maamri, K., Benidir, M., Hafsi, M., 2012. Canopy temperature efficiency as indicators for drought tolerance in durum wheat (*Triticum durum* Desf.) in semi arid conditions. Journal of Agriculture and Sustainability. 1(1): 23-38.

Hagos, H.G., Abay, F., 2013. AMMI and GGE biplot analysis of bread wheat genotypes in the northern part of ethiopia. Journal of Plant Breeding and Genetics. 1(1): 12-18.

Islam, MR, Haque, K.M.S, Akter, N., Karim, M.A., 2014. Leaf chlorophyll dynamics in wheat based on spad meter reading and its relationship with grain yield. Scientia Agriculturae. 8(1): 13-18.

Jones, H.G., Zeiger, E., Farguhar, G.D., Cowan, I.R., 1987. Breeding for stomatal characters. In: Stomatal Function. pp. 431-443. Stanford University Press, Stanford.

Karatopak, G., Dinçer, N., 1999. Çukurova Bölgesi için uygun ekmeklik buğday (T*riticum aestivum* L.) çeşitlerinin belirlenmesi üzerine araştırmalar. Türkiye 3. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 343-348. 15-20 Kasım, Adana.

Karimizadeh, R., Mohammadi, M., Ghaffaripour, S., Karimpour, F., Shefazadeh, M.K., 2011. Evaluation of physiological screening techniques for drought-resistant breeding of durum wheat genotypes in Iran. African Journal of Biotechnology. 10(56) :12107-12117.

Kumari, M., Singh, V.P., Tripathi, R., Joshi, A.K., 2007. Variation for staygreen trait and its assocıation with canopy temperature depression and yield traits under terminal heat stress in wheat. H.T.Buck *et al.* (Eds.), Wheat Production in Stressed Environments. pp. 357-363.

Monostori, I., Arendas T., Hoffman, B., Galiba, G., Gierczik, K., Szira, F., Vagüjfalvi, A., 2016. Relationship between SPAD value and grain yield can be affected by variety, environment and soil nitrogen content in wheat. Euphytica. 1: 103-112.

Okur, Ö., Yıldırım, A., Sakin, M.A., Gökmen, S., 2003. Tokat Artova-Kazova koşullarında bazı yazlık ekmeklik buğday hatlarının verim ve verim unsurlarının belirlenmesi. Türkiye 5. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 446-450. 13-17 Ekim, Diyarbakır.

Öztürk, İ., 2022. Environment by genotype interaction and stability of bread wheat (*Triticum aestivum* L.) genotypes under rainfed conditions in Trakia Region. Ekin Journal of Crop Breeding and Genetics. 8(2): 118-127.

Rawson, H.M., Hulse, B., 1996. An inexpensive pocket-sized instrument for rapid ranking of wheat genotypes for leaf resistance. In: R.A. Richards *et al.* (Eds.), Proc. 8th Ass. Wheat Breed. Soc. Australia. pp. 127-129. CSIRO Plant Industry, Canberra.

Ray, J., Ahmed, J.U., 2015. Canopy temperature affects on yield and grain growth of different wheat genotypes. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372. 8(7) Ver. II (July. 2015), pp. 48-55.

Rebetzke, G.J., Condon, A.G., Richards, R.A., Read, J.J., 2001. Phenotypic variation and sampling for leaf conductance in wheat (*Triticum aestivum* L.) breeding populations. Euphytica. 121:335-341.

Reynolds, M.P., Balota, M., Delgado, M.I.B., Amani, I., Fischer, R.A., 1994. Physiological and morphological traits associated with spring wheat yield under hot, dry irrigated conditions. Aust. J. Plant Physiol. 21:717-730.

Reynolds, M.P., Singh, R.P., Ibrahim, A., Ageeb, O.A.A., Largue-Saavedra, A., Quick, J.S., 1998. Evaluating physiological traits to complement empirical selection for wheat in warm environments. Euphytica 100:85-94.

Reynolds, M.P., Nagarajan, S., Razzaque, M.A., Ageeb, O.A.A., Reynolds, M.P., Monasterio, O., McNab, J.I., 2001. Breeding for Adaptation to Environmental Factors: Heat Tolerance in Application of Physiology in Wheat Breeding. pp. 124-135.

Royo, C., Villegas, D., Garcia, Del Moral, L.F., Elhani, S., Aparicio, N., Rharrabti, Y., Araus, J.L., 2002. Comparative performance of carbon isotope discrimination and canopy temperature depression as predictors of genotypes differences in durum wheat yield in spain. Aust J Agric Res. 53: 561-569.

Skovmand, B., M.P., Reynolds, I.H., DeLacy., 2001. Mining wheat germplasm collections for yield enhancing traits. Euphytica 119:25-32.

Steel, R.G.D., Torrie, J.H., 1980. Principles and Procedures of Statistics, Second Edition, New York: McGraw-Hill Book Co.

Şener, O, Kılınç, M, Yağbasanlar, T., Gözübenli, H., Karadavut, U., 1997. Hatay koşullarında bazı ekmeklik (*Triticum aestivum* L. Em Thell) ve makarnalık buğday (*Triticum durum* Desf.) çeşit ve hatlarının saptanması. Türkiye 2. Tarla Bitkileri Kongresi. Bildiriler s. 1-5. 22-25 Eylül, Samsun.

Toklu, F., Yağbasanlar, T., Özkan, H., 1999. Ekmeklik buğdayda (*Triticum aestivum* L.) hektolitre ağırlığı ile danenin fiziksel ve kalite özellikleri arasındaki ilişkilerin saptanması üzerine bir araştırma. Türkiye 3. Tarla Bitkileri Kongresi. Bildiriler Cilt: 1. 339-342. 15-20 Kasım, Adana.

Tsenov, N., Gubatov, T., Atanasova, D., Nankova, M., Ivanova, A., 2014. Genotype x environment effects on the productivity traits of common wheat (*Triticum aestivum* L.) II. Analysis of genotype reaction. Turkish Journal of Agricultural and Natural Sciences. Special Issue. 1: 1198-1208.

Ünsal, R., Geren, H., 2008. Climatic factors affecting wheat yields in Aegean coastal region and adaptation of varieties. Anadolu, Journal of AARI 18(2): 1-10.

Yüce, S., Konak, C., Demir, İ., Tosun, M., Turgut, İ., Akçalı, R.R., 2001. Ege Bölgesinde bazı ekmeklik buğday çeşit ve hatlarında verim ve kimi özellikler üzerinde araştırmalar. Türkiye 4. Tarla Bitkileri Kongresi. Bildiriler Cilt: I. 29-35. 17-21 Eylül, Tekirdağ.

Zadoks, J.C., Chang, T.T., Konzak, C.F., 1974. A Decimal Code for Growth Stages of Cereals. Weed Res. 14: 415-421.