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Investigation of Bread Wheat Genotypes with Different Characteristics by Physiological and Quality Traits

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Abstract: Instruments measuring spectral reflectance are very important to determine the relationship between grain yield (GY), quality and physiological traits of bread wheat genotypes at different developmental stages. This study was carried out under rain-fed conditions in 2019-2020 and 2020-2021 growing seasons in Muş province. The experiment was set up in a Randomized Blocks Experimental Design with 3 replicates. Except to flowering stage chlorophyll content (FSC), statistically significant differences were determined among genotypes at the level of $p \leq 0.01$ in all examined characteristics. More explicitly, G6, G8, G10, Müfitbey, Hanlı and Metin in terms of GY; Cemre, Kenanbey and Bezostaja 1 as regards quality traits; Ekiz, G8, and G9 with regard to physiological traits were found as significant genotypes. Biplot model analysis, used to determine the relationship genotype-trait and stability, showed that thousand grain weight (TGW) and plant height (PH) were positively associated with both GY and Normalized Difference Vegetation Index (NDVI). GY was found to be related to canopy temperature (CT) and heading time (HT) negatively. Notably, NDVI were positively related to protein ratio. Hanlı, Metin, G6, G8, and G10 were established as the high-yielded stabile genotypes which are least affected from environmental conditions.

Farklı Karakterli Ekmeklik Buğday Genotiplerinin Fizyolojik ve Kalite Özellikleri yönüyle İncelenmesi

Anahtar Kelimeler
Ekmeklik buğday,
Stabilite,
Korelasyon,
Biplot

Öz: Buğdayın farklı gelişim dönemlerinde, fizyolojik özellikler ile tane verimi ve kalite özellikleri arasındaki ilişkiyi belirlemek amacıyla spektral yansıma aletleri farklı araştırıcılar tarafından yoğun bir şekilde kullanılmaktadır. Çalışma, Muş ilinde yağışa dayalı koşullarda 2019-2020 ve 2020-2021 sezonlarında yürütülmüştür. Deneme, Tesadüf Blokları Deneme Deseninde 3 tekrarlamalı olarak kurulmuştur. Çiçeklenme dönemi klorofil içeriği (FSC) hariç, incelenen tüm özelliklerde genotipler arasında $p \leq 0.01$ düzeyinde istatistiki olarak önemli farklılıklar belirlenmiştir. Varyans analizi sonuçlarına göre, tane veriminde (GY); G6, G8, G10, Müfitbey, Hanlı ve Metin, Kalitede; Cemre, Kenanbey ve Bezostaja 1, Fizyolojik özelliklerde; Ekiz, G8 ve G9 genotipleri öne çıkmıştır. Genotip-özellik ve stabilite biplot modeline göre; bin tane ağırlığı (TGW) ve bitki boyu (PH)'nun hem GY ile hem de Normalize Edilmiş Vejatasyon İndeksi (NDVI) ile pozitif ilişkili olduğu görülmüştür. GY'nin bitki örtüsü sıcaklığı (CT) ve başaklanma süresi (HT) ile negatif ilişkili olduğu belirlenmiştir. NDVI ile protein oranı (PR) arasında pozitif ilişki görülmesi dikkate değerdir. Güncel çalışmada; Hanlı, Metin, G6, G8 ve G10 hem yüksek verimli hemde değişen çevre koşullarından en az etkilenen kararlı genotipler olarak öne çıkmıştır.

1. INTRODUCTION

Bread wheat (2n= 42) is one of most cultivated staple crops in Turkey and around the world because it has higher adaptive capacity and grows in various soils and environmental conditions. It is known that grain yield (GY) and quality traits of wheat show a considerable variation in terms of years and ecological factors [1-3]. In order for wheat genotypes to be classified at best category, the traits such as GY, thousand grain weight (TGW), and protein ratio (PR) should be in a certain range.

TGW and PR are affected by ecological conditions along with inheritance and the results of the studies conducted in various ecologies indicated that PRs of the wheat changes between 9.8 and 16.2 % [4-6, 1, 3]. The measurement these mentioned parameters along with physiological traits in plant breeding programs increase the success of the breeding [7, 8].

Chlorophyll content (represented as SPAD readings), normalized difference vegetation index (NDVI), and canopy temperature (CT) are used widely in field studies as selection parameters to determine the relationships between physiological traits, and GY and quality trait (QT) [9-13]. SPAD readings under stress conditions help determine the performances of genotypes and flag-leaf chlorophyll content in plant breeding studies since there is a positive correlation between increase of GY and chlorophyll content [14, 15]. Likewise, the highest CT values are observed before heading time and the CT values show higher correlations in determining the GY potential during grain filling stage [16, 17].

The effects of morphological, physiological, phenological, agronomic, genetic and ecological factors over GY, NDVI, CT, SPAD values are taken into consideration in the wheat cultivation and affect the success of the wheat breeding programs [17]. Therefore, in the present study, it is aimed to identifying the best genotypes for Muş ecological conditions based on GY, physiological, and quality traits.

2. MATERIALS AND METHODS

The study was conducted in 2019-2020 and 2020-2021 growing seasons under rain-fed conditions in Yildiz Farm in Muş, Turkey (Figure 1).

Figure 1. The map showing the location of the trial area

The materials used in the trial were consisted of 25 wheat genotypes with different characters (winter, alternative, spring) (Table 1). The trial was setup on the 6 m^2 plots which are comprised of 6 rows having 20 cm row spacing in 5 m long. The seeds were sown between 15 October and 15 November. According to soil analysis, the trial area had insufficient organic matter with moderately alkaline pH. Also, it was determined that the soil structure was clayey and the phosphorus content was insufficient (Table 2). Therefore, 9 kg da^{-1} N and 5 kg da^{-1} P_2O_5 were applied to the soil. Nitrogen fertilization was given in two stages as 2.3 kg da^{-1} during sowing and as 6.7 kg da^{-1} at the end of tillering stage Zadoks 26 [18], respectively, whilst all phosphorus fertilization was applied at once during sowing. Each plot was harvested during July with a plot combine.

Table 1. The origins and pedigrees of the genotypes used in the study

Genotypes	Character	Origin
Cemre	Spring	GAP International Agricultural Research and Traning Center
Bezostaja 1	Winter	Maize Research Institute
Hanlı	Spring	Maize Research Institute
Metin	Alternative	Maize Research Institute
Konya-2002	Winter	Bahri Dağdaş International Agricultural Research Institute
Beşköprü	Alternatif	Maize Research Institute
Syrena odes'ka	Winter	Yıldız Plant Productions, Seed, and Agricultural Industry Crop
Yıldırım	Winter	East Anatolian Agricultural Research Institute
Müfitbey	Alternative	Transitional Zone Agricultural Research Institute
Ahmetağa	Winter	Bahri Dağdaş International Agricultural Research Institute
Sönmez 2001	Winter	Transitional Zone Agricultural Research Institute
Ayyıldız	Winter	East Anatolian Agricultural Research Institute
Bayraktar 2000	Alternative	Field Crops Central Research Institute
Kenanbey	Winter	Field Crops Central Research Institute
Ekiz	Winter	Bahri Dağdaş International Agricultural Research Institute
G1	Winter	IWWIP
G2	Winter	IWWIP
G3	Winter	IWWIP
G4	Winter	IWWIP
G5	Alternative	IWWIP
G6	Winter	IWWIP
G7	Alternative	IWWIP
G8	Alternative	IWWIP
G9	Alternative	IWWIP
G10	Alternative	IWWIP

IWWIP: International Winter Wheat Improvement Program

Table 2. The soil properties of trial area

Texture	Salt (%)	pH	$CaCO_3$ (%)	P_2O_5 (kg da^{-1})	Organic Matter (%)	Saturation (%)
Clay	0.2	8.2	7.96	3.21	1.74	77

Source: Anonymous [19]

The precipitation and temperature data are given in Table 3. The precipitation in 2019-2020 (749.6 mm) was similar the long-term average (762.9 mm) while lower (386.6 mm) than the long-term average in 2020-2021. Notably, the precipitation of March and May during 2019-2020 growing season was approximately two-fold the long-term average. The temperature values, other than observed in October, December, and January of 2020-2021, were higher than those in 2019-2020.

Table 3. The climate data of experimental area during 2019-2021 seasons

Months	Precipitation of Muş (mm)			Temperature of Muş (^{0}C)		
	2019-2020	2020-2021	Long-Term	2019-2020	2020-2021	Long-Term
September	0.0	1.2	14.7	19.9	23.8	20.0
October	37.0	0.0	63.5	16.7	16.2	12.6
November	27.2	38.2	94.1	6.9	9.8	4.5
December	74.4	16.6	89.7	4.2	-2.3	3.0
January	36.8	94.0	86.0	-7.7	-8.1	-7.4
February	89.2	49.8	100.4	-3.8	2.7	-6.1
March	198.0	166.4	103.3	3.7	3.9	0.6
April	117.0	7.8	107.4	11.2	14.6	9.0
May	113.2	11.6	69.0	17.6	19.1	14.9
June	29.0	0.6	28.2	20.5	23.0	20.2
July	27.8	0.4	6.6	25.4	27.5	25.3
Total	749.6	386.6	762.9	-	-	-

Source: Anonymous [20]

2.1. The Investigated Parameters

2.1.1. Grain yield (GY): After harvesting and threshing of each plot, the grains were weighted in a scale (±0.001 g) and the yields were expressed as kg da^{-1}.

2.1.2. Heading time (HT): Heading time was the total number of days beginning from the emergence of the plants until the 70% of the plants in each plot were spiked at the rate of ½.

2.1.3. Plant height (PH): After selecting plants with 10 spikes in dough developmental stage, each plant's height was measured from soil surface to the upper most spikelet and expressed as cm.

2.1.4. Flag-leaf chlorophyll content (represented as SPAD values): A total of two chlorophyll content were measured made during flowering (FSC) and milk stages (MSC) to determine the chlorophyll content of flag leaf using SPAD 502 Chlorophyll-Meter (Minolta, Osaka, Japan). Values were determined by reading from the middle of the flag leaf between 10.00-12.00 hours of the day [21].

2.1.5. Normalized Difference Vegetation Index (NDVI): It was measured using GreenSeeker (Handheld crop) instrument between $11.^{00}$-$15.^{00}$ in a day of flowering stage when weather was open, without wind and sunny, and plant surface was dry.

2.1.6. Plant canopy temperature (CT): it was measured using infrared thermometer (91KB JPG) between 12.00-$14.^{00}$ in a day of flowering stage and expressed in Celsius (ºC) [22].

2.1.7. Thousand grain weight (TGW): Four samples each of which consisted of 100 seeds were weighted in grams (g). After the mean weight of all samples were calculated, it was multiplied by 10.

2.1.8. Protein ratio (PR) (%): PR was measured on wheat grains using NIT (IM 550) instrument.

2.2. Statistical Analyses

The statistical analyses were conducted using JMP 13.0. The differences among means were determined by LSD method ($p \leq 0.01$ and $p \leq 0.05$) [23]. Genstat 12th was employed for graphical visualization.

3. RESULTS AND DISCUSSION

ANOVA results of GY, physiological traits, and other agricultural parameters obtained from the trial which was conducted with 25 genotypes (15 varieties and 10 lines) with three replicates in 2019-2020 and 2020-2021 growing seasons are given in Table 4. Except to FSC, In terms of the genotypes all parameters were found significant at $p \leq 0.01$ level, while year and year*genotype interaction was significant only in some parameters ($p \leq 0.05$ or $p \leq 0.01$) (Table 4).

Table 4. Analysis of variance results for traits of the examined in bread wheat genotypes

Variance Resources	df	GY		HT		PH		FSC		NDVI	
		MS	F	MS	F	MS	F	MS	F	MS	F
Year	1	34132.4	11.9*	10651.3	4318.1**	15080.1	440.3**	4201.9	8.0*	0.038	11.0*
Rep.[Year]&Random	4	2861.1	2.6	2.5	2.0	34.3	1.6718	524.1	56.9	0.003	2.0
Genotype	24	8083.5	7.4**	44.5	35.7**	174.3	8.5**	11.9 n.s	1.3	0.006	3.3**
Year * Genotype	24	8856.1	8.1**	1.6	1.3	52.9	2.6**	10.6	1.1	0.003	1.5
Error	96	1089.6	-	1.2	-	20.5	-	9.3	-	0.002	-
CV(%)		13.8		0.6		6.4		6.8		6.4	
		CT		MSC		TGW		PR			
		MS	F	MS	F	MS	F	MS	F		
Year	1	240.3	2.6	923.1	27.7**	5925.2	607.3**	360.6	106.6**		
Rep.[Year]&Random	4	93.2	57.5	33.3	5.9	9.8	2.5	3.4	19.5		
Genotype	24	4.8	3.0**	17.0	3.0**	25.7	6.5**	2.5	14.1**		
Year * Genotype	24	2.5	1.5	8.8	1.6	8.9	2.3**	2.4	14.0**		
Error	96	1.6	-	5.6	-	3.9	-	0.2	-		
CV(%)		4.0		4.9		6.3	-	2.8			

GY: Grain yield; HT: Heading time; PH: Plant height; FSC: Flowering stage chlorophyll content; NDVI: Normalized difference vegetation index; CT: Canopy temperature; MSC: Milk stage chlorophyll content; TGW: Thousand grain weight; PR: Protein ratio; Rep.: Replication; df: degrees of freedom; MS: Mean of squares; *: $p \leq 0.05$; **: $p \leq 0.01$; n.s: not significant

Table 5. Mean values of wheat genotypes tested in different years with relation to parameters of GY, HT and PH

Genotype	GY			HT			PH		
	2019-2020	**2020-2021**	**Mean**	**2019-2020**	**2020-2021**	**Mean**	**2019-2020**	**2020-2021**	**Mean**
Cemre	281.3 abc	180.8 ıj	231.1 e-ı	209.0 def	193.3 efg	201.2 cde	84.0 b-g	65.7 bcd	74.8 b-e
Bezostaja 1	240.8 c-g	123.1 k	181.9 k	210.7 bcd	192.0 g-j	201.3 cde	85.7 b-f	64.7 b-e	75.2 bcd
Hanlı	266.3 b-e	307.5 a-d	286.9 b	207.7 f	191.0 h-k	199.3 fg	76.3 g-j	61.0 d-h	68.7 f-ı
Metin	237.1 c-ı	309.2 a-d	273.1 bc	207.7 f	192.7 fgh	200.2 ef	80.3 c-ı	57.3 ghı	68.8 f-ı
Konya-2002	174.6 jkl	239.7 e-h	207.2 g-k	210.7 bcd	192.3 f-ı	201.5 cd	73.7 hıj	62.3 d-g	68.0 f-ı
Beşköprü	184.6 h-l	282.1 cde	233.3 d-ı	208.0 ef	189.0 lm	198.5 g	80.7 c-ı	62.7 c-g	71.7 c-g
Syrena odes'ka	264.4 cde	208.1 hı	236.3 c-h	209.7 de	192.0 g-j	200.8 de	70.0 j	57.7 ghı	63.8 ıj
Yıldırım	195.4 f-k	280.6 cde	238.0 c-h	210.0 cd	193.0 fg	201.5 cd	86.7 bcd	56.7 ghı	71.7 c-g

Müfitbey	321.3	ab	248.3	e-h	284.8	b	211.7	abc	195.7	abc	203.7	b	97.0	a	64.7	b-e	80.8	a
Ahmetağa	169.2	jkl	210.6	hı	189.9	k	212.0	ab	195.0	b-e	203.5	b	75.3	hıj	56.7	ghı	66.0	hı
Sönmez 2001	271.7	a-d	134.4	jk	203.1	h-k	210.3	bcd	194.0	c-f	202.2	c	86.3	b-e	53.0	ıj	69.7	e-h
Ayyıldız	185.3	g-l	272.2	c-f	228.8	f-j	213.0	a	196.0	ab	204.5	ab	92.0	ab	66.7	bcd	79.3	ab
Bayraktar 2000	182.8	ı-l	348.3	a	265.6	b-f	201.7	ı	186.0	n	193.8	ı	85.0	b-f	73.0	a	79.0	ab
Kenanbey	242.1	c-f	257.2	d-h	249.7	b-f	213.0	a	197.3	a	205.2	a	87.3	bc	62.7	c-g	75.0	bcd
Ekiz	213.3	e-k	300.8	a-d	257.1	b-f	211.7	abc	195.3	bcd	203.5	b	78.7	d-ı	59.0	e-ı	68.8	f-ı
G1	135.0	l	268.8	c-g	201.9	h-k	209.7	de	193.7	d-g	201.7	cd	81.7	c-h	62.7	c-g	72.2	c-f
G2	263.8	cde	241.7	e-h	252.7	b-f	209.7	de	193.0	fg	201.3	cde	72.3	ıj	48.3	j	60.3	j
G3	160.8	kl	223.8	f-ı	192.3	jk	207.7	f	190.7	ı-l	199.2	fg	78.0	e-j	54.7	ı	66.3	hı
G4	196.9	f-k	218.3	ghı	207.6	g-k	210.3	bcd	193.3	efg	201.8	cd	77.3	f-j	55.0	hı	66.2	hı
G5	211.7	e-k	273.8	c-f	242.7	c-g	209.7	de	193.0	fgh	201.3	cde	87.7	bc	70.3	ab	79.0	ab
G6	239.4	c-h	304.4	a-d	271.9	bc	207.7	f	190.3	jkl	199.0	fg	74.3	hıj	59.0	e-ı	66.7	ghı
G7	222.5	d-j	312.1	abc	267.3	b-e	207.7	f	189.3	klm	198.5	g	74.7	hıj	58.0	f-ı	66.3	hı
G8	322.9	a	334.2	ab	328.5	a	205.7	g	188.0	m	196.8	h	85.0	b-f	68.7	abc	76.8	abc
G9	180.0	jkl	212.1	hı	196.0	ıjk	212.7	a	195.3	bcd	204.0	ab	75.7	g-j	58.0	f-ı	66.8	ghı
G10	257.5	cde	282.9	b-e	270.2	bcd	203.7	h	188.3	m	196.0	h	78.0	e-j	64.0	c-f	71.0	d-e
Min. value	135.0		123.1		189.9		201.7		186.0		194		70.0		48.3		60.3	
Max. value	322.9		348.3		328.5		213.0		197.3		205		97.0		73.0		80.8	
General Mean	224.8		255.0		239.9		209.2		192.4		201		80.9		60.9		70.9	
LSD (0.05)	56.2**		52.1**		37.8**		1.9**		1.8**		1.3**		8.5**		6.2**		5.2**	
CV(%)	15.2		12.4		13.8		0.6		0.6		0.6		6.4		6.1		6.4	

3.1. Grain Yield (kg da^{-1})

Significant differences were found between years and genotypes in terms of GY (Table 4 and 5). G8 yielded the highest GY (322.9 kg da^{-1}) in 2019-2020. Cemre, Müfitbey, Sönmez 2001 were placed in the same group with G8. Bayraktar 2000 (348.3 kg da^{-1}) yielded the best GY in 2020-2021 and was in the same group with Hanlı, Metin, Ekiz, G6, G7, and G8. When the means of GY was evaluated by years, 30.2 kg da^{-1} less GY was obtained despite the higher rainfall in 2019-2020 growing season (Table 3 and 5). This situation is probably stemmed from the water logging (or flooding) stress occurred as a result of rainfalls which are accompanied by snow-melting of March and May in the first growing season. The combined analysis results indicated that G8, Hanlı, and Müfitbey were significant genotypes with relation to GY. GY results in this study were similar to those of Fagnano et al. [24], Aydoğan ve Soylu [6], and Ülker [25], who obtained 213-362 kg da^{-1}, 154.58-258.43 kg da^{-1}, and 164-301 kg da^{-1}, respectively.

3.2. Heading Time (day)

The earliest heading variety was identified as Bayraktar 2000 (201.7 and 186.0 day) in both growing seasons whereas the latest heading varieties were Ayyıldız (213.0 and 196.0 days) and Kenanbey (213.0 and 197.3 days), which were in the same group. The heading time was shortened 16.8 day, when the means of growing seasons were compared, due to the drought conditions in 2020-2021. Combined means of HT showed that there was a considerable variation (194-205 day) among genotypes. Moreover, Bayraktar 2000 was the earliest variety whereas Kenanbey, Ayyıldız, and G9 were the latest genotypes sharing the same group (Table 5). When HT is compared to GY, the inheritance was more effective over HT than ecological conditions [26]. In regions where heat or drought stress is seen in the late period, early varieties may be more productive with the advantage of escaping from stress. Indeed, some researchers reported that early varieties were more productive [27, 28].

3.3. Plant Height (cm)

Year (environment) and genotype were found to be effective over PH and a wide-range variation among genotypes were established (Table 4 and 5). Müfitbey (97.0 cm) were identified as the tallest genotype whereas Syrena odes'ka (70 cm) was the shortest in 2019-2020. Bayraktar 2000 (73.0 cm) were found to be the tallest whereas G2 (48.3 cm) was the shortest genotype in 2020-2021. When mean values of PH were compared by years, PHs in 2020-2021 were 20 cm were shorter. This may be originated from the drought effect in the season. According to the results of the combined analysis, PHs changed in a range of 60.3 cm - 80.8 cm. Müfitbey, Ayyıldız, Bayraktar 2000, G5, and G8 were the tallest genotypes involved in the same group whereas G2 was the shortest genotype. In the studies conducted in different regions by different authors related to the PH, a wide range results were obtained. In this regard, Aydın et al. [29], Aydoğan and Soylu [6], Çağlar et al. [30], and Demirel et al. [31] found bread wheat PHs as follows: 68.1-95.6 cm, 79.5-108.2 cm, 72.5-99.3 cm, and 52.16-96.66 cm, respectively.

Table 6. Mean values of wheat genotypes tested in different years with relation to parameters of FSC, NDVI, and CT

Genotype	FSC			NDVI			CT		
	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean
Cemre	39.20	46.10 k	42.65	0.677	0.623 e-ı	0.650 c-f	37.60 a	31.73 ab	34.67 a
Bezostaja 1	43.30	49.77 d-j	46.53	0.643	0.677 a-e	0.660 b-e	32.38 b-e	30.80 b-e	31.59 b-h
Hanlı	43.57	52.33 a-d	47.95	0.660	0.700 ab	0.680 a-d	34.90 ab	30.42 c-f	32.66 bcd
Metin	42.17	49.17 e-k	45.67	0.673	0.617 e-j	0.645 c-g	33.47 bcd	32.18 a	32.83 bc
Konya-2002	37.13	50.03 c-j	43.58	0.643	0.560 ıj	0.602 gh	32.42 b-e	30.48 c-f	31.45 b-h
Beşköprü	41.33	49.20 e-k	45.27	0.707	0.647 b-f	0.677 a-d	33.45 bcd	30.25 c-f	31.85 b-h
Syrena odes'ka	39.23	53.57 ab	46.40	0.600	0.647 b-f	0.623 e-h	34.45 bcd	30.08 c-f	32.27 b-g
Yıldırım	39.10	48.13 ıjk	43.62	0.667	0.603 f-j	0.635 d-h	30.47 e	30.48 c-f	30.48 h
Müfitbey	39.67	51.70 a-f	45.68	0.690	0.693 abc	0.692 abc	31.92 cde	30.17 c-f	31.04 fgh
Ahmetağa	38.83	51.23 b-ı	45.03	0.643	0.603 f-j	0.623 e-h	34.00 bcd	31.82 ab	32.91 b
Sönmez 2001	41.90	48.30 h-k	45.10	0.663	0.623 e-ı	0.643 d-h	32.25 b-e	30.20 c-f	31.23 d-h
Ayyıldız	38.87	49.13 e-k	44.00	0.713	0.690 a-d	0.702 ab	32.22 b-e	29.87 ef	31.04 fgh
Bayraktar 2000	38.13	51.43 a-g	44.78	0.623	0.623 e-ı	0.623 e-h	32.60 b-e	29.78 ef	31.19 e-h
Kenanbey	37.77	48.60 f-k	43.18	0.680	0.670 a-e	0.675 a-d	32.33 b-e	30.07 c-f	31.20 d-h
Ekiz	38.97	49.23 d-j	44.10	0.710	0.717 a	0.713 a	32.88 b-e	30.98 bc	31.93 b-h
G1	39.60	47.97 jk	43.78	0.673	0.580 g-j	0.627 e-h	34.67 bc	30.62 cde	32.64 b-e
G2	37.50	50.37 c-j	43.93	0.673	0.623 e-ı	0.648 c-g	34.03 bcd	30.97 bc	32.50 b-f
G3	35.97	51.40 a-h	43.68	0.617	0.627 d-h	0.622 e-h	31.75 de	30.60 cde	31.18 fgh
G4	39.73	50.17 c-j	44.95	0.683	0.620 e-j	0.652 c-f	32.40 b-e	31.08 bc	31.74 b-h
G5	36.80	48.40 g-k	42.60	0.660	0.613 e-j	0.637 d-h	33.30 bcd	29.45 f	31.38 c-h
G6	40.13	52.23 a-e	46.18	0.657	0.630 c-g	0.643 d-h	32.32 b-e	29.75 ef	31.03 gh
G7	40.23	53.00 abc	46.62	0.660	0.557 j	0.608 fgh	32.50 b-e	29.78 ef	31.14 fgh
G8	40.83	49.07 f-k	44.95	0.670	0.667 a-f	0.668 a-e	32.28 b-e	29.88 def	31.08 fgh
G9	40.07	49.70 d-j	44.88	0.700	0.653 a-f	0.677 a-d	32.17 b-e	30.95 bcd	31.56 b-h
G10	40.03	54.47 a	47.25	0.630	0.563 hıj	0.597 h	32.68 b-e	29.75 ef	31.22 d-h
Min. value	36.00	46.10	42.60	0.665	0.557	0.649	30.47	29.45	30.48
Max. value	43.60	54.47	47.95	0.713	0.717	0.713	37.60	32.18	34.67
General Mean	39.60	50.19	44.90	0.665	0.633	0.649	33.02	30.49	31.75
LSD $_{(0.05)}$	n.s	3.1**	n.s	n.s	0.07**	0.05**	2.8*	1.1**	1.5**
CV(%)	9.7	3.8	6.8	6.4	6.3	6.4	5.1	2.2	4.0

n.s: not significant

3.4. Flowering Stage Chlorophyll Content (FSC)

There is no statistical difference among genotypes in term of the results of combined analysis and of 2019-2020 season. However, the differences among genotypes were found significant in 2020-2021 and the G10 was identified as the genotype with the highest FSC (54.47 mg/m^2). FSC in 2020-2021 was found 10.59 mg/m^2 higher compared to the previous year and it changed from 42.60 to 47.95 mg/m^2 in terms of two-year data (Table 6). In a study carried out by Dalkılıç et al. [17] in Kahramanmaraş, it was reported that FSC in durum wheat showed a variation between 46.9 and 52.3 mg/m^2. FSCs were found between 42.6-47.95 mg/m^2 in the present study.

3.5. Normalized Difference Vegetation Index (NDVI)

NDVI values of genotypes showed no statistical significance in 2019-2020. Nonetheless, a significant differences was found among genotypes in 2020-2021 growing season and combined analysis. Ekiz (0.717 and 0.713) variety had the highest NDVI value (Table 6). When means of the years were compared, the NDVI values during 2019-2020 were 0.032 higher. Before flowering 20 days and after 10 days, the maximum leaf area forms in wheat and therefore, it is stated that there is a positive relationship between NDVI readings and GY [32, 33]. Nevertheless, no relationship was established between NDVI readings and GY in this study (Figure 2).

3.6. Canopy Temperature (ºC)

Genotypes showed significant differences in terms of CT. Yıldırım variety (30.47 ºC) in 2019-2020, and G5 (29.45) genotype in 2020-2021 were significantly kept their leaves cool. CT values in 2019-2020 growing period were 2.53 ºC higher than those in 2020-2021 (Table 6). According to the results of combined analysis, Yıldırım, Müfitbey, Ayyıldız, G6, and G8 were the significant genotypes in keeping their leaves cool. These results were similar to those of the study carried out by Fahlani and Assad in Iran [34], in which CT values of bread wheat genotypes showed significant difference at the stem elongation, booting, and flowering stages. In another study, conducted with 15 bread wheat genotypes under Mediterranean conditions for three years, CTs did not differ significantly in the period between the beginning of the heading and of the milk stages [35, 17]. However, in a study conducted in Diyarbakir conditions in landraces bread wheat, it was reported that there was a negative and significant relationship between CT and GY during the heading time period [36].

3.7. Milk Stage Chlorophyll Content (MSC)

The flag leaf chlorophyll content is an important indicator in showing photosynthetic activity and GY potential [37]. The effects of years and the genotypes were found significantly different in the present study**.** Sönmez 2001 in 2019-2020 (49.10 mg/m^2), G7 (53.37 mg/m^2) and G9 (53.57 mg/m^2) in 2020-2021 had significantly more high MSC (Table 7). The comparison of the means of the growing years indicated that MSC was 4.96 mg/m^2 higher at the milk stage in 2020-2021. According to the combined analysis results, Beşköprü, G4, G7, G9, and G10 were in the same group and having the highest chlorophyll content. In a study conducted on durum wheat in rainfed and irrigated conditions in Diyarbakır province, a positive and significant relationship was found in both environments between the chlorophyll content in the milk stage and grain yield [38]. In our study, no relationship was found between the chlorophyll content of the milk production period and the grain yield (Figure 2).

3.8. Thousand Grain Weight (TGW) (g)

TGW was found significantly different in terms of years and genotypes. G8 (43 g) had the highest TGW, followed by G1 which was involved in the same group in 2019-2020. On the other hand, Konya-2002 (29.25 g) genotype had the highest TGW in 2020-2021. It shared the same group with Cemre, Müfitbey, Ayyıldız, Ekiz, G5, and G8 (Table 7). According to the means of the TGW, lower value 12.6 g was obtained in 2020-2021 (Table 7). This result may be explained by the effect of the drought. The combined analysis showed that Cemre, Konya-2002, Yıldırım, Müfitbey, Ayyıldız, G5, and G8 were shared the same group with the highest TGWs. In a study conducted with 14 bread wheat genotypes for three years in Yozgat, Turkey, TGW values showed changes between 29.2 and 38.4 g [39]. TGW values in this study was ranged between 27.63 - 34.58 g. The differences among genotypes are usually explained by inheritance and environmental factors. Additionally, genotypes benefiting from the ecological conditions after heading stage usually have better TGWs [40, 41].

3.9. Protein Ratio (PR) (%)

PR is an important quality parameter for flour mill owners to make decision to which product of (flour, semolina, pasta, and etc.) wheat will be processed [42, 43, 41]. According to the PRs of genotypes, Cemre in 2019-2020 and Kenanbey in 2020-2021 had the highest PR as 15.57 % and 19.57 %, respectively. The comparison of the means by years showed that PR was 3.10 % higher in 2020-2021 compared to the previous year. Moreover, Cemre and Kenanbey had the highest PRs as 16.45 % and 16.32 % at the combined analyse, respectively (Table 7). PRs of the wheat genotypes are affected by ecological conditions and are genotype-specific, and range between 6-22 % depending on the ecological conditions [44, 39]. In the present study, PRs of the studied genotypes were between 13.97 % and 16.45 %.

Table 7. Mean values of wheat genotypes tested in different years with relation to parameters of MSC, TGW, and PR

Genotype	MSC			TGW			PR		
	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean	2019-2020	2020-2021	Mean
Cemre	42.37 def	48.03 def	45.20 fg	37.83 bcd	29.00 a	33.42 abc	15.57 a	17.33 bc	16.45 a
Bezostaja 1	46.50 a-d	50.73 a-e	48.62 a-d	37.83 bcd	24.92 b-g	31.38 c-f	14.17 cd	17.43 b	15.80 b
Hanlı	46.27 a-e	49.50 b-f	47.88 a-f	35.50 d-g	23.75 e-h	29.63 fgh	13.23 h-k	16.17 e-h	14.70 f-ı
Metin	42.50 c-f	48.77 c-f	45.63 efg	33.92 gh	24.67 c-g	29.29 fgh	12.57 lmn	16.03 fgh	14.30 ıjk
Konya-2002	46.30 a-e	51.13 a-d	48.72 a-d	39.92 b	29.25 a	34.58 a	12.80 klm	16.03 fgh	14.42 h-k
Beşköprü	47.90 ab	52.07 abc	49.98 a	34.83 e-h	24.42 c-g	29.63 fgh	13.07 ıjk	15.77 ghı	14.42 h-k
Syrena odes'ka	41.30 f	52.80 ab	47.05 b-f	38.25 bcd	24.67 c-g	31.46 c-f	13.63 e-h	16.27 e-h	14.95 efg
Yıldırım	45.73 a-e	47.47 ef	46.60 d-g	40.08 b	25.00 b-g	32.54 a-d	13.77 d-g	16.63 b-f	15.20 cde

Müfitbey	47.60	ab	51.03	a-e	49.32	abc	39.92	b	28.50	ab	34.21	ab	11.80	o	17.27	bcd	14.53	g-j
Ahmetağa	46.63	abc	51.43	a-d	49.03	a-d	32.67	h	23.25	e-h	27.96	gh	12.23	no	15.70	hı	13.97	k
Sönmez 2001	49.10	a	50.03	a-e	49.57	ab	36.83	c-f	25.00	b-g	30.92	def	12.43	mn	16.57	c-g	14.50	g-j
Ayyıldız	47.70	ab	51.53	a-d	49.62	ab	37.50	b-e	27.75	a-d	32.63	a-d	12.50	lmn	17.17	bcd	14.83	e-h
Bayraktar 2000	44.67	b-f	48.77	c-f	46.72	c-g	39.17	bc	24.67	c-g	31.92	cde	13.23	h-k	14.93	ı	14.08	jk
Kenanbey	46.37	a-e	50.97	a-e	48.67	a-d	36.92	c-f	21.75	gh	29.33	fgh	13.07	ıjk	19.57	a	16.32	a
Ekiz	47.07	ab	51.50	a-d	49.28	a-d	36.67	c-g	26.25	a-f	31.46	c-f	12.83	klm	16.91	b-e	14.87	e-h
G1	46.97	ab	49.10	c-f	48.03	a-e	40.25	ab	24.25	d-h	32.25	b-e	14.80	b	16.50	c-h	15.65	bc
G2	42.30	ef	51.77	abc	47.03	b-f	38.67	bc	23.08	e-h	30.88	def	12.93	jkl	16.77	b-f	14.85	e-h
G3	42.60	c-f	51.57	a-d	47.08	b-f	34.17	fgh	20.75	h	27.46	h	14.23	c	16.10	e-h	15.17	def
G4	48.50	ab	51.33	a-d	49.92	a	35.75	d-g	24.25	d-h	30.00	efg	14.30	c	16.70	b-f	15.50	bcd
G5	42.40	def	46.00	f	44.20	g	39.25	bc	27.92	abc	33.58	abc	13.87	c-f	16.47	d-h	15.17	def
G6	47.23	ab	51.40	a-d	49.32	abc	39.75	b	24.33	c-h	32.04	b-e	13.37	g-j	14.97	ı	14.17	jk
G7	47.70	ab	53.37	a	50.53	a	38.17	bcd	23.75	e-h	30.96	def	13.30	hıj	16.13	e-h	14.72	f-ı
G8	44.90	b-f	51.77	abc	48.33	a-e	43.00	a	26.50	a-e	34.75	a	13.50	f-ı	16.43	d-h	14.97	efg
G9	46.43	a-e	53.57	a	50.00	a	32.50	h	22.75	fgh	27.63	h	12.93	jkl	16.87	b-f	14.90	efg
G10	47.47	ab	52.90	ab	50.18	a	38.25	bcd	22.92	e-h	30.58	def	14.07	cde	14.97	ı	14.52	g-j
Min. value	41.3		46.0		44.2		32.50		20.8		27.63		11.8		14.97		13.97	
Max. value	49.1		53.37		50.5		43.00		29.00		34.58		15.6		19.57		16.45	
General mean	45.78		50.74		48.3		37.50		24.90		31.22		13.37		16.47		14.92	
LSD $_{(0.05)}$	4.18**		3.58**		2.7**		2.8**		3.6**		2.3**		0.5**		0.9**		0.5**	
CV(%)	5.6		4.3		4.9		4.6		8.8		6.30		2.0		3.2		2.80	

3.10. The Stability of Yield and The Associations Among Traits by Using the GGE Biplot Model

The relationships genotype-trait, GY, GY stability, and many binary or multiple comparisons, made by using many parameters, can be visualized and presented using GGE biplot. The angle (<90º positive relationship, >90º negative relationship, =90º no relationship) between vectors and the positions of the vectors are important for interpretation of genotype-trait relationships the model [45]. Additionally, the lengths of the vectors give ideas about the variations among genotypes. In this regard, whilst the short vector indicates lower variation, the long vector shows higher [46-48].

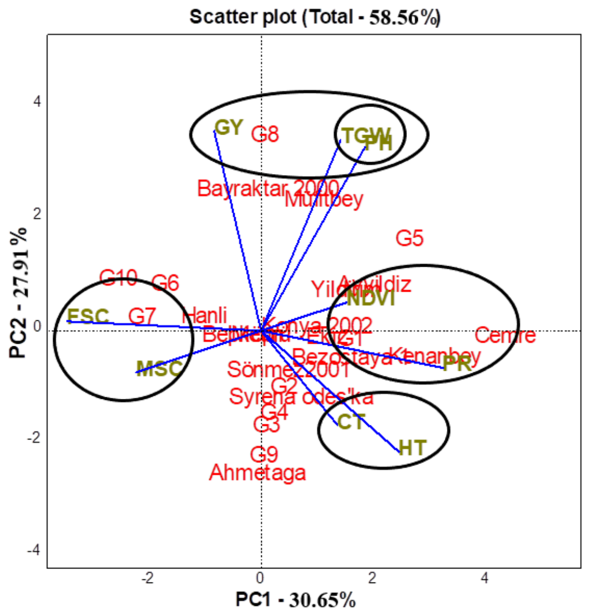

Figure 2. GGE biplot model show the relationships genotype-trait.

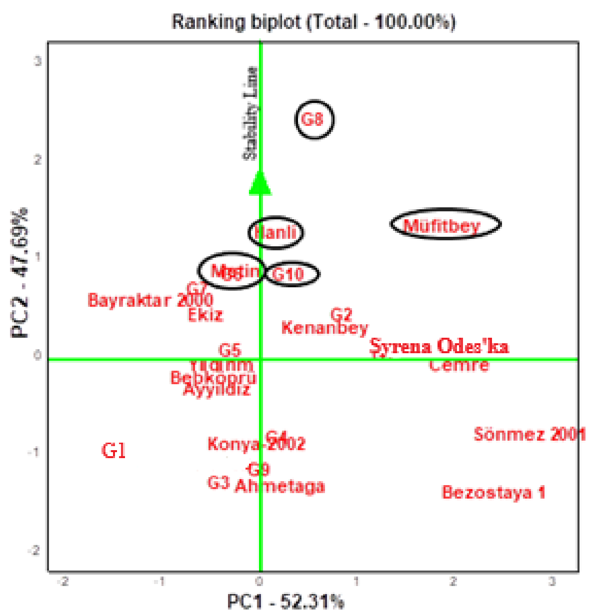

Figure 3 . Ranking biplot model show the stability of genotypes based on GY

The GGE biplot model is given in Figure 2 and it accounts for genotype-trait relationships in the study as 30.65 %, 27.91 %, and 58.56 % for PC1, PC2, and PC1+PC2, respectively (Figure 2). According to Figure 2, a positive relationship was observed among GY, TGW, and PH. The relationship between TGW and PH were found stronger. On the other hand, there was a negative relation GY, and HT, CT, PR. FSC and MSC had the negative relationship with NDVI. In terms of quality parameters, PR was negatively associated with GY, FSC and MSC. When yield and quality parameters were taken into consideration, the genotypes G8, Bayraktar 2000, and Müfitbey were prominent according to GY whilst Cemre stood out in terms of PR.

The ranking biplot, the stability plot of the examined genotypes, indicates that genotypes above x axis have higher GY whereas below *x* axis have lower GY than the average of GY (Table 5 and Figure 3). The G8 genotype, located in the utmost right side of the stability line, was found as moderately stabile genotype with the highest GY. Müfitbey, Hanlı, Metin, G6, and G10 were established as genotypes with higher GYs following G8. G1, Bezostaja 1, and Sönmez 2001 were found as instable genotypes with lower GYs.

Ideal genotype was described as a stabile genotype with higher GY which does not change from one experimental field to another (Yan and Kang, 2003) [40]. Müfitbey was found as a genotype having higher GY with low stability. On the other hand, although Hanlı and G10 genotypes are not as high yielding as G8, they were established as genotypes with higher stability. G9 and Ahmetağa genotypes were stabile genotypes; however, their GYs were much below the trial averages.

4. CONCLUSION

Negative or positive relationships were found between GY and other traits in the study conducted with 25 genotypes having different characters in rain-fed conditions in Muş. G8, Hanlı, Müfitbey, G10, G6, Metin and Kenanbey were the best genotypes in terms of GY. Cemre, Kenanbey, Bezostaja 1, Konya-2002, Müfitbey, and G8 were the established as significant genotypes according to quality traits. GYs of Cemre, Bezostaja 1, Beşköprü, Yıldırım, Sönmez 2001, Ayyıldız and G1 genotypes were below averages and instabile. Metin, Ekiz, G5, G6, and G7 had GYs above the trial averages and were found as moderately stabile under environmental conditions. Although Bayraktar 2000 had higher GY above the trial average, it was highly affected by environmental conditions. Hanlı, Kenanbey, G6, G8, and G10 were the most stabile genotypes whose GYs were above the trial average. Notably, NDVI readings were found correlated with PR in the study. The genotypes with higher GYs were found to keep CT lower levels compared to other genotypes. To elaborate this important result, different studies should be conducted examining the relationship between CT and GY at different stages of the generative period.

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