Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2023, Vol. 7 (1), 114-125
https://doi.org/10.29329/ijiaar.2023.536.8

Original article

Flag Leaf of Bread Wheat (*Triticum aestivum* L.) Genotypes and Relation with Yield Component under Rainfed Conditions

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Abstract

An experiment was carried out to assess flag leaf fresh and dry weight of advanced bread wheat genotypes and their relation with yield and yield components. A total of 25 bread wheat genotypes were tested during the 2017-2018 cycles in four locations in the Trakia region, Turkey. The experiment was conducted in a randomized complete blocks design (RCBD) with four replications. Grain yield (GY), spike number per square meter (SNM), kernel number per spike (KNS), spikelet number per spike (SNS), spike weight (SW), plant height (PH), peduncle length (PL), spike length (SL), flag leaf fresh weight (FLFW), flash leaf dry weight (FLDW) were investigated. The combined ANOVA revealed significant differences among genotypes (G), environments (E) and their interaction (G×E) for grain yield ($p<0.01$). The highest grain yield was performed by G21 (6807 kg ha-1) and G20 (6776 kg ha-1). Both genotypes also had higher yield potential across four environments. Therefore, they were considered stable genotypes. Flag leaf fresh and dry weight in wheat genotypes positively affected spike length, spikelet number per spike, kernel number per spike and spike weight. As the plant density per unit area increased, there was a decrease in flag leaf fresh and dry weight. Increasing in the spike number per square meter negatively affected and reduced flag leaf fresh and dry weight in wheat genotypes. Results showed that spike weight, flag leaf fresh and dry weight of the wheat genotypes could be used in the selection of wheat breeding study for yield components. The longest spike, the highest number of grains per spike and the number of spikelets were determined in G17, together with the yield above the average. In addition, G17 had the highest spike weight and flag leaf fresh and dry weight. For this reason, G17 has been determined that can be used in breeding studies due to its agronomic characteristics. The results of the research showed that flag leaf dry and fresh weight could be used for yield components in wheat breeding selection under rainfed conditions.

Keywords: Bread wheat, Genotypes, Flag leaf, Yield component, Comparison.

Received: 08 September 2022 * **Accepted:** 21 March 2023 * **DOI:** https://doi.org/10.29329/ijiaar.2023.536.8

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INTRODUCTION

Due to the effects of climate change, the extreme adverse natural events are increasing, and environmental stress is one of the major causes of crop loss around the world, with annual yield losses of more than 50% for major crops (Chaves and Oliveira, 2004). Minimizing yield gaps in major crops by using optimal management practices may lead to improvements in production while offering both environmental benefits and economic value. Assessing the yield gaps in major field crops can help us understand yield variability, yield potential, and the input efficiency of major crops and may indicate appropriate pathways for improving agricultural efficiencies (Fischer et al., 2009; Carberry et al., 2013; Van Ittersum et al., 2013). Reduced leaf water potential and turgor pressure, stomatal closure, and decreased cell growth and enlargement are all symptoms of drought stress in plants (Farooq et al., 2009). Two major components can be distinguished in crop biomass production - the amount of accumulated intercepted radiation and the efficiency of conversion of light into new dry matter (Hay and Walker 1989). These components are affected by several morphological traits of the flag leaf, among them posture, rolling and glaucousness (Reynolds et al. 2000). Leaf posture considerably affects the interception of incident radiation and its distribution within the canopy. Flag leaves can have curved, planophile or erectophile shapes (Borojevic 1988). Light penetration into the canopy is improved in genotypes with erect leaves. Consequently, upper leaves are less likely to be super-saturated by light and leaf sheaths may become significant sources of assimilates and contribute more to total crop biomass (Hay and Walker 1989). Morphological and agronomic traits have a special role to determine the importance of each trait in increasing yield, as well as to use those traits in the breeding programs, which at least leads to improving yield and introduction of commercial varieties. Morphological characters include root length, spike number, grain number per spike, 1000 grain weight, awn length (Eskandari and Kazemi, 2010; Ahmadizadeh et al., 2011a,b). Contribution to the yield of cereals has traditionally been studied using yield and different yield components, thus neglecting the function of other organs such as ear awns and flag leaf. In recent times, it is seriously important to investigate the effects of genotypes on the photosynthetic activity of the flag leaf blade and the ear awns of spring wheat. The parameters connected with the photosynthetic activity were examined about the grain yield and dissimilar yield components at maturity (Khaliq et al., 2008).

In wheat, the leaves especially the flag leaves have been considered to be the key organs contributing to higher yields. More to the point, their results suggested that awns play a dominant role in contributing to large grains and high grain yield in awned wheat cultivars, particularly during the grain-filling stage (Li et al., 2006). Leaves play a very important role in plant development because they are the major sites of photosynthesis in plants in turn photosynthesis is responsible for assimilating production. More photosynthesis will be assimilated and available for storage in grain. Besides leaves, awns also play an important role in photosynthesis, respiration and transpiration (Abbad et al. 2003).

The flag leaf has an important role in establishing the main yield components and yield quality, its contribution being accentuated by the favorability of the environmental conditions during each phenological stage. The genetic constitution of each studied variety had a specific response to the lack of the flag leaf for both leaf photosynthetic pigments and main grain yield components (Razc et al., 2022). The contribution rate of the flag leaf to daily photosynthetic products varies from 50 % to 60 %. However, the contribution rate of ear-to-grain yield is associated with ear type (awned ear or awnless ear; compact ear or sparse ear). The contribution of glumes and awns to grain yield can be extremely high depending on environmental conditions (Evans and Rawson, 1970). Water stress at later stages may also result in a decrease in the number of kernels per ear and the weight of the kernels (Gupta et al., 2001). Bread wheat production in the Trakya region is important because of the high-yielding capacity of wheat thanks to favourable environmental conditions. However, the fluctuations in rainfall in April and May cause yield losses and low-quality products in wheat (Öztürk et al., 2021; Öztürk, 2022) In the study, it was investigated and compared with flag leaf fresh and dry weight and yield component in bread wheat genotypes under rainfed environments conditions.

MATERIALS and METHODS

Plant Materias and Studied Traits

An experiment was carried out to assess the flag leaf of advanced bread wheat genotypes and their relation with yield and yield components. A total of 25 bread wheat genotypes (Table 1) were tested during the 2017-2018 growing year at four locations in the Trakia region, Turkey. The experiment was conducted in a randomized complete blocks design (RCBD) with four replications. Grain yield (GY), spike number per square meter (SNM), kernel number per spike (KNS), spikelet number per spike (SNS), spike weight (SW), plant height (PH), peduncle length (PL), spike length (SL), flag leaf fresh weight (FLFW), flash leaf dry weight (FLDW) were investigated. Agronomic data were investigated in the Edirne location. In the experiment, each plot was 6 meters long and had 6 rows, spaced 0.17 meters apart. Using a plot drill was performed for sowing and 500 seeds per square meter were used. The Zadoks Decimal Code (Z) was used to describe the plant growth stages of cereals (Zadoks et al., 1974).

Flag leaf fresh and dry weight (g): The flag leaf was removed at Zadoks 60 growth phase (Zadoks et al, 1974) and then weighed for fresh weight. After that flag leaves were oven-dried at 105ºC for 24 h to obtain the dry weight.

Spike number per square meter (SNM): The spike number per square meter (SNM) was determined by counting the spike per 1 square meter in each plot.

The number of kernels per spike (KNS): Ten heads were randomly selected before harvest and then it was determined by averaging the total number of the kernel.

The spikelet number per spike (SNS): Ten heads were randomly selected before harvest and then it was determined by averaging the total spikelet number per spike.

Spike weight (g): In the experiment, 10 heads were randomly selected in each subplot and their weight was measured and averaged.

Plant height (cm): The height of ten randomly taken plants was measured at harvest maturity from the ground level to the tip of the tallest spike in centimetres and averaged.

Peduncle length (PL) (cm): The length of ten randomly taken plants was measured at harvest maturity in centimetres and averaged.

Spike length (SL) (cm): The length often randomly taken plants was measured at harvest maturity in centimetres and averaged.

Table 1. Pedigree of the bread wheat genotypes investigated in the experiments

Genotype	Pedigree
G1	Pehlivan (LC)
G2	Psk/Nac//Sabalan/3/Gun91/Mnch
G3	Tek/4/Lau/Agd/3/Odes95//Olv/B16
G4	Tek/4/Lau/Agd/3/Odes95//Olv/B16
G5	Selimiye (LC)
G6	Tek/4/Lau/Agd/3/Odes95//Olv/B16
G7	GKElet/8/Dmnt/7/Bez/Tvr/5/Cfn/Bez//Suw92/CI13645/3/Nai60/4/Emu"S"/6/Una
G8	Sdv-1/5/Agrı"S"/093-4//3/Kkk/Itd//Lov29/4/FKong15//Bow/Pvn
G9	F.Odes/5/Lov29/3/Ftg/Spwx//AfghH996/ Mex120/4/Lov29/3/Jsw6/Lov13//Jsw3/6/GkOth/Blu2/7/Glty
G10	Gelibolu (LC)
G11	F.Odes/5/Lov29/3/Ftg/Spwx//AfghH996/ Mex120/4/Lov29/3/Jsw6/Lov13//Jsw3/6/GkOth/Blu2/7/Glty
G12	Lufer-1/MV.Optima//F6038W12.1/3/MV Kemence
G13	15.99/3/Pehl//Rpb8-68/Chrc/4/Chatelet
G14	Rumba//Chirya3/GK Othalon
G15	Saban (LC)
G16	Dmnt/Dakha//Tr.aestivum L. DBA-409
G17	Dmnt/Dakha//Tr.aestivum L. DBA-409
G18	Lufer-1/MV.Optima//F6038W12.1/3/MvKemence
G19	F08037G2
G20	Köprü (LC)
G21	Enola/7/Sau41/Sad1/5/Agri"S"/093-44/3/Kkk/ltd/Lov29/4/FKong15//Bow/Pwn/6/1518-4-38K
G22	Mino/898.97/4/Pfau/Seri.1B//Amad/3/Kronstad F2004
G23	15.99/3/Pehl//Rpb8-68/Chrc/4/Chatelet
G24	15.99/3/Pehl//Rpb8-68/Chrc/4/Chatelet
G25	Ulugbeg600/3/FRET2/WBLL1//TacupetoF2001

Statistical Analyses

Data were analyzed statistically for analysis of variance the method described by Gomez and Gomez (1984). The analysis of variance (ANOVA) was performed in order to evaluate significant differences between genotypes. The differences between genotype means of parameters were tested by the L.S.D test (0.05). Letter groupings were generated by using a 5% level of significance. The regression equations were calculated according to Finlay and Wilkinson (1963), and Eberhart and Russell (1969). Regression graphs were used to predict the adaptability of genotypes and the correlations between the quality parameters were determined by Pearson's correlation analysis.

Meteorological Data

Summarized meteorological data for the crop cycles from September to June is provided in Table 2. Monthly precipitations, relative air humidity, maximum, minimum and mean temperature were recorded from the weather station of the Institute experimental site.

Table 2. Meteorological conditions in experimental field in 2017-2018 growing year in E1

Months	**Rainfall (mm)**	**Mean 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	-11.0	35.9	13.0

Average mean temperatures during plant growth stages (from September to June) were 13.0 °C, the absolute maximum temperature was 35.9°C, and the absolute minimum temperature was -11.0 °C. Total rainfall was 833.8 mm and mean humidity was 75.4%. The total amount of precipitation was very low during the stem elongation and heading stage when the plant water consumption, evaporation and water loss were high (Table 2).

RESULTS and DISCUSSION

The results of variance analysis (ANOVA) of the research in grain yield across four environments are presented in Table 3. The combined ANOVA revealed significant differences among genotypes (G), environments (E) and their interaction (G×E) for grain yield ($P<0.01$). Adaptation of genotypes to different environmental conditions such as soil structure, precipitation and temperature depends on their adaptability. It is important in genetic structure for adaptation to different environments condition, sowing time and fertilization are some other factors.

Table 3. Result of the variance analysis for grain yield across four environments in genotypes

Source of variation	DF	SS	MS	F Ratio
Environment (E)	3	1.003	3341691.0	422.577**
Genotypes (G)	24	774935.0	32288.90	16.007**
Environment × Genotype (G×E)	72	423678.0	5884.42	2.917**
Error	288	580932.0	2017.0	
C. Total	399	11899512.0		

*, ** Significant at p<0.05 and p<0.01 respectively. ns: non-significant. DF: Degree of freedom, SS: Sum of square, MS: mean of square

The results of variance analysis (ANOVA) of yield components are presented in Table 4. The combined ANOVA revealed significant differences among genotypes for all parameters (p<0.01 and p<0.05). Analysis of variance revealed a highly significant difference among genotypes for grain yield. The mean grain yield across four environments for 25 genotypes was 6161 kg ha^{-1}. The highest grain yield was recorded at G21 (6807 kg ha^{-1}) and G20 (6776 kg ha^{-1}). Both genotypes also had higher yield potential across four environments. Therefore, they were determined as stable genotypes.

Table 4. Result of the variance analysis for parameters in 25 wheat genotypes

Parameters	SS	MS	F Ratio
Plant height (PH)	3027.333	126.139	8.077**
Peduncle length (PL)	856.922	35.705	18.015**
Spike length (SL)	36.464	1.519	5.686**
Spike number per square meter (SNM)	152577.010	6357.375	3.109**
Spikelet number per spike (SNS)	147.282	6.137	5.707**
Kernel number per spike (KNS)	2510.452	104.602	3.889**
Spike weight (SW)	6.473	0.270	2.006*
Flag leaf fresh weight (FLFW)	77.969	3.249	4.718**
Flag leaf dry weight (FLDW)	5.985	0.249	4.127**

*, ** Significant at p<0.05 and p<0.01 respectively. ns: non-significant. SS: Sum of square, MS: mean of square

In the study, the lowest variation was determined in G8 and G1 genotypes, since they were least affected by environmental conditions (Table 5). It has been determined that a Tekirdağ location (E3) has the highest yield potential. The E3 location had 83.4% more grain yield than the E4 (Keşan location) and 72.4% more than the E2 (Lüleburgaz location). For this reason, it is seen that this location has environmental conditions that can be used in the selection of high-yielding genotypes in breeding studies. Over four environments, according to the standard deviation values, the most stable genotypes were G8, G15 and G1. In the study, genotypes with unstable and variable values were determined as G24, G21, G14 and G13 (Table 5).

Table 5. Mean grain yield and standard deviation across four environments in genotypes

No	**Genotype**	**Environments**				**Mean yield and standard deviation (kg ha^{-1})**
		Edirne (E1)	**Lüleburgaz (E2)**	**Tekirdağ (E3)**	**Keşan (E4)**	
1	G1	7704^{a}	4954^{b-f}	7477^{ıj}	5004^{a}	6285±1511^{b-e}
2	G2	6765^{def}	3918^{ıj}	7763^{hıj}	4396^{b-e}	5711±1850^{hı}
3	G3	7295^{a-d}	5312^{abc}	8858^{a-e}	4900^{ab}	6591±1838^{ab}
4	G4	7610^{ab}	4494^{e-h}	7923^{f-j}	4951^{a}	6244±1772^{c-f}
5	G5	6990^{b-e}	4630^{d-h}	8090$^{f-ı}$	4770^{ab}	6120±1701^{d-g}
6	G6	7474^{abc}	5011^{a-e}	8671^{b-f}	4566^{abc}	6430±1966^{bcd}
7	G7	6593^{ef}	4428$^{f-ı}$	7904^{g-j}	3859^{f}	5696±1885^{ı}
8	G8	6879^{cde}	4830^{c-h}	7310^{j}	4415^{bcd}	5858±1447^{ghı}
9	G9	6124^{f}	3769^{j}	6137^{k}	3023^{g}	4763±1608^{j}
10	G10	7543^{ab}	4955^{b-f}	8346^{d-h}	4868^{ab}	6428±1782^{bcd}
11	G11	6864^{cde}	4608^{e-h}	7281^{j}	3930^{def}	5671±1651^{ı}
12	G12	6715^{def}	4544^{e-h}	8028^{f-j}	4213^{c-f}	5875±1814^{ghı}
13	G13	7354^{a-d}	4413$^{f-ı}$	8235^{e-h}	3862^{ef}	5966±2153$^{f-ı}$
14	G14	6560^{ef}	4319^{g-j}	8583^{c-g}	3930^{def}	5848±2161^{ghı}
15	G15	7576^{ab}	5175^{a-d}	7628^{hıj}	4830^{ab}	6302±1508^{b-e}
16	G16	7142^{a-e}	5277^{abc}	9226^{abc}	4562^{abc}	6552±2088^{abc}
17	G17	7210^{a-e}	5538^{a}	8899^{a-e}	4654^{abc}	6575±1877^{ab}
18	G18	7259^{a-d}	4449$^{e-ı}$	7903^{g-j}	4475^{abc}	6021±1820^{e-h}
19	G19	7511^{abc}	4867^{b-g}	8183$^{e-ı}$	4958^{a}	6380±1717^{bcd}
20	G20	7781^{a}	5334^{abc}	9182^{abc}	4808^{ab}	6776±2062^{a}
21	G21	7702^{a}	5533^{a}	9400^{ab}	4593^{abc}	6807±2164^{a}
22	G22	6782^{def}	4511^{e-h}	8323^{d-h}	4630^{abc}	6061±1834^{efg}
23	G23	7554^{ab}	4268^{hıj}	7611^{hıj}	4379^{b-f}	5953±1882$^{f-ı}$
24	G24	7329^{a-d}	4644^{d-h}	9498^{a}	4609^{abc}	6520±2359^{abc}
25	G25	6992^{b-e}	5418^{ab}	9059^{a-d}	4865^{ab}	6584±1880^{ab}
Mean		7172	4768	8221	4482	6161
LSD (0.05)		65.8	56.3	74.9	53.3	31.1

Tall genotypes could cause lodging in rainy conditions due to the use of excess seeds and fertilizers and may cause low yields. Therefore, plant height is an important character. The plant height of the genotypes ranged from 80.0 cm to 110.3 cm and the mean value was 96.9 cm. There were significant differences among genotypes for peduncle length and spike length in wheat genotypes. Spike length is one of the important yield components that contribute to yield in productive environment conditions. The peduncle length of the genotypes varied among genotypes from 22.9 cm to 37.9 cm and, the mean was 30.3 cm. The longest spike was determined with 11.0 cm in genotype G17. The mean spike length of the genotypes was 9.46 cm (Table 6).

Table 6. Mean morphological, agro-physiological and yield components of the genotypes

Genotype	PH	PL	SL	SNM	SNS	KNS	SW	FLFW	FLDW
G1	105.0^{a-d}	35.5^{b}	$8.8^{ı-m}$	475^{a}	18.3^{ef}	32.6^{k}	1.96^{de}	5.56^{jkl}	$1.46^{ı-l}$
G2	95.7^{f-k}	31.0^{def}	10.1^{b-e}	394^{b-g}	18.5^{ef}	53.1^{a}	2.49^{a-d}	$5.82^{ı-l}$	1.57^{h-l}
G3	89.3^{k}	32.2^{cde}	9.1^{g-m}	$377^{d-ı}$	19.3^{de}	39.4^{e-k}	2.22^{a-e}	7.67^{b-f}	1.92^{b-h}
G4	91.0^{jk}	32.6^{cde}	9.1^{g-m}	461^{ab}	18.3^{ef}	36.9^{g-k}	2.30^{a-e}	7.41^{b-h}	1.93^{b-h}
G5	96.7^{f-j}	33.0^{cd}	8.9^{h-m}	463^{ab}	18.5^{ef}	$34.4^{ıjk}$	1.82^{e}	4.95^{l}	1.41^{kl}
G6	92.7^{h-k}	30.5^{efg}	9.2^{f-m}	396^{b-g}	18.5^{ef}	35.3^{h-k}	2.10^{cde}	7.60^{b-g}	1.94^{b-h}
G7	98.7^{d-h}	23.7^{kl}	9.3^{e-l}	$327^{ghı}$	20.7^{a-d}	47.7^{a-e}	2.11^{b-e}	8.16^{a-d}	2.24^{abc}
G8	80.0^{l}	$28.4^{ghı}$	9.5^{d-j}	401^{a-f}	19.9^{b-e}	46.7^{a-f}	2.71^{ab}	8.00^{a-e}	2.12^{a-e}
G9	90.0^{k}	22.9^{l}	9.8^{b-g}	$309^{ı}$	18.8^{ef}	$42.4^{c-ı}$	2.43^{a-d}	7.44^{b-h}	2.04^{a-f}
G10	97.0^{f-j}	$29.5^{f-ı}$	8.8^{j-m}	410^{a-e}	18.5^{ef}	41.8^{c-j}	2.13^{b-e}	5.30^{kl}	1.36^{l}
G11	$97.7^{e-ı}$	$27.4^{ıj}$	9.1^{g-m}	398^{b-g}	17.3^{f}	38.3^{f-k}	2.09^{cde}	$7.02^{c-ı}$	1.82^{d-j}
G12	107.0^{ab}	31.4^{c-f}	8.5^{lm}	396^{b-g}	19.2^{de}	36.5^{g-k}	1.99^{de}	6.56^{f-k}	1.63^{g-l}
G13	94.0^{g-k}	$27.4^{ıj}$	9.7^{c-h}	438^{a-d}	21.2^{abc}	48.5^{a-d}	2.61^{abc}	6.62^{f-k}	1.78^{e-k}
G14	110.3^{a}	$27.4^{ıj}$	8.7^{lm}	$358^{e-ı}$	19.6^{b-e}	43.2^{b-h}	2.44^{a-d}	6.25^{g-l}	1.93^{b-h}
G15	94.0^{g-k}	30.3^{e-h}	9.5^{e-k}	458^{abc}	18.3^{ef}	40.1^{d-k}	2.06^{cde}	6.87^{d-j}	1.79^{e-k}
G16	99.3^{c-g}	32.1^{cde}	10.6^{abc}	$356^{e-ı}$	21.7^{a}	45.6^{a-f}	2.71^{ab}	8.37^{abc}	2.30^{ab}
G17	99.0^{d-h}	32.2^{cde}	11.0^{a}	$363^{e-ı}$	22.3^{a}	51.1^{ab}	2.79^{a}	9.15^{a}	2.37^{a}
G18	105.7^{abc}	$28.7^{ghı}$	8.4^{m}	413^{a-e}	18.3^{ef}	33.7^{jk}	1.81^{e}	7.30^{b-h}	$1.86^{c-ı}$
G19	93.3^{g-k}	26.0^{jk}	9.0^{h-m}	$367^{d-ı}$	18.4^{ef}	48.0^{a-d}	2.62^{abc}	6.21^{h-l}	1.45^{jkl}
G20	97.3^{f-j}	31.1^{def}	8.7^{klm}	396^{b-g}	19.5^{cde}	43.9^{b-g}	2.28^{a-e}	7.75^{b-f}	1.94^{b-h}
G21	104.0^{a-e}	33.6^{bc}	10.6^{ab}	$311^{hı}$	21.3^{ab}	46.4^{a-f}	2.45^{a-d}	8.41^{ab}	2.20^{a-d}
G22	$92.0^{ıjk}$	32.0^{cde}	$9.7^{d-ı}$	384^{c-h}	19.0^{def}	45.0^{a-g}	2.23^{a-e}	$7.10^{b-ı}$	1.59^{h-l}
G23	96.7^{f-j}	$28.1^{hıj}$	10.1^{b-e}	424^{a-e}	21.6^{a}	49.5^{abc}	2.61^{abc}	7.50^{b-h}	2.01^{a-g}
G24	101.3^{b-f}	37.9^{a}	10.0^{b-f}	$369^{d-ı}$	17.3^{f}	49.9^{abc}	2.71^{ab}	8.11^{a-d}	2.18^{a-e}
G25	95.7^{f-k}	32.8^{cd}	10.4^{a-d}	$334^{f-ı}$	17.4^{f}	39.3^{e-k}	1.95^{de}	6.68^{e-j}	1.70^{f-l}
Mean	96.9	30.3	9.46	392	19.26	42.76	2.31	7.11	1.86
$LSD_{(0.05)}$	6.49	2.31	0.85	74.21	1.7	8.5	0.6	1.36	0.4

PH: Plant height (cm), PL: Peduncle length (cm), SL: Spike length (cm), SNM: Spike number per square meter, SNS: Spikelet number per spike, KNS: Number of kernel per spike, SW: Spike weight (g), FLFW: Flag leaf fresh weight (g), FLDW: Flag leaf dry weight (g).

The tillering ability may vary according to some factors such as genetics, soil structure, planting time and depth. Genotypes G1, G4 and G5 had a higher tillering ability. Although genetic factors are effective in the number of spikelets, environmental factors can also be effective. Spikelet number has also been highly correlated with spike length. The highest spikelet number per spike was found in G17 (22.3), G16 (21.7), and G17 (21.6). Kernel number per spike varied from 32.6 (G1) to 53.1 (G2) among wheat genotypes. Furthermore, genotypes G17, G23 and G24 had also higher kernel numbers per spike. The temperature of the flowering period determines the number of grains per spike. The spike weight of the genotypes varied from 1.82 g to 2.79 g. The highest spike weight was determined in G17 (2.79

g), G16 (2.71 g), and G8 (2.71 g) while the lowest was in G18 (1.81 g). Spike weight is directly related to the length of the spike and the number of grains per spike (Table 6).

The flag leaf can be an important vehicle for high grain yield due to its position and photosynthetic characteristics (Razc et al., 2022). There were significant differences among genotypes for flag leaf fresh and dry weight. The average five-flag leaf fresh weight of the genotypes was 7.11 g. The highest flag leaf fresh weight was weighted for G17 (9.15 g), G21 (75.49 g), and G16 (74.21 g) while the lowest was in G5 (4.95 g). The mean flag leaf dry weight of the genotypes was 1.86 g, the lowest was 1.36 g (G10) g and the highest was 2.37 g (G17). The highest flag leaf dry weight was weighted for G17 (2.37 g), and G16 (2.30 g), while the lowest was in G10 (1.36 g) and G5 (1.41 g) (Table 6). It is known that the flag leaf makes a very important contribution to yield in wheat. The numbers of spikes per unit area, the number of grains per spike and the increase in spike weight also have a positive effect on yield. The contribution of the above-ground parts of the plant to the yield depends on the development of the root structure of the plant and the moisture in the soil. All of these factors vary according to environmental conditions and this difference is also reflected in the yield in genotypes.

Table 7. Coefficients of correlation among grain yield and several quantitative traits

Traits	GY	PH	PL	SL	SNM	SNS	KNS	SW	FLFW
PH	0.041								
PL	0.469*	0.219							
SL	-0.034	-0.165	0.198						
SNM	0.454*	-0.074	0.265	-0.443*					
SNS	0.052	0.054	-0.172	0.480*	-0.236				
KNS	-0.100	-0.165	-0.159	0.629**	-0.425*	0.515**			
SW	0.014	-0.239	-0.061	0.599**	-0.321	0.546**	0.831**		
FLFW	0.037	-0.140	0.014	0.526**	-0.494*	0.513**	0.377	0.489*	
FLDW	-0.085	-0.023	-0.055	0.529**	-0.497*	0.568**	0.398*	0.531**	0.928**

*, ** Significant at $p<0.05$ and $p<0.01$ respectively. GY: Grain yield (kg ha^{-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: Number of kernel per spike, SW: Spike weight (g), FLFW: Flag leaf fresh weight (g), FLDW: Flag leaf fresh weight (g).

Correlation coefficients among investigated parameters were determined by Pearson's correlation analysis (Table 7). The correlations of the assessed parameters are shown in Table 7. Peduncle length and spike number per square meter contributed to grain yield and positively correlated with grain yield. No correlation was found between spike weights with grain yield. Spike weight was significantly positively correlated with spike length (r=0.599**), spikelet number per spike (r=0.546**), and kernel number per spike (r=0.831**). Flag leaf fresh and dry weight in wheat genotypes positively affected spike length, spikelet number per spike, kernel number per spike and spike weight. As the plant density per unit area increased, there was a decrease in flag leaf fresh and dry weight. Flag leaf fresh weight was significantly positively correlated with spike length (r=0.526**), spikelet number per spike (r=0.513**), and spike weight (r=0.489*). Flag leaf dry weight was also significantly positively correlated with spike length (r=0.529**), spikelet number per spike (r=0.568**), kernel number per spike (r=0.398*) and spike weight (r=0.531**). Increasing in spike numbers per square negatively affected and reduced flag leaf area in wheat genotypes. So, the correlation coefficient among flag leaf fresh weight and dry weight with spikelet number per square meter was significant. The difference in environmental conditions was also reflected in the yield and different results were obtained between locations. The difference in environmental conditions resulted from the changes in soil structure, rainfall amount and distribution, relative humidity and temperature values.

Conclusion

The study's results revealed significant differences among genotypes, environments and their interaction for grain yield. Factors such as soil structure, precipitation and temperature are the main environmental factors. The highest grain yield was performed by G21 and G20. Both genotypes also had higher yield potential across four environments. Different environmental conditions create a suitable environment for effective selection. Therefore, they were determined as stable genotypes. It has been determined that E3 was the highest-yielding environment. Environment E3 had more grain yield than E4 and E2. Flag leaf fresh and dry weight in wheat genotypes had an appositive effect on spike length, spikelet number per spike, kernel number per spike and spike weight. The contribution of the flag leaf to the yield components has shown that it is an important selection parameter. So, results showed that flag leaf fresh and dry weight of wheat genotypes could be used in the selection of bread wheat for yield component. The high tillering capacity increased the number of plants and spikes per unit area, thus causing a decrease in the flag leaf area. The longest spike, the highest number of grains per spike and the number of spikelets were determined in G17, together with the yield above the average. In addition, G17 had the highest spike weight and flag leaf fresh and dry weight. For this reason, G17 has been determined as the line that can be used in breeding studies due to its agronomic characteristics. This study showed that flag leaf fresh and dry weight could also use as selection parameters for yield components. The increase in the number of plants and spikes per unit area caused the yield components to decrease.

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