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Original scientific article

GENOTYPIC DIFFERENCES FOR CHLOROPHYLL, ASH AND N CONTENTS AND THEIR RELATIONS WITH GRAIN YIELD IN TURKISH BREAD WHEAT LANDRACES

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The genetic differences in the landraces are very important for plant breeding. The aim of this study was to determine the genetic differences for chlorophyll, ash and N contents and their relations with grain yield in Turkish bread wheat landraces. There were significant genetic differences for grain yield (GY), ash content of flag leaf at anthesis (AFLAC), ash content of spike at anthesis (ASAC), ash content of flag leaf at maturity (MFLAC), grain ash content (GAC), chlorophyll content at anthesis (ACC), chlorophyll content at early milk maturity (EMCC), chlorophyll content at late milk maturity (LMCC), chlorophyll content at early dough maturity (EDCC), N content of flag leaf at anthesis (FLN) and spike N contents (SN). The grain yield was positively and significantly related with AFLAC, ASAC, MFLAC and ACC, negatively and significantly related with GAC, EDCC and SN, not significantly related with EMCC, LMLC and FLN.
Keywords: ash, chlorophyll, nitrogen contents, wheat landraces, yield

INTRODUCTION

Genotypes that can use small amounts of water available in the soil provide a drought adaptation power (HURD, 1968). Instead of direct and difficultly measurable traits, indirect

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information based on easily measurable traits such as vegetation temperature difference, relative humidity content, stomatal conductivity and ash content is more preferable to study (REYNOLDS, 2002).

FISCHER (2001) reported that the use of SPAD meters to determine the chlorophyll content and nitrogen content of leaves is a cheap and fast method that does not harm leaf greenness, and the best reading time is after flowering when chlorophyll is at the highest level. It has been determined that there is a genotypic variation in terms of chlorophyll reductions due to early damages caused by stress conditions, especially heat stress (SIDDIQUE *et al*., 1989). FISCHER (2001) reported that chlorophyll contents reflect the photosynthetic capacities of leaves.

SIDDIQUE *et al*. (1989) found that while total chlorophyll increased in Australian wheats, chlorophyll a/b ratio decreased relatively. Similar trends were also observed in CIMMYT material (REYNOLDS, 2002). For this reason, flag leaf chlorophyll ratios at heading are examined.

Under favorable conditions, about 70-90% of the final grain yield is obtained from assimilates produced during the grain filling period (AUSTIN *et al*., 1977; BIDINGER *et al*., 1977). In leaves of higher plant, the main photosynthetic pigment, chlorophyll containing chlorophyll a and b, and its amount in chloroplasts directly affect the plant photosynthetic yield (ARAUS *et al*., 1997; THOMAS *et al*., 2005). Increased chlorophyll content in plant leaves increases both biomass production and grain yield (WANG *et al*., 2008). Since chlorophyll is the main pigment in photosynthesis, its abundance and stable presence in the leaf significantly affect grain filling and yield (WANG *et al*., 2008; FISCHER *et al*., 1998; RAMESH *et al*., 2002; ZHAO *et al*., 2007; SHAO *et al*., 2013).

The chlorophyll content is known to correlate with leaf N, Rubisco activity and photosynthetic capacity (EVANS, 1983; SEEMANN *et al*., 1987) and quantitatively with the green color of leaves (INADA, 1963). Minolta SPAD is a good indicator for determining leaf N and chlorophyll content in various plants (MONJE and BUGBEE, 1992; BULLOCK and ANDERSON, 1998; CHANG and ROBISON, 2003; LOPEZ-BELLIDO *et al*., 2004). The established close relationship between chlorophyll and nitrogen content (EVANS, 1983; FILED and MOONY, 1986; AMALIOTIS *et al*., 2004) is understandable because nitrogen is a structural element of chlorophyll and protein molecules and therefore affects chloroplast formation and chlorophyll accumulation in them (TUCKER, 2004; DAUGHTRY *et al*., 2000). Some recent studies have revealed that the N content of the spike can be used as a good indicator in determining the grain setting ability. It has been stated that the N content of the spike may be effective in determining the sterility of the flower, thus the number of grains (ABBATE *et al*., 1995; VAN HERWAARDEN, 1996). It has been determined that there is a positive relationship between spike N content and the number of grains per spike, pre-anthesis and at anthesis (DEMOTES-MAINARD and JEUFFROY, 2004; PRYSTUPA *et al*., 2004). Therefore, increasing the N content of spike at anthesis can provide significant benefits in terms of increasing the number of grains.

Ash content has been suggested as an alternative selection criterion for yield under drought conditions (MASLE *et al*., 1992). Correlation between leaf ash content and grain yield in different C3 species has also been put forward by different researchers such as MASLE *et al.* (1992), MAYLAND *et al*. (1993), MERAH *et al*. (1999, 2001), TSIALTAS *et al*. (2002), FEBRERO *et al*. (1994), VOLTAS *et al*. (1998) and MERAH *et al.* (1999, 2001). It also reported that there is a negative correlation between the ash content in grain and grain yield of winter cereals grown in Mediterranean conditions (MISRA *et al*., 2006).

Wheat landraces are defined as local wheat varieties that have been developed by farmers through years of natural and artificial selection and adapted to local environmental conditions and traditional growing techniques (HARLAN, 1992; JARADAT, 2013). Local wheat landraces are generally preferred in terms of yield stability under local conditions. Because landraces are more resistant to changes in environmental and stress conditions (REYNOLDS *et al*., 2005, 2007; FEUILLET *et al*., 2007; JARADAT, 2013; 2014). Since the majority of the root dry matter contents are concentrated in the deeper layers of the soil, they can benefit better from moisture. They are capable of high transpiration (JARADAT, 2013). Due to the excessive carbohydrate concentrations accumulated in the stem parts, the transport of sufficient photosynthesis products to the grain is guaranteed under unfavorable conditions. The amount of N they carry to the grain is higher (ACQUISTUCCI *et al*., 1995; JARADAT, 2013).

This study aimed to determine genotypic differences for leaf chlorophyll, ash and N contents and to evaluate their relations with grain yield and among them.

MATERIALS AND METHODS

Experimental details

Table 1. Short information about genetic materials used in the experiment

Biplot No	Landraces Name	Area of Collection
G1	Polatli Yazligi-4	Ortaoren / Ekinozu
G2	AlaBugday-5	Boylu / Caglayancerit
G3	AlaBugday-11	Bostanlı / Andirin
G4	Ak Bugday-13	Doluca / Turkoglu
G5	Nurhak Bugdayi-19	Duzbag / Caglayancerit
G6	Kirmizi Bugday-21	Alacik / Caglayancerit
G7	Polatli Yazligi-24	Ambarcik / Elbistan
G8	Beyaz Bugday-31	Boylu / Caglayancerit
G9	Elbistan Yazligi-33	Tepebasi / Elbistan
G10	Ofis Yazligi-35	Cogulhan / Afsin
G11	Ankara Yazligi-48	Tarlacik / Afsin
G12	Ziron Yazligi-49	Buyuk Kizilcik / Goksun
G13	Yerli Bugday-50	Buyuk Kizilcik / Goksun
G14	Goksun Bugdayi-51	Buyuk Kizilcik / Goksun
G15	Adana-99	Commercial cultivar
G16	Seri-82	Commercial cultivar
G17	Golia	Commercial cultivar

Field experiments were carried out and arranged in a randomized complete block design with four replications. The seeds were planted at 550 germinable seeds m^{-2} rate in November using an experimental drill in 1.2 m x 8 m plots consisting of six rows with 20 cm row space.

Fertilizers were applied as 80 kg ha^{-1} N and 80 kg ha^{-1} P_2O_5 at planting. In addition, top-dressing was applied as 100 kg ha^{-1} N at tillering. Weeds were controlled with Tribenuron–Methyl 75% at the tillering stage of wheat.

Soils and weather

The soil type is a sandy clay, low in organic matter and slightly alkaline (pH 7.4-7.7). Available P and K contents of the soil (0–0.20 m) were 51.9 and 1059 kg ha^{-1}, respectively. The climate of the region is typical of Mediterranean climate with a long-term average of the annual rainfall of 660 mm. The annual total precipitations in the 2005-08 crop years were 645.3, 522.2 and 550.1 mm, respectively, 14.7 mm lower in the first crop year, 137.8 mm in the second crop year, and 109.9 mm less in the third crop year, compared to the average of long term annual precipitation. In addition to the amount of precipitation, its distribution within the vegetation period has also shown a significant difference between years. Especially in November-December period of second year, during germination, emergence and first growth stages, the amount of precipitation was lower than the long term average while in January and February, in the first year, considerably higher than other two years and long term rainfall (Table 2). On the other hand, the second crop year was superior to the other crop years and the average long-term in terms of rainfall in March, April and May, during generative development. In three experiment years, there was a higher annual average temperature compared to the long-term average and temperatures during the grain-filling period were greater than the long-term averages.

Table 2. Some average climatic data belong to experiment years and long-term (1983-2005) in Kahramanmaraş province.

Months	Rainfall (mm)				Temperature (^{0}C)			
	2005-06	2006-07	2007-08	Long-term	2005-06	2006-07	2007-08	Long-term
November	69.6	77.0	105.9	99.9	10.8	10.3	13.2	10.9
December	93.5	1.1	96.2	124.8	8.4	6.8	6.1	6.2
January	102.0	63.1	78.6	115.7	3.8	4.9	3.3	5.2
February	232.7	133.6	121.5	105.8	6.9	7.8	5.5	6.2
March	96.8	99.9	69.5	96.1	11.7	11.4	14.4	10.3
April	36.6	87.8	54.7	71.9	17.0	13.3	18.1	15.5
May	14.1	58.9	23.7	40.9	21.9	23.4	20.2	20.4
June	0.0	0.8	0.0	4.9	27.4	27.5	27.3	25.0
Total	645.3	522.2	550.1	660.0				
Mean					13.5	13.2	13.5	12.5

Data recorded

Chlorophyll content at anthesis (ZGS 65), at early milk maturity (ZGS 71), at late milk-maturity (ZGS 77), at early dough maturity (ZGS 83) were recorded by a portable chlorophyll meter (Minolta SPAD-502, Osaka, Japan) on the flag leaf of ten plants taken at random in each plot.

Ash contents were determined in flag leaf at anthesis and maturity, in spike at anthesis and in grains at maturity. Samples were oven-dried at 80 ^{0}C for 48 h and ground. Approximately 1.5 g of dry mass was incinerated at 575 ^{0}C for 16 h until light grey ash was obtained. Ash content (%) was expressed on dry mass basis. Nitrogen contents of flag leaf and spike were determined at anthesis, by the standard Kjeldahl method (KAMALAK *et al*., 2010; KAPLAN *et al*., 2014; KAPLAN *et al*., 2015). At the maturity, the four rows in the middle of plots were harvested and the grain yield (GY) was determined and expressed as kg per hectare (kg ha^{-1}).

Data and correlations analyses were performed by using SAS statistical software (SAS INSTITUTE, 1999). Biplot analysis was performed using the Genstat program (GENSTAT, 2010).

RESULTS AND DISCUSSION

There were significant ($P \leq 0.01$ and $P \leq 0.05$) differences in all characters, except for grain ash content at maturity, over the growth stages (Table 3). As the average of three years, standard cultivars had a high grain yield, there were not significant differences in grain yields of standard cultivars, but there were significant differences from the grain yields of landraces. Grain yields varied between 5890 - 6505 kg/ha in standard cultivars and between 3079 - 3777 kg/ha in landraces. The lowest grain yield in landraces was obtained from Ziron Yazligi-49 genotype. Previous researchers also reported varying grain yields with the genotypes (BALTENSPERGER *et al*., 2001; XUE *et al*., 2002; MONNEVEUX *et al*., 2006; DRECCER *et al*., 2009; AKÇURA, 2011).

In addition to grain yield, local cultivars had lower values than standard cultivars in most of the traits examined. In some studies where bread wheat landraces and standard varieties are used together under stress conditions, it has been reported that local varieties have superior characteristics, while standard varieties have superior characteristics under non-stress conditions (AKÇURA *et al*., 2011).

There were significant positive correlations between grain yield and ash content of flag leaf in flowering (r = 0.58**) and ripening (r = 0.68**) stages. There were significant positive correlations also between GY and ASAC (r = 0.24**) (Table 5). MONNEVEUX *et al*. (2005) reported significant correlations between post-flowering leaf ash content and GY, but there were not any correlations between grain ash content and GY and indicated that post-flowering leaf ash content may offer important information in yield studies conducted under irrigated conditions.

Correlations between grain yield and chlorophyll contents varied with the growth stages. While there were significant positive correlations in flowering stage (r = 0.19*), significant negative correlations were seen in soft dough stage (r = -0.34**). DELGADO *et al*. (1994) indicated that grain yields were related to chlorophyll content; REYNOLDS *et al*. (1997) reported positive correlations in flowering stage and negative correlations in soft dough stage; ASHRAF (2000) reported positive, but insignificant correlations between grain yield and total chlorophyll content. There were significant negative correlations between grain yield and SN (r = -0.15*). In winter wheat, significant positive correlations were reported between GY and SPAD values in heading (BAVEC and BAVEC, 2001) and grain-fill (JIANG *et al*., 2004) stages. YILDIRIM *et al*. (2011) and (2013) reported positive correlations between grain yield and SPAD values in heading and soft dough stages.

Table 3. Mean performance of genotypes in GY, AFLAC, ASAC, MFLAC and GAC over growing seasons

Genotypes	GY (kg/ha)	AFLAC (%)	ASAC (%)	MFLAC (%)	MGAC (%)
Polatli Yazligi-4	3160 ef	10.986 def	6.149 bcd	11.973 cd	1.592
AlaBugday-5	3627 cde	10.182 fgh	5.479 ef	11.844 cde	1.622
AlaBugday-11	3411 cdef	9.575 h	5.895 cde	11.039 def	1.554
Ak Bugday-13	3238 def	11.114 def	5.984 cde	11.372 cde	1.524
Nurhak Bugdayi-19	3434 cdef	10.455 efgh	5.585 def	11.337 cde	1.619
Kirmizi Bugday-21	3672 cd	10.412 efgh	5.116 f	11.447 cde	1.559
Polatli Yazligi-24	3299 def	10.698 defg	5.994 cde	11.730 cde	1.630
Beyaz Bugday-31	3660 cd	10.510 efgh	5.613 def	10.369 f	1.638
Elbistan Yazligi-33	3518 cdef	11.445 cde	6.431 bc	12.149 c	1.495
Ofis Yazligi-35	3777 c	11.630 cd	5.815 cde	12.224 c	1.609
Ankara Yazligi-48	3079 f	10.031 fgh	5.793 de	11.574 cde	1.529
Ziron Yazligi-49	3306 cdef	9.741 gh	5.477 ef	11.005 ef	1.665
Yerli Bugday-50	3436 cdef	9.815 gh	5.618 def	11.412 def	1.551
Goksun Bugdayi-51	3601 cde	10.935 def	5.726 def	12.058 def	1.611
Adana-99	6116 ab	13.406 b	6.616 b	14.968 b	1.448
Seri-82	6505 a	12.474 bc	6.002 bcde	14.477 bcde	1.358
Golia	5890 b	15.610 a	7.269 a	19.598 a	1.650
Mean	3925	11.12	5.915	12.387	1.567
Lsd	47.274	1.111	0.619	0.956	0.262
CV	14.93	12.38	12.97	9.56	20.74
Prb	**	**	**	**	ns

ns – not significant,* – significant at 0.05, ** – significant at 0.01. GY: grain yield, AFLAC: ash content of flag leaf at anthesis, ASAC: ash content of spike at anthesis, MFLAC: ash content of flag leaf at maturity, GAC: grain ash content.

It was also indicated that SPAD values had a high correlation with grain yield (TANG *et al*., 2017), but such correlations varied with the cultivars (MONOSTORI *et al*., 2016). SILVA-PERAZ *et al*. (2020) conducted a study in Mexico and reported insignificant correlations between grain yield and SPAD values. BLACKMER and SCHEPERS, (1995), MAITI *et al.* (2004) and BOGGS *et al*. (2003) indicated that leaf chlorophyll values measured with SPAD chlorophyll meter were closely related to grain yields. Level of such relations varied with the locations and phenological stages (REYNOLDS *et al*., 1997).

In flowering stage, the Golia cultivar had the greatest values in terms of flag leaf and spike ash content and MFLAC. In flowering stage, Alabugday-11 genotype had the lowest flag leaf ash content (9.575%), Kirmizi Bugday-21 genotype had the lowest ASAC value (5.116%) and Beyaz Bugday-31 genotype had the lowest MFLAC value (10.369%). KOÇ *et al.* (2008) indicated that the cultivars with a high flag leaf ash content were more tolerant to high temperatures. DE VITA *et al.* (2007) indicated that new cultivars had lower ash contents than the old cultivars. In ripening stage, differences in grain ash contents of the genotypes were not found to be significant. ÖZER *et al.* (2006) reported that grain ash content of wheat varied between 1.86 - 2.18% and differences in grain ash contents of wheat genotypes were not significant. In the flowering period, flag leaf ash content had significant positive correlations with ASAC (r = 0.51**) and MFLAC (r = 0.71**) and significant negative correlations with GAC (r = -0.17**) and EDCC (r = -0.26**).

Table 4. Mean performance of genotypes in ACC, EMCC, LMCC, EDCC, SN and FLN over growing seasons

Genotypes	AC (SPAD)	EMCC (SPAD)	LMCC (SPAD)	EDCC (SPAD)	SN	FLN
Polatli Yazligi-4	43.973 cde	45.025 abc	44.400 ab	17.020 a	1.770 abcde	3.445 abcde
AlaBugday-5	40.713 hi	39.130 fg	40.373 defg	13.114 bcde	1.752 abcdef	3.280 defg
AlaBugday-11	41.888 fghi	41.245 ef	41.603bcdefg	15.330 abc	1.709 bcdef	3.300 cdefg
Ak Bugday-13	42.683 efg	44.180 abcd	40.136 efg	17.244 a	1.832 a	3.320 cdefg
Nurhak Bugdayi-19	40.035 i	38.644 g	39.903 fg	16.930 a	1.743 abcdef	3.415 abcde
Kirmizi Bugday-21	40.696 hi	41.780 de	42.285 abcdef	15.300 abc	1.674 ef	3.220 efg
Polatli Yazligi-24	42.818 ef	43.131 bcde	41.861 bcdefg	12.936 bcde	1.707 cdef	3.326 bcdefg
Beyaz Bugday-31	41.980 fgh	41.810 de	39.086 g	12.760 cde	1.667 ef	3.344 bcdef
Elbistan Yazligi-33	43.480 def	42.666 cde	43.368 abc	16.258 abc	1.768 abcde	3.043 g
Ofis Yazligi-35	43.580 def	44.261 abcd	43.140 abcd	14.530 abcd	1.801 abcd	3.444 abcde
Ankara Yazligi-48	43.334 def	44.185 abcd	42.453 abcdef	14.711 abcd	1.768 abcde	3.324 bcdefg
Ziron Yazligi-49	42.874 ef	45.219 ab	43.080 abcd	14.069 abcd	1.694 def	3.654 a
Yerli Bugday-50	45.713 bc	46.643 a	44.875 a	16.564 ab	1.819 ab	3.623 ab
Goksun Bugdayi-51	40.876 ghi	42.213 de	42.895 abcde	17.073 a	1.655 f	3.090 fg
Adana-99	45.134 cd	43.123 bcde	40.764 cdefg	11.084 de	1.716 bcdef	3.366 abcdef
Seri-82	47.145 ab	45.926 a	39.656 fg	11.189 de	1.786 abcd	3.595 abc
Golia	48.274 a	45.771 a	44.125 ab	9.781 e	1.804 abc	3.528 abcd
Mean	43.25	43.23	42.00	14.46	1.745	3.371
Lsd	1.878	2.520	2.826	3.747	0.110	0.30
CV	4.38	5.87	6.78	26.10	7.82	8.97
Prb	**	**	**	**	*	**

* – significant at 0.05, ** – significant at 0.01. ACC: chlorophyll content at anthesis, EMCC: chlorophyll content at early milk maturity, LMCC: chlorophyll content at late milk maturity, EDCC: chlorophyll content at early dough maturity, SN: spike N contents, FLN: N content of flag leaf at anthesis.

In the flowering stage, the greatest SPAD value was obtained from Golia cultivar and the lowest SPAD value was obtained from Nurhak Bugdayi-19 genotype. In soft dough stage, the greatest chlorophyll contents were obtained from Yerli Bugday-50, Seri-82 and Golia cultivars, as it was in flowering period, Nurhak Bugdayi-19 genotype had the lowest SPAD value. In hard dough stage, the greatest SPAD value was observed in Yerli Bugday-50 genotype and the lowest SPAD value was observed in Beyaz Bugday-31 genotype. It was reported that wheat cultivars had a wide range of chlorophyll content (ASHRAF *et al*., 1994), the plants with a high chlorophyll content had a high photosynthetic activity and there were significant correlations between chlorophyll content and net photosynthesis rate (ASHRAF, 2000). In soft dough stage, Ak Bugday-13, Goksun Bugdayi-51, Polatli Yazligi-4 and Nurhak Bugdayi-19 genotypes had the greatest SPAD values and Golia cultivar had the lowest SPAD value. In cultivar development programs, genotypes with high chlorophyll contents are desired. Had high photosynthesis rates. In the absence of water stress, plants prolong open durations of stomas to make more photosynthesis. Therefore, high chlorophyll content is desired. The genotypes with high chlorophyll contents generally have dark green color. Besides, in hot and dry regions, these genotypes have greater canopy temperatures, thus the genotypes and generations yielding negative combination values play an important role in genotype breeding programs for dry regions (REYNOLDS *et al*., 1996). Current cultivars generally had slightly greater SPAD values than the local cultivars since the lines with dark leaf color were selected in breeding programs of these cultivars or in yield-based selections, the lines with high chlorophyll content had high yield potential (YILDIRIM *et al*., 2009). Besides large variations of chlorophyll contents of the genotypes, variations of chlorophyll contents based on growth stages indicate that low chlorophyll content of a genotype may increase in further growth stages of the plant and genotype ranks in chlorophyll contents may also vary with the growth stages. Therefore, selection programs should include a greater number of growth stages.

Chlorophyll contents in flowering, soft dough and hard dough stages were close to each other. On the other hand, EDCC values decreased with increasing temperatures. It was reported for plants under high temperature stress that chloroplasts were structurally and functionally damaged, thus chlorophyll contents, then photosynthesis rates decreased accordingly (XU *et al.*, 1995). It was reported in another study that when the plants were exposed to high temperatures, chlorophyll biosynthesis was negatively influenced (HAVAUX, 1993; 1998). SPAD values were similar in flowering, soft dough and hard dough stages, but decreased in grain fill stage (BABAR *et al*., 2006). Changes in SPAD values of the cultivars varied based on temperature and drought conditions (FOTOVAT *et al*., 2007; BALOUCHI, 2010; PRASAD *et al*., 2011). SPANER *et al.* (2005) reported significant decreases in SPAD values of wheat and barley from ZGS 59 to ZGS 75-79 under different temperature and nitrogenous fertilizer regimes. In the flowering stage, chlorophyll content had significant positive correlations with EMCC (r = 0.58**), LMCC (r = 0.28**), FLN (r = 0.35**) and SN (r = 0.59**) (Table 5).

In this sense, SPANER *et al.* (2005), PAPASAVVAS *et al.* (2008) and NYI *et al.* (2012) successfully used leaf chlorophyll concentrations estimated with a SPAD meter in assessment of N status of wheat, Beta vulgaris and Jatropha. SWAIN and SANDIP (2010) reported significant positive correlations between flag leaf N content and SPAD value in different growth stages (R^2 = 0.80) and between grain yield of rice and SPAD value. Leaf nitrogen content is related to leaf color (CABRERA, 2004). SPAD values were also successfully used in the estimation of grain yield and protein content under low nitrogen conditions (DABAEKE *et al*., 2006).

In terms of spike N content, Ak Bugday-13 genotype had the greatest value and Goksun Bugdayi-51 genotype had the lowest value. The greatest flag leaf N content was obtained from Ziron Yazligi-49 genotype and the lowest flag leaf N content was obtained from Elbistan Yazligi-33 genotype. In flowering stage, there were significant positive correlations between flag leaf N content and spike N content (r = 0.35**). It was reported in previous studies that in flowering period, spike nitrogen content had significant correlations with number of grains per spike and spike dry matter (DEMOTES-MAINARD *et al.*, 1999; DEMOTES-MAINARD and JEUFFROY, 2004).

Table 5. Correlation of coefficients among GY, AFLAC, ASAC, MFLAC, GAC, ACC, EMCC, LMCC, EDCC, FLN and SN

	GY	AFLAC	ASAC	MFLAC	GAC	ACC	EMCC	LMCC	EDCC	FLN
AFLAC	0.58 **	1.00								
ASAC	0.24 **	0.51 **	1.00							
MFLAC	0.68 **	0.71 **	0.51 **	1.00						
GAC	-0.18 **	-0.17 *	-0.09	-0.15 *	1.00					
ACC	0.19 *	-0.01	0.06	0.16	0.37 **	1.00				
EMCC	0.12	-0.03	0.04	0.04	0.25 **	0.58 **	1.00			
LMCC	-0.14	0.03	0.03	-0.01	0.14	0.28 **	0.40 **	1.00		
EDCC	-0.34 **	-0.26 **	-0.14	-0.27 **	0.06	-0.11	0.02	0.17 *	1.00	
FLN	0.06	-0.08	-0.09	0.01	0.29 **	0.35 **	0.33 **	0.13	-0.02	1.00
SN	-0.15 *	-0.07	-0.04	-0.06	0.37 **	0.59 **	0.31 **	0.22 **	0.04	0.35 **

* and ** mean significant difference at 0.05 and 0.01, respectively. GY: grain yield, AFLAC: ash content of flag leaf at anthesis, ASAC: ash content of spike at anthesis, MFLAC: ash content of flag leaf at maturity, GAC: grain ash content, ACC: chlorophyll content at anthesis, EMCC: chlorophyll content at early milk maturity, LMCC: chlorophyll content at late milk maturity, EDCC: chlorophyll content at early dough maturity, SN: spike N contents, FLN: N content of flag leaf at anthesis.

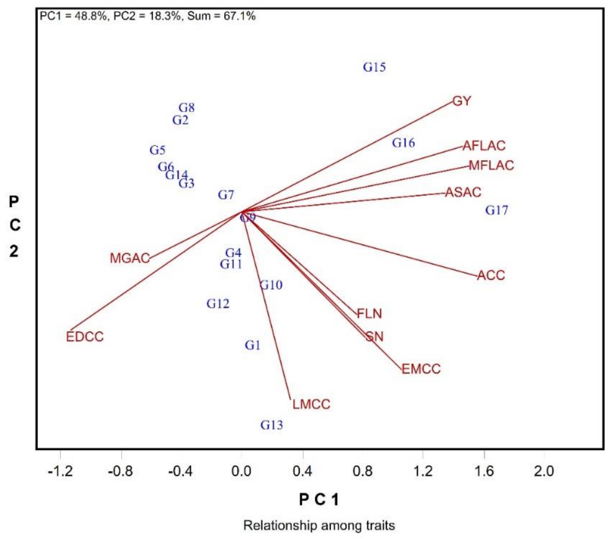

Figure 1. The genotype by trait (GT) biplot of 17 genotypes (14 landraces, 3 modern cultivars) for 11 traits.

CONCLUSIONS

The fact that there are important relationships between grain yield and ash content shows that the genotypes in the study have the necessary genetic structure for selection in terms of resistance to heat. The relationship between SPAD values and grain yield was stronger in a cool environment, the relationship decreased as the temperature increased. In addition, additional studies should be carried out in different stress conditions and different plant growth periods to better determine the relationship of SPAD with yield and to be used as selection criteria in breeding.

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GENOTIPSKE RAZLIKE ZA SADRŽAJ HLOROFILA, PEPELA I AZOTA I NJIHOVA POVEZANOST SA PRINOSOM ZRNA KOD POPULACIJE TURSKE HLEBNE PŠENICE

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Izvod

Genetske razlike kod populacija su veoma važne za oplemenjivanje biljaka. Cilj ovog istraživanja bio je da se utvrde genetske razlike u sadržaju hlorofila, pepela i N i njihov odnos sa prinosom zrna kod lokalnih populacija turske hlebne pšenice. Postojale su značajne genetske razlike u prinosu zrna (GI), sadržaju pepela u listu zastavičaru (AFLAC), sadržaju pepela u klasu pri sazrevanju (ASAC), sadržaju pepela u listu zastavičaru tokom sazrevanja (MFLAC), sadržaju hlorofila tokom cvetanja (ACC), sadržaj hlorofila u ranoj mlečnoj zrelosti (EMCC), sadržaj hlorofila u kasnoj mlečnoj zrelosti (LMCC), sadržaj hlorofila u ranoj voštanoj zrelosti (EDCC), sadržaj N lista zastavičara u fazi cvetanja (FLN) i sadržaj N u klasovima (SN). Prinos zrna je bio pozitivno i značajno povezan sa AFLAC, ASAC, MFLAC i ACC, negativno i značajno povezan sa MGAC, EDCC i SN, nije bio značajno povezan sa EMCC, LMLC i FLN.

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