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Research Article

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Assessment of Drought Tolerance Criteria in Winter Bread Wheat under Organic and Conventional Growth Conditions

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Abstract This study which focused on some drought tolerance criteria such as excised leaf water loss (ELWL), relative water content (RWC), membrane thermal stability (MTS), chlorophyll content (Chl) and ash content (Ash) of the flag leaf was aimed to detect effects of these criteria on the grain yield (GY) and yield components (grain number per spike, GNPS; thousand kernel weight, TKW and spike yield, SY). Trial was conducted with eight winter bread wheat genotypes under organic and conventional conditions, with three replication according to randomized blocks design, in 2013-2014 growth season. Significant differences among genotypes for plant height (PH) and GY while TKW and test weight (TW) showed significant differences for genotypes and growth conditions. RWC showed significant variations for growth conditions. MTS statistically differed for genotypes and genotype × growth conditions while ELWL, ELWR, Ash, and Chl (at anthesis and milky stages) presented significant differences. Results showed that GY was significant positive correlated with ELWR but negative correlated with ELWL under organic growth conditions. Ash of the flag leaf was also significant positive correlated with PH, TKW, and MTS (at anthesis) under organic conditions. MTS (at both stages) was significant positive correlated with PH and GY under organic conditions. RWC showed significant positive correlations with GY and TW under conventional growth conditions. However, as seen from the results, physiological selection criteria such as ELWL, ELWR, MTS, Chl, and Ash were mostly significantly related to each other and yield and yield components in organic conditions. Thus, with this study, it is concluded that these selection criteria can be used more effectively in organic wheat breeding programs for drought tolerance.

Keywords Bread wheat, Drought tolerance, ELWL, MTS, Chlorophyll content

1. Introduction

Approximately half of the world's total agricultural land (3.2 billion ha) is being processed (1.48 billion ha); half of it (724 million ha) is planted with cereals; wheat constitutes 30% of the cereal cultivation areas [1]. Considering that fallow lands in arid and semi-arid regions are also empty for cereals on a large scale, the importance of wheat for humanity will be better understood. Thus, global warming or seasonal droughts that may occur in reproductive stage of wheat will also negatively affect the production potential of such a strategic cereal crop. Therefore, the development of drought-resistant or -tolerant wheat varieties is very important. This main breeding purpose is essential for arid or semi-arid areas [2]. Drought tolerance in wheat varies according to the interaction of genotypes with environmental conditions and is a multi-factorial complex feature [3]; in severe water constraints, membrane damage occurs and drought sensitivity is associated with poor antioxidant defense responses in wheat [4]. It is reported that structural damage in organelles is also observed in other plants and is related with drought sensitivity [5]. In researches, leaf relative water content (RWC), stomatal resistance, leaf temperature and transpiration rate [6]; relative water protection [7] and canopy temperature [8] have been reported to be the main physiological criteria used to regulate plant-water relations and used in drought

tolerance. One of the most common measurements of plant water stress is excised leaf water loss (ELWL) [9]; in bread wheat, yield stability index was significant positive correlated with RWC and significant negative correlated with ELWL under drought stress [10]. It was reported that ELWL is a moderate hereditary feature and in a study conducted in winter wheat, this trait can easily be used as a criterion in terms of earlier drought period together with RWC. In addition, ELWL is a quick method to predict drought in field conditions; under severe drought, it was reported that excised leaves are simple model for examining the water loss from healthy plants, and because the leaves close their stomata after cutting, water loss from the cuticle and some water loss is still from the stomata which are not fully closed [11]. Thus, ELWL is used very often for drought tolerance. However, in this study, unlike previous studies; in organic and conventional conditions, the effects of ELWL, ELWR, membran thermostability, chlorophyll content and ash content of flag leaf on grain yield and yield components were examined.

2. Materials and Methods

2.1. Materials

The trial was conducted in the area rented from the farmer in Siran, Gumushane (in Turkey) in the 2013-2014 growth season, with eight winter bread wheat genotypes. The names, pedigrees and origins of the genotypes were shown in Table 1; total precipitation amounts, monthly average temperature, and relative humidity averages and their long-term averages were given in Table 2 [12]. Also, some physical and chemical properties of trial soil were given in Table 3.

Table 1: Names/pedigrees and origins of winter bread wheat genotypes used in the trial

No	Pedigree	Origin
1	Bezostaja	Russia
2	Gun-91	TR-Ankara
3	Sultan-95	TR-Eskisehir
28	KARL/NIOBRARA//TAM200/KAUZ/3/TAM200/KAUZ	Turkey/Cimmyt/Icarda
47	PYN*2/CO725052/4/PASTOR/3/KAUZ*2/OPATA//KAUZ	Mexica -Turkey/Cimmyt/Icarda
48	OK98649/TX95V6608/3/ID#840335//PIN39/PEW	ABD-Turkey/Cimmyt/Icarda
114	ST.ERYHTR 1287-08	Ukraina
133	TX98D1170*2/TTCC365	ABD

Table 2: Total rainfall, average temperature and relative humidity values for monthly and long years in Gumushane province of Turkey in 2013-14 growth season

Months	Total precipitation (mm)		Average temperature (^oC)		Relative Humidity (%)	
	2013-14	Long years	2013-14	Long years	2013-14	Long years
October	28.2	42.3	12.3	11.4	53.5	62.0
November	19.6	41.3	8.7	5.1	63.4	66.7
December	31.3	39.4	-2.2	0.5	65.0	68.2
January	28.5	35.1	2.1	-1.7	62.9	66.9
February	22.1	32.4	3.3	-0.5	54.3	64.2
March	45.3	41.7	8.9	3.7	55.7	62.0
April	38.1	60.0	13.5	9.4	53.8	60.2
May	66.7	66.4	17.1	13.7	58.5	60.8
June	31.0	44.8	20.8	17.2	51.5	59.8
July	19.3	12.7	26.0	20.2	48.7	58.5
Total/Average	**330.1**	**416.1**	**11.1**	**7.9**	**56.7**	**62.9**

Climatic data show that during the growth season, lower precipitation (330.1 mm) was received than the average for many years (416.1 mm); and the highest precipitation (66.7 mm) was occurred in May for the growth season. Monthly average temperature of the growth season (11.1^{o}C) was recorded above the average (7.9 ^{o}C) for many years. The relative humidity of the growth season (% 56.7) was lower than the average (% 62.9) for many years.

Table 3: Some physical and chemical properties of trial soil

Analyze	Saturation (%)	Total salt (%)	pH	$CaCO_3$ (%)	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})	Organic matter (%)
Value	68.0	0.15	7.99	10.66	1.95	149.1	1.63
Degree	Clayey	Saltless	Slightly alkaline	Limy	Too little	Sufficient	Little

From the soil analysis related to the trial area were determined in the laboratories of Kahramanmaras Sutcu Imam University; those related to lime, according to the methods specified by Schlicting and Blume [13], pH and salt by Richards [14] and texture by Bouyoucos [15]. As seen in Table 3, the soil of the trial is clayey in terms of texture; unsalted (0.2%), slightly alkaline (pH = 8), lime (10.7% $CaCO_3$); organic matter content is low (1.6%); phosphorously poor (20 kg ha^{-1}), potassium (15 kg ha^{-1}) is sufficient.

2.2. Methods

The trial was set up in three replications according to the randomized blocks trial design. After the seeds of the genotypes were cleaned and sieved with a diameter of 2.5 mm, sowing was carried out in October 2013 with a seed drill in a way that 500 seeds per square meter. Each plot was 1.2 m (6 rows with 17.5 cm spacing) x 5 m = 5.25 m^2 area; 20-20-0 fertilizer was given with 60 kg pure N and 60 kg P_2O_5 per hectar at the planting time.During the tillering and stem elongation periods, total nitrogen as ammonium nitrate was completed to 120 kg ha^{-1} in two equal parts. During the development of the plants, the weeds seen among the plots and in the plot were removed by hand. After the ripening was completed, the plots were harvested with sickles and threshed with laboratory tresher machine (LDHM-250, Monomakine, Turkey).

Agricultural characteristics such as plant height, thousand grain weight, number of grain per spike, grain yield, grain yield and test weight according to Bell and Fischer [16]; physiological traits were determined as follows:

Relative water content (RWC, %): The flag leaves were cut into 2 cm pieces and weighed (fresh weight, FW). And, these pieces were placed in distilled water for 4 hours and re-weighed for turgor weight (TW). After that, they were dried in oven for 48 hours under the temperature of 70 ^{o}C, weighed and used as dried weight (DW). RWC was calculated using as similar to the equation of Ritchie et al. [17]:

$$RWC\ (\%) = [(FW - DW) / (TW - DW)] \times 100$$

Excised leaf water loss (ELWL): It was calculated (g/g) using the following formula, according to Rahman et al. [18]: ELWL = (Fresh weight – Wilted weight) /Dry weight

Excised leaf water retention (ELWR, %): The flag leaves were collected and weighed (Fresh weight); and kept at 30ºC for 5 hours and reweighed (wilted weight). It was calculated using the following equation of Lonbani and Arzani [19]: ELWR = [1– (Fresh weight – Wilted weight)/ Fresh weight]×100:

Ash content (Ash, %): It was determined by the method of AOAC [20].

Membrane thermal stability (MTS, %): It was calculated as modified to the following formula of Blum and Ebercon [21]:

$$MTS\ (\%) = [1 - (T_1/T_2)] \times 100$$

On the above equation; T refers to heat treated samples, 1 and 2 refer to EC readings before and after boiling. According to the MTS experiment procedure; five flag leaves were cut from the middle part, put in 50 ml falcon tubes, 25 ml of distilled water was added. And, they were kept in pure water set at 25 ^{o}C for 5 hours and rested at room temperature for another 1 hour and the first readings (T_1) were performed. After the first readings, 5 ml more pure water is added to the falcon tubes; boiled at 100^{o}C in a water bath; they were cooled for 2 hours and the second readings (T_2) were done. MTS measurements were repeated two times (at anthesis and milky ripeness stages).

Chlorophyll content (Chl, SPAD): It was measured as SPAD units with a handheld chlorophyll meter (SPAD 502 Plus) at anthesis and milky ripeness stages. It was determined at the mid-point of each intact flag leaf from ten main stems for each genotype and recorded by chlorophyll meter.

3. Results & Discussion

3.1. Agronomic traits

The results of variance analysis of agronomic traits of bread wheat genotypes under conventional and organic growth conditions were shown in Table 4; mean values were given in Table 5.

Plant height (PH) and grain yield (GY) differed only for genotypes ($P<0.01$) while thousand kernel weight (TKW) and test weight (TW) showed variation interms of growth conditions ($P<0.05$) and genotypes ($P<0.01$).On the other hand, it was determined that all variation sources (growth condition, genotype and genotype × growth condition interaction) did not show statistical changes in terms of grain number per spike (GNPS) and spike yield (SY) (Table 4).

Table 4: Mean squares for agronomical traits

Variation source	D_f	PH	TKW	GNPS	SY	GY	TW
Replication (R)	2	98.226	30.464	138.212	0.206	0.198	8.016
Growth condition (GC)	1	27.908	120.397*	9.720	0.094	0.029	14.301*
Error 1 (R*GC&Random)	2	13.623	5.88	82.501	0.096	0.154	0.406
Genotype (G)	7	655.488**	14.168**	78.597	0.292	0.299**	23.536**
G×GC	7	19.628	5.018	21.727	0.132	0.126	0.406
Error 2	28	18.159	3.919	52.602	0.169	0.071	0.645
CV (%)		5.74	5.41	16.99	22.81	15.18	0.99

*, ** significance level of P=0.05 and P=0.01, respectively; D_f, degree of freedom; CV, variation of coefficient; PH, plant height; TKW, thousand kernel weight; GNPS, grain number per spike; SY, spike yield; GY, grain yield; TW, test weight.

The effect of growth conditions on plant height was not significant (Table 4); however, conventional and organic conditions showed similarities for PH (73.4 and 75.0 cm, respectively) (Table 5). In addition, according to the average of conventional and organic conditions, PH values of the genotypes ranged from 64.5 cm to 91.1 cm. Thus, the lowest value was in genotype 7 (64.5 cm) while the highest values were Genotype 1 (91.1 cm) and Genotype 2 (89.8 cm) for PH (Table 5). Even, genotype × growth condition interaction was not statistically significant for PH (Table 4); these values ranged from 63.3 cm (Genotype 7) to 90.0 cm (Genotype 2) under conventional conditions, 64.7 cm (Genotype 8) to 93.5 cm (Genotip 1) under organic conditions.

TKW was higher under organic growth conditions (38.16 g) than under conventionel conditions (34.99 g) (Table 5). For the average of conventional and organic conditions, TKW values of the genotypes varied from 34.04 g (Genotip 5) to 38.25 g (Genotip 1). Also, Genotype 2 (by 38.23 g) shared the first group with Genotype 1 for TKW. Although the genotype × growth condition interaction was not significant; genotypes except Genotype 4 showed higher TKW in organic conditions (Table 5).

Although there were no significant differences in all variation sources for GNPS, range of this trait in the genotypes were between 38.7 (Genotype 1) and 50.4 (Genotype 3). GNPS showed similarity under conventional and organic conditions (42.3 and 43.2, respectively) (Table 5).

SY also showed no differentiation for the all variation sources; however, SY values of the genotypes were between 1.435 g (Genotype 5) and 2.039 g (Genotype 3). Even though genotype × growth condition interaction was not effective on SY, these values ranged from 1.388 g (Genotype 5) to 2.234 g (Genotype 4) under conventional conditions, 1.482 g (Genotype 5) to 2.225 g (Genotype 3) under organic conditions (Table 5).

The effect of growth conditions on GY was not significant (Table 4); in other words, conventional and organic conditions were similar each other for PH (1.77 and 1.73 t ha^{-1}, respectively) (Table 5). In addition, according to the average of conventional and organic conditions, GY values of the genotypes ranged from 1.45 t ha^{-1} (Genotype 3) to 2.18 t ha^{-1} (Genotype 2). Though genotype × growth condition interaction was not statistically significant for GY (Table 4); these values ranged from 1.41 t ha^{-1} (Genotype 5) to 2.20 t ha^{-1} (Genotype 2) for conventional conditions, 1.46 t ha^{-1} (Genotype 3) to 2.16 t ha^{-1} (Genotip 2) for organic conditions (Table 5).

TW was higher under organic growth conditions (80.9 kg hl^{-1}) than under conventional conditions (79.8 kg hl^{-1}) (Table 5). For the average of conventional and organic conditions, TW of the genotypes differed from 79.9 kg hl^{-1} (Genotip 6) to 78.2 kg hl^{-1} (Genotip 8). Also, Genotype 7 (by 78.6 kg hl^{-1}) shared the last group with Genotype 8 for TW (Table 5).

Table 5: Mean values for agronomic traits of winter bread wheat genotypes under conventional (Con.) and organic (Org.) growth conditions

	PH (cm)			TKW (g)			GNPS (no)		
Genotype	**Con.**	**Org.**	**Mean**	**Con.**	**Org.**	**Mean**	**Con.**	**Org.**	**Mean**
1	88.6	93.5	91.1[a]*	36.31	40.19	38.25[a]	38.6	38.7	38.7
2	90.0	89.6	89.8[a]	36.73	39.73	38.23[a]	40.2	48.0	44.1
3	75.3	73.8	74.6[b]	33.85	38.35	36.10[abc]	49.0	51.9	50.4
4	70.7	70.2	70.5[bc]	38.01	37.16	37.58[ab]	46.2	41.5	43.9
5	65.9	72.9	69.4[cd]	31.86	36.21	34.04[c]	40.4	39.4	39.9
6	65.2	69.2	67.2[cd]	34.42	36.45	35.44[bc]	41.0	41.8	41.4
7	63.3	65.7	64.5[d]	33.43	37.57	35.50[bc]	39.5	42.8	41.2
8	68.3	64.7	66.5[cd]	35.34	39.64	37.49[ab]	43.0	41.3	42.1
Mean	73.4	75.0	74.2	34.99[b]	38.16[a]	36.58	42.3	43.2	42.7
LSD_{gc}		ns			3.012			ns	
LSD_{g}		5.04			2.341			ns	
$LSD_{g\times gc}$		ns			ns			ns	
	SY (g)			**GY (t ha^{-1})**			**TW (kg hl^{-1})**		
Genotype	**Con.**	**Org.**	**Mean**	**Con.**	**Org.**	**Mean**	**Con.**	**Org.**	**Mean**
1	2.101	1.639	1.870	1.84	1.89	1.86[b]	80.9	81.7	81.3[b]
2	2.053	2.010	2.031	2.20	2.16	2.18[a]	81.4	82.6	82.0[b]
3	1.853	2.225	2.039	1.44	1.46	1.45[c]	77.6	78.2	77.9[b]
4	2.234	1.692	1.963	2.09	1.61	1.85[b]	82.9	83.3	83.1[a]
5	1.388	1.482	1.435	1.41	1.85	1.63[bc]	81.0	82.9	82.0[b]
6	1.890	1.750	1.820	1.67	1.48	1.58[bc]	79.4	80.3	79.9[c]
7	1.545	1.592	1.568	1.69	1.83	1.76[bc]	78.0	79.2	78.6[d]
8	1.707	1.676	1.692	1.86	1.51	1.68[bc]	77.4	79.1	78.2[d]
Mean	1.847	1.758	1.802	1.77	1.73	1.75	79.8[b]	80.9[a]	80.4
LSD_{gc}		ns			ns			0.791	
LSD_{g}		ns			0.314			0.950	
$LSD_{g\times gc}$		ns			ns			ns	

* The same letters in a single column are not statistically different using LSD test at 0.05 level of significance. CV, coefficient of variation; LSD_{gc}, LSD_{g}, $LSD_{g\times gc}$ least significance difference for growth conditions, genotypes, genotype × growth condition interaction, respectively; ns, non significant; PH, plant height; TKW, thousand kernel weight; GNPS, grain number per spike; SY, spike yield; GY, grain yield; TW, test weight.

3.2. Physiological Traits

Variance analysis results related to the physiological characteristics of winter bread wheat genotypes in conventional and organic conditions are shown in Table 6; the average values for the examined traits are given in Table 7.

While leaf relative water content (RWC) differed only in terms of growth conditions ($P<0.01$); excised leaf water loss (ELWL), leaf water retention capacity (ELWR), flag leaf ash content (Ash) and chlorophyll content (Chl_1) measured at the growth stage of full anthesis were found different only in terms of genotypes ($P<0.01$). On the other hand, while statistically significant differences were observed in terms of genotypes ($P<0.01$) and genotype × cultivation conditions ($P<0.05$) for membrane thermal stability (MTS_1) measured during the anthesis stage and chlorophyll content (Chl_2) at the stage of milky maturity of the grain. In terms of membrane thermal stability (MTS_2) measured at the milky stage, it was determined that the all variation sources did not show any statistically significant changes (Table 6).

Bread wheat genotypes showed higher values in terms of RWC in organic growth conditions (85.2%) compared to conventional conditions (78.8%) (Table 7). Although there was no statistically significant difference in terms of genotypes (Table 6); according to the average of growth conditions, RWC values of the genotypes ranged from 79.6% (genotype 8) to 84.3% (genotype 4) (Table 7). Arjenaki et al. [22] reported that RWC ranged between 72.2-79.9% for drought resistant and 59.3-73.2% for susceptible varieties. On the other hand, Rahman et al. [18] reported that the RWC average of the 100 F_3 families was 85.40%.

Table 6: Mean squares for physiological traits

Variation source	D_f	RWC	ELWL	ELWR	Ash	MTS_1	MTS_2	Chl_1	Chl_2
Replication (R)	2	280.642	0.041	16.820	2.559	14.734	83.153	5.296	45.417
Growth condition (GC)	1	479.297**	0.267	61.369	12.243	99.097	71.586	84.005	75.250
Error 1 (R*GC & Random)	2	4.857	0.023	30.811	3.954	21.152	67.019	4.992	17.844
Genotype (G)	7	14.934	0.114**	89.325**	4.413**	33.470**	29.654	8.419**	32.957**
G×GC	7	16.25	0.015	12.635	1.929	25.032*	29.889	2.071	15.124
Error 2	28	427.858	0.456	11.992	1.054	8.529	13.568	2.221	7.195
CV (%)		4.77	11.02	5.97	9.47	3.47	4.69	2.97	5.85

*, ** significance level of P=0.05 and P=0.01, respectively; D_f, degree of freedom; CV, variation of coefficient; RWC, relative water content; ELWL, excised leaf water loss; ELWR, excised leaf water retention; Ash, ash content; GY, grain yield; TW, test weight.

ELWL of the genotypes showed statistically significant changes only according to the average of growth conditions (Table 6); these values ranged from 0.972 g (genotype 2) to 1.393 g (genotype 4) (Table 7). The growth conditions did not differ statistically in terms of ELWL (Table 6); ELWL values in conventional conditions (0.914-1.380 g distribution and 1.087 g average) were higher than organic conditions (0.995-1.405 g distribution and 1.236 g average) (Table 7); in fact, all genotypes increased their ELWL values in organic conditions compared to conventional conditions (i.e. they lost more water), so the interaction of genotype × growth condition was not observed in terms of ELWL (Table 6, 7). Rahman et al. [18] reported that average ELWL for 100 F_3 families was 0.99 g while their parents had the highest ELWL values (1.50 and 1.84 g).

Although ELWR did not differ statistically from the growth conditions (Table 6), ELWR of the genotypes in conventional conditions were 59.1%, while it was 56.9% under organic conditions (Table 7). In fact, the decreasing in ELWR values under organic conditions can be accounted for all the genotypes; therefore, it is understood that genotypes do not interact with growth conditions in terms of ELWR (Table 6, 7). However, bread wheat genotypes showed significant changes for ELWR. The highest value was observed in genotype 2 with 63.0% and the lowest value (51.6%) was in genotype 4 (Table 7). As a concept similar to ELWR, Hasheminasab et al. [7] found the RWP (relative water protection) between 54.6% to 69.9% under normal conditions and 65.7% to 85.5% under stressful conditions in 20 wheat genotypes. Also, Ghobadi et al. [23] reported the ranging values between 17.9% to 60.5% for ELWR in 21 bread wheat genotypes.

Although ash content of the flag leaf (Ash) did not show significant differences for the growth conditions and the interaction of genotype × growth condition (Table 6); Ash under conventional conditions (10.33%) was lower than under organic conditions (11.34%). However, the variation of Ash for the genotypes were between 9.18% (genotype 6) and 11.82% (genotype 1) (Table 7).).

While the overall average of membrane thermostability at full anthesis stage (MTS_1) of wheat genotypes was 84.1%, membrane thermostability at the middle milky maturity stage (MTS_2) was 78.5% (Table 7). MTS_1 values showed significant differences in terms of genotypes and the interaction of genotype × growth condition; however, the difference between conventional and organic conditions was not statistically significant (Table 6). According to the average of conventional and organic conditions, MTS_1 values of bread wheat genotypes ranged from 80.6% (genotype 6) to 87.5% (genotype 1). MTS_1 values under conventional conditions ranged from 80.2-85.8%, and it changed between 79.2% and 92.3% under organic conditions (Table 7). When the interaction of genotype × growth condition is evaluated, while the MTS_1 values of genotypes tend to increase in organic conditions; it is thought that genotypes 3 and 6 have high membrane thermostability under conventional conditions and low membrane thermostability under organic conditions (Table 7).

It is understood that MTS_2 measured at the milky maturity stage was not statistically significant in terms of all variation sources (Table 6), so both the growth conditions and genotypes showed similar values in terms of MTS_2. However, MTS_2 values of the genotypes ranged from 75.1% to 81.8% (Table 7). Hasheminasab et al. [7] measured the MTS at rates ranging from 50.1% to 78.7% for 20 wheat genotypes. Also, Yildirim et al. [24] stated that MTS decreased at the late growth stages of the bread wheat genotypes. Indeed, in our study, MTS decreased from anthesis (84.1%) to milky stage (78.5%).

While the overall average of chlorophyll content at the full anthesis stage (Chl_1) of the bread wheat genotypes was 50.2 spad units, the general average of the chlorophyll content at the middle milky maturity stage (Chl_2) was 45.9 spad unit (Table 7). While Chl_1 and Chl_2 values showed significant differences in terms of genotypes, it was not found statistically different for the other variation sources (growth conditions and the interaction of genotype × growth condition) (Table 6).

According to the average of conventional and organic conditions, Chl_1 values of bread wheat genotypes ranged from 48.3 spad units (genotype 6) to 52.0 spad units (genotype 4). Although the differences were not statistically significant, Chl_1 values under conventional conditions ranged from 49.3 to 52.8 spad units, and Chl_1 values under organic conditions ranged from 47.2 to 51.1 spad units. Even though the chlorophyll content were 51.5 and 48.9 spad units, respectively under conventional and organic conditions which were not statistically different each other, it turned out that the aging of the genotypes were faster under organic conditions than under conventional conditions (Table 7). Arjenaki et al. [22] determined the Chl spad values as 49.3 to 51.9 for drought resistant genotypes; 44.3 to 46.9 for susceptible genotypes.

Table 7: Mean values for physiological traits of winter bread wheat genotypes under conventional (Con.) and organic (Org.) growth conditions

Genotype	RWC (%)			ELWL (g/g)			ELWR (%)		
	Con.	Org.	Mean	Con.	Org.	Mean	Con.	Org.	Mean
1	78.6	84.1	81.3	0.914	1.175	1.045^{cd*}	64.3	58.1	61.2^{ab}
2	80.1	84.9	82.5	0.950	0.995	0.972^{d}	63.7	62.4	63.0^{a}
3	76.4	86.3	81.4	1.036	1.262	1.149^{bc}	61.7	56.0	58.8^{bc}
4	82.9	85.8	84.3	1.380	1.405	1.393^{a}	50.6	52.7	51.6^{e}
5	78.9	82.9	80.9	1.203	1.312	1.257^{ab}	54.8	54.5	54.6^{de}
6	76.8	87.0	81.9	1.039	1.318	1.179^{bc}	60.2	55.9	58.1^{bcd}
7	78.9	89.2	84.0	0.969	1.141	1.050^{cd}	61.8	60.5	61.2^{ab}
8	78.2	81.1	79.6	1.214	1.281	1.248^{ab}	56.1	54.9	55.5^{cde}
Mean	78.8^{b}	85.2^{a}	82	1.087	1.236	1.162	59.1	56.9	58.0
LSD_{gc}		2.737			ns			ns	
LSD_{g}		ns			0.151			4.096	
$LSD_{g×gc}$		ns			ns			ns	

Genotype	Ash (%)			MTS_1 (%)			MTS_2		
	Con.	Org.	Mean	Con.	Org.	Mean	Con.	Org.	Mean
1	10.50	13.14	11.82^{a}	82.7^{cde}	92.3^{a}	87.5^{a}	77.3	82.9	80.1
2	10.46	12.53	11.50^{abc}	84.2^{cd}	89.5^{ab}	86.8^{ab}	74.5	83.6	79.1
3	10.98	12.25	11.61^{ab}	85.8^{bc}	84.4^{cd}	85.1^{abc}	76.3	77.6	77.0
4	10.33	11.18	10.76^{abc}	81.6^{cde}	85.4^{bc}	83.5^{bcd}	80.4	80.1	80.3
5	10.20	10.38	10.29^{cd}	83.1^{cde}	85.4^{bc}	84.2^{abc}	78.5	85.1	81.8
6	8.56	9.80	9.18^{d}	81.9^{cde}	79.2^{e}	80.6^{d}	76.0	77.1	76.5
7	10.10	11.00	10.55^{bc}	80.2^{de}	86.0^{bc}	83.1^{cd}	80.7	75.7	78.2
8	11.54	10.46	11.00^{abc}	81.6^{cde}	81.8^{cde}	81.7^{cd}	74.5	75.8	75.1
Mean	10.33	11.34	10.84	82.6	85.5	84.1	77.3	79.7	78.5
LSD_{gc}		ns			ns			ns	
LSD_{g}		1.214			3.454			ns	
$LSD_{g×gc}$		ns			4.884			ns	

Genotype	Chl_1			Chl_2		
	Con.	Org.	Mean	Con.	Org.	Mean
1	52.5	49.6	51.1^{ab}	46.0	47.9	47.0^{abc}
2	52.1	49.9	51.0^{ab}	47.8	48.5	48.2^{a}
3	50.3	48.5	59.4^{bc}	50.0	47.6	48.8^{a}
4	52.8	51.1	52.0^{a}	51.0	44.6	47.8^{ab}
5	52.0	47.6	49.8^{bc}	45.9	42.4	44.1^{cd}
6	49.3	47.2	48.3^{c}	45.5	39.6	42.6^{d}
7	51.7	47.2	49.4^{bc}	43.6	43.8	43.7^{d}
8	51.4	49.8	50.6^{ab}	47.2	42.3	44.8^{bcd}
Mean	51.5	48.9	50.2	47.1	44.6	45.9
LSD_{gc}		ns			ns	
LSD_{g}		1.762			3.172	
LSD_{g*gc}		ns			ns	

* The same letters in a single column are not statistically different using LSD test at 0.05 level of significance. CV, coefficient of variation; LSD_{gc}, LSD_{g}, $LSD_{g\times gc}$ least significance difference for growth conditions, genotypes, genotype × growth condition interaction, respectively; ns, non significant; RWC, relative water content; ELWL, excised leaf water loss; ELWR, excised leaf water retention; Ash, ash content; GY, grain yield; TW, test weight.

According to the average of conventional and organic conditions, Chl_2 values of bread wheat genotypes ranged from 42.6 spad units (genotype 6) to 48.8 spad units (genotype 3). However, differences were not statistically significant; Chl_2 values in conventional conditions ranged from 43.6 to 51.0 spad units, and Chl_2 values under organic conditions ranged from 39.6 to 48.5 spad units (Table 7). Although the chlorophyll contents (47.1 and 44.6 spad units, respectively) for conventional and organic conditions are not statistically different, the values obtained indicate that the genotypes aging faster organic conditions compared to conventional contditions during the milky maturity stage, as at the full anthesis stage.

3.3. Relationships among traits

According to Table 8, RWC showed significant positive correlations with GY (r = 0.69*), TW (r = 0.76*), and Chl_1 (r = 0.81*) under conventional conditions while there were not any correlation among them under organic growth conditions. GY was also significant positive correlated (r = 0.72*) with ELWR but negative correlated (r = -0.77*) with ELWL under only organic conditions. Ash showed significant positive correlations with MTS (r = 0.86**) on the growth stage of full anthesis and chlorophyll content (r = 0.97**) on the growth stage of milky maturity under organic growth conditions. Ash was also significant positive correlated with PH (r = 0.83**) ve TKW (r = 0.72*) under organic conditions. MTS at both full anthesis and milky maturity showed positive correlation with PH (r = 0.83**, r = 0.71*) and GY (r = 0.78** and r = 0.69*) under organic growth conditions. MTS at the stage of milky maturity was also significantly positive correlated with TW (r = 0.82**) under organic conditions. Chlorophyll content at milky maturity presented significant positive correlations with GNPS (r = 0.83**) under conventional growth conditions, and it was significant positive correlated with Ash (r = 0.97**) and MTS at full anthesis (r = 0.82**) under organic conditions. Chlorophyll content at milky maturity was also significant positive correlated with PH (r = 0.75*) under organic growth conditions (Table 8).

Table 8: Genotypic correlation coefficients (r) between investigated traits of winter bread wheat genotypes under conventional and organic growth conditions (n = 8).

§	RWC	ELWL	ELWR	PH	TKW	GNPS	SY	GY	TW	Ash	MTS_1	MTS_2	Chl_1	Chl_2
RWC		-0.14	0.34	-0.15	-0.37	0.31	0.19	-0.02	-0.23	0.01	-0.06	-0.36	-0.42	0.01
ELWL	0.52		-0.97**	-0.58	-0.59	-0.36	-0.29	-.77*	0.04	-0.57	-0.58	-0.21	0.03	-0.58
ELWR	-0.54	-.99**		0.50	0.47	0.32	0.24	0.72*	-0.08	0.48	0.51	0.10	-0.16	0.48
PH	0.14	-0.47	0.55		0.59	0.07	0.23	0.68	0.44	0.83**	0.83**	0.71*	0.34	0.75*
TKW	0.63	0.17	-0.09	0.55		0.18	0.32	0.32	-0.15	0.72*	0.57	0.06	0.54	0.68
GNPS	0.01	0.50	-0.39	-0.15	0.14		0.94**	-0.07	-0.42	0.36	-0.04	-0.18	0.02	0.50
SY	0.43	0.02	0.06	0.62	0.92*	0.24		-0.14	-0.36	0.47	0.00	-0.13	0.17	0.55
GY	0.69*	0.07	-0.03	0.51	0.90*	-0.15	0.71		0.56	0.49	0.78*	0.69*	0.12	0.50
TW	0.76*	0.29	-0.32	0.38	0.51	-0.17	0.51	0.50		0.11	0.44	0.82**	0.41	0.11
Ash	0.12	0.17	-0.09	0.28	0.16	0.34	-0.03	0.12	-0.24		0.86**	0.40	0.45	0.97**
MTS_1	-0.32	-0.21	0.31	0.53	-0.07	0.45	0.16	-0.20	0.00	0.26		0.64	0.38	0.82**
MTS_2	0.48	0.27	-0.37	-0.42	-0.10	-0.01	-0.12	-0.14	0.29	-0.21	-0.50		0.23	0.39
Chl_1	0.81*	0.22	-0.25	0.38	0.44	-0.22	0.23	0.51	0.62	0.44	-0.20	0.40		0.48
Chl_2	0.38	0.54	-0.42	0.26	0.54	0.83**	0.59	0.29	0.31	0.39	0.51	-0.10	0.16	

§ **:**While the coefficients in the lower corner belong to conventional conditions, upper ones refer to organic growth conditions. *: Significant at P<0.05, **: Significant at P<0.001. RWC, LWL, LWR, PH, TKW, GNPS, SY, GY, TW, Ash, MTS_1, MTS_2, Chl_1, Chl_2 stated relative water content, excised leaf water loss, excised leaf water retention, plant height, thousand kernel weight, grain number per spike, spike yield, grain yield, test

weight, ash content, membrane thermostability at anthesis, membrane thermostability at milky maturity, chlorophyll content at anthesis, and chlorophyll content at mily maturity.

4. Conclusion

In this study, some winter wheat genotypes under organic and conventional conditions were evaluated for some physiological selection criteria thought to be effective in drought tolerance was determined that genotypes showed significant differences for all evaluated physiological traits except RWC. Also, RWC showed statistical differences according to the growth conditions. In addition, MTS differed for genotypes and genotype × growth condition interaction during the anthesis stage. Investigated physiological criteria for drought tolerance statistically mostly varied by the genotypes. Routine drought tolerance criteria, RWC had positive correlations with GY, TW and Chl under conventional conditions; however, significant relationships among the other physiological selection criteria and the examined traits are more prominent under organic conditions. Thus, for wheat breeders who work under organic conditions, these selection criteria (ELWL, ELWR, Ash, MTS, and Chl) will be very important to include in breeding programs in terms of drought tolerance.

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