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Stability Parameters for Yield and Yield Component of the Bread Wheat Genotypes under Various Drought Stress Condition

İrfan ÖZTÜRK[1,*], Kayıhan Z. KORKUT[2]

[1]Trakya Agricultural Research Institute, Edirne/TURKEY
[2]Namık Kemal Uni. Fac. of Agr. Dep. of Field Crops. Tekirdağ/TURKEY
*Corresponding author: irfan.ozturk@tarim.gov.tr

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Drought is the main abiotic stress factor and low rainfall during grain filling period affect bread wheat yield and yield component. This experiment was carried out in the experimental field of Trakya ARI, Edirne (Turkey), in 2008-2009 and 2009-2010 years. Totally, 15 genotypes were planted in RCBD in a split-plot with three replications. The main plots were assigned to five moisture regimes, which included 3 drought stress environments, one non-stress and one non-treatment environment. Droughts were created under mobile rain shelter at various plant growth stages from shooting up to maturating stage. Stability parameters were determined for grain yield, biological yield, harvest index, spike number per square meter, kernel and spikelet number per spike were investigated. A joint regression analysis was applied to grain yield and other yield component to estimate the stability parameters; mean yield (x), determinations coefficient (R^2), regression coefficient (b), deviation from regression coefficient (S^2d), and intercept value (a). The highest yield (658.3 kg/da) was determined in Bereket and biological yield (2539.4 kg/da) in Kate A-1 cultivar. The highest grain and biological yield was obtained under non-stress condition. For grain yield, it was determined that Kate A-1 and BBVD7 were adapted to well environmental conditions, Bereket was well adapted to all environment condition. For biological yield Pehlivan, BBVD7 and Bereket were well adapted to all environmental conditions. Wide range of stability statistics was determined among cultivars for all the parameters. Gelibolu and Bereket were the stable cultivars on the basis of overall mean yield and stability parameters.

Keywords: Bread wheat, genotypes, yield component, stability parameters

Introduction

Trakya region is located in the North western part of Turkey and covered about 3% of Turkey. Mostly winter and facultative bread wheat cultivars are grown average wheat yield is over 4.5 tons/ha. The amount of the rainfall (589.1 mm) during growing season is enough for wheat production but the distribution of this rainfall is not regular. Fluctuation of rainfall causes reducing grain yield and quality (Öztürk and Korkut, 2015). Wheat is the world most important cereal crop and it has been grown in a wide range of arid and semi-arid areas, where drought occurs frequently because of rainfall fluctuations in rain-fed regions (Mardeh et al. 2006). Drought stress tolerance is a complex trait that is obstructed by low heritability and deficiency of successful selection approaches (Blum 1988). Almost all breeding programs in the world aim to improve varieties with stable yields. The yield stability is generally grouped as static or dynamic stability (Pfeiffer and Braun, 1989). Therefore, selection of wheat genotypes should be adapted to drought stress. In addition, drought tolerance mechanism should be identified during the development of new cultivars in order to increase the productivity (Rajaram et al. 1996). Stable yield performance of genotypes under both favorable and drought stress conditions is vital for plant breeders to identify drought tolerant genotypes (Pirayvatlou, 2001). Moreover, high-yielding genotypes under optimum conditions may not be drought tolerant (Blum, 1996; Mardeh et al. 2006); therefore, many studies preferred the selection under stress and non-stress conditions (Clarke et al. 1992; Fernandez, 1992; Rajaram and Van Ginkle, 2001). In the same pattern, the selection in the current study was conducted under optimum, moderate, and sever stress conditions. The objective of this study was to evaluate the performance of the advance genotypes and cultivars and to investigate their yield stability across various drought stress condition over two consecutive years.

Materials and Methods

This research was carried out in the experimental field of Trakya ARI, Edirne (Turkey) (41 m above sea level, 41º64´ N, 26º59´ E), during two years (2008-2009 and 2009-2010) and 15 genotypes were evaluated in randomized completely blocks design in a split-plot with three replications. Plot size was 6 rows, 6 m long and 17 cm between the rows. Kate A-1, Gelibolu, Pehlivan, Tekirdağ, Selimiye, Aldane, Bereket, Flamura-85, Golia cultivars and 6 advanced lines were used. The main plots were assigned to five moisture regimes, which included 3 drought stress environments, one non-stress and one non-treatment environment. Drought treatments are placed on main parcel and genotypes on the sub-plot. Droughts were created under mobile rain shelter at various plant growth stages from shooting up to maturating stage. A mobile rain shelter was used to exclude rain and induce drought stress. In this experiment, all parcels were covered only when raining. A drip irrigation set was used and each plot was irrigated separately by controlling dripping irrigation system. Grain yield, biological yield, spike length, spike number per square meter, kernel and spikelet number in spike and harvest index with stability parameters were investigated under different drought stress conditions. Drought treatments are placed on main parcel and genotypes on the sub-plot. The Zadoks Decimal Code (GS) was used to describe plant growth stages. The described plant development stages are; Drought stress applied from GS31 (stem starts to elongate) to GS51 (10% of spikes visible), Drought stress applied from GS51 (10% of spikes visible) to GS94 (over-ripe, straw brittle), Drought stress applied from GS31 (stem starts to elongate) to GS94 (over-ripe, straw brittle), non-treatment and non-stress. Stability analysis (genotypes x environment interaction) was done according to Eberhardt and Russel (1966) and Finlay and Wilkinson (1963). Mean yield (x), regression coefficient (b), coefficient of determination (R^2), deviation from regression coefficient (S^2d), intercept value (a) and determination coefficient (CV) were evaluated as stability parameters. The statistical analyses of measurements were performed by using statistics program for and the differences among the means were compared with L.S.D at a 5% significant level. The entire statistical analysis was done using the computer (Gomez and Gomez, 1984; Kalaycı 2005).

Results and Discussion

The stability parameters analysis for the yield and some of the selected yield components was performed and given in Table 1, 2 and 3. The mean yield and biological yield was 583.0 and 2252.9 kg/da, respectively.

Table 1. Determined stability parameters for yield and biological yield of the genotypes

No	Genotypes	stability parameters for grain yield					Stability parameters for biological yield				
		X	R^2	S^2d	A	b	X	R^2	S^2d	a	b
1	Kate A-1	631.5	0.99	52.3	-54.7	1.18	2539.2	0.98	2433.9	-391.3	1.30
2	Gelibolu	613.0	0.99	47.3	32.3	1.00	2205.8	0.99	448.1	170.4	0.90
3	Pehlivan	587.7	0.99	34.9	-0.6	1.01	2417.4	0.99	800.1	142.9	1.01
4	Tekirdağ	594.5	0.95	147.8	71.2	0.90	2193.2	0.92	3525.1	476.9	0.76
5	Selimiye	608.9	0.97	111.9	9.5	1.03	2382.0	1.00	335.5	-438.6	1.25
6	Aldane	551.1	0.96	135.1	11.5	0.93	2356.0	0.96	3947.8	-406.2	1.23
7	Flamura-85	518.9	0.96	108.2	-14.3	0.91	2028.4	0.93	5066.2	-187.3	0.98
8	Golia	610.4	0.99	35.0	113.8	0.85	2037.8	0.91	4004.5	329.1	0.76
9	BBVD7	651.0	0.96	249.4	-129.3	1.34	2439.4	0.95	3683.0	192.1	1.00
10	Bereket	658.3	0.99	35.4	25.8	1.08	2364.6	0.97	2289.0	55.9	1.02
11	ÖVD26-07	579.1	0.97	103.2	-17.5	1.02	2218.4	0.90	4758.6	479.1	0.77
12	ÖVD2/21-07	563.0	0.90	235.3	112.2	0.77	2017.2	0.99	1166.0	-419.4	1.08
13	ÖVD2/27-07	617.8	1.00	8.5	114.7	0.86	2259.4	0.97	1228.3	551.9	0.76
14	EBVD24-07	577.4	0.99	87.3	-205.1	1.34	2228.4	0.96	2833.6	140.1	0.93
15	BBVD21-07	383.0	0.94	144.0	-69.3	0.78	2106.6	0.93	8318.6	-695.5	1.24

The results of variance analyses showed that there were significant differences ($P<0.01$) among genotypes and treatments for investigated yield and yield components under varied drought stress condition. The highest grain yield with 658.3 kg/da was determined in Bereket cultivar and also BBVD7 with 651.0 kg/da and Kate A-1 with 631.5 kg/da were other highest yielding cultivars (Table 1). A genotype having stabile grain yield across the environment condition is very important in wheat. Genotype x environment interaction is a mainly issue for plant breeders in improving high yield across variable environments. Stability analysis showed a wide variation among genotypes. Some genotypes exhibited wide adaptation and other showed specific adaptation to favorable or un-favorable environments. The regression coefficients (b) ranged between 0.77-1.34 in grain yield, 0.76-1.30 in biological yield among genotypes. It was determined that Kate A-1 and BBVD7 were adapted to well environmental conditions while Bereket was well adapted to all environment condition. Cultivar Bereket produced the highest yield (658.3 kg/da) in all environments averaged for two years, and had regression coefficient (b) close to unity (1.08) and R^2 close to zero (0.99) and positive intercept value (a). This result indicated wide adaptation and stability of performance of Bereket in all environments conditions. Gelibolu (R^2=0.99, b=1.00), Pehlivan (R^2=0.99, b=1.01), Selimiye (R^2=0.97, b=1.03), and Aldane (R^2=0.96, b=0.93) cultivars were medium adaptable to all environmental conditions with suitable determination coefficient and regression coefficient.

Genotypes Pehlivan, Bereket, and BBVD7 produced high biological yield over two years and five environments showed regression coefficient (b=1.01; b=1.02, b=1.00) close the unity and suitable determination coefficient (R^2=0.99, R^2=0.97, and R^2=0.95). Also, Kate A-1, Selimiye, and Aldane were well adapted to all environment condition with their biological yield and regression coefficient over average.

Table 2. Determined stability parameters for spike number in square meter and harvest index

No	Genotypes	Stability parameters for spike in square meter					Stability parameters for harvest index				
		X	R^2	S^2d	a	b	X	R^2	S^2d	a	b
1	Kate A-1	457.3	0.86	92.82	10.7	1.04	36.9	0.32	0.53	14.8	0.60
2	Gelibolu	435.8	0.96	30.14	-55.5	1.14	39.5	0.83	0.38	-21.3	1.65
3	Pehlivan	436.0	0.93	73.79	-130.5	1.32	36.0	0.87	0.14	-6.4	1.15
4	Tekirdağ	411.0	0.77	72.37	122.5	0.67	37.5	0.02	0.67	32.9	0.13
5	Selimiye	455.9	0.78	243.28	-88.2	1.27	37.5	0.94	0.05	-2.9	1.10
6	Aldane	433.8	0.99	3.93	11.2	0.98	35.6	0.32	2.21	-9.0	1.21
7	Flamura-85	371.2	0.97	12.48	26.5	0.80	36.4	0.11	1.87	14.7	0.59
8	Golia	486.6	0.86	116.70	-14.0	1.16	40.8	0.50	0.77	1.8	1.06
9	BBVD7	448.1	0.91	57.59	4.7	1.03	36.6	0.17	0.47	22.8	0.37
10	Bereket	451.4	0.99	5.21	-101.4	1.29	37.5	1.00	0.00	2.3	0.96
11	ÖVD26-07	429.6	0.93	30.16	68.5	0.84	39.3	0.95	0.12	-29.6	1.87
12	ÖVD2/21-07	409.9	0.79	95.04	56.7	0.82	38.1	0.68	0.87	-21.2	1.61
13	ÖVD2/27-07	433.4	0.62	97.77	200.2	0.54	38.2	0.64	0.13	17.1	0.57
14	EBVD24-07	460.1	0.98	11.27	-16.3	1.11	36.0	0.93	0.12	-20.0	1.52
15	BBVD21-07	328.8	0.98	13.11	-94.9	0.99	26.9	0.29	0.67	4.1	0.62

Stability analysis for spike in square meter, kernel number in spike and spikelet number in spike showed there was wide variation among genotypes. The mean value of the spike in square meter was 429.9, kernel number in spike was 34.6 and spikelet number in spike was 16.0. Some other tested cultivars, Selimiye and Golia were able to adapt to favourable conditions, as their spike number in square meter were stable only under favourable conditions. Also, Bereket, Tekirdağ and

Gelibolu were could be adapt to fertile environment conditions, with their kernel number in spike were stable only under favourable conditions. Cultivars Bereket, Gelibolu and Tekirdağ produced high kernel number in spike over range of environments showed over regression coefficient (b=1.59, b=1.17, b=1.16 and respectively) and higher determination coefficient (R^2= 0.97, 0.95 and 0.95 respectively), and higher deviation from regression (S^2d= 0.50, 0.41 and 0.45 respectively) indicated specific adaptability of these cultivars to favourable environmental conditions.

For spikelet number in spike the highest determinations coefficient (R^2) was obtained in Pehlivan and Tekirdağ. There was variation in regression coefficients (b) and ranged between 0.80 and 1.20, and optimal regression coefficient (b) determined in Aldane, Selimiye and Kate A-1cultivar. According to spikelet number in spike it could be seen that optimal determinations coefficient (R^2) determined in Pehlivan followed by Tekirdağ, Aldane and Golia cultivars.

Table 3. Determined stability parameters for kernel number and spikelet number in spike

No	Genotypes	Stability parameters for kernel number in spike					Stability parameters for spikelet number in spike				
		X	R^2	S^2d	a	b	X	R^2	S^2d	a	b
1	Kate A-1	36.5	0.93	0.47	-0.12	1.06	16.31	0.62	0.185	1.71	0.91
2	Gelibolu	36.4	0.95	0.41	-4.13	1.17	15.89	0.96	0.021	-2.12	1.12
3	Pehlivan	30.2	0.91	0.26	7.51	0.66	15.94	1.00	0.000	0.34	0.97
4	Tekirdağ	36.0	0.95	0.45	-4.18	1.16	16.65	0.99	0.007	-0.92	1.10
5	Selimiye	33.2	1.00	0.01	-4.31	1.09	16.02	0.97	0.007	3.26	0.80
6	Aldane	31.3	0.94	0.41	-3.95	1.02	14.90	0.98	0.006	-1.48	1.02
7	Flamura-85	34.8	0.96	0.19	2.75	0.93	15.44	0.86	0.051	0.56	0.93
8	Golia	33.9	0.99	0.05	7.75	0.76	15.46	0.98	0.008	0.35	0.94
9	BBVD7	34.3	0.91	0.47	2.73	0.91	16.39	0.91	0.029	1.69	0.92
10	Bereket	36.9	0.97	0.50	-17.99	1.59	16.92	0.94	0.031	-2.38	1.20
11	ÖVD26-07	34.4	0.93	0.40	2.46	0.92	14.36	0.89	0.029	1.51	0.80
12	ÖVD2/21-07	34.5	0.89	0.64	1.83	0.95	17.47	0.91	0.047	-0.44	1.12
13	ÖVD2/27-07	38.3	0.98	0.16	-4.84	1.25	14.89	0.98	0.006	0.25	0.91
14	EBVD24-07	34.0	0.89	0.67	0.63	0.97	15.67	0.90	0.056	-3.58	1.20
15	BBVD21-07	33.4	0.86	0.30	13.85	0.57	18.22	0.66	0.211	1.25	1.06

Note: X: mean, R^2: determinations coefficient, S^2d: deviation from regression, a: intercept value, b: regression coefficient, CV: variation coefficient

Table 4. Correlation coefficients among stability parameters based on investigated characters

Grain yield						**Biological yield**				
	X	**R^2**	**S^2d**	**CV**	**a**	**X**	**R^2**	**S^2d**	**CV**	**a**
R^2	0.518*					0.456				
S^2d	-0.241	-0.832**				-0.357	-0.778**			
CV	-0.241	-0.832**	1.000**			-0.357	-0.778**	1.000		
A	0.156	-0.136	-0.215	-0.215		-0.029	-0.352	-0.215	-0.215	
B	0.510	0.452	0.032	0.032	-0.771**	0.405	0.494	0.062	0.062	-0.925**
Harvest index						**Spike number in square meter**				
R^2	0.306					-0.165				
S^2d	-0.160	-0.638*				0.371	-0.677**			
CV	-0.161	-0.639*	1.000**			0.371	-0.677**	1.000**		
A	-0.153	-0.727**	0.124	0.125		-0.025	-0.653**	0.015	0.015	
B	0.312	0.750**	-0.146	-0.147	-0.987**	0.411	0.529*	0.133	0.133	-0.921**
Spikelet number in spike						**Kernel number in spike**				
R^2	-0.435					0.350				
S^2d	0.548*	-0.977**				0.140	-0.635*			
CV	0.548*	-0.977**	1.000**			0.140	-0.635*	1.000**		
A	0.013	-0.315	0.227	0.227		-0.507	-0.532*	-0.206	-0.206	
B	0.476	0.065	0.067	0.067	-0.873**	0.678*	0.540*	0.210	0.210	-0.977**

Note: X: mean, R^2: determinations coefficient, S^2d: deviation from regression, a: intercept value, b: regression coefficient, CV: variation coefficient

Correlation analysis was used to study the relationships between mean yield and stability parameters, between studied stability parameters. The results of coefficient of rank correlations showed that mean yield was statistically significant ($P<0.05$) and positively correlated with determinations coefficient (R^2=0.518*). Also, the correlation was negative between mean yield and S^2d, but this correlation was statistically nonsignificant. The results of correlations coefficient of the stability parameters showed that biological yield was statistically nonsignificant ($P<0.05$) with determinations coefficient (R^2=0.456), and negatively correlated with determinations coefficient (S^2d=-0.357). Furthermore, the spikelet number in spike was statistically significant and positively correlated with determinations coefficient (S^2d=0.548*), and negatively nonsignificant correlated with determinations coefficient (R^2=-0.435).

Conclusions

Drought is the main abiotic stress factor and low moisture during grain filling period affected bread wheat yield and yield component. The highest yield was determined in Bereket and biological yield in Kate A-1 cultivar. The highest grain and biological yield was obtained under non-stress condition. For grain yield, it was determined that Kate A-1 and BBVD7 were adapted to well environmental conditions, Bereket was well adapted to all environment condition. For biological yield Pehlivan, BBVD7 and Bereket were well adapted to all environmental conditions. Wide range of stability statistics was determined among cultivars for all the parameters. Gelibolu and Bereket were the stable cultivars on the basis of overall mean yield and stability parameters.

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