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YIELD PERFORMANCES OF WINTER WHEAT (*T. aestivum*) GENOTYPES IMPROVED FOR DRY ENVIRONMENTAL REGION OF TURKEY

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ABSTRACT

The purpose of he study was to determine the progress of winter wheat cultivars developed during the last 45 years under the ecological conditions of Kirsehir province located in central Anatolia. A field trial arranged in Randomized Complete Block Design (RCBD) with four replications was conducted in 2017 and 2018.As a result of two years of research, it has been determined that cultivars have a grain yield between 2490 kg ha^{-1} (Gun 91) - 3620 kg ha^{-1} (Karahan 99) and fertile spikes number per square meter 377 - 552, grain number per spike 28.81 – 41.83, grain weight per spike 1.07 g – 1.52 g, harvest index 26.17% - 37.07%. The annual yield increase of the cultivars with genetic progress was found to be 10,29 kg ha^{-1}. While it was determined genetic progress in 6 of total 11 traits, was observed negative genetic change in the other traits. Specifically, it was determined that the genetic improvement seen in the grain number per spikelet, grain number per spike, grain weight per spike, biomass yield and harvest index characteristics were found to contribute to the increase in grain yield. Characteristics seen genetic progress, have come to the forefront as selection parameters that wheat breeders working on rainfed conditions should emphasize. In addition, Karahan 99, Nacibey, Bayraktar 2000, Izgi 2001 and Bagci 2002 cultivars were determined as cultivars that could be recommended to be grown in dry environments of in winter region of Turkey.

Key Words: Agronomic traits, bread wheat, genetic improvement, yield

INTRODUCTION

It is considered that the increase in wheat yield in the world and the genetic progress in cultivars and the development of cultivation techniques have an almost equal share. The higher productivity level of cultivars developed in breeding programs is attributed to having higher yield potential or increasing resistance to biotic and abiotic stresses (Slafer et al., 1994). Therefore, plant breeders develop new wheat varieties based on their yield performance using different selection parameters under drought conditions (Ilker et al., 2011). The genetic superiority of the new cultivars over the old cultivars can be measured by the amount of genetic progress achieved with new cultivars. This is a method used to evaluate the success of breeding studies. Genetic improvement in grain yield has been assessed in most major wheat producing countries. For instance, annual yield increase with genetic progress was determined as 30.0 kg ha^{-1} from 1908 to 1978 in England (Austin et al., 1980), 10.6 kg ha^{-1} from 1919 to 1987 in USA (Kansas) (Cox et al., 1988), and 5.8 kg ha^{-1} from 1884 to 1982 in Australia (Perry and D'Antuono, 1989). The improvement of bread wheat cultivars for dry farming areas in Turkey have been carried out. As a result of these studies, many cultivars have been developed and registered and presented to the farmers. In Turkey, there are few studies to determine the genetic progress obtained by breeding studies. Some of those, Zencirci and Baran (1992) stated that there was a 74% genetic improvement in grain yield in bread wheat cultivars developed for Central Anatolia and the transition areas between 1932 and 1991. Avcin et al. (1997), in the study carried out to determine the genetic improvements in yields of bread wheat cultivars in Central Anatolia conditions for the period covering 1933-1991 years, genetic progress in cultivars was determined as 16.1 kg ha^{-1}, and also the lowest and highest yield cultivars according to average yields Sivas-111/33 and Gerek 79, respectively.

In conventional wheat breeding programs, it is aimed to develop cultivars with high yield and quality, tolerant to biotic and abiotic stress factors. The grain yield is considered as the main selection parameter. According to this understanding, the grain yield in the plant occurs as a separate contribution of each of components supporting the grain yield and as a cumulative output. That's why, the change in yield components directly affects the grain yield.

In the study, it was determined the genetic improvements in grain yield over 24 bread wheat cultivars registered at different dates in 45-years historical period covering 1968-2013 years. In addition, it was investigated which yield components changes were effective in the background of yield. It is hoped that the findings obtained in the study will make important contributions to the determination of new strategies and targets for the future in wheat breeding programs carried out in our country.

MATERIALS AND METHODS

This research was carried out in Kirsehir ecological conditions in Kirsehir Ahi Evran University Faculty of Agriculture research fields for two years in 2016-2017 and 2017-2018 growing periods. The study area is between 39º07’42 north parallels and 34º06’27 east meridians, approximately 1060 m above sea level. In the study, it was used as plant material a total of 24 bread wheat cultivars as Karahan 99, Bayraktar 2000, Gerek 79, Dagdas 94, Bezostaja 1, Kate A-1, Gun 91, Ikizce, Pehlivan, Harmankaya 99, Demir 2000, Altay 2000, Sonmez 2001, Izgi 2001, Soyer, Bagci 2002, Tosunbey, Mufitbey, Nacibey, Kenanbey, Bereket, Es26, Aldane and Mesut which was developed and registered for dry farming areas placed in winter region of Turkey.

According to the results of some physical and chemical analysis of the soil in which the research was conducted, the texture class was clayey loam, organic matter content 1.39% - 1.27%, lime content 30.9% - 32.4%, pH 7.59, useful phosphorus amount 18.3 kg ha^{-1} – 20.6 kg ha^{-1}, potassium content was 665.1 kg ha^{-1} - 749.7 kg ha^{-1}.

The climatic values of the research site for long term and trial years were given in Table 1. While the total rainfall was 297.6 mm in 2016-2017, 398.3 mm in 2017-2018. Compared to the long-term average, it was below the average (380.3 mm) in the first year of the trial, but exceeded the average in the second year. In the first year of the trial, no precipitation was received in October, which caused disruption in the plant emergence. At the same time, the drought in February (4.9 mm) delayed the vegetation period of the plants by about 20 days. However, in the second year of the trial, especially April rainfall was insufficient (4.4 mm). The lack of rainfall in this period negatively affected the spikelet number in the spike of the plants, the fertile flower number in the spike, and fertile grain formation. These effects have led to the formation of grain losses in the unit area due to the temperature and relative humidity values supporting the stress in the process corresponding to the same periods. On the other hand, especially in May (69.5 mm) and June (26.5 mm), it has been seen that the rainfall was the positive reflection on the grain yield as related to increase at thousand kernel weights.

Table 1. Rainfall (mm), mean temperature ºC and relative humidity (%) of the research site.*

	Total Rainfall (mm)			Mean Temperature (ºC)			Relative Humidity (%)		
	Long term**	2016-17	2017-18	Long term	2016-17	2017-18	Long term	2016-17	2017-18
September	12.70	42.7	0.0	18.6	18.4	23.1	52.6	48.2	31.7
October	29.09	0.0	20.6	12.5	13.3	12.4	62.3	49.9	53.0
November	37.19	26.0	56.0	6.2	5.5	6.3	71.4	56.7	71.6
December	46.02	40.0	35.6	1.8	-1.3	4.4	77.9	77.3	77.2
January	45.75	28.8	74.3	-0.2	-2.4	2.1	78.7	77.9	81.6
February	33.24	4.9	17.0	1.4	1.0	6.5	74.5	67.0	68.5
March	38.66	41.5	87.7	5.6	7.3	9.7	67.9	60.8	66.2
April	44.20	29.0	4.4	10.7	10.7	14.0	63.6	52.4	49.1
May	45.87	49.9	69.5	15.2	15.2	17.3	61.5	59.4	64.8
June	34.86	18.4	26.5	19.5	20.7	21.5	55.0	54.3	53.4
July	7.17	0.4	3.5	23.1	26.0	25.3	48.3	36.0	43.0
August	5.56	16.0	3.2	23.0	25.6	25.0	48.4	43.2	39.7
Total	380.31	297.60	398.30						
Mean				11.5	11.70	14.00	63.5	56.9	58.3

* Values were taken from Kirsehir Meteorology Directorate.
** The average of 56 years (1962-2018)

The trial was established as randomized complete block design with 4 replications. The trials were carried out in fallow-wheat alternation. Each plot consisted of six rows of 5 m length and 1.2 m width, and line spacing 20 cm. Seeding rate and field management were determined according to the results of regional research, with about 550 seeds per m^{-2}. The trials were sown 5-6 cm depth in early October and harvested in mid-July, depending on the years. Before planting, di ammonium phosphate (about 60 kg ha^{-1} of P_2O_5, 23.5 kg ha^{-1} of N) was broad-casted and incorporated. An additional 46.5 kg ha^{-1} of N was top-dressed at stem elongation (Zadoks Stage 30). Weeds were controlled by 2,4-D Ester herbicide (about 1500 cc ha^{-1}) at beginning of stem elongation.

In the study, the grain yield, stem number per square meter, fertile spike number per square meter, fertile stem ratio, spike length, spikelet number per spike, grain number per spike, grain weight per spike, biomass yield and harvest index were determined by basing to the observation and measurement methods applied in wheat trials of Bell and Fischer (1994), Kalayci et al. (1998) and Ozturk (1999).

In each trial, significance of cultivar effects was determined by variance analysis by using JMP 5.0 statistical program (SAS Institute, Inc., 1987). LSD multiple range test was used to separate cultivars means. Genetic advance of the traits was determined by regression analysis. In the regression analysis, the registration years of the cultivars were considered as independent variables and the investigated traits were considered as dependent variables and the annual genetic advance amount was determined by linear regression equation: $y_i = a + bx_i$. Where y_i is the mean grain yield for four replications in each trial of cultivar *i*, in(y_i) is the natural log of y_i, and x_i is the year in which cultivar *i* was released. The intercept of equation is estimated by *a*, while *b* measures the grain yield advance (Ortiz-Monasterio et al., 1997).

RESULTS AND DISCUSSION

The mean square from the combined variance analysis and regression analysis for the grain yield (GY), stem number per square meter (SNSM), fertile spike number per square meter (FSNSM), fertile stem rate (FSR), spike length (SL), and spikelet number per spike (SNS) for 24 bread wheat cultivars was shown in Table 2. The average values of these parameters were given in Table 3. The mean square from the combined variance analysis and regression analysis for grain number per spikelet (GNSL), grain number per spike (GNS), grain weight per spike (GWS), biomass yield (BY), and harvest index (HI) were given in Table 4. The average values of these parameters were also given in Table 5. Genetic progress graphs of the grain yield and some yield components were shown in Figure 1. The differences between the cultivars and year x cultivar interaction were found to be statistically significant.

Table 2. Mean square (MS) from the combined analysis of variance for grain yield and other agronomic traits of bread wheat genotypes

Source of Variation	DF	GY	SNSM	FSNSM	FSR	SL	SNS
Years (Y)	1	181848129**	11044805.00**	4920961.70**	2531.455**	14.186**	58.742**
Replication [Yrs]	6	3100164.8	18541.50	10201.93	14.088	1.761	3.247
Genotypes (G)	23	763725.5**	26243.48**	16702.13**	57.326**	2.276**	7.640**
Y x G	23	526483.6**	18928.09**	11213.02**	58.192**	0.342*	1.226
Error	138	110958	4003.00	2300.00	16.746	0.182	0.841
Total	191	1285006.2	66740.68	31108.08	39.706	0.576	2.085
CV (%)		10.92	10.43	10.59	5.37	4.9	5.67
GA		10.03	-0.48	-0.42	-0.04	-0.01	-0.01
R^2		0.76*	0.07	0.08	0.23	0.36	0.05

Significant at *P< 0.05, and **P < 0.01 levels, respectively.
GY: Grain yield, **SNSM**: Stem number per square meter, **FSNSM:** Fertile spike number per square meter, **FSR**: Fertile stem rate, **SL**: Spike length and **SNS**: Spikelet number per spike, **GA:** Genetic Advance.

The mean grain yield of trials carried out two-years was 3050 kg ha^{-1}. In the first year of the trial, the mean grain yield (2080 kg ha^{-1}) was low compared to the second year (4020 kg ha^{-1}). This result is thought to be caused by receiving rainfall less 80 mm than the mean of long term precipitation in the region and especially the drought seen in October (0 mm) and February (4.9 mm) (Table 1). According to the two-year results obtained, the GY of cultivars has changed between 2550 kg ha^{-1} (Bezostaja 1) and 3620 kg ha^{-1} (Karahan 99) (Table 3). One of the main objectives of this study is to determine whether new cultivars developed by breeding studies provide genetic superiority about performance over old cultivars. In the study, the annual genetic progress in grain yield during the period 1968-2013 was determined as 10.3 kg ha^{-1}, and the linear regression equation as y = -17527.3 + 10.3 x (Figure 1.a). When the yields of the cultivars were evaluated according to their registration years, it was noteworthy that the majority of the cultivars registered before 1999 were below the trial mean (3050 kg ha^{-1}). The annual increase in yield ha^{-1} by genetic progress in research conducted in different countries is 30 kg in England from 1908 to 1978 (Austin et al., 1980), 16 kg in USA-Kansas from 1919 to 1987 (Cox et al., 1988), and 5.8 kg in Australia from 1884 to 1982 (Perry and D'Antuono, 1989).

Table 3. Grain yield, number of stems per square meter, number of fertile spikes in square meter, fertile stalk rate, spike length and spikelet number in spike of bread wheat varieties as average of 2016-2017 and 2017-2018 growing years

Cultivars	Registration Year	GY** (kg ha^{-1})	SNSM (number)	FSNSM (number)	FSR (%)	SL (cm)	SNS (number)
Bezostaja 1	1968	2550 kl*	563 f-i	438 f-k	78.7 a-d	8.66 e-i	16.8 bcd
Gerek 79	1979	3090 e-i	698 abc	491 b-e	73.7 f-i	8.59 f-j	15.4 h-k
Kate A-1	1988	2950 e-j	520 i	409 jkl	78.4 a-e	8.52 g-j	15.8 e-i
Gün 91	1991	2490 l	604 d-h	420 h-l	71.6 i	9.54 ab	17.8 a
Dagdas 94	1994	2820 h-l	619 def	444 e-k	74.4 e-i	9.20 bcd	16.5 c-f
Ikizce	1996	3030 e-j	611 d-g	466 d-h	76.6 b-h	8.25 i-m	15.7 f-j
Pehlivan	1998	2860 g-k	543 hi	419 h-l	78.4 a-e	8.23 j-m	16.7 cde
Harmankaya	1999	2790 i-l	604 d-h	480 c-f	80.3 ab	8.76 e-h	17.2 abc
Karahan 99	1999	3620 a	641 cd	505 a-d	79.6 abc	9.21 a-d	14.8 jkl
Demir 2000	2000	2880 e-k	576 e-ı	423 g-l	75.1 d-i	9.63 a	17.4 abc
Bayraktar	2000	3530 ab	733 a	552 a	77.3 b-g	7.90 m	14.1 l
Altay 2000	2000	2880 e-k	543 hi	377 l	72.9 hi	9.34 a-d	16.2 d-h
Sonmez 2001	2001	2920 e-j	602 d-h	469 d-g	78.5 a-d	8.92 d-g	15.6 g-j
Izgi 2001	2001	3500 abc	659 bcd	533 ab	81.7 a	8.04 k-m	16.2 d-h
Soyer	2002	3190 c-f	704 ab	524 abc	77.7 b-f	8.38 h-l	15.2 i-k
Bagci 2002	2002	3420 a-d	630 de	440 f-k	71.9 i	9.46 abc	16.8 bcd
Tosunbey	2004	3150 d-g	638 cd	459 d-h	73.4 g-i	8.98 def	15.8 e-i
Mufitbey	2006	3200 b-e	606 d-h	442 f-k	76.3 c-h	8.40 h-k	17.2 abc
Nacibey	2008	3530 a	602 d-h	450 e-j	74.4 e-i	8.74 e-h	16.2 d-h
Kenanbey	2009	3190 c-f	663 bcd	490 b-e	76.0 c-h	8.37 h-l	14.6 kl
Bereket	2010	2880 e-j	554 g-i	417 i-l	75.1 d-i	8.25 i-m	17.7 ab
Es 26	2010	2720 j-l	548 h-i	398 kl	74.0 f-i	9.07 cde	16.1 d-h
Aldane	2010	2870 f-k	556 g-i	415 i-l	75.1 d-i	7.90 m	15.5 h-j
Mesut	2013	3120 d-h	532 i	400 kl	75.3 d-i	7.97 lm	16.5 c-g
2016-17		2080	366	293	80	8.40	16.70
2017-18		4020	846	613	73	8.95	15.60
Mean		3050	606	453	76.1	8.67	16.15
LSD (%5)		329.3	62.5	47.4	4.05	0.42	0.91

*Means marked with the same letter are no different from each other.
GY: Grain yield, **SNSM**: Stem number per square meter, **FSNSM:** Fertile spike number per square meter, **FSR**: Fertile stem rate, **SL**: Spike length and **SNS**: Spikelet number per spike.

Table 4. Mean square (MS) from the combined analysis of variance for grain yield and other agronomic traits of bread wheat genotypes

Source of Variation	DF	GNSL***	GNS	GWS	BY	HI
Years (Y)	1	0.061	387.319**	0.105*	1946519296**	787.55**
Replication [Yrs]	6	0.214	104.093	0.208	18905343,7	2.66
Genotypes (G)	23	0.335**	124.686**	0.152**	4393880.48**	60.35**
Y x G	23	0.049**	20.117**	0.046**	3223984.9**	27.61**
Error	138	0.022	9.452	0.019	905233,6	5.74
Total	191	0.069	29.564	0.045	12356463.4	18.95
CV (%)		0.71	8.9	10.3	10.6	7.15
GA		0.005	0.067	0.003	6.2	0.092
R^2		0.68*	0.30	0.42	0.07	0.79*

Significant at *P< 0.05, and **P < 0.01 levels, respectively. **GA:** Genetic Advance
***GNSL**: Grain number per spikelet, **GNS**: Grain number per spike, **GWS**: Grain weight per spike, **BY**: Biomass yield and **HI**: Harvest index

Table 5. Grain number per spikelet, grain number in spike, grain weight per spike, biological yield and harvest index of bread wheat cultivars as average of 2016-2017 and 2017-2018 growing years

Cultivars	Registration Year	GNSL** (number)		GNS (number)		GWS (g)		BY (kg ha^{-1})		HI (%)	
Bezostaja 1	1968	1.92	k-n*	32.7	f-i	1.41	a-d	8430	fgh	31.0	i
Gerek 79	1979	1.97	j-n	29.9	i-k	1.07	i	8910	c-g	31.5	hı
Kate A-1	1988	2.38	bc	37.8	bc	1.35	b-e	8210	gh	36.6	ab
Gun 91	1991	2.04	g-l	37.8	bc	1.30	d-g	8680	d-g	28.5	j
Dagdas 94	1994	1.85	n	30.7	h-k	1.38	b-e	10910	a	26.2	j
Ikizce	1996	2.05	g-l	32.1	g-j	1.15	hı	8380	fgh	33.4	d-h
Pehlivan	1998	1.87	mn	31.2	h-k	1.41	a-d	8580	efg	36.7	ab
Harmankaya	1999	2.45	b	41.8	a	1.53	a	8960	c-g	32.9	e-i
Karahan 99	1999	2.01	h-m	29.7	jk	1.21	f-i	10190	ab	33.3	d-i
Demir 2000	2000	1.97	j-n	35.6	c-f	1.47	ab	8690	d-g	31.9	ghı
Bayraktar	2000	2.06	g-k	28.9	k	1.18	ghi	8520	efg	37.1	a
Altay 2000	2000	2.26	cde	37.3	bcd	1.47	ab	8130	gh	34.7	b-e
Sonmez 2001	2001	2.29	cd	35.9	cde	1.47	ab	8520	efg	34.7	b-f
Izgi 2001	2001	2.09	fgh	33.8	e-h	1.25	e-h	9430	b-e	36.1	abc
Soyer	2002	1.90	lmn	28.8	k	1.10	i	9400	b-e	32.3	f-i
Bagci 2002	2002	2.04	g-l	34.3	d-g	1.20	f-i	9590	bcd	34.2	c-g
Tosunbey	2004	2.64	a	41.8	a	1.46	abc	9220	c-f	33.7	d-h
Müfitbey	2006	1.95	j-n	33.7	e-h	1.44	abc	9530	bcd	31.4	hı
Nacibey	2008	2.44	b	39.6	ab	1.48	ab	9610	bcd	36.6	ab
Kenanbey	2009	2.12	e-i	30.9	h-k	1.17	ghi	9810	bc	32.4	e-i
Bereket	2010	2.22	def	39.3	ab	1.46	abc	8430	fgh	35.5	a-d
Es 26	2010	2.15	d-g	34.6	d-g	1.38	b-e	8530	efg	31.0	i
Aldane	2010	1.98	i-n	30.8	h-k	1.33	c-f	7560	h	36.1	abc
Mesut	2013	2.13	e-h	35.3	c-f	1.45	abc	8920	c-g	35.6	a-d
2016-17		2.13		35.7		1.31		5770		35.4	
2017-18		2.10		32.9		1.36		12150		31.4	
Mean		2.12		34.3		1.33		8960		33.4	
LSD (5%)		0.15		3.039		0.137		941		2.36	

*Means marked with the same letter are no different from each other.
GNSL: Grain number per spikelet, **GNS: Grain number per spike, **GWS**: Grain weight per spike, **BY**: Biomass yield and **HI**: Harvest index

The mean stem number per square meter was 606 for two-years. While it was 366 in the first year, it increased in the second year due to climate conditions and it was 846 in the second year. According to the two-year results obtained, the SNSM of cultivars varied between 520 (Kate A-1) and 733 (Bayraktar 2000) (Table 3). In a study conducted in Tokat, confirming our results, the SNSM was reported to vary between 379.3 and 723.8 (Gokmen, 1989). In general, while the mean of SNSM was 606 at the cultivars registered until 2000, increased to 632 among the years 2000-2009. However, this again decreased to 548 in the cultivars registered among 2010-2013. Especially Bereket, Es 26, Aldane and Mesut cultivars, which were registered recently, were included in this group. The results of the SNSM reflected to the regression analysis, and the genetic change in the SNSM was determined by linear regression equation (y = 1578.94 – 0.48 x).

The fertile spike number per square meter determined as the mean of the trial years was 453. While this was 293 in the first year, was 613 by increasing in the second year due to climatic conditions. According to the two-year results obtained, FSNSM in cultivars ranged between 377 (Altay 2000) and 552 (Bayraktar 2000) (Table 3). Our findings related FSNSM were found to be consistent with the results in Haymana (242.8-597.5) and Erzurum (373.8-604.4) of other researchers (Caglar et al., 2006). Grain yield per area includes grains per spike, grain weight and spikes per area; whereas grain yield per spike comprises spikelet number per spike, grain number and grain size per spike and/or spikelet. There are multiple interactions and compensation mechanisms between the different yields components, dependent on genotype x environment x agronomy interactions (Slafer et al., 2014). When the FSNSM was evaluated about genetic progress, it was found that FSNSM was determined at the trial mean (453) in the cultivars registered until 2000, it increased to 469 in average with very little acceleration between 2000-2009. In the cultivars registered between 2010 and 2013, this as in the SNSM, again has entered the trend of decreasing, and down to the average level of 410. The linear regression equation (y = 1291.78 - 0.42 x) obtained in the regression analysis of the FSNSM, in a similar way to the SNSM, showed that FSNSM was reduction -0.42 per year as a negative change.

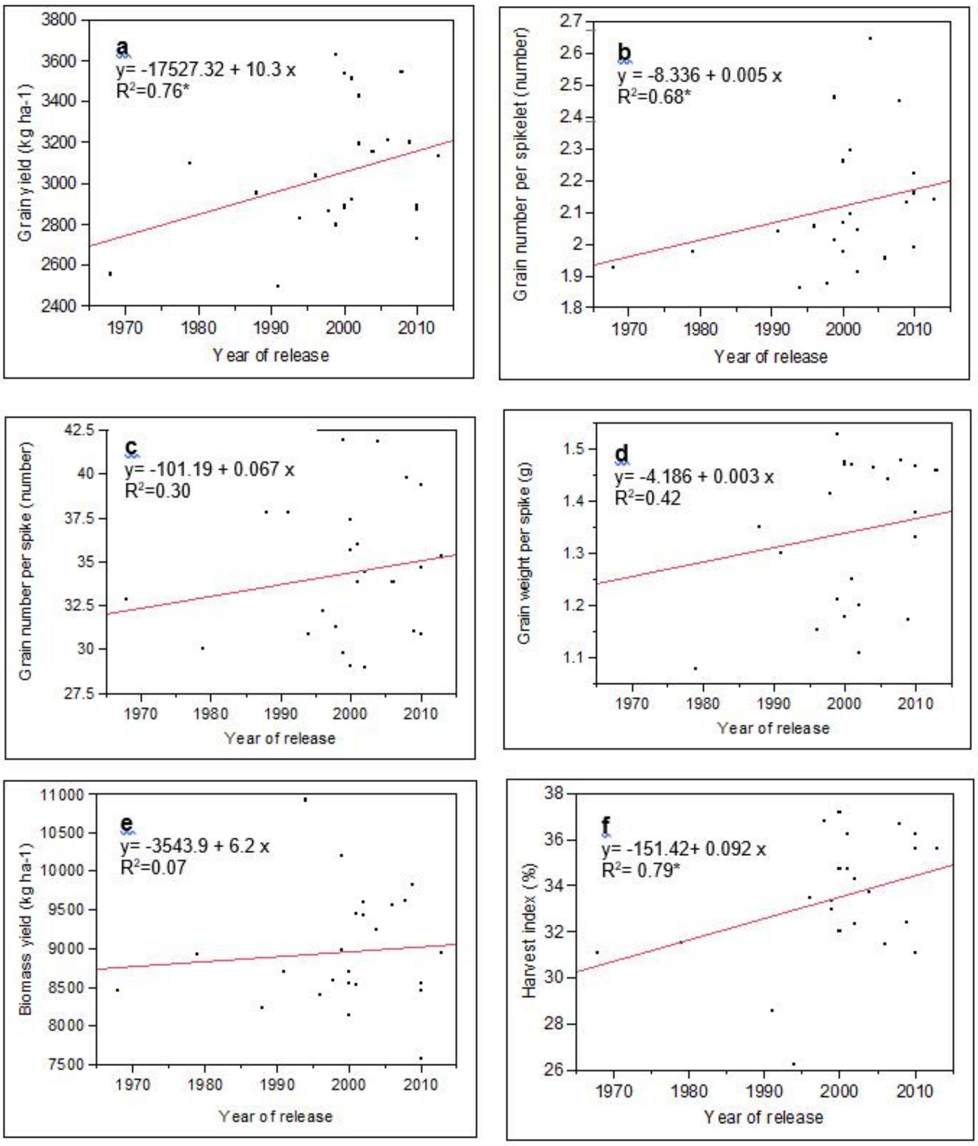

Figure 1. Genetic progress between 1968-2013 determined for grain yield and yield components in bread wheat cultivars. (**a**) GY: Grain Yield, (**b**) GNSL: Grain number per spikelet, (**c**) GNS: Grain number per spike, (**d**) GWS: Grain weight per spike, (**e**) BY: Biomass yield and (**f**) HI: Harvest index

The fertile stem ratio determined as the average of trial years was 76.3%. While this was 80% in the first year, was 73% by decreasing in the second year due to climatic conditions. Although the precipitation in March (87.7 mm) positively affected sibling in 2017-2018, the absence of almost no precipitation (4.4 mm) and high temperature in April caused deaths in subsequent siblings. This situation negatively affected the fertile stem ratio. According to two-year results, FSR ranged between 71.6% (Day 91) and 81.7% (Izgi 2001). In a study conducted in Konya, FSR showed a variation between 71.26% and 79.44% (Ayranci, 2012). When the FSR was evaluated about genetic progress, it was found that the average fertile stem rate of the cultivars registered before 2000 was 1% higher than the following 2000-2009 period, whereas it was 1% lower in the cultivars registered in 2010-2013 period. Thus, a steady decrease with a low acceleration was determined. This, excluding the period of 2010-2013, can be said to be associated with the increase in the SNSM. The linear regression equation (y = 156.44 - 0.04 x) obtained by regression analysis of FSR showed to had a negative genetic change at a rate of -0.04 per year.

The average spike length was 8.67 cm. This was 8.4 cm in the first year, but increased in the second year with the effect of the climate and was determined as 8.95 cm. According to the two-year results, SL ranged between 7.9 cm (Bayraktar 2000) and 9.63 cm (Demir 2000). These results were longer than those determined by other researchers in Isparta (4.5-6.8 cm) and Tokat (5.4-9.1 cm) (Gokmen, 1989), Bursa (7.48-9.68 cm) and Aydin (7.9 to 9.8 cm) and similar to (Sengun, 2006), a little shorter than that obtained in Tekirdag (Bilgin and Korkut, 2005). When evaluated about genetic progress, all of the cultivars registered until 2010 were above 8.25 cm except for Bayraktar 2000 (7.9 cm) and an increase can be mentioned, albeit at a low acceleration. However, it can be said that Aldane (7.9 cm) registered in 2010 and Mesut (7.97 cm) registered in 2013 caused the linear line to evolve in the negative direction for the last period. The linear regression equation (y = 28.43 – 0.01 x) obtained in the regression analysis of SL revealed a negative genetic change of -0.01 cm per year.

The spikelet number per spike, which was determined as the average of the trial years, was 16.15. This was 16.7 in the first year and 15.6 in the second year. According to the two-year results, SNS ranged between 14.1 (Bayraktar 2000) and 17.8 (Day 91). These results were similar to the findings of Ayranci (2012) in Konya (12.85-15.19), while they were less than the findings of Dagustu (2008) in Bursa (16.90-22.09).

When the SNS was evaluated about genetic progress, it was seen that the cultivars that share the "a" group in the LSD test were those registered in different years ranging from 1991 to 2010. This shows that SNS is considered as an important parameter in the selection of genotypes for high yield, but some other components that support yield in the arid environment occasionally come to the fore. Especially the cultivars such as Tosunbey (15.8 units), Kenanbey (14.6 units) and Aldane (15.5 units) registered in recent years can be given as examples. The linear regression equation (y = 29.19 – 0.01 x) obtained in the regression analysis of SNS showed that there was a negative genetic change -0.01 per year.

The grain number per spikelet determined as the average of the trial years was 2.12. While this was 2.13 in the first year, as 2.10 in the second year (Table 5). According to the two-year results, GNSL ranged between 1.85 (Dagdas 94) and 2.64 (Tosunbey). In a study conducted in Aydin, GNSL ranged between 2.9-3.4 (Erkul and Unay, 2009) and 1.73-2.55 in Konya (Ayranci, 2012). It can be said that genotype and environmental differences are effective in this variation. Increasing the GNSL has an important share in increasing the grain yield. The grain number per spikelet depends on the fertile flower number in the spikelet and the ability of these fertile flowers to form grains. When the GNSL was evaluated about genetic progress, it was determined that the cultivars registered especially in 2000-2010 period had higher grain number in spikelet and there was a slight increase depending on the years in 45-years period. The linear regression equation (y = -8.336 + 0.005 x) obtained in the regression analysis of the GNSL showed that there was +0.005 genetic progress per year in the grain number in spikelet (Figure 1.b).

The grain number per spike was 34.3. While it was 35.7 in the first year, it decreased to 32.9 in the second year due to insufficient spring rainfall (April) and the excessive of spikes count per square meter. According to the two-year results, GNS showed a variation between 28.8 (Soyer) and 41.8 (Harmankaya 99). This study showed that the findings obtained in GNS was in agreement with the results of other researchers (Gokmen, 1989; Avcin et al., 1997). When the GNS was evaluated about genetic progress, for the periods of 1968-1999, 2000-2009 and 2010-2013, it was determined that GNS values changed as 33.7, 34.6 and 35.0, respectively. This showed an increase in the 45-year period, albeit at a low acceleration depending on the registration years. The linear regression equation (y = -101.19 + 0.067 x) obtained in the regression analysis of the GNS showed that there was +0.067 genetic progress in the grain number in spike per year (Figure 1.c).

The grain weight per spike which was determined as the mean of the trial years was 1.33 g. This increased from 1.31 g in the first year to 1.36 g in the second year due to the effect of late rainfall (June). According to the two-year results obtained, GWS ranged between 1.07 g (Gerek 79) and 1.53 g (Harmankaya 99). In studies conducted, the GWS was reported changed between as 1.23-1.89 g in Bursa (Dogan and Yurur, 1992), 1.1-1.9 g in Kahramanmaras (Dokuyucu et al., 1999), and 1.50-2.23 g in the Cukurova barren conditions (Kaya, 2006). When the GWS was evaluated about genetic progress, for the periods of 1968-1999, 2000-2009 and 2010-2013, it was determined that GWS values changed as 1.31 g, 1.33 g and 1.40 g, respectively. This showed that there was a genetic improvement in the 45-year period, albeit at a low acceleration depending on the registration years. Linear regression equation (y = -4.18663 + 0.003 x) obtained in the regression analysis of GWS showed that there is a genetic progress +0.003 g per year in GWS (Figure 1.d).

The biological yield was 8960 kg ha^{-1} as the mean of the trial years. While it was 5770 kg ha^{-1} in the first year, it increased in the second year due to the effect of May and June rainfall and was 1215 kg da^{-1}. According to the two-year results obtained, BY ranged from 7560 kg ha^{-1} (Aldane) to 10910 kg ha^{-1} (Dagdas 94). In studies conducted about subject, it was reported that BY ranged between 9490-13720 kg ha^{-1} in Cukurova (Aykanat, 2009) and 7264-9630 kg ha^{-1} in Konya (Inanli, 2014). When BY is evaluated for genetic progress, BY which was 9030 kg ha^{-1} in 1968 - 1999 period, rise to the level 9130 kg ha^{-1} by increasing in 2000-2009 period, but decreased to 8360 kg ha^{-1} in the last period (2010-2013). In here, the effect of Aldane (7560 kg ha^{-1}) was high. However, when the 45-year process was evaluated, it was observed that there was an increase, albeit at a low acceleration, by depending on the registration years. The linear regression equation (y = -3543.9 + 6.2 x) obtained in the regression analysis of BY showed that there was a genetic progress +6.2 kg ha^{-1} in the BY per year (Figure 1.e).

The harvest index which was determined as the mean of the trial years was 33.4%. This decreased from 35.4% in the first year to 31.4% in the second year. According to the two-year results obtained, HI showed a change between 31.0% (Bezostaja 1) and 37.1% (Bayraktar 2000). In studies conducted related to subject, it was reported that HI changed between 23.2-35.1% in Tokat (Gokmen, 1989), and 29.7-31.5% in Haymana (Aktas, 2010). When HI was evaluated about genetic progress, for the periods of 1968-1999, 2000-2009 and 2010-2013, it was determined that HI values changed as 32.2%, 34.1% and 34.6%, respectively. This showed an increase in the

45-year period, albeit at a low acceleration depending on the registration years. The linear regression equation (y = -151.42 + 0.092 x) obtained in the regression analysis of the HI showed that there was +0.092% a genetic progress in the HI per year (Figure 1.f).

CONCLUSION AND SUGGESTIONS

Our results showed that grain yield was achieved 10.3 kg ha^{-1} annual genetic progress with winter bread wheat varieties improved for dry conditions in 45-years period covering the years 1968-2013 of Turkey.

In the study, although there was a negative change in the stem number and elongation in the new varieties, the increase in biomass and HI properties showed that the progress in yield was more dependent on the improvement in the spike system. As a matter of fact, grain number per spikelet (0.005 number yr^{-1}), grain number per spike (0.067 number yr^{-1}), grain weight per spike (0.003 g yr^{-1}), biomass (6.2 kg ha^{-1} yr^{-1}) and harvest index (0.092 % yr^{-1}) positively contributed to genetic progress. Particularly in terms of wheat breeders, it is of a great importance to consider yield components that will provide improvement in hereditary increase of grain yield as selection parameters in breeding programs. In the grain yield components such as the stem number per square meter (-0.48 number yr^{-1}), fertile spike number per square meter (-0.42 number yr^{-1}), fertile stem rate (-0.04 % yr^{-1}), spike length (-0.01 cm yr^{-1}), and spikelet number per spike (-0.01 number yr^{-1}), it was determined that there was a negative change in genetic capacity with low an acceleration. When developing new cultivars for low-rainfall areas, we can conclude that more precision should be considered above these characteristics which are important about drought tolerance. It is difficult to predict the future increase in yield. Emphasis on the development of physiological properties related to resistance to environmental stress factors in the new cultivars to be developed may be important about giving new impetus to the grain yield.

In this study carried out in Kirsehir ecological conditions, Karahan 99, Nacibey, Bayraktar 2000, Izgi 2001 and Bagci 2002 cultivars came to the forefront about yield capacity in arid conditions, adaptation to the region and drought tolerance properties in the components supporting yield. It is concluded that these cultivars have the potential to grow in regions with low precipitation, including Kırşehir.

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