http://dergipark.ulakbim.gov.tr/trkjnat/index
Trakya University Journal of Natural Sciences, 14(2): 97-102, 2013
ISSN 2147–0294

Original Article/Orijinal Makale

PRODUCTIVE POTENTIAL OF BULGARIAN AND TURKISH VARIETIES AND LINES OF BARLEY IN THE CONDITIONS OF SOUTHEAST BULGARIA

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Received (Alınış) : 13 October 2014, Accepted (Kabul Ediliş) : 21 December 2014, Published (Basım): August 2015

Abstract: The study was conducted in 2006-2009 in the experimental field of the Institute of Agriculture, Karnobat. The aim was to identify the productive capacity of the feed barley varieties and advanced lines. The results show that promising winter feed barley lines with the highest yields were CRF 47, CRF 292 and CRF 146в.

Key words: barley, productivity

Bulgar ve Türk Arpa Çeşit ve Hatlarının Güneydoğu Bulgaristan Koşullarındaki Verimlilik Potansiyelleri

Özet: Yemlik arpa çeşit ve hatlarının verimlilik kapasitelerinin tanımlanması amacıyla yapılan bu çalışma 2006-2009 yılları arasındaki 3 yıllık periyotta Karbonat'daki Tarım Enstitüsü'nde gerçekleştirilmiştir. Elde edilen sonuçlar hüksek verime sahip kışlık yemlik arpa soylarının CRF 47, CRF 292 and CRF 146в olduklarını göstermiştir.

Anahtar kelimeler: Arpa, verimlilik

Introduction

Barley productivity results from the genetic potential of the studied material manifested in the specific environmental conditions and is a summarized expression of complex relationships between yield components and other traits related to it (Ganusheva et al., 1990; Zapryanov, 1990; Ganusheva et al., 1991; Ganusheva et al., 2004; Mihova, 2006; Kim, 1978). One of the main tasks of a barley breeding program is to increase its productivity and at the same time preserve and improve grain quality. It is entirely possible to increase the yield by means of selection by combining favorable values of traits which determine the yield structure in a genotype (Valcheva et al., 2011). In practice these efforts are constrained by the overall physiological system of the plant, which is genetically determined (Dyson, 1977). As far as the early 1931 Woodwoth reached the conclusion that selection of just one of the yield components is ineffective. Grafius et al. (1964) concluded that there are no yield genes, rather than genes of yield components and the complex polygene driven trait should be dismembered to its natural constituents to the extent of monofactorial inheritance.

The aim of this study was to investigate the productive potential of varieties and lines of barley in the conditions of Southeast Bulgaria.

Material and Methods

The study was conducted in the period 2006-2009 on the experimental field of the Institute of Agriculture in Karnobat, Bulgaria. 13 multi-row barley accessions were tested. Out of them 10 were bred in Bulgaria and 3 at the Trakya Agricultural Research Institute in Edrine, Turkey. Eleven of the materials belonged to var. pallidum and two to var. paralellum. The Bulgarian-bred lines had been created in the direction of biotic and abiotic stress resistance. The material of introduction was obtained under a Cooperation Agreement between the Institute of Agriculture in Karnobat and Trakya Agricultural Research Institute in Edrine and under Project No CC1506, funded by the Ministry of Education and Science. The varieties and lines were tested in a field trial, set by the method of Latin rectangle. The yield plot was 10 m^2 in size in 4 replications. The yield was taken by years and the results were statistically processed. Annually all studied varieties and lines of barley were taken biometrical measurements of 25 plants by the following indexes: number of spikes per m^2, spike length (cm), number of grains per spike, number of sterile spikelets per spike, grain weight per spike (g), 1000-grain weight (g).

The results were statistically processed with analysis of variance, Fit analysis, PCA and cluster analyses with program software JMP version 5.0 1a (2002) and SPSS Statistics 19.

The testing period included 4 consecutive years, which were very different in terms of weather conditions. Table 1 and 2 show data on the average monthly temperatures and amount of rainfall by months during barley vegetation. The first year of study was characterized with cold and humid winter. Exceptionally low temperatures in January, accompanied by optimal amount of rainfall led to formation of ice cover. As a result of this, about 30% of the plants in the plots died from frost heaving and drowning. Year 2006/2007 had average monthly temperatures, which were much higher than the average multi-annual values. The deviation reached up to 4.7 C^0 in January, whereas in the other months it ranged within 0.5 C^0 and 2.7 C^0. These higher temperatures during vegetation were accompanied by significantly smaller amount of rainfall in the autumn of 2006 and early spring of 2007. The vegetational year of 2007/2008 was the most favorable for the studied period. The values of average monthly air temperatures and rainfall by months were close to the average multi-annual values. The weather conditions allowed a normal wintering of the plants and realization of the yielding potential of the accessions. The fourth year of the study had two stages – favorable conditions for autumn and winter development and severe drought, which started in the early spring of 2009 and continued until harvesting.

Results and Discussion

Table 1 shows data about the obtained grain yield from the tested varieties and lines of barley. In the period 2006-2009 the highest yield was formed in 2008 when the average yield for the group was 6.20 t/ha. Low yields were registered in 2006 as a result of frost damage to part of the plants and in 2007 as a result of severe drought and extremely high temperatures during vegetation. After statistical processing of the results, it was observed that total for the group the variability was insignificant with VC% ranging from 2.90 to 7.50% over the years. In 2006, the highest yield was recorded from Bulgarian-bred lines, created as cold-resistant – CRF 47, CRF 292, CRF 146 b and CRF 259. Good adaptivity to severe winter conditions in 2006 was seen in the Turkish variety Arda, which was also among the high-yielding accessions. During the dry and hot 2007 again lines CRF 292 and CRF 146 b ranked first in yield, followed by the Lord variety. Their yields exceeded 500 kg da-1. In the climatically favorable year of 2008 first in yield were lines K 2419-03 and K 2538-01, whose yields were 7.02 t/ha and 6.92 t/ha, respectively. High yields were also obtained from lines DRF 206-2 and CRF 292. Based on LSD differences the four lines in 2008 fell into group **a**. Very good productive abilities were also seen in the accessions in group **b –** Arda and CRF 47. In 2009 first in yield were again the Bulgarian lines, bred in the direction of abiotic stress resistance - CRF 47, CRF 302-2 and DRF 206-2, whose yields ranged from 5.62 to 6.39 t/ha. Line CRF 292 in three out of the four studied years was first in yield, whereas line CRF 47 was first in two of the years. Average for the period CRF 47 (590 kg da-1) had high yield compared to the standard Veslets variety, followed by CRF 292 with an average yield of 583 kg da-1. Average for the period the highest yield was formed by line CRF 47 from the Bulgarian breeding, and the Arda variety – from the Turkish.

Table 1. Yield of varieties and lines barley in the period 2006-2009

№	Varieties and lines	2006 year			2007 year			2008 year			2009 year			Average for the period	
		t/ha	group	rank	t/ha	group	rank	t/ha	group	rank	t/ha	group	rank	t/ha	%
1.	Veslets - St	4.33	d	6	3.73	hi	12	5.94	cd	9	5.15	c	4	4.79	100.00
2.	Lord	3.58	f	10	5.04	bc	3	6.06	c	7	4.12	ef	12	4.70	98.12
3.	Arda	4.94	c	5	4.01	gh	10	6.48	b	5	4.32	f	13	4.94	103.13
4.	AVD – 19	3.80	ef	9	3.82	h	11	5.49	e	12	4.55	de	11	4.42	92.48
5.	DRF 206-2	3.55	f	11	4.41	fg	9	6.85	a	3	5.62	b	3	5.11	106.68
6.	CRF 302-2	3.53	f	12	4.64	c-f	6	6.05	c	8	6.02	ab	2	5.06	105.64
7.	PG 43-65	3.18	g	13	3.33	i	13	5.79	d	10	4.76	cd	10	4.27	89.14
8.	K 2419-03	3.97	e	8	4.90	b-e	5	7.02	a	1	4.81	cd	9	5.18	108.14
9.	K 2538-01	4.33	d	7	4.47	ef	8	6.92	a	2	4.98	c	6	5.18	108.14
10.	CRF 47	5.90	a	1	4.97	bcd	4	6.35	b	6	6.39	a	1	5.90	123.17
11.	CRF 259	4.99	bc	4	4.54	c-f	7	5.22	f	13	5.13	c	5	4.97	103.76
12.	CRF 292	5.83	a	2	5.80	a	1	6.80	a	4	4.88	cd	8	5.83	121.71
13.	CRF 146 в	5.28	b	3	5.19	b	2	5.68	de	11	4.97	c	7	5.28	110.23
	Mean		4.40			4.53			6.20			5.05		5.05	
	LSD		0.31			0.44			0.26			0.42			
	VC%		4.96			7.50			2.90			5.79			

Table 2 presents an average data for several productivity elements in the period of 2006-2009. Tillering is a main element of productivity, which varies significantly under the environmental conditions (Tapsel et al. 1983). The variability of productive tillers per plant in this study was an average of VC% - 13.88% and the average for the group was 888 per m^2. The highest number of spikes per m^2 was formed by the lines CRF 47 and CRF 259 with 1158 and 1048, respectively. The lowest productive tillers were in the Lord variety and the line PG 43-65. The LSD values divided the accessions into 6 groups.

Spike length is a trait, which greatly depends on the genetic peculiarities of the representatives of different varieties and is less influenced by the year conditions. In the group studied, the variability of spike length was significant (VC-28.91%). The results (Table 2) from the study also confirmed other reports, which established that the representatives of var. pallidum had a longer spike compared to accessions of var. paralellum (Dimova et al., 2010). The lines of var. paralellum K 2419-03 and K 2538-01 formed the shortest spikes with 5.1 cm and 4.0 cm, respectively. Lines CRF 47 (7.4 cm) and CRF 302-2 (7.1 cm), which belong to var.pallidum, formed the shortest spikes. T number of grains is also considered as a trait, which is strongly influenced by the year conditions and is directly dependent on the number of sterile spikelets (Mersinkov 2000; Sinha et al. 1985). The trait had an average variability in the present study. The highest number of grain per spike was seen in lines CRF 146 b и K 2419-03, and the lowest was in K 2538-01 and AVD – 19.

Spike sterility is an index, which is strongly influenced by the year conditions (Dimova et al., 2007; Dimova et al., 2010). The number of sterile spikelets also depends on the systematics of the accessions and some scientists found that in two-row barley they are far fewer compared to the multi-row forms (Valcheva et al. 2009). The results from this study confirmed the statements about a large number of sterile spikelets in multi-row forms, the average for the group being 16.93. The lowest number of sterile spikelets was formed by lines K 2419-03, DRF 206-2 and Arda variety.

Grain weight per spike is one of the important traits affecting yield formation. Average for the period and average for the accessions, grain weight per spike was 1.67 g with average variability of the trait within the group. The heaviest grains per spike were in CRF 292 and CRF 146 b, 1.9 g and 2.2 g, respectively. Their grains, as well as those of Lord variety, were not only heavy, but also big with 1000-grain weight ranging from 39.90 g to 41.31 g.

Figure 1 presents a dendrogram, which demonstrates clusterization of the varieties and lines based on obtained yield and values of several productivity elements. The tested accessions were divided into 2 clusters; the first included 10 of them and the second included 3 lines. In the first cluster, 4 subgroups were formed with the fewer distance units seen between DRF 206-2 and Arda variety. Their similarity was manifested in a large number of spike-bearing tillers per m^2 and a small number of sterile spikelets. Similar closeness was also observed in lines CRF 302-2 and CRF 259. The second cluster separated the most highly productive lines. Cluster line CRF 47 stood detached with its typical high number of spike-bearing tillers per m^2 and long spikes. CRF 292 and CRF 146 b formed a group in the second cluster based on high yield, long spike, high number of grains per spike, small number of sterile spikelets, high grain weight per spike and high 1000-grain weight. In the breeding work on increasing productivity good combinations may be obtained by crossing lines CRF 47 x DRF 206-2; CRF 47 x CRF 146 b. Genetically most remote lines were Veslets and PG 43-65 from the lines forming the second cluster, which came to show that it is possible to make good combinations to increase productivity.

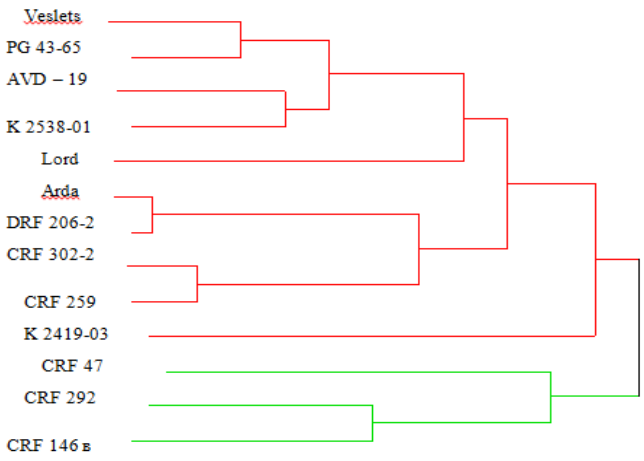

Figure 1. Dendrogram varieties and lines of winter barley on the basis of yield and yield components of in the period 2006-2009

In the process of investigating the productive potential of the barley in the collection correlations were also found between yield and productivity elements (Table 3). There was a positive correlation between yield and grain weight per spike (r=0.605), spike length correlated positively with 1000-grain weight (r=0.670), high positive correlation between number of grains and their weight per spike (r=0.862), which showed that selection by these traits may increase productivity.

Table 2. Mean values of some elements of productivity or the period 2006-2009

№	Varieties and lines	Number of spike m^2			Spike length /cm /			Number of grains in the spike			Numbers of sterile spikelets			Grain weight per spike /g /			1000 grain weight /g /		
		number	group	rank	cm	group	rank	number	group	rank	number	group	rank	g	group	rank	g	group	rank
1.	Veslets - St	828	cd	9	5.9	de	11	40.5	fgh	11	18.3	cde	10	1.6	de	10	37.40	cd	7
2.	Lord	731	d	13	6.9	a-d	4	40.7	e-h	10	19.0	de	12	1.7	cd	6	41.28	a	2
3.	Arda	924	bc	3	6.4	a-d	7	46.3	cd	5	14.6	ab	3	1.6	cde	7	35.08	def	11
4.	AVD – 19	919	bc	4	6.0	de	10	38.3	h	13	17.8	bcd	8	1.3	f	13	38.02	bc	5
5.	DRF 206-2	916	bc	5	6.8	a-d	5	48.1	bc	3	13.4	a	2	1.8	bc	3	37.19	cde	8
6.	CRF 302-2	904	bcd	6	7.1	ab	2	44.4	c-f	7	17.8	bcd	7	1.6	cde	8	37.01	cde	9
7.	PG 43-65	750	cd	12	6.1	cde	9	41.7	efg	9	18.8	de	11	1.5	ef	11	34.88	ef	12
8.	K 2419-03	821	cd	10	4.0	f	13	52.5	ab	2	13.1	a	1	1.8	bc	5	33.50	f	13
9.	K 2538-01	903	bcd	7	5.1	e	12	38.8	gh	12	18.1	cd	9	1.4	f	12	35.90	def	10
10.	CRF 47	1158	a	1	7.4	a	1	45.1	cde	6	21.8	e	13	1.8	bc	4	39.25	abc	4
11.	CRF 259	1048	ab	2	6.4	a-d	6	43.0	d-g	8	16.9	bcd	6	1.6	cde	9	37.50	bc	6
12.	CRF 292	829	cd	8	6.3	bcd	8	47.6	c	4	14.9	abc	4	1.9	b	2	39.90	ab	3
13.	CRF 146 в	815	cd	11	7.0	abc	3	54.2	a	1	15.7	a-d	5	2.2	a	1	41.31	a	1
	Mean	888			6.26			44.57			16.93			1.67			37.49		
	LSD	176.00			1.01			4.59			3.43			1.83			2.40		
	VC%	13.88			28.91			18.49			36.80			19.76			11.55		

Table 3. Correlations between yield and productivity elements

	Y	NSm^2	SL	NGS	NSS	GWS	1000GW
Y	1	0.464	0.175	0.504	-0.079	0.605*	0.308
Sm^2		1	0.296	-0.057	0.284	-0.092	-0.005
SL			1	-0.010	0.391	0.288	0.670*
NGS				1	-0.631*	0.862**	0.050
NSS					1	-0.337	0.305
GWS						1	0.485
1000GW							1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
Y - yield
NSm^2 - number of spike m^2
SL - spike length
NGS - number of grains in the spike
NSS - numbers of sterile spikelets
GWS - grain weight per spike
1000GW - 1000 grain weight

A principal component analysis was carried out to give a clearer view on the relationship between yield and productivity elements in the studied accessions. 3 principal components stood out with values higher than 1 and explaining 86.95% of the variability (Table 4 and 5). The first principal component was related to yield, grain number and weight per spike. The high positive correlations between them showed that it is possible to increase the productivity through selection by these traits. The second component explained the variability in spike length and number of sterile spikelets. The third component was related to the number of productive tillers per m^2 and 1000-grain weight. The third component's small share of the total variability shows that the traits related to it are less significant in the total variability.

Figure 2 shows the position of accessions and studied traits in the factoral space. The shortest vector was spike length and the longest ones were grain number and weight per spike. The traits of greatest significance for the productive potential of the accessions are number of grains and their weight per spike.

The weakest correlation occurred between yield and number of sterile spikelets. The acute angles between number of grains and their weight per spike and yield proved the strong relationship between them. The visualization of varieties and lines of the studied assortment proved the correlation between the productivity elements to obtain high yield. The yield of line CRF 146 b was directly dependent on grain number and weight per spike and 1000-grain weight, whereas with CRF 292 K 2419-03 and DRF 206-2 it was mainly dependent on the number of grains per spike.

In the studied group, Veslets, Lord, AVD-19 and PG 43-65 were the least productive. Their yields were strongly dependent on the number of sterile spikelets and 1000-grain weight. The Bulgarian lines CRF 146 b, CRF 292, K 2419-03 and DRF 206-2, and from the Turkish accessions – the Arda variety can be used for breeding purposes towards productivity.

Table 4. Values of the main components

Main components	Percent of variation	Cumulative value
PC 1	38.84	38.84
PC 2	30.82	69.66
PC 3	17.29	86.95

Table 5. Values of the examined traits on the main components

№	Traits	PC 1	PC 2	PC 3
1.	Yield	**0.46**	-0.10	**-0.43**
2.	Number of spike/m2	0.08	-0.33	**-0.74**
3.	Spike lenght	0.23	**-0.52**	0.20
4.	Number of grains in the spike	**0.50**	0.33	-0.04
5.	Numbers of sterile spikelets	-0.20	**-0.57**	0.01
6.	Grain weight per spike	**0.58**	0.09	0.17
7.	1000 grain weight	0.32	-0.42	**0.43**

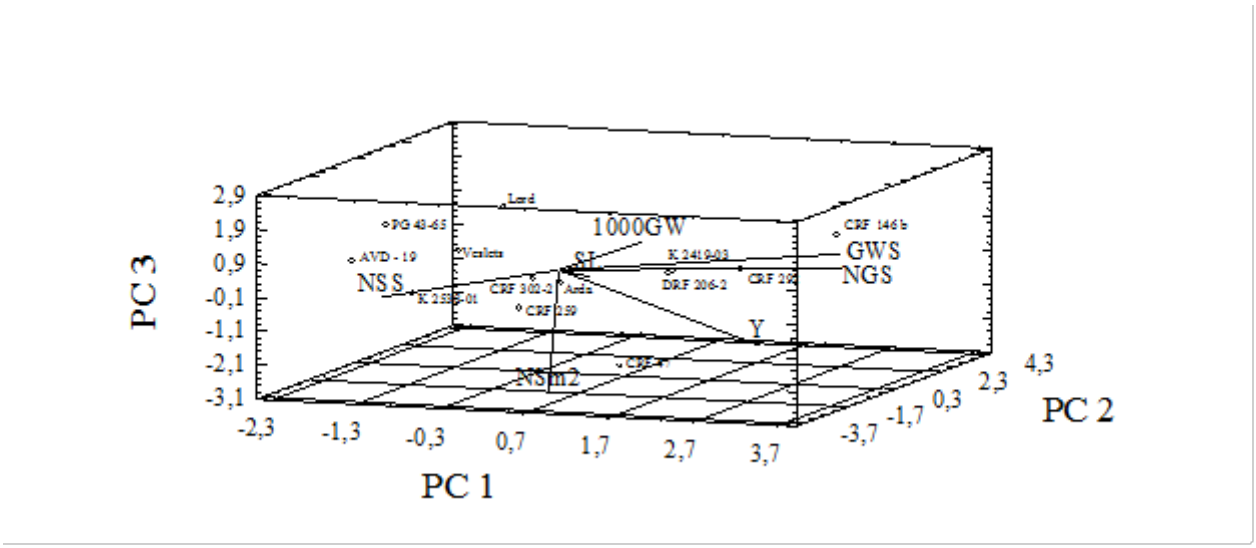

Figure 2. Projection of varieties and lines a factor space

Conclusion

The highest-yielding Bulgarian-bred lines were CRF 47, CRF 292 and CRF 146 b, and the Turkish Arda variety.

Most productive tillers per m^2 and longest spikes were formed by the line CRF 47. CRF 146 b was the line with highest number of grains, biggest length and with highest weight per spike, whereas DRF 206-2 formed the least sterile spikelets.

Good combinations can be obtained by crossing lines CRF 47 x DRF 206-2; CRF 47 x CRF 146 b to increase productivity.

High positive correlations were found between yield and grain weight per spike, between the number of grains and their weight, between spike length and 1000-grain weight. There is strong negative correlation between number of grains per spike and number of sterile spikelets.

The traits of greatest significance for the productive potential of accessions are the number of grains and their weight per spike.

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