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Breeding assessment of several economic and biological traits in winter two-row barley

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Abstract

The objective of this study was to investigate newly created lines and regionalized varieties of two-row barley by yield and some economic traits, as well as to establish the possibilities of using them in the crop breeding program. To achieve this purpose a research was carried out at the Institute of Agriculture in Karnobat in the period of 2011-2013. Subject of study were 4 regionalized varieties and 6 newly created lines of winter two-row barley. The experimental design was a randomized block method in four replications. Data was obtained on grain yield (t ha-1); biometric measurements were taken for several traits: spike length, number of spikelets per spike, number of grains per spike, grain weight per spike and 1000-grain weight. Two-factor analysis of variance, PC and cluster analyses were used. The results of the investigation showed that out of the tested lines of winter two-row barley, the yield was greatest Кt 1241, Кt 1239 and Кt 1228. The lines of the first cluster, which formed longer spikes and could cross with Кt 1241, are suitable for source material. Line Кt 1241 distinguished by heaviest spike and biggest grain, which allows its successful inclusion it various breeding programs. It is characterized by high grain yield, which makes it suitable for further testing as a variety

Key words: Lines; Barley; Traits; Yield

Introductıon

Barley is one of the most significant cereals, which economically ranks third after wheat and maize in Bulgaria. The main breeding requirements aim at creating varieties of high and stable yield and high quality grain. Genetic diversity underlies successful breeding (Ifftikhar et al., 2009). Studies on a large number of accessions in different environments and the investigation of their traits are source of new geneplasm and directly related to the efficiency of the breed improvement work on barley (Valcheva 2000; Ganusheva et al., 2010; Mihova et al., 2010). The application of modern multivariate analyses in these experiments enables the assessment of both genetic diversity at the final stage of breeding and the advancement of different genotypes to be used in hybridization of the crop (Franco et al., 2003; Georgiev et al., 2013). Using PC analysis allows to identify correlations between individual traits and the relationships of genotypes with different traits (Valkova, Dechev, 2008; Valkova, Dechev, 2012; Kaya, Y et al., 2003). Analyzing the genetic remoteness by cluster analysis can also provide comparative measurement of the genetic diversity and indicate the parental selection and the structure of population groups (Souza at al., 1991, Ganusheva et al., 2010).

The aim of this study was to investigate several new biological and economic traits of newly created breeding lines and to identify possibilities for their use in the production and in the breeding program for this crop.

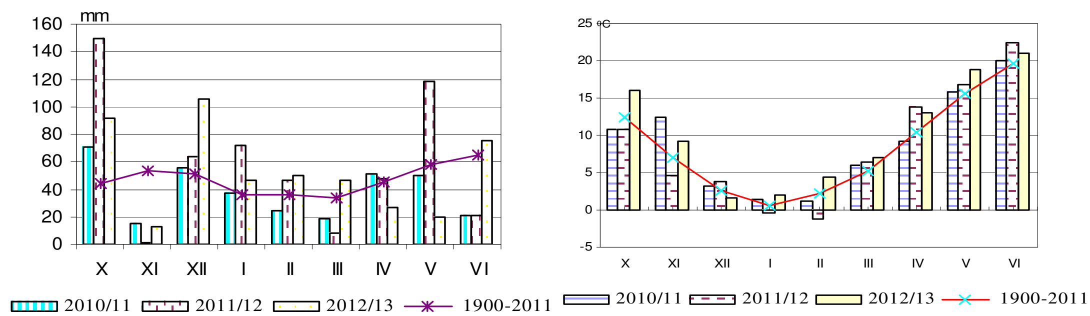
Meterıal and Methods

Subject of study were 4 regionalized varieties and 6 newly created lines of winter two-row barley. The research was carried out during the period of 2011-2013 at the Institute of Agriculture in Karnobat. The trial was set on leached vertisol soil type, in 4 replications. The size of the yield plot was 10 m^2. The seeding rate was 430 germinating seeds per $1m^2$. The predecessor was a mix of pea and sunflower. At the beginning of spring vegetation was applied 0.1t ha-1 active nitrogen. The agrotechnical actions, which are not subject of this study, were conformed to the traditionally accepted cultivation technology for the crop. Before harvest we collected 25 plants from each block, which were then taken biometrical measurements of: spike length (LS), cm; number of spikelets per spike (NSS); number of grains per spike (NGS); grain weight per spike (WGS), g;1000-grain weight (W_{1000}); grain yield (Y), t ha-1. By applying a two-factor analysis of variance was determined the relative share of the factors year, genotype and the interaction between them, in the formation of yield and some traits of the traits. To the studied traits and yield was applied clustering, based on the differences measured by Euclidean distance between two objects. Before computing our data was standardized. The experimental data was processed with Excel and statistical software Statgraphs 5.

Results and dıscussıon

The environmental conditions in the experiments were various **(Fig.1).** In 2011 the total amount of rainfall was about 80 mm less than the values of the multi-annual period. The highest humidity deficit was in November, May and June. Year 2011 can be described as dry. In 2012 and 2013 was observed certain similarity between the amount of rainfall during the vegetation of barley (more compared to the multi-annual period) and were defined as humid

Figure 1. Weather conditions – rain fall, (mm), temperature, (C^0) in Karnobat



The average daily temperatures had no significant deviations from the multi-annual values, but higher average daily temperatures were recorded in April, May and Jule.

The low temperatures in January and February in 2012 accompanied by thin snow cover caused the barley about 25% frost damage and about 10-15% frost heaving, which determined the year as not very favorable.

The genotypes were characterized by significant variability in almost all traits. The average results for the three years shows that line Kt 1241 stands out in most of the traits **(Table 1).** It has greater spike length (8.6 cm) and most grains per spike (30.7), as well as the heaviest grain per spike (1.65 g) and highest 1000-grain weight.

Table 1. Mean values for haracters in two-row winter barley lines

№	Variety	LS	NSS	NGS	WGS	MASS
1	**Obzor**	7.5 ^{cd}	28.4^{bcd}	27.1bc	1.40 ^{b}	52.13 ^{a}
2	**Emon**	7.2 ^{de}	30.3^{ab}	28.8^{ab}	1.30 ^{bc}	45.30 ^{d}
3	**Kaskadjor**	6.9 ^{ef}	28.0 $^{b-e}$	26.5 ^{bcd}	1.31 ^{bc}	49.69 ^{ab}
4	**Perun**	9.3 ^{a}	26.5^{def}	25.3 ^{cde}	1.29 ^{c}	51.09 ^{a}
5	**Kt 1228**	8.2 ^{b}	27.8 $^{b-e}$	26.4 ^{bcd}	1.20 ^{c}	45.53 ^{cd}
6	**Kt1239**	6.3 ^{f}	27.3 $^{c-f}$	25.6 ^{cde}	1.23 ^{c}	48.10 ^{bcd}
7	**Kt1241**	8.6 ^{b}	31.9 ^{a}	30.7^{a}	1.65 ^{a}	53.32 ^{a}
8	**Kt3032**	8,1 ^{bc}	25.6^{ef}	24.0^{de}	1.16 ^{c}	48.95 ^{abc}
9	**Kt3033**	8.6 ^{b}	25.0 ^{f}	23.7 ^{e}	1.22 ^{c}	51.83 ^{a}
10	**Kt1718**	9.7 ^{a}	29.7^{abc}	27.7^{bc}	1.42 ^{b}	52.14 ^{a}
	Mean	8,0	28,1	26,6	1,32	49,81
	St.error	0,111	0,334	0,333	0,027	0,668
	CV%	15,32	13.44	8,03	13,32	14,63

*a, b, c .... Degrees of significant at P = 0.05%

In the group of highest 1000-grain weight are also belong lines Kt 1718, Kt 3033, Obzor variety and Perun variety, which have a long spike but the values of grain weight and number of grain per spike were lower compared to Kt1241. Lower grain weight per spike and lower 1000-grain weight were seen in lines Kt 1228, Kt 3032, Kt 1229.The analysis of yield by year and the mean values for the period showed that the highest yield from the studied lines was obtained in 2013 **(Table 2)**.

Table 2. Results for grain yield of tested varieties in the 2011-2013 year

	Lines	**Yield 2011**		**Rank**	**Group**	**Yield 2012**		**Rank**	**Group**	**Yield 2013**		**Rank**	**Gro up**	**Mean**		**Rank**
		t	**%**			**t**	**%**			**t**	**%**			**t**	**%**	
1	**Obzor**	5.90ns	98.99	8	E	6.08***	105.38	1	A	7.01ns	101.45	4	BC	6.33	101.93	5
2	**Emon**	6.16**	103.36	7	D	5.50***	95.32	6	A	7.03ns	101.74	3	ABC	6.23	100.32	8
3	**Kaskadjor**	5.83-	97.82	9	E	5.73ns	99.306	4	A	6.69ns	96.81	6	C	6.08	97.90	9
	Meanstandart	5.96	100.00			5.77	100			6.91	100			6.21	100	
4	**Perun**	6.43***	107.83	6	C	4.93---	85.44	7	B	6.79ns	98.26	5	C	6.05	97.42	10
5	**Kt 1228**	6.63***	111.18	5	C	5.88**	101.91	3	A	6.79ns	98.26	5	C	6.43	103.54	3
6	**Kt1239**	7.00***	117.38	4	B	6.00***	103.99	2	A	6.57---	95.08	7	C	6.52	104.99	2
7	**Kt1241**	*7.20****	*120.74*	*2*	*B*	*6.00****	*103.99*	*2*	*A*	*7.32***	*105.93*	*1*	*A*	*6.84*	*110.14*	*1*
8	**Kt3032**	7.05***	118.22	3	B	5.88**	101.91	3	A	5.78---	83.65	9	D	6.24	100.48	7
9	**Kt3033**	7.43***	124.59	1	A	5.58-	96,71	5	A	6.10---	88.28	8	D	6.37	102.58	4
10	**Kt1718**	7.20***	120.74	2		4.38---	75,91	8	B	7.28***	105.35	2	AB	6.29	101.29	6
	Mean	6.68				5.60				6.74				6.34		
	VC%	8.55				9.65				7.90				8.70		
	GD 5%	11.96				10.01				12.06						
	1%	16.27				13.63				16.41						
	0.1%	21.97				18.39				22.15						

Line Кt 1241 formed a yield of 7.32 t ha-1 and exceeded the average standard by 5.93% with very good demonstration. High yield was also obtained from Кt 1718, -7.28 t ha-1, where as Emon and Obzor were almost equal in yield= On the grounds of border differences the varieties were divided into groups, where the most highly productive fell into groups A, AB and ABC.

The lowest yields were obtained in 2012, when there was frost damage and thinning of the crops. The yield from Obzor was 5 % higher than the average standard, whereas lines Кt 1241 and Кt 1239 were equal in yield and exceeded the standard by nearly 4% with very good demonstration. In 2011, productivity ranged from 5.83 to 7.43 t ha-1. 7 lines were included in the high-yielding groups A, B and C, where the highest yield was observed in Кt 3033, Кt 3032, which exceeded the standard by 24.59% and 18.22%, respectively. Line Кt 1718 in that year again kept its high productivity and exceeded the standard by 20.74 %.

Good results were also seen in lines Кt 1239 and Кt 1228, which ranked 4th and 5th in the group. Average for the period the most high-yielding line was Кt 1241, with an average yield of 6.84 t ha-1. It stood out as an advanced line combining good performance, good stability and high productivity. **Table 3** presents the results obtained from the two-factor analysis of variance on the tested genotypes for the three years of study. The established F criteria showed significant differences between genotypes and years, as well as regarding the genotype x environment interaction. The genotype impact and the genotype x environment interaction were proven for all traits. The impact of the environment factor was proven not only by spike length. The factor effect (genotype) was demonstrated in all traits, which showed that the varieties had a proven effect in the total variability, where the greatest relative share was in the formation of spike length (76.58%), and the smallest – in the number of grains per spike (6.74%). 1000-grain weight was a comparatively conservative trait, which facilitated the selection in the breeding process (Valcheva et al., 2010). Our 3-year study found almost equal impact of genotype and year conditions and weaker genotype x environment interaction. The results can be explained with the specific combination of weather conditions during grain filling. In 2011 high temperatures accompanied by low relative air humidity caused lower values of the index, whereas in 2012 and 2013 the rainfall in the period of grain filling and lack of high temperatures favored the formation of grain with good physical properties. The year conditions had greatest effect on the grain yield. They held about 54% of the total variability, which is indicative of the significance of the ecological conditions on the yield formation. For the weight grain per spike, number of grains per spike and number of spikelets, the year conditions were also significant and determined between 43.69% and 34.08% of the total variability.

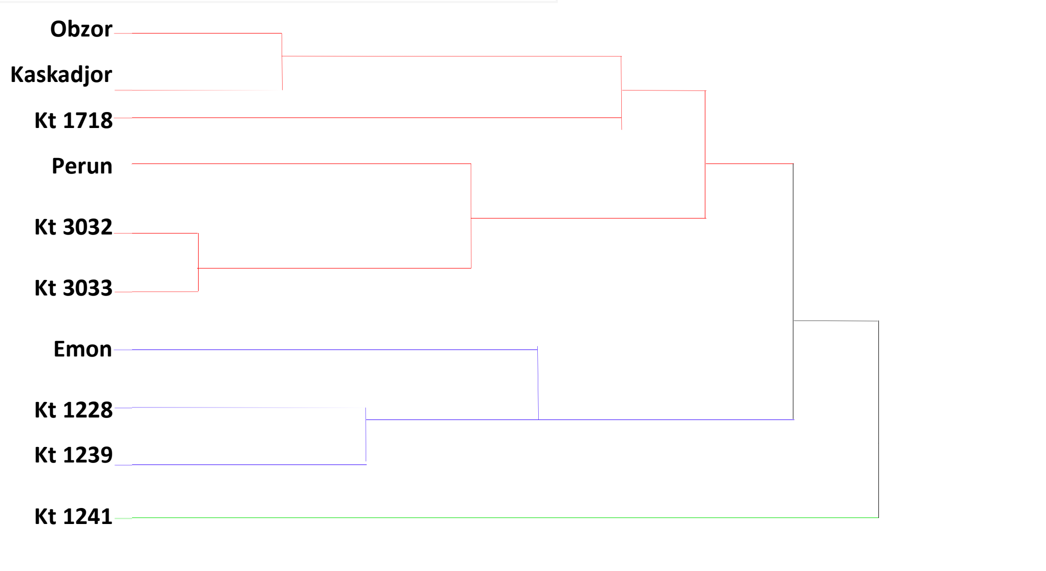
The groups of studied materials by yield and traits, e.g. genetic remoteness, are presented in **Figure 3.** It is clear from the dendrogram that the studied genotypes form 3 big clusters. The first cluster includes Obzor, Kaskadior, Perun and lines Кt 1718, Кt 3032, Кt 3033.

Table 3 Analysis of variance in the two-row winter barley lines from the three years of study

SOUR SE	GENOTYPE			LOCATION			GXL		
	SS	η	F-count	SS	η	F-count	SS	η	F -count
L	118.390	76.58	13.154**	0.7103	4.59	0,65ns	30.608	19.49	5.14**
NSS	463.960	34.81	3.29**	525	39.44	37,88**	282.283	21.18	3.95**
NGS	480	6.74	3.36**	441.117	34.08	22.75**	285.550	22.04	4.1**
WGS	1.008	19.48	27.03**	2.258	43.69	2.59**	1.741	33.64	6.58**
MASS	854.097	36.17	2.95**	738.615	31.26	17.38**	578.340	24.47	2.06*
YIELD	6.060	9.72	0.87**	33.798	54.14	124.14**	21.340	34.18	14.79**

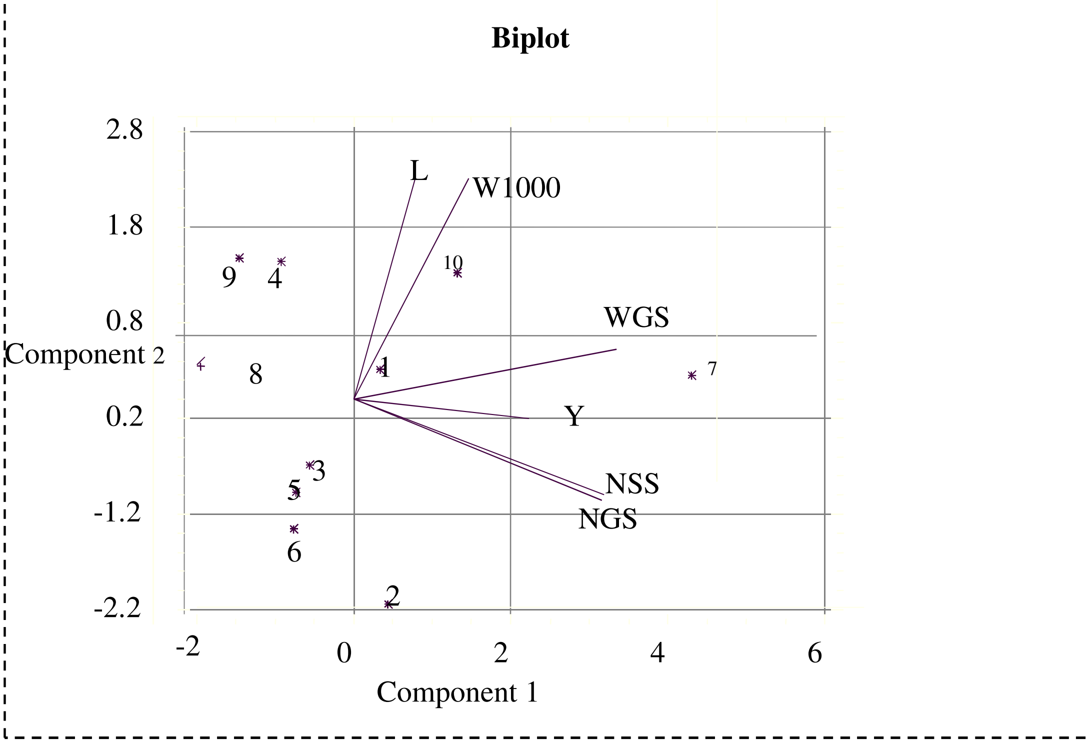
which were created by means of experimental mutagenesis and have similar properties – grain weight per spike, number of spikelets per spike, spike length. Obzor and Kaskadior form a subgroup of similar 1000-grain weight. Within the second cluster, similarity is found between Kt 1239 and Kt 1228 by grain weight per spike. Genetically closest to them is the Emon variety. The genetic remoteness between the genotypes by studied traits was greatest between the first cluster varieties and line Kt 1241. The representatives of the first cluster, which formed longer spikes and could cross with Kt 1241, are suitable for source material. Line Kt 1241 distinguished with heaviest spike and biggest grain and is suitable for various breeding programs.

F igure 3. Hierarchical cluster analysis of two-row barley lines



A principal component analysis was carried out as it allows a combination of the traits and the correlations with genotypes **(Figure 4).** There are 2 eigenvalues bigger than 1, which determined the choice of 2 principal components. These components explain about 79% of the total variability. The first component explains 53.42%, the second - 26.21% of the total variability. Not very high values of the principal components speak of complexity of the traits correlations. The first component is mainly related to grain weight per spike, number of grain per spike and number of spikelets per spike. 1000-grain weight and spike length take part in forming the second component. As the first axis has greatest relative share to explain the total variability, then the traits of highest correlation to this axis have greatest relative share to explain the variability. Grain yield is in negative correlation with grain weight per spike, 1000-grain weight and spike length, and these three traits are in positive correlation, whereas the last one (spike length) is not related to number of grains per spike. The position of the genotype points can lead us to conclude about their relationship with the traits. The closer the genotype points are to a given trait, the better expressed genotype we see by this trait. As you can see, there is certain similarity in the distribution of genotypes in the dendrogram. Closest to the vector number of spikelets per spike and number of grains per spike are Kt 1228, Kt 1239 and the Kaskadior variety. In spite of the higher number of grains per spike, this group has lower grain weight per spike. Lines Kt 3032 and Kt 3033 and the Perun variety have a longer spike but less grain in it and lower weight. Grain yield from lines Kt 1241, Kt 1718 and Obzor are directly related to the high grain weight per spike and high 1000-grain weight. Because of the good combination of these traits, the group can be successfully used for hybridization. Line Kt 1241, not only has big grain and heavy spike, but it also boasts a high yield, which makes it suitable for further testing as a variety.

Figure 4. Principal component analysis



On the grounds of the analisys we can draw the following

Conclusıons:

Out of the tested lines of winter two-row barley the most high-yielding were Kt 1241, Kt 1239 and Kt 1228.

The lines of the first cluster, which formed longer spikes and could cross with Kt 1241, are suitable for source material .

Line Kt 1241 distinguished by heaviest spike and biggest grain, which allows its successful inclusion it various breeding programs. It is characterized by high grain yield, which makes it suitable for further testing as a variety.

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