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QUANTITATIVE AND COMPLEX ASSESMENT OF MALTING BARLEY GENOTYPES IN RELATION TO THEIR USE FOR THE BREEDING

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Abstract

The investigation was conducted on the experimental field of the Agricultural University - Plovdiv, during the period 2010 - 2013 year. The present study includes 24 local and foreign genotypes two-row barley. For the first time have been assessed advantages of perspective genotypes as initial material by applying the "Model of quantitative and complex assessment" of the breeding lines and varieties in relation to their use in different barley breeding directions. The model was created as a methodology, approach and mathematical expression by Prof. Georgiev (2013) and can be applied in all cultures. Based on this model there was established the advantages of studied genotypes in the corresponding direction and combination of beneficial traits in each of them. As a result may be selected the most perspective varieties for barley breeding, implementation in practice and selection the trends in the most suitable parental forms for hybridization.
Analysis of the results reveal five of studied cultivars: ***Caravela*** *(102.17 p.),* ***Kaskadior*** *(101.30 p.),* ***Neda*** *(103.83 p.) and* ***Gorast*** *(101.0 p.) which exceed the standard* ***(Obzor****-95.63 p.) with the highest comprehensive overall assessment, which make them useful for direct application in the malting barley breeding .The advantages of using method was that allow us not only to estimate the common comprehensive assessment of the studied genotypes as a initial material, but It gave us the possibility to see exactly in which breeding areas they have strong express traits.*

Key words*: initial material, barley breeding, selection, two-row barley, yield.*

INTRODUCTION

To achieve good results in the barley breeding, is necessary to use different initial genetic material, which have to be preliminary studying (Ganusheva et al., 2004; Zakova et al., 2004; Vulcheva et al., 2008).
The main malting barley breeding problems are referring to the improvement of traits related to productivity, quality, adaptive potential and suitability for mechanized farming (Marcheva et al., 2005; Spunar et al., 2008).
The barley breeding program represents the characterization of agronomic, grain and malt quality traits of potential new genotypes (Knežević et al., 2004, Marcheva and Koteva, 2013). Testing of newly cultivars in different environmental condition giving us the possibility of estimation genotypes / environments interactions and characteristics of the variety or group of varieties to one unit in order to make them comparable and measurable. That means all parameters and directions to obtain a numerical representation (Georgiev et al., 2013).

MATERIALS AND METHODS

The experimental work is carried out on the field of the Agricultural University - Plovdiv, during the period 2010-2013 year.
Current research involves analysis of 24 varieties two-row barley with different origin. Genotypes 82105326, 89105100, 96105023, 96105024, 96105027, 96105046, 96105050, 99105020, 99105030, I-Da/102 are provided by the National Gene Bank (IPGR) - Sadovo. Perspective breeding lines 508, 511, 622 are result from the breeding work done in the department of "Genetics and Plant breeding", Agricultural University - Plovdiv. There are also used cultivars: Alexis, Beta Ketzoras, Emon, Kamenitza, Caravela, Cascadior, Obzor and newly established varieties Neda and Gorast as initial material (Table 1). Orphey and

Kyfi are provided from the Institute of Agriculture, Karnobat.
Obzor is used as a standard and all studied genotypes have been compared with it.

Table 1. Genotypes used as an initial material

N	Genotype	breeding line/cultivar	Origin
1	Obzor St	cultivar	Bulgaria
2	82105326	Weibills/Clara	Germany
3	89105100	Biiru/Hadaka	Japan
4	96105023	Felice	France
5	96105024	Douchka	France
6	96105027	Baronesse	France
7	96105046	Teleno	France
8	96105050	Freke	France
9	99105020	NRPB801116/Cameo	France
10	99105030	VDH405388/Ragtime	France
11	508	breeding line	Bulgaria
12	511	breeding line	Bulgaria
13	622	breeding line	Bulgaria
14	ID-a/102	cultivar	Syria
15	Alexis	cultivar	Germany
16	Beta Ketzoras	cultivar	Hungary
17	Emon	cultivar	Bulgaria
18	Kamenitza	cultivar	Bulgaria
19	Caravela	cultivar	Portugal
20	Kaskadior	cultivar	Bulgaria
21	Neda	cultivar	Bulgaria
22	Gorast	cultivar	Bulgaria
23	Orphey	cultivar	Bulgaria
24	Kyfi	cultivar	Hungary

To assess promising breeding lines and varieties is used "The model of quantitative and complex assessment" of prof. S. Gergiev, applied for the first time in malting barley in current research.
Transformation of agronomic evaluation data of the studied samples to mathematical model was based on the equation introduced by Федин и кол. (1978).

$$H=a_1 \bar{x}_1+a_2 \bar{x}_2+\ldots+a_n \bar{x}_n$$

Where H is the middle value of breeding index of the trait.
$\bar{x}_1, \bar{x}_2 \bar{x}_n$ are the real values of single trait:
a_1, a_2, a_n are coefficients of the specific weight or importance of the trait
In quantitative and complex assessment there are introduced not single traits and breeding index, but used the breeding directions. Input equation is transformed by prof. Georgiev (1988, 2013) in the following form:

$$H=a_1A+a_2B+a_3C+a_4D+a_5E$$

Where adapted for the malting barley, breeding direction:
"A" is a real yield for the different genotypes;
"B" - biological features;
"C" - vegetation period;
"D" - malting-technological qualities;
"E" - ability for mechanized harvesting.
Because the analyzed traits participated in the every breeding direction are measured with the different measurement units-kg, %, day, degree and go on, they have to be transformed in simple numbers to be done comparable. To achieve this transformation we give different numbers as coefficients for specific weight or importance of the traits as following:
a_1= 30:, a_2 =20:, a_3 =10: a_4 =30: a_5 =10. Sum has to be 100 (Table 2)
All these numbers are given for the real value of the traits of standard. There were studied and analyzed some of the important quantitative and qualitative traits in relation to productive potential and malting quality.
Yield (A) is reported based on real production of every genotype in three consecutive years, calculated in comparison with standard.
The second barley breeding direction (B) reflects the adaptive potential of genotypes. It is determined by the ability of plants to survive in spite of abiotic and biotic stress factors. The cold resistance was assessed by the percentage of surviving plants after wintering in field conditions during the three years of study. Drought tolerance is determined based on degree of root and seedling depression of plants in terms of osmotic stress (Божанова, 2007). With higher number are evaluated genotypes with a lower degree of depression, which corresponds to their drought tolerance. Percentage of uninfected plants of economically significant diseases in natural conditions, without extra inoculation has been established. Highest number as a coefficient is given to uninfected genotypes.
The vegetation period (C) is reported in days, with higher coefficient values were assessed forms with short vegetation period.
The values of the traits determining brewing technology qualities (D) are reported by standard laboratory methods in the Institute of Agriculture, Karnobat.
Indicators that measure the criterion suitability for mechanized harvesting (E) are; plant height,

resistance to beaten down, uniformity and spike impairment. The rated values of these parameters are calculated according the standard cultivar Obzor.

RESULTS AND DISCUSSIONS

The data from agronomic characteristics of promising studied lines and cultivars is in different units. Application of mathematical model of Quantitative and complex assessment allows to transform all data into simple numbers, and make possible comparison between them.

Coefficient of importance for each selection criteria is determined according to its significance in the barley breeding program. The sum of all is equal to 100 points (Table 2).

Table 2. Breeding directions and coefficients of importance

Breeding directions	Indicators of phenological observations, biometric measurements and laboratory analyzes		Coefficient of importance of the direction	Coefficient of importance of the trait
Yield (A)	Yield		**A-30**	A_1-30
Biological features (B)	Cold resistance		**B-20**	B_1-5
	Drought resistance			B_2-5
	Disease resistance	Resistance to Powdery mildew		B_3-4
		Resistance to Loose smut		B_4-1
		Resistance to Stripe disease		B_5-1-
		Rust disease		B_6-3
		Resistance to BYDV		B_7-1
Vegetation period (C)	Vegetation period		**C-10**	C_1-10
Malting-technological qualities (D)	Protein content		**D-30**	D_1-7
	Extract content			D_2-6
	Starch			D_3-6
	Uniformity – 2.5-2.8			D_4-6
	Mass of 1000-kernels			D_5-5
Ability for mechanical harvesting (E)	Plant height		**E-10**	E_1-2
	Resistance to lodging			E_2-4
	Uniformity of tillers			E_3-2
	Spike impairment			E_4-2

The yield, as a breeding direction of paramount importance in all cultures, current barley breeding program is given highest coefficient - 30. To be established the "best cultivar" or „perspective line", they have to exceed the yield of standard - Obzor -575kg/ha^{-1}, which has 30 points as a coefficient of importance of this trait.

According to this model for quantitative and complex assessment the newly approved cultivar Neda gives yield 691 kg/ha^{-1}. What number of points will receive it? We calculate 691/575 =120 % x a_1 - 30 = 36.0 points. In this way is calculating yield of all varieties. Some of significantly more productive varieties with highest numbers than the standard are: Gorast (656 kgha^{-1} = 34.23 points), Kaskadior (650 kgha^{-1} = 33.91 p.), Kamenitza (630 kgha^{-1} = 32.87 p.), 96105046 (623 kgha^{-1} = 32.50 p.), Beta Ketzoras (623 kgha^{-1} = 32.50 p.), Caravela (623 kgha^{-1} = 32.50 p.) and Orphey (619 kgha^{-1} = 32.30 p.) (Table 3).

Biological features presented by the criterion B, whose total value is 20 points, includes the traits cold, drought resistance and resistance to diseases. Each of them is with coefficient 5, 5 and 10 points, respectively. Resistance to abiotic stress factors is established according to Material and methods. Coefficient of importance 5 to cold resistance is given to the actual values of Obzor cultivar. Cultivars Neda (5.6 points) and Kamenitza (5.6 p.) received the highest number of points due to a proportion of wintered plants (95%) compared to the standard (85%), respectively 5.6=(5x95)/85. Similar calculations are for drought tolerance of the studied genotypes. Criteria for disease resistance (B), according to the applied mathematical model - maximum coefficient is given to immune varieties. Current research is conducted in natural inoculation, therefore we can not state with certainty that the lack of damage to some varieties due to their resistance. For greater precision high number's values are given to 100% uninfected plants. Economically significant barley diseases in Bulgaria recent years are: Powdery mildew (note 4), Loose smut (1), Stripe disease (1), Rust disease (3) and BYMV (1), each receiving a different number values depending on distribution and the total is 10 points. In case of lack of Loose smut attack and BYMV all genotypes are evaluated with 1 point. For other diseases, on a reported assault shall be placed

and to calculate the percentage of healthy plants. According to the complex evaluation of studied varieties, all of them has coefficient over 10 points and are perspective in Biological features breeding direction (B). With higher adaptive potential are Emon (17.45 points), Kamenitza (18.05 p.), Neda (17.71 p.) and Orphey (17.20 p.) (Table 3).

Table 3. 100 note quantitative and complex evaluation of perspective barley breeding lines

	Yield (A)	Biological features (B)							Veget. period (C)	Malting-technological qualities (D)					Ability for mechanical harvesting (E)			
Genotype	Yield - /note/ $A_1$30	Cold resistance /note/ $B_1$5	Drought resistance /note/ $B_2$5	Resistance to Powdery mildew /note/ $B_3$4	Resistance to Loose smut /note/ $B_4$1	Resistance to Stripe Disease /note/ $B_5$1	Rust disease /note/ $B_6$3	Resistance to BYDV /note/ $B_7$1	Vegetation period /note/ $C_1$10	Protein content /note/ $D_1$7	Extract content /note/ $D_2$6	Starch /note/ $D_3$6	Uniformity – 2.5-2.8 /note/ $D_4$6	Mass of 1000-kernels /note/ $D_5$5	Plant height /note/ $E_1$2	Resistance to lodging /note/ $E_2$4	Uniformity of productive tillers /note/ $E_3$2	Spike impairment /note/ $E_4$2
Obzor St	30	5	5.00	2.4	1	0.4	1.5	1	10	7.00	6	6	6	5	2	3.6	1.8	2
82105326	22.6	4.4	4.37	2.0	1	0.8	1.5	1	13.1	6.93	5.9	5.0	5.9	5.4	1.8	4.0	1.8	1.8
89105100	20.8	4.4	4.03	2.8	1	0.8	1.8	1	10.0	7.12	5.7	5.0	6.0	5.7	1.8	4.0	2.0	1.8
96105023	30.3	4.1	5.39	1.6	1	0.7	1.2	1	10.0	7.33	5.9	6.0	5.5	5.5	1.8	4.0	2.0	1.8
96105024	30.8	4.1	4.93	2.4	1	0.5	0.9	1	10.0	7.02	5.5	6.1	5.8	6.2	1.7	4.0	1.6	2.0
96105027	24.8	2.4	4.46	1.2	1	0.4	0.6	1	13.1	7.11	5.9	6.1	6.1	5.5	1.8	4.0	2.0	2.0
96105046	32.5	5.0	4.59	1.6	1	0.4	1.5	1	10.0	7.17	6.0	6.4	5.8	4.7	1.6	4.0	1.8	2.0
96105050	32.1	4.1	4.91	1.2	1	0.7	1.5	1	10.0	7.24	6.0	5.0	6.0	4.7	1.6	4.0	2.0	2.0
99105020	31.8	4.1	4.50	2.4	1	0.6	1.2	1	13.1	7.23	6.2	6.7	5.4	4.4	1.6	4.0	2.0	2.0
99105030	31.2	4.1	4.89	2.4	1	0.6	1.2	1	13.1	7.21	5.8	6.6	5.4	4.6	1.6	4.0	1.6	2.0
508	26.2	4.7	4.19	2.8	1	0.7	0.6	1	6.5	6.95	5.9	4.7	5.9	4.7	1.7	4.0	1.8	1.8
511	25.6	4.7	4.57	1.2	1	0.7	0.9	1	6.5	7.08	5.9	4.6	5.4	4.4	1.2	4.0	2.0	1.8
622	24.5	4.7	4.54	3.2	1	0.7	0.9	1	**13.1**	6.81	5.7	4.7	6.1	5.2	1.9	3.6	1.6	1.8
ID-a/102	21.3	3.5	**5.19**	0.8	1	0.9	0.6	1	13.1	6.81	5.9	5.2	6.0	4.8	1.5	3.6	1.8	1.6
Alexis	26.1	4.1	4.37	2.4	1	0.4	1.2	1	13.1	7.01	6.0	5.6	6.1	3.7	1.5	4.0	2.0	1.6
B.Ketzoras	**32.5**	5.3	4.48	2.4	1	0.3	1.8	1	6.5	7.09	6.0	6.4	5.6	5.9	2.0	3.6	2.0	2.0
Emon	31.4	5.3	5.06	2.4	1	0.6	2.1	1	10.0	6.73	6.0	6.2	6.1	5.5	2.1	3.6	1.8	2.0
Kamenitza	**32.9**	**5.6**	5.06	2.8	1	0.5	2.1	1	6.5	6.86	5.6	6.0	5.7	5.3	1.9	3.6	1.6	2.0
Caravela	**32.5**	5.3	5.06	2.4	1	0.7	1.5	1	13.1	6.96	5.8	6.6	5.9	4.8	2.0	3.6	2.0	2.0
Kaskadior	**33.9**	5.3	4.90	2.4	1	0.5	1.2	1	10.0	7.08	6.0	6.7	5.9	5.8	1.6	4.0	2.0	2.0
Neda	**36.1**	**5.6**	4.71	2.8	1	0.6	1.8	1	10.0	7.14	5.5	6.4	5.9	5.6	1.8	4.0	2.0	2.0
Gorast	**34.2**	5.3	4.63	2.8	1	0.7	1.5	1	10.0	7.17	5.5	6.0	5.6	5.9	1.7	4.0	2.0	2.0
Orphey	**32.3**	5.0	**5.51**	2.4	1	0.7	2.1	1	6.5	7.11	6.1	6.6	4.6	4.6	2.0	3.6	1.8	2.0
Kyfi	24.5	4.4	4.34	2.0	1	0.5	1.5	1	10.0	6.88	5.9	4.6	4.8	5.2	1.5	4.0	1.6	1.6

Three groups are observed according vegetation period in the survey: genotypes with 225, 217 and 210 days. As a breeding direction – C, 10 coefficient is given to the standard Obzor with 217 days vegetation. The cultivar is with winter-spring biotype. According to mathematical model perspective forms for the breeding will be those with highest number - 13.3 points (210 days vegetation). Most of them are typical spring forms, which are not that suitable for Bulgarian agro-meteorological conditions. Among genotypes with early vegetation, only breeding line 622 is with winter biotype (13.1 p.).

Main traits formed malting-technological qualities (D) of barley are: protein content, extract, starch, uniformity and mass of 1000-kernels. Total value of the breeding direction (D=30 points) coefficient, decomposes to component traits according to their importance. are given to the standard Obzor. Malting quality is determined mainly by low protein content. In this study protein content of lines and cultivars vary from 9.43% (for 96105023) to 16.88% (for Emon). With coefficient 7 for Obzor (13.52%), the note of the breeding line with lowest protein content, as perspective for malting barley breeding will be (7*(100-9.43)/100-13.52)=7.33 points. At the opposite, for the other traits, important for barley breeding programs are genotypes with higher percent extract, starch, uniformity and higher values of mass for 1000-kernels. For example if one genotype has 78.8% extract (99105020), then the number's value will be (6*78.8)/76.6 (Obzor).

Mainly indicators that determine the direction ability for mechanized harvesting (E) are plant height, resistance to beaten down, uniformity of productive tillers and spike impairment. In general, according to significance of breeding direction is given coefficient of importance 10. Coefficients values of studied genotypes varies from 8.36 points to 9.77 p. with maximum

score 10, which defines all lines as suitable for mechanized harvesting and determines progress in breeding improvement works in malting barley in that direction.

Possible coefficient values that can reach the standard Obzor can be 100 points, in case that plants are not infected by diseases (Table 4). All other varieties are compared with the standard and if they exceed, receive higher values on specific criteria and thus in the common overall assessment.

Table 4. Quantitative and complex evaluation

N	Variety/breeding line	Total bal	
		points	%
1	Obzor St	95.63	100.00
2	82105326	89.24	93.32
3	89105100	85.68	89.60
4	96105023	95.08	99.42
5	96105024	95.54	99.90
6	96105027	89.30	93.38
7	**96105046**	**97.04**	**101.48**
8	96105050	95.05	99.39
9	**99105020**	**99.25**	**103.79**
10	**99105030**	**98.17**	**102.65**
11	508	85.04	88.93
12	511	82.40	86.17
13	622	90.94	95.09
14	ID-A/102	84.34	88.19
15	Alexis	91.23	95.40
16	Beta Ketzoras	95.71	100.09
17	**Emon**	**98.70**	**103.21**
18	Kamenitza	95.84	100.22
19	**Caravela**	**102.17**	**106.83**
20	**Kaskadior**	**101.30**	**105.93**
21	**Neda**	**103.83**	**108.57**
22	**Gorast**	**101.00**	**105.61**
23	Orphey	94.88	99.22
24	Kyfi	85.27	89.17

Based on the comprehensive evaluation of studied varieties, which percentage exceed the standard in complex of traits are: 96105046 (1.48%), 99105020 (3.79%), 99,105,030 (2.65%), Emon (3.21%), Caravela (6.83%), Kaskadior (5.93%), Neda (8.57%) and Gorast (5.61%). Depending on this, varieties and lines can be recommended for testing and introduce directly in production, and as an initial material for crosses.

CONCLUSIONS

As a result of conducted quantitative and complex assessment of studied genotypes, variety Neda (103.83 points) is with highest comprehensive assessment, followed by Caravela (102.17 p.), Kaskadior (101.30 p.) and Gorast (101.0 p.). Applied mathematical model show us the varieties and breeding lines, which possess many positives traits combined in complex and allow us to prefer these varieties, as the best parents for the hybridization, to combine the desirable and appropriate traits in hybrid generations of the barley breeding.

Using the method it is possible to identify the advantages of the relevant genotypes in different breeding directions. The most productive ones stand newly established varieties in Bulgaria: Neda (36.05 p.) and Gorast (34.23 p.), with an average value of direction A=30 points (for Obzor).

Considerable variety of forms seen in the direction B (biology features). With high adaptive potential according quantitative and complex assessment are genotypes: Emon (17.45 points), Kamentitza (18.05 p.), Caravela (16.95 p.), Neda (17.50 p.), Gorast (16.92 p.) and Orphey (17.71 p.) etc.

With short vegetation 210 days (13.3 points) differ genotypes: 82105326, 96105027, 99105020, 99105030, 622, ID-a/102, Alexis and Caravela. All of them can be donors of desirable traits in vegetation period breeding direction-C.

With good brewing technological qualities and highest complex assessment over 30 points are: 96105023 (30.23 p.), 96105024 (30.65 p.), 96105027 (30.63 p.), 96105046 (30.05 p.), Beta Ketzoras (30.88 p.), Emon (30.43 p.), Caravela (30.05 p.), Kaskadior (31.46 p.), Neda (30.51 p.) and Gorast (30.11 p.).

All studied samples fully cover the requirements for mechanized harvesting, as shown by their similar coefficients of importance in this direction (from 8.36 to 9.77 with maximum points 10).

As a result some of the tested genotypes with high overall value and highest comprehensive evaluation in breeding direction brewery technological qualities were selected as initial parental forms in crosses.

REFERENCES

Божанова В., 2007. Изследване на сухоустойчивостта на твърда пшеница чрез депресията на растежа при осмотичен стрес. II-ра научна конференция

"Проблеми на влакнодайните и зърнено-хлебни култури", Чирпан, p. 78-83.

Георгиев С., 1988. Агробиологично и технологично проучване на таксономичните разновидности фъстъци (*A. hypogaea* L.) при условията на Централна Южна България. Дисертация за присъждане на научната степен "Доктор на селскостопанските науки".

Федин М.А., Силис Д.Я., Смиряев А.В., 1978. Метод индексов, основанныій на дискриминантныіх функциях для отбора сортов. Генетика количествеіх признаков селсохозяйственныі растений. Наука, Москва, p. 58-62.

Vulcheva D., Vulchev D., 2008. Studies on phenotypic diversity in models double-breasted winter barley introduction. Union of Scientists-Stara Zagora, International Scientific Conference, June 5-6.

Ganusheva N., Dimova D., Toshev N., 2004. Prospective study of two-row barley lines. Plovdiv, Scientific Works, Vol. XLIX, p. 159-164.

Georgiev S., Ganusheva N., Stamatov S., Deshev M., 2013. Approaches and methods as a model in the breeding of self-pollinated crops. Academic Publishing Agricultural University

Knežević D., Pržulj N., Zečević V., Đukic N., Momčilović V., Maksimović D., Mićanovic D., Dimitrijević B., 2004. Breeding strategies for barley quality improvement and wide adaptation Kragujevac J. Sci., 26: 75-84.

Marcheva M., Koteva V., 2013. Correlation between quantitative traits and quality parameters of barley, cultivated in different environmental conditions. Proceedings of the Second Scientific Conference with international participation "Theory and Practice in Agriculture" UF, November 22 to 24, Undola, p. 25-32.

Marcheva M., Gorastev Ch., Bozhanova V., 2005. Evaluation of drought tolerance of perspoctive barley lines of a complex population. Collection of scientific works of the Balkan Conference, 80th anniversary of the establishment of the Institute of Agriculture - Karnobat, June 2, 2005, Selection and agrotechnics arable crops, p. 173-178.

Spunar J., Blumel H., Fouquin G., 2008. Global warming impact-winter barley as reserve crop for brewing industry in the traditional European countries declaring exclusive or dominant spring malting barley utilization. Proceedings of the 10th International Barley Genetics Symposium 5-10 April, Alexandria, Egypt, p. 395-405.

Zakova M., Benkova M., 2004. Genetic Diversity of Genetic Resources of Winter Barley Maintained in the Genebank in Slovakia. Czech J. Genet. Plant Breed., 40 (4): 118-126.