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YIELD POTENTIAL AND STABILITY OF SOME SPRING BARLEY VARIETIES AND LINES

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Abstract

The experimental results were processed according to the polyfactorial experiences of type A x B x C where: A- was represented by the factor of locations with two graduations (Turda and Fundulea), B was the factor of year with three graduations (2016, 2017 and 2018) and C- factor genotypes with 25 graduations. Lines To 2027/10, To 2208/02 and the reselection of the Jubileu variety, are particularly noticeable in terms of average yield with relative increases compared to the control of 10, 9 and 5% respectively. The variation of the absolute productions was between 3683 kg/ha and 4862 kg/ha in Turda conditions and between 3265 kg/ha and 4143 kg/ha in Fundulea conditions. Following the use of the method proposed by Francis and Kannenberg (1978), the lines To 2027/10, To 2208/20, To 2167/01, To 2054/97, To 2095/01 and To 2013/99) which have a coefficient of variation below the average value and high output above average have proved to be production stable.

Key words: *spring barley, genotype, yield, stability, location*

INTRODUCTION

In our country, the spring barley meets very favourable conditions of culture in a quite restricted area (Bârsei Country, Sfântul Gheorghe and Târgul Secuiesc, Someșului Valley, Aries Valley, Mureş Valley, Criş Valley and the sub-Carpathian area of Moldova) a humid and cool climate. The dry and semi-dry areas of the country as well as the areas with light sandy soils are unfit for the culture of barley. In these less favourable areas, the production of barley is affected both quantitatively and qualitatively, an aspect which refers in particular to barley for beer. The most important quantitative reductions in barley yield occur when the grain filling phenomena occur longer periods with high temperatures, as a result of soil drought, reducing the period of accumulation of carbohydrates in grain, very common phenomena in most areas of the country [6]. The humid and cool climates positively mark the quality of barley for beer, as it favours the accumulation of starch in detriment of proteins [2, 3]. Yield capacity is determined by internal factors (genetic) and external factors (environmental conditions). According to Ceapoiu (1984), 56% of the total variance of a variety's production is affected by external conditions. This implies that 40-50% of the total variance would be genetically determined [1]. In some cases, the intrinsic genetic contribution to increasing production capacity has been associated with improved resistance to disease, fall or unfavourable environmental conditions. To prove their genetic contribution in this regard [7] performed an experiment with old and new varieties of wheat, which created artificial conditions for disease and fall prevention. Under these conditions, the production of new varieties exceeded the old varieties by about 2 tonnes per hectare, both at a high fertilisation level and at a reduced nitrogen fertilisation.

In determining the value of a cultivar, in addition to the yield potential, an important weight must have the stability of production. The lack of this trait can make a variety valuable only under certain, very specific conditions. Unfortunately, ideal conditions do not exist because between years and localities, there are differences of climate and soil, the attack of diseases and pests and so on. The differences can be bigger or smaller, in any case, they exist. However, the need to appreciate the value of a variety must take into account the phenotypic stability [1].

Recent climate data analysis confirms the signals of increasing average annual temperatures to scientists. This is being felt more and more often in the established areas of spring barley culture. Furthermore, in many areas of the country, the years with dry autumn are more frequent, which directly contribute to the reduction of the areas sown with wheat, barley and oats. Given these considerations, the identification of genotypes with high ecological plasticity, capable of forming reasonable harvests from one year to the next or in less favourable geographical areas, becomes a new challenge for the ARDS Turda breeding team. These prerogatives could be materialized by testing the material (varieties and lines) under various pedoclimatic conditions or by using the hybridization works of genetically differentiated but also geographically differentiated parents. Thus, in a first stage we set out to test some lines and varieties of spring barley in an area where this crop does not meet favourable conditions, namely in the south of the country at NARDI Fundulea.

MATERIALS AND METHODS

The biological material that was the object of this experiment was represented by 25 lines and varieties of spring barley created at ARDS Turda (24) and ARDS Suceava (1), by the hybridization method followed by selection. For the field placement of the experiments the randomized blocks method was used in five replications. The sown area of the experimental plots was 14 m^2, being harvested only 10 m^2 according to the rules of experimental technique. In both areas, the same sowing rate of 550 germinated seeds/m^2 was used, the work being performed in the spring in the first instance, practical when in each location, the humidity of the land allowed this work to be carried out under optimal conditions. The experimental protocol provided for the use of identical doses of N mineral fertilizers in both locations (100 kg commercial product/ha). The fertilizer used was ammonium nitrate, applied in a single spray, spring after emergence. The experimental results were processed according to the polyfactorial experiences of type A x B x C in which: A- was represented by the factor of locations with two graduations (Turda and Fundulea), B- was the factor of year with three graduations (2016, 2017 and 2018) and factor C- genotypes with 25 graduations. The climatic data recorded in the three years in the two areas are presented in Table 1. The monthly distribution of rainfall over the three experimental years compared to the multiannual average reflects a significant variation. According to the data it could be said that the winter months are poorer in precipitation in the area of Turda compared to that of Fundulea. It can also be observed that in both areas, in March, there was excess rainfall, above the multiannual average of the area. The precipitations of April, the precipitations that have a remarkable impact on the tillering capacity and implicitly on the production, exceeded the multiannual average characteristic of each area. However, it should be noted that in 2018, the precipitation this month was below average in both locations, the most pronounced water deficit being recorded at Fundulea, an area where the precipitations of this month were almost completely absent. It could be mentioned further that this year continued with one more month of rainfall deficiency, a deficit that was more pronounced under the conditions at Fundulea. The evolution of precipitation from 2018 in the two areas showed a considerable impact on the yield potential of the studied variants. From the point of view of the temperatures it is possible to see the positive tendency of deviation of them in comparison with the multiannual average in almost all the months of the three years and in both areas.

Table 1. Rainfall and thermal regime, ARDS Turda and NARDI Fundulea (2016, 2017 and 2018)

	Turda						Fundulea					
months	**January**	**February**	**March**	**April**	**May**	**June**	**January**	**February**	**March**	**April**	**May**	**June**
Rainfall (mm)												
2016	25	23.8	47	62.2	90.4	123.2	53.3	10.3	54.9	73.7	81.2	43.7
2017	2.6	19.2	46.1	65.2	65.4	30.6	35.4	50.5	47.6	73.4	65.8	96.4
2018	16.7	33.4	40.9	26.2	56.8	98.3	36.0	58.6	40.6	2.4	34.0	120.6
multiannual average	21.8	18.8	23.6	45.9	68.6	84.8	34.5	31.7	37.1	44.6	61.5	74.1
Temperature (°C)												
2016	-2.8	4.6	5.9	12.4	14.3	19.8	-4.3	6.2	7.3	13.9	15.9	22.9
2017	-6.4	1.5	8.4	9.9	15.7	20.7	-5.5	-0.1	8.5	10.6	16.8	22.2
2018	0.2	-0.3	3.3	15.3	18.7	19.4	0.7	1.6	3.3	15.8	19.4	22.6
multiannual average	-3.4	-0.9	4.7	9.9	15	17.9	-2.3	-0.3	4.8	11.2	17.0	20.8

Primary data source: Turda and Fundulea weather station (longitude: 23°47 '; latitude 46°35'; altitude 427 m).

RESULTS AND DISCUSSIONS

The experimental conditions (3 years x 2 locations) constituted a varied framework for the study of biological material, an assertion that emerges from the meanings of the sample values "F" corresponding to the years and locations, values that are statistically assured as being very significant (Table 2). Regarding the production potential of cultivars, from the analysis of the variance it can be noted the presence of yield differences, very significant between genotypes, differences that were not cancelled out by the variances of years and locations.

Table 2. ANOVA for grain yield at 25 spring barley genotypes in a multifactorial experience

The source of variability	GL	s^2	F
Year (A)	2	147560400	8790 ***
AxL	2	12654840	465 ***
Localities (L)	1	77775230	2856 ***
Genotype (C)	24	1461607	310 ***
AXC	48	364 373	77 ***
LxC	24	816 896	173 ***
AxLxC	48	330 572	70 ***
Error A	8		
Error L	12		
Error G	576		

Source: original, obtained through the statistical program.

According to the data presented in Table 3, it can be said that only in one year, the three conditions favourable for the crop of spring barley were met.

The year 2017 showed a positive impact on the capacity of expressing the production potential of the 25 variants, the yield differences from the control being very significant, the quantitative increase was 879 kg/ha. The smallest productions were registered in 2018, the differences from the control being smaller by 541 kg/ha, which represents very significant negative differences. In the context of climate change, the claims regarding the importance of the stability of crop yield are largely confirmed.

Table 3. The influence of the year factor on the average yield at 25 spring barley genotypes tested in two locations (Turda and Fundulea)

Years	Yield (kg / ha)	%	Difference	Significance
Average	3.961	100	0.00	Mt.
2016	3.622	92	-339	000
2017	4.841	122	879	***
2018	3.420	86	-541	000
DL (p 5%)	27			
DL (p 1%)	39			
DL (p 01%)	58			

Source: original, obtained through the statistical program.

Table 4. Influence of localities factor on average yield at 25 spring barley genotypes (2016, 2017 and 2018)

Places	Production kg/ha	%	Difference	Significance
Turda	4.283	100	0.00	Mt.
Fundulea	3.639	85	-644	000
DL (p 5%)	26			
DL (p 1%)	37			
DL (p 01%)	52			

Source: original, obtained through the statistical program.

The differences in yield between the two areas reflect the major involvement of the environment on the production potential of the 25 studied variants. Results shown in Table 4 are indicative in this respect, as the climatic conditions in the production Fundulea record a very significant decline compared to the control, represented by Turda. In choosing Turda as a control, it was considered that this area is very favourable to the barley culture, whereas if the average control between the two areas were preferred, the discrepancy between them was less obvious. The average yield capacity of the 25 variants ranged from 3.510 to 4.389 kg/ha (Table 5). In an important part of the genotypes (8) there were higher productions than the control, the differences being very significant in seven variants and only significant in one variant, represented by the line To 2270/94. Of the seven genotypes lines can be seen in particular To 2027/10, To 2208/02 and the reselection of the Jubileu variety, with increases relative to the control 10, 9 and 5%. At the opposite pole are located seven genotypes, their productions registering very significant negative deviations compared to the control.

Table 5. Average yield at 25 spring barley genotypes (Turda and Fundulea)

Genotypes	Production kg / ha	%	Difference	Significance
Average (Mt.)	3.961	100	0.00	Mt.
Daciana	3.961	100	-0.47	-
Turdeana	3.983	100.6	22.27	-
Camomile	3.927	99.1	-33.77	-
Adina	3.885	98.1	-76.60	000
To 2270/94	3.998	100.9	36,67	*
To 2208/02	4.330	109.3	368.53	***
To 2330/98	4.088	103.2	127.13	***
To 2172/01	4.128	104.2	166.73	***
To 2168/01	4.114	103.9	153.07	***
To 2115/94	3.942	99.5	-19.03	-
To 2051/99	3.754	94.8	-206.67	000
To 2054/97	4.025	101.6	64,00	-
To 2013/99	4.013	101.3	51.97	-
To 2095/01	4.038	101.9	76.47	-
To 2149/99	3.510	88.6	-450.93	000
To 2017/93	3.559	89.8	-402.37	000
To 2014/99	3.855	97.3	-105.90	000
To 2247/01	3.773	99.4	-21.90	-
To 2167/01	4.237	107	276.33	***
To 2051/10	3.943	99.5	-18.23	-
To 2123/01	3.611	91.2	-350.50	000
To 2027/10	4.389	110.8	428.33	***
To 2170/01	3.973	100.3	11.63	-
To 2011/92	3.651	92.2	-309.87	000
Jubileu	4.174	105.4	213.10	***
DL (p 5%) 35; DL (p 1%) 46; DL (p 01%) 59				

Source: original, obtained through the statistical program.

The considerable fluctuations of the average yield from one locality to another but also the interannual ones, suggest the significant involvement of the environment in the formation of the spring barley crops. In all experimental years under the conditions at Fundulea, the barley yield were reduced to very significant negative differences compared to the control (Figure 1). The year in which the lowest productions were registered at Fundulea was the year 2018, in which the precipitations of April and May were well below the multiannual average.

Providing the rainfall and thermal necessities at a level that is as close as possible to the optimal one of the spring barley is a decisive factor in increasing yield. An eloquent example in this regard is the year 2017, a year in which in both areas the highest productions were obtained. The yield differences between those obtained this year and the other two were: 1.480 and 1.234 kg/ha under Turda conditions and 956 and 1.606 kg/ha under Fundulea conditions.

Also, based on the data presented in Fig. 1, it could be stated that in the years in which climatic conditions are met close to the necessity of the spring barley, even in the less favorable cultivation areas satisfactory yields are obtained. Thus, in 2017, when the area of Fundulea met near (humidity and thermal) conditions, the average production was higher than that obtained in Turda in 2016 and 2018.

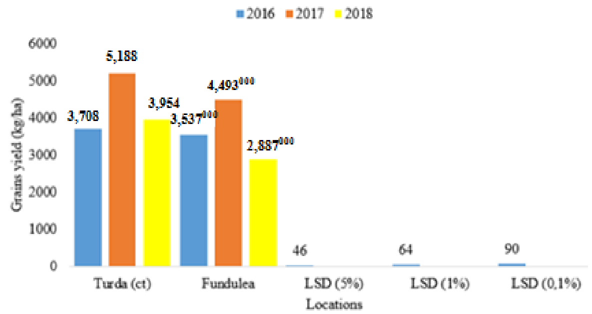

Fig.1. The influence of the interaction between localities and years on the average yield
Source: original, obtained through the Excel program.

Harvest is the result of the interaction between genotype and ecological environment or climate and is specific for each crop grown. In this sense, the production capacity of any cultivated genotype represents one of the essential and priority objectives for the process of genetic improvement of the new genotypes.

Studying the interaction between genotypes and localities (Table 6), it was found that there were differences regarding the contributions of these factors in achieving the average production per unit area. The variation of absolute yield was between 3,683 kg/ha and 4,862 kg/ha in Turda conditions and between 3,265 kg/ha and 4,143 kg/ha in Fundulea conditions.

In the conditions of the agroecosystem from Turda, the lines To 2027/10, To 2208/02 and Jubileu were located on the first three places, all with very significant differences from the average of the experiment. A two year field experiment (2013, 2014) conducted by Russu (2015) on 13 spring barley genotypes in the soil and climatic conditions from ARDS Turda demonstrated that the reselection from the Jubileu variety very significantly increased grain yield compared to the control [4]. In the less favourable climatic conditions from Fundulea, the top of the lines with the highest yields is made up of To 2208/02, To 2167/01 and To 2027/10. At the opposite end, the most important yield losses were recorded in To 2123/01 and To 2011/92. In 2019, Porumb et al. (2019) evaluated 66 spring barley genotypes in two different years (2016, 2017) and confirmed that Romaniţa, Daciana and Jubileu varieties as well as some perspective lines had the protein content between: 11.18% and 11.88% and and starch content of 55.48%. Based on these results, the studied genotypes are recomended to be used in the brewing industry [5].

By the fact that these lines have been statistically ensured and have recorded the highest yields in both locations, it can be seen the production stability, and at the same time the important contribution and role of the genotype in expressing its real potential.

The relative stability or constancy of genotype yield under the experimental conditions (years and localities) is generally illustrated by the values of the variants of genotype interactions with years and localities (Table 2). From these values it is clear that the analysed genotypes do not generally show a relatively constant behaviour in all the experimental conditions, they rather have a specific behaviour depending on the given conditions. This does not mean that from the analyzed cultivars cannot be identified forms that show an appreciable constancy of the yield under the experimental conditions.

In this case, for the assessment of the stability of production, we used the method proposed by Francis Kannenberg (1978), it is considered that genotypes which are relatively stable are those that have low values of coefficient of variation, while the genotypes with high values of the coefficient of variation are considered slightly stable.

The genotypes placed in quadrant I (Fig. 2) have a simultaneous genetic advantage, both for yield and for stability, recording a higher than average production and a coefficient of variation below the average value. The six genotypes listed in Figure 2 have a satisfactory overall adaptive capacity, producing considerable and constant yields under various environmental conditions. Also, the genotypes placed in quadrant II can be said to have above average productions and a good adaptive capacity but only under specific conditions.

Table 6. The influence of genotype x locality interaction (G x L) on the yield of the studied genotypes

Turda			Fundulea		
genotypes	**Yield kg/ha**	**difference**	**genotypes**	**Yield kg/ha**	**difference**
Average (Mt.)	4.283	0.00 ^{Mt}	**Average (Mt.)**	3.639	0.00 ^{Mt}
Daciana	3.952	-331.26 ^{000}	**Daciana**	3.969	130.33 ***
Turdeana	4.421	138.2 ***	**Turdeana**	3.545	-93.67 ^{000}
Romanița	4.264	-18.79	**Romanița**	3.590	-48.74
Adina	4.354	71.01 **	**Adina**	3.415	-224.21 ^{000}
To 2270/94	4.534	250.61 ***	**To 2270/94**	3.462	-65.27 ^{000}
To 2208/02	4.516	232.87 ***	**To 2208/02**	4.143	504.19 ***
To 2330/98	4.443	160.01 ***	**To 2330/98**	3.733	94.26 ***
To 2172/01	4.591	308.34 ***	**To 2172/01**	3.664	25,13
To 2168/01	4.163	-120.13 ^{000}	**To 2168/01**	4.065	426.26 ***
To 2115/94	4.314	30,74	**To 2115/94**	3.570	-68.81 ^{00}
To 2051/99	4.193	-89.99 ^{000}	**To 2051/99**	3.316	-323.34 ^{000}
To 2054/97	4.270	-13.06	**To 2054/97**	3.780	141.06 ***
To 2013/99	4.347	64.07 *	**To 2013/99**	3.679	39.86
To 2095/01	4.187	-95.66 ^{000}	**To 2095/01**	3.888	248.59 ***
To 2149/99	3.683	-599.79 ^{000}	**To 2149/99**	3.337	-302.07 ^{000}
To 2017/93	3.763	-519.99 ^{000}	**To 2017/93**	3.354	-284.74 ^{000}
To 2014/99	4.445	161.94 ***	**To 2014/99**	3.265	-373.74 ^{000}
To 2247/01	3.829	-121.13 ^{000}	**To 2247/01**	3.716	77.33 **
To 2167/01	4.441	158.34 ***	**To 2167/01**	4.033	394.33 ***
To 2051/10	4.367	83.94 ***	**To 2051/10**	3.519	-120.41 ^{000}
To 2123/01	3.867	-416.19 ^{000}	**To 2123/01**	3.354	-284.81 ^{000}
To 2027/10	4.862	578.47 ***	**To 2027/10**	3.917	278.19 ***
To 2170/01	4.374	90.81 ***	**To 2170/01**	3.572	-67.54 ^{00}
To 2011/92	3.778	-505.53 ^{000}	**To 2011/92**	3.525	-114.21 ^{000}
Jubileu	4.785	502.14 ***	**Jubileu**	3.563	-75.94 ^{00}
DL (p 5%) 49; DL (p 1%) 65; DL (p 01%) 83					

Source:original.

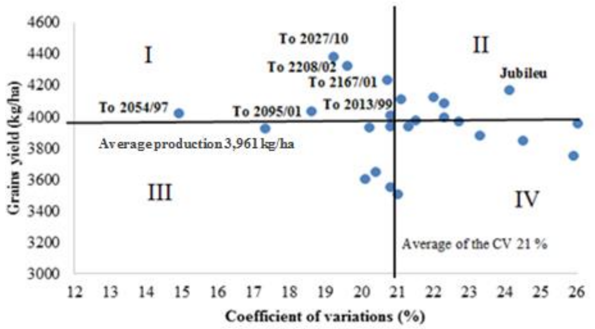

Fig .2. Stability of genotypes analysed according to the variation coefficient and the average yield kg/ha
Source:original, obtained through the Excel program.

CONCLUSIONS

The analysis of the genotypes under very different climatic conditions, allows to identify possible genotypes with a good general adaptation capacity. Thus the lines To 2027/10 and To 2208/02, show a high yield capacity and a good adaptability to the various environmental conditions. In addition to these lines can be mentioned the reselection of the Jubileu variety, which in favourable areas to the spring barley crop can produce high yields quantitatively.

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