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RELATIONSHIP BETWEEN YIELD AND GRAIN QUALITY IN PERSPECTIVE WINTER OAT LINES

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Abstract

This research was conducted within the period 2011-2013 in the Department of Plant-growing experimental facility at the Agricultural University of Plovdiv (Bulgaria). The method of fractional plots in three repetitions over an area of 10.5 m^2 was used. The object of this research are eight winter oat genotypes (Avena sativa L.) - № 1, 07/Z 1, Dunav 1, 08/Z 2, M-K, Kt 651, Ressor 1 and line Kt 718. The aim of the study is to establish the correlations between the studied genotype grain yield and some of its quality indicators.

A genotype specificity of the correlative interconnections has been determined. For Dunav 1 and line 07/Z 1 those between yield and 1000-grain weight are medium to strongly positive. Line 08/Z2 is with small grain but high quantity of beta-glucans (4.6%). The correlative interconnections of this indicator for yield and 1000-grain weight are positive. Line Kt 718 has also got potential in terms of grain weight (1000-grain weight - 28.7 g) and beta-glucan content (3.75%). The correlation between them is positive.

Key words*: Avena sativa L., winter oat, correlation, yield, 1000-grain weight, hectolitre weight, β-glucans.*

INTRODUCTION

Oat has demonstrated unquestionable advantages of grain compared with other cereal commodities. The high content of proteins and their nutritional indispensability make it a preferred diet both for adolescents and people with specific nutrition needs.

For the last decades, beta-glucans have been provoking particular interest as they are mandatorily included in the healthy diet.

Oat has the highest content of beta-glucans among other cereal commodities (Wood, 1994; Lee et al., 1997). According to Aman and Graham (1987), and Welch and Lloyd (1989), oat contains between 25 and 66 g/kg β-glucans.

Beta-glucans correlation with other quantitative and qualitative grain characteristics, were examined in the process of testing various cultivars. Aman and Graham (1987), for example, has not found a proven correlation with 1000-grain weight for 121 tested cultivars. Peterson (1991) confirms the same interconnection. The correlation with grain weight is also negative and unproven, according to Holthaus et al. (1996). Whereas the correlation between β-glucan content and husked grain percentage is positive (Peterson, 1995).

Beta-glucan content is not always in one-way correlation with grain yield (Kibite & Edney, 1998). Holthaus et al. (1996) published data for low positive phenotype correlation, and Saastamoinen et al. (1992) reported a strong positive correlation with the yield. Contrary to that, Kibite and Edney (1998), established low negative phenotype correlation, while Peterson et al. (1995) reported both - low positive and negative correlation with grain yield. According to Brunner and Freed (1994), phenotype correlation between beta-glucans and yield can also vary from positive to negative, depending on the growing conditions.

All this has provoked our scientific interest towards a profound analysis of correlative interconnections between basic quantitative and qualitative indicators in perspective Bulgarian lines of winter oats.

MATERIALS AND METHODS

This research was conducted within the period 2011-2013 in the experimental facility of the Department of Plant-growing at the Agricultural University of Plovdiv, on Mollic fulvisols (FAO). A field trial was executed with two selected and well-established winter cultivars (Dunav 1 and Ressor 1) and line №1,

07/Z1, 08/Z2, M-K (Agricultural University of Plovdiv, Bulgaria), Kt 651, Kt 718 (Institute of Agriculture of Karnobat, Bulgaria). Sunflower was used as predecessor. Three repetitions with size of the reporting plot of 10.5 m^2 were used. Statistical data processing was performed using the SPSS program for Microsoft Windows 9.4 (SAS Institute Inc., 1999). In order to establish the relationships between yield and quality, a correlation analysis was applied.

RESULTS AND DISCUSSIONS

Table 1 shows the results of realized grain productive capacity in kg/da for the tested 8 genotypes, 1000-grain weight, hectolitre weight and ß-glucan content in grain. On the average, the highest yield for the three-year period was observed with Dunav 1 cultivar (427.89 kg/da) - which is the yield standard for Bulgaria, followed by the new line 07/Z1. The lowest yield was detected for lines 08/Z2 (selection of the Agricultural University) and Kt 718 - selection of the Institute of Agriculture of Karnobat). The way indicators for 1000-grain weight and hectoliter weight are reported, is extremely important, related to the use of oats for human consumption in the form of whole grains or flour. They define the yield rate of the final product and are directly related to the processing industry.

Table 1. Yield, 1000-grain weight, hectolitre weight and β-glucan content (average for the period 2011-2013)

Variant	Yield* (kg/da)	1000-grain weight* (g)	Hectolitre weight* (kg)	β-glucans* (%)
№1	370.12b	26.67bc	50.47b	3.03 c
07/Z1	421.89a	32.12a	51.62ab	2.52 d
Dunav1	427.26a	26.58bc	50.33b	3.04 c
08/Z2	332.90b	23.97c	46.38c	4.06 a
M-K	402.64ab	28.78b	51.56ab	3,15 c
Kt 651	393.82ab	27.47bc	48.26c	3.44 b
Resor 1	355.43b	27.40bc	51.02ab	2.39 d
Kt 718	332.55b	28.57b	53.23a	3.75 b

**Data in the same column and heading followed by the same letter are not statistically different (P≤0,05%) by Dunkan's multiple range test*

The results presented in Table 1 show that line 07/Z1 definitely distinguishes for largest seeds. These findings are a good reason for relating the line to genotypes utilized for oat flakes production. Line 08/Z2 shows the lowest value for the same indicator.

Line Kt 718 displays highest hectolitre weight. This fact is partially explained with the comparatively low share of grain husk (Zorovski et al., 2013).

Despite all other grain qualities, the beta-glucan content has recently aroused people's sound interest in healthy food consumption. Line 08/Z2 - 4.06% has displayed outstanding values within our experiment, followed by two lines selected at the Institute of Agriculture, Karnobat - Kt 718 -3.75% and Kt 651 - 3.44%.

The succeeding tables (from Table 2 to Table 9) show the calculated correlative interconnections between the studied quantitative and qualitative grain indicators per variant. The obtained results demonstrate genotype specificity which has to be considered in accordance with the particular selection objective or production sphere.

Table 2 makes it clear that (as it is with many genotypes) yield is in strong negative correlative interconnection with 1000-grain weight, whereas with hectolitre weight it is positive. Beta-glucans are in positive interconnection with 1000-grain weight.

Table 2. Correlative interconnections between yield and grain quality for line № 1

Indicator	Yield (kg/da)	1000-grain weight (g)	Hecto-litre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.940	0.721	-0.397
1000-grain weight, g		1,000	-0.914	0.686
Hectolitre weight, kg			1,000	-0.922
β-glucans, %				1,000

Table 3 shows the interconnections for 07/Z1 - one of the highly productive genotypes.

The most valuable asset for this new line is the fact that, yield is in positive correlative interconnection with: the 1000-grain weight, hectoliter weight and beta-glucans. This allows this line to be rated as particularly perspective both in terms of yield and tested qualitative indicators for 1000-grain weight and hectolitre weight.

Table 3. Correlative interconnections between yield and grain quality for line 07/Z1

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolite weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.344	0.803	0.491
1000-grain weight, g		1,000	-0.284	-0.650
Hectolitre weight, kg			1,000	0.913
β-glucans, %				1,000

Dunav 1 is the standard for winter oats yielding in Bulgaria. It behaves as leader among the tested cultivars in terms of yield but gives way to the best lines for 1000-grain weight, hectoliter weight and beta-glucans. On the other hand, the calculated correlative interconnections (Table 4) between yield and studied qualitative indicators show high positive values, thus explaining the permanent users' interest in this cultivar.

Table 4. Correlative interconnections between yield and grain quality for Dunav 1 cultivar

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.711	0.884	0.626
1000-grain weight, g		1,000	0.299	0.993
Hectolitre weight, kg			1,000	0.188
β-glucans, %				1,000

Line 08/Z2 is distinguished for highest β-glucan content - over 4%. It is not competitive in terms of yield and grain size, but β-glucans are in medium positive correlative interconnection with yield and in very strong - with 1000-grain weight (Table 5).

Therefore, this line allows simultaneous activities directed to achieving both better yield and quality, motivated by the high β-glucan content.

Table 5. Correlative interconnections between yield and grain quality for line 08/Z2

Indicator	Yield, (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.413	-0.965	0.399
1000-grain weight, g		1,000	-0.161	0.998
Hectolitre Weight, kg			1,000	-0.146
β-glucans, %				1,000

M-K is a new line selected by the Agricultural University of Plovdiv. It is one of the most productive new lines tested in the experiment (Table 1). Its grain is comparatively large, with positive correlation between weight and yield (Table 6), which allows simultaneous exploration for higher yield and larger grain size. The beta-glucan content is over 3%, nevertheless, the strong negative correlative interconnection between the latter and yield must be taken into consideration in the course of selection.

Table 6. Correlative interconnections between yield and grain quality for line M-K

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	0.720	-0.243	-0.778
1000-grain weight, g		1,000	-0.848	-0.123
Hectolitre weight, kg			1,000	-0.421
β-glucans, %				1,000

Line Kt 651 yield is slightly lower than the standard Dunav 1, but with larger grain size and higher beta-glucan content (Table 1). Besides, the 1000-grain weight is in positive correlation with β-glucans (Table 7), thus raising the interest in the cultivar for using in food production. Kt 651 is among the three tested genotypes with highest β-glucan content - 3.44%.

Table 7. Correlative interconnections between yield and gain quality for line Kt 651

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.999	0.624	-0.589
1000-grain weight, g		1,000	-0.584	0.547
Hectolitre Weight, kg			1,000	-0.999
β-glucans, %				1,000

The Bulgarian Ressor 1 cultivar is used as quality standard in Bulgaria. However, it gives way on grain size and, particularly, on β-glucan content (Table 1).

Table 8. Correlative interconnections between yield and grain quality for Ressor 1 cultivar

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.892	-0.512	0.912
1000-grain weight		1,000	0.846	-0.999
Hectolitre Weight, kg			1,000	-0.819
β-glucans, %				1,000

On the other hand, a very strong negative interconnection of -0.999 between 1000-grain weight (g) and β-glucan content (%) has been determined (Table 8). This fact defines the cultivar as non-preferred, whenever both grain quality characteristics are required at the same time.

Table 9. Correlative interconnections between yield and grain quality for line Kt 718

Indicator	Yield (kg/da)	1000-grain weight (g)	Hectolitre weight (kg)	β-glucans (%)
Yield, kg/da	1,000	-0.839	-0.335	0.166
1000-grain weight		1,000	-0.232	0.397
Hectolitre weight, kg			1,000	-0.985
β-glucans, %				1,000

Line Kt 718 shows a very well balanced indicator values for yield, 1000-grain weight, hectolitre weight and especially beta-glucans (Table 1).

The established correlative interconnections show contradiction between yield and 1000-grain weight, while between yield and beta-glucans, 1000-grain weight and beta-glucans a positive correlation is observed (Table 9)

CONCLUSIONS

The present study shows best performance of genotype Dunav 1, lines 07/Z1 and M-K in terms of yield (over 400 kg/da).

For the first two, the correlative interconnections between yield and 1000-grain weight are medium to strongly positive which defines them as perspective for yield and large-size grain. Line 08/Z2 has small grain but high beta-glucan content (4.06%).

The correlative interconnections between yield and 1000-grain mass, as well as between yield and beta-glucans, on the one hand, and between 1000-grain weight and beta-glucans, on the other, are positive.

This is a good precondition for evaluating this line as particularly perspective in terms of high yield and quality selection.

Line Kt 718 is also considered perspective from point of view of grain size (1000-grain weight - 28.57g) and beta-glucan content (3.75%). The correlation between both indicators is positive.

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