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Correlation, path-coefficient and principal component analysis of yield and some traits related to the productivity of winter barley accessions with Bulgarian origin

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Abstract

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The aim of the study was to generate information on interrelationships of some important productivity elements, direct and indirect effects of grains per spike and height of the plants. The study was conducted in the IPGR – Sadovo, during the period 2018-2020 and included 13 two-row winter barley accessions with Bulgarian origin. In all tested barley accessions was found statistically proven strong correlation (r = 0.896) between yield and number of spikes per m^2. Path-coefficient analysis shows that the traits number of spikes per m^2 and grain mass per spike have the highest direct effect on yield. Principal components analysis shows that Kuber and Asparuh have positive values for first PC. These cultivars were characterized by high yield, high plant height, high spike length, high grain number per a spike, high grain mass per a spike and high 1000 grains mass.

Keywords: winter barley; productivity; yield; correlation analysis; path-coefficient analysis

Introduction

The productivity of winter barley depends on the potentialities of the material under study and is an expression of the complex interrelations between the components of the yield and other traits associated with it (Dimova et al., 2014; Chipilski, 2016). Information on the correlation relationships between productivity elements makes it possible to increase the efficiency of the breeding process (Dimova et al., 2007; Doneva et al., 2017). One of the effective methods for analysing the relationships between quantitative traits is path-coefficient analysis. Applied as a continuation of correlation analysis, path-coefficient analysis helps to increase the accuracy in selection criteria (Arora et al., 2003; Parveen et al., 2011; Dimitrova-Doneva et al., 2018).

The purpose of this study is to identify the traits on which winter barley productivity depends, to establish a relationship between them and to determine the direct and indirect effects on grain yield.

Materials and Methods

The experimental work was conducted during the 2018-2020 growing seasons in the experimental field of the Institute of plant genetic resources – Sadovo, South Central Bulgaria.

The studied genotypes of winter barley are based on soil type Meadow Cinnamon Soil middle-ground (A + B = 60–80 cm). They are poorly stocked with nitrogen, on average well-stocked with phosphorus and rich in potassium. The soil response is close to neutral with pH = 6.5. Marginal humidity ranges from 24% to 26%.

The experiment was set up as a randomized block design in comparative cultivar trials in four repetitions of an area of

10 m^2, with sowing rate of 450 germinating seeds per m^2 .The genotypes were evaluated for seven traits – yield (kg/ha), spike number per m^2, plant height, spike length (cm), grain number per spike, grain mass per spike (g), 1000 grains mass (g). The plant material studied included 13 winter two-row genotypes with Bulgarian origin.

Phenotypic correlations and path-coefficient were calculated on the basis of the average values of the traits for the three years of study. Statistical data processing is made with Microsoft Excel.

The statistical processing of the results was done through Analysis of variance, Principal components analysis and cluster analyses. Statistical processing was performed with use of JMP (2002) software.

Results and Discussion

Under field seven quantitative traits were observed for 13 varieties of barley. Analysis of variance exposed considerable level of variability among accessions for majority of the traits observed. Basic descriptive statistics are presented for 6 characters in Table 1.

The highest variation was found for yield, plant height, grain mass per a spike and number of spikes per m^2.Relatively, low variation was noticed for grain number per a spike, spike length and 1000 grains mass.

The observed variability found among barley genotypes can probably attribute to the inherent genetic differences and the environment in which they were grown.

In the present study, the yield of winter barley accessions depend most from the traits number of spikes per m^2, spike length, grain number per spike, grain mass per spike and 1000 grains mass, in which the correlation dependencies found are medium to strong and statistically proven (Table 2).There is a strong positive very well-proven correlation (r = 0.823**) between plant height and spike length which should be considered in future breeding work. Positive, average, well-proven correlation between plant height and number of grains per spike (r = 0.438*) was found, which are in accordance with the results reported by Valcheva et al. (2014). The study data also show a strong positive correlation (r = 0.896**) between yield and number of spikes per m^2 and correspond to the results of Srivastava et al. (2012). The correlation analysis showed weak to strong positive correlation between yield and all other traits included in the study, as found by Bhutta et al. (2005). Of particular importance is the very well-proven mean and strong positive correlation between number of grains per spike and yield (r = 0.495*), mass of grains per spike and yield (r = 0.500*) and spike length and yield (r = 0.493*), which was also reported by Dimitrova-Doneva (2016). An average positive correlation was found between yield and 1000 grains mass, results consistent with those obtained by Mahmood (2010).

Table 1. Descriptive statistics of yield and some traits related to the productivity of winter barley accessions with Bulgarian origin for the period 2018–2020

Traits	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance	CV%
Yield kg/ha	1740	4950	6690	5820.571	136.423	508.606	256823.568	8.73
Number of spikes per m^2	120	775	895	835.846	9.99197	36.40455	1256.582	4.35
Plant height, cm	19.1	63.5	82.6	73.064	1.690	5.923	32.090	8.10
Spike length, cm	1	7.7	8.7	8.243	0.175	0.325	0.090	3.94
Grain number per a spike	1.6	23.8	25.4	24.586	0.296	0.794	0.637	3.22
Grain mass per a spike, g	0.25	1.36	1.61	1.485	0.091	0.096	0.008	6.46
1000 grains mass, g	4.88	39.33	44.21	41.767	0.456	1.536	2.300	3.67

Table 2. Correlations between yield and some traits associated with productivity of winter barley accessions with Bulgarian origin for the period 2018–2020

№	Traits	1	2	3	4	5	6	7
1	Yield, kg/ha	1	0.896**	0.152	0.493*	0.495*	0.500*	0.380*
2	Number of spikes per m^2		1	-0.139	0.221	0.336	0.250	0.372
3	Plant height, cm			1	0.823**	0.438*	0.186	0.093
4	Spike length, cm				1	0.742**	0.472*	0.445*
5	Grain number per spike					1	0.443*	0.370*
6	Grain mass per spike, g						1	0.172
7	Mass of 1000 grains							1

* Sufficient evidence for reliability α=0.05; ** sufficient evidence for reliability α=0.01

Table 3. Direct and indirect influence of the elements of productivity on grain yield of winter barley accessions with Bulgarian origin for the period 2018–2020

№	Traits	Direct effect	Indirect effect						Total indirect coefficient	Correlation coefficient (r)
			1	2	3	4	5	6		
1	Number of spikes per m^2	0.790	–	0.028	0.010	0.005	0.059	0.006	0.106	0.896
2	Plant height	0.100	0.060	–	0.015	-0.021	0.021	-0.023	0.052	0.152
3	Spike length	0.043	0.158	0.165	–	0.010	0.111	0.007	0.450	0.493
4	Grain number per spike	-0.014	0.378	0.088	0.032	–	0.006	0.005	0.509	0.495
5	Grain mass per spike	0.230	0.217	0.037	0.020	-0.006	–	0.003	0.270	0.500
6	Mass of 1000 grains	-0.015	0.322	0.019	0.019	-0.005	0.040	–	0.395	0.380

Table 3 shows the results of the direct and indirect effects of productivity elements on grain yield of tested accessions winter barley. According to path-coefficient analysis number of spikes per m^2 and grain mass per spike has the highest direct effect on yield total for the whole group and correspond to the results of Hailu et al. (2016). Highest overall indirect effect on the formation of the yield is grain number per spike, spike length and mass of 1000 grains. For creation high yielding hybrids should be selected genotypes with high number of spikes per m^2 and grain mass per spike. For accessions winter yield is indirectly influenced by grain number per spike, spike length and mass of 1000 grains.

The variation studied through Principal Component Analysis revealed that two principal components having greater than 1 eigenvalues contributed 72% of the total variation (Table 4). It was found that Principal Component 1 (PC1) contributed 49.085% and PC2 contributed 23.65032% respectively of the total variation. All traits contributed positively to PC1. Maximum genetic variance to PC1 was contributed by spike length (0.468), yield (0.439) and grain number per a spike (0.436).Plant height and spike length contributed positively to PC2 (0.599) and 0.359.

Table 4. Principal Component Analysis of 13 winter barley accessions with Bulgarian origin

	PC1	PC2
Eigenvalue	3.43592	1.61224
Percent of variance	49.085	23.032
Cumulative percentage	49.085	72.117
Characters	Component Weights	
Yield, kg/ha	0.439708	-0.378071
Number of spikes per m^2	0.329766	-0.570773
Plant height	0.283166	0.59931
Spike length	0.468814	0.359773
Grain number per a spike	0.436495	0.148503
Grain mass per a spike	0.337704	-0.0150885
Mass of 1000 grains	0.305564	-0.142798

Figure 1 represent a biplot in the dimension of the first and second PCs. Kuber and Asparuh have positive values for first PC. These cultivars were characterized by high yield, high plant height, high spike length, high grain number per a spike, high grain mass per a spike and high 1000 grains mass.

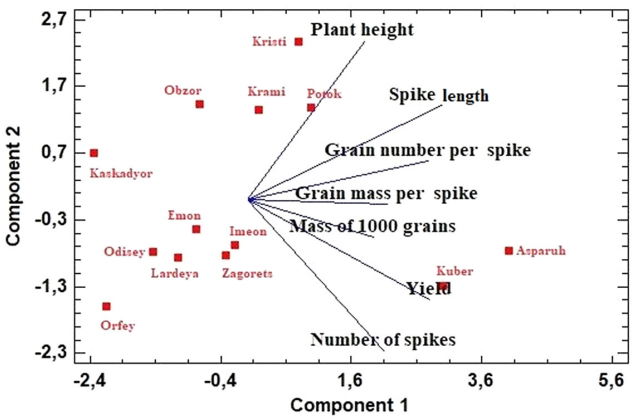

Fig. 1. Biplot of the principal components analysis of studied traits of winter barley accessions with Bulgarian origin

Conclusions

In all tested barley accessions was found statistically proven strong correlation (r = 0.896) between yield and number of spikes per m^2. Path-coefficient analysis shows that the traits number of spikes per m^2 and grain mass per spike have the highest direct effect on yield.

These relationships should be taken into account when determining the criteria for increasing barley productivity.

Principal components analysis shows that Kuber and Asparuh have positive values for first PC. These cultivars were characterized by high yield, high plant height, high spike length, and high grain number per a spike, high grain mass per a spike and high 1000 grains mass.

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