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Original article

Investigation on the Adaptability of A Group of Topical Common Winter Wheat Cultivars [1]

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Abstract

Sixteen new Bulgarian common winter wheat cultivars developed at DAI – General Toshevo currently in mass production were investigated. The aim of the study was to evaluate their response to changes in the climatic conditions. The following important economic parameters were assessed: productivity, protein content, test weight, bread volume, valorimetric value, sedimentation, wet gluten content, softening degree and H:D. The experiment was carried out during 2015 – 2017 according to the block design method, the size of the trial plot being 10 m2. The interaction genotype x climatic conditions was studied using AMMI models. The assessed statistical parameters were at the basis of the ranking of the investigated cultivars by the economic indices regarding their adaptability to the changes in the climate. The cultivars were grouped according to the different indices through cluster analysis..

Keywords: winter wheat, adaptability, AMMI models, cluster analysis.

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INTRODUCTION

Wheat is a main agricultural crop in Bulgaria. It is grown on millions of hectars from the arable land of the country. The climatic changes are becoming ostensible during the last decade in different regions of Bulgaria. The main wheat cultivars, which are sown in mass production, demonstrate variable adaptability to those changes. Some of them keep their productivity level and quality parameters, while in others the response is susceptible (Penchev and Stoeva, 2004). The study on the main common winter wheat cultivars used in practice with regard to their reaction to the above changes is important to both farmers and breeders (Tsenov et al., 2009).

The adaptation of the individual cultivars to changeable climatic conditions can be evaluated by studying their response during different years and in different regions. The application of AMMI models (Dias and Krzanowski, 2003; Abamu et al., 2007) allows precisely assessing their adaptability to variable climatic conditions.

Materials and Methods

Sixteen Bulgarian cultivars: Aglika, Enola, Kristi, Karat, Antonovka, Lazarka, Karina, Korona, Kosara, Albena, Dragana, Kiara, Katarzhina, Sladuna, Kalina and Kami, were studied in a randomized block-designed experiment with four replications during 2015 – 2017. The parameters yield (t/ha), sedimentation (ml), wet gluten content (%), hectoliter weight, bread volume(cm ^{3}), valorimetric value, softening degree (fu) and protein content (%) were analyzed.

The type of the model of the applied dispersion analysis was the following:

$$\mathbf{Yijk = Y.. + Gi + Yj + (GY)ij + Eijk,}$$

where Gi is the factor genotype, Yj are the climatic conditions, (GY)ij is the interaction genotype x climatic conditions, and Eijk is the error of the experiment (Cornelius and Crossa,1999).

When dividing the studied cultivars according to productivity and quality parameters, cluster analysis was applied (linkage model) by calculating the Euclidean distance using the formula:

$$\mathbf{d(X,Y) = ((x_i – x_k)^2 + (y_i - y_k)^2)^{0.5}} \quad \mathbf{(2)}$$

The regression coefficients, the mean stability and the varietal adaptability to the changes of the environment were evaluated. The data were processed with SPSS 19.0 and Biostat 6.0.

Results and Discussion

The period of the experiment was characterized with variable climatic conditions during the vegetative growth of wheat. In October of harvest year 2015, the considerable amount of rainfalls favored the fast emergence of the crops. The high registered amplitudes between the day- and night-time temperatures inhibited the growth of the plants. The good winter moisture reserves in soil contributed to the accumulation of sufficient biomass during the spring. Drought occurred after heading, but there were no extreme high temperatures and this favored the normal grain filling and the formation of good physical properties. Year 2016 was favorable for growing of the crop – there were good autumn-and-winter moisture reserves in soil and the winter was mild, but in spring unusually low temperatures were observed, which affected the normal heading and facilitated the occurrence of powdery mildew, brown and yellow rust. In 2017, some drought was observed – mild winter with low autumn-and-winter moisture reserves, dry spring and higher mean air temperatures.

Table 1 presents the MS results from the dispersion analysis carried out according to the linear statistical model (1).

Table 1. Dispersion analysis (MS) of the studied parameters

	Yield	Bread volume	Wet gluten content	Sedimentation	Softening degree	Test weight	Protein content
G	1909.8 [c]	6105.8 [c]	1452.4 [c]	521.6 [c]	615.4 [c]	14.4 [b]	0.64
Y	779 [c]	974.1 [c]	2751.1 [c]	492.7 [c]	479.8 [c]	10.6 [a]	0.10
G x Y	141.1 [c]	428 [c]	894.6 [b]	331.4 [a]	81.3 [a]	6.4	0.17
Error	28.4	24.5	95.2	57.3	20.9	2.5	0.34

a – significant at p=0.05 ,b –significant at p=0.01 , c – significant at p=0.001

The applied F-criterion proved the different genetic potential of the group of cultivars according to the studied parameters at the highest degree of statistical significance for the parameters yield, bread volume, wet gluten content, sedimentation and softening degree. For the parameter test weight, the significance was at level p=0.01 of the alternative hypothesis, and for the parameter protein content, variation between the studied cultivars was not found.

The effect of the climatic conditions was determined at the highest level of significance for all parameters, with the exception of test weight, for which the level of significance was p=0.05 of the alternative hypothesis, and for the parameter protein content the effect was not significant. For the parameters yield, bread volume, wet gluten content, sedimentation and softening degree, the interaction genotype x ecological conditions was significant to various levels, which was a necessary condition (Penchev et al., 2005) to apply AMMI models for assessment of the cultivars adaptability according to the investigated parameters. For the parameters test weight and protein content, this interaction was not statistically significant.

Table 2. Results from application of AMMI models

Cultivar	Yield t/ha			Bread volume cm ^{3}			Sedimentation ml		
	Rank	ASV	I	Rank	ASV	I	Rank	ASV	I
Dragana	1	0.022	2.432	5	0.064	2.227	10	0.198	1.596
Karat	2	0.084	2.213	11	0.158	1.625	16	0.296	0.844
Karina	3	0.111	1.945	15	0.211	1.616	3	0.055	2.224
Kosara	4	0.165	1.929	16	0.252	1.105	12	0.242	1.388
Kalina	**5**	0.180	1.896	6	0.083	2.115	9	0.187	1.681
Korona	6	0.187	1.854	13	0.182	1.459	2	0.041	2.331
Aglika	7	0.208	1.805	3	0.051	2.412	13	0.264	1.182
Antonovka	8	0.233	1.725	10	0.137	1.806	4	0.068	2.119
Kiara	9	0.276	1.664	14	0.196	1.505	8	0.161	1.725
Enola	10	0.285	1.525	12	0.174	1.421	6	0.119	1.948
Albena	11	0.297	1.332	1	0.017	2.674	15	0.288	0.876
Lazarka	12	0.332	1.031	8	0.109	2.084	5	0.097	2.022
Kristi	13	0.397	0.944	7	0.095	2.102	1	0.032	2.422
Katarzhina	14	0.412	0.866	9	0.127	1.933	7	0.135	1.827
Sladuna	15	0.434	0.813	4	0.059	2.338	11	0.218	1.475
Kami	16	0.451	0.786	2	0.045	2.439	14	0.275	0.922

The application of the AMMI models (Dias and Krzanowski, 2003; Rane et al., 2006) allowed evaluating the ecological plasticity and stability on the basis of the statistical parameters ASV and on the basis of the reliability index I. By the parameter yield, cultivar Dragana demonstrated the highest adaptability to the climatic conditions, ranking first among the cultivars. According to this parameters cultivars Karat, Karina, Kossara, Kalina and Korona showed stable reaction. More susceptible to the changes of the climatic conditions according to the parameter productivity were cultivars Aglika, Antonovka, Kiara and Enola. Cultivars Albena, Lazarka, Kristi, Katarzhina, Sladuna and Kami were characterized with lower ecological plasticity and stability. Figure 1 presents the grouping of cultivars according to this parameter with the help of cluster analysis.

The grouping of the cultivars by productivity according to the cluster analysis, which was carried out, was as follows: group 1 included cultivars Albena, Kami and Karat; group 2 involved Dragana, Kossara, Korona and Kristi, group 3 – Karina, Katarzhina, Enola, Kalina and Kiara, and group 4 – Antonovka, Lazarka and Aglika.

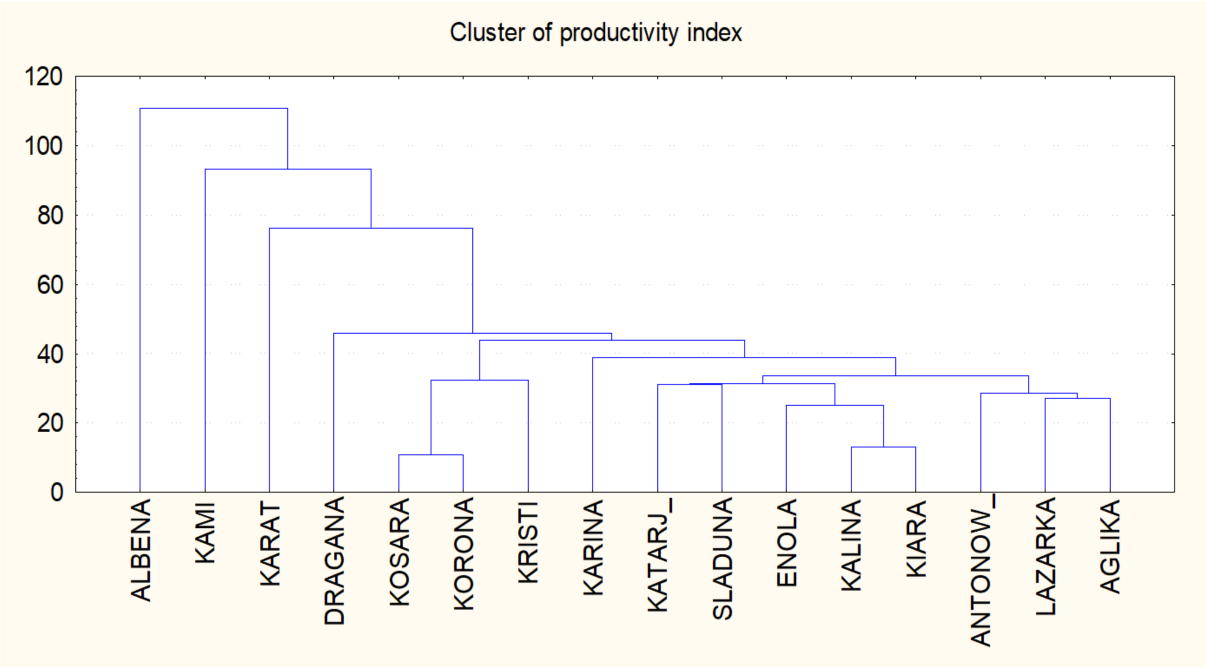

Figure 1. Cluster of productivity index

For the parameters test weight and protein content, the interaction genotype x climatic conditions was not significant. The possible conclusion is that the investigated cultivars did respond with susceptible reaction to the changes of the climate. For the parameters bread volume, sedimentation, valorimeric value, wet gluten content and softening degree, this interaction was significant at different levels. By the parameter bread volume, cultivars Albena, Aglika, Kami, Sladuna, Dragana and Kalina were with high level of adaptability. The values of the statistical parameters were ASV < 1, and the reliability index was I > 2. Cultivars Kristi, Lazarka and Katarzhina were influenced to a higher degree by the climatic conditions, but also demonstrated plasticity by this parameter. The following cultivars had susceptible reaction to the changes of the environment: Antonovka, Karat, Enola, Kiara, Korona and Kossara. By the parameter sedimentation, cultivars Kristi, Korona, Karina, Anonovka and Lazarka showed high adaptability, with respective indices ASV < 0.1, I >2. Cultivars Enola, Katarzhina and Kiara demonstrated good ecological plasticity and stability.

The variation of the cultivars Kalina, Dragana, Sladuna, Kossara, Aglika, Kiara and Karat according to this parameter was significant at level p=0.001 of the alternative hypothesis. Another important parameter, which correlates positively with the volume of bread and which determines the quality of wheat is the valorimetric value.For this parameter cultivars Albena, Aglika , Kami , Sladuna , Kalina and Dragana showed high level of adaptability and were evaluated with statistical parameters ASV < 1.5 and reliability index I >2 .

Cultivars Lazarka, Kristi, Antonovka and Karat were with good ecological plasticity and stability. Susceptible reaction to the different climatic conditions was found in cultivars Katarzhina, Enola, Karina, Kossara, Kiara and Korona. The obtained values were analogous to that of the parameter bread volume. For the parameter wet gluten, high ecological plasticity and stability were determined in cultivars Kristi, Korona, Karina, Lazarka, Antonovka, Enola and Katarzhina. The respective parameters were ASV<1.4 and I >2.

The variation of cultivars Kiara, Dragana, Kalina and Sladuna was significant at p=0.05 of the alternative hypothesis. Susceptible reaction was observed in cultivars Kossara, Aglika, Kami, Albena and Karat. The ranking of the cultivars by the parameter softening degree revealed the high level of adaptability of cultivars Aglika, Korona, Sladuna, Karina, Katarzhina and Karat with ASV <1.3 and I>2. Good ecological plasticity and stability characterized cultivars Lazarka, Kiara and Kami. The variation according to this parameter in cultivars Kristi, Albena, Antonovka, Dragana, Enola, Kossara and Kalina was significant at p=0.001 of the alternative hypothesis.

Table 3. Results from the application of AMMI models

Cultivar	Valorimetric value			Wet gluten %			Softening degree fu		
	Rank	ASV	I	Rank	ASV	I	Rank	ASV	I
Dragana	6	0.145	2,108	9	0.178	1.915	13	0.267	0.811
Karat	10	0.227	1.418	16	0.337	0.714	6	0.128	2.045
Karina	13	0.319	0.861	3	0.095	2.265	4	0.109	2.196
Kossara	14	0.337	0.788	12	0.207	1.328	15	0.337	0.727
Kalina	**5**	0.121	2.142	10	0.183	1.863	16	0.369	0.685
Korona	16	0.379	0.725	2	0.086	2.348	2	0.085	2.241
Aglika	2	0.085	2.322	13	0.219	1.275	1	0.066	2.527
Antonovka	9	0.207	1.577	5	0.118	2.135	12	0.259	0.824
Kiara	15	0.368	0.752	8	0.166	1.927	8	0.169	1.721
Enola	12	0.297	0.925	6	0.124	2.114	14	0.292	0.766
Albena	1	0.077	2.429	15	0.309	0.756	11	0.247	0.935
Lazarka	7	0,169	1.986	4	0.107	2.218	7	0.135	1.986
Kristi	8	0.183	1.733	1	0.044	2.527	10	0.212	1.107
Katarzhina	11	0.249	1.275	7	0.139	2.055	5	0.116	2.088
Sladuna	4	0.108	2.169	11	0.195	1.642	3	0.094	2.213
Kami	3	0.097	2.214	14	0.274	0.869	9	0.195	1.346

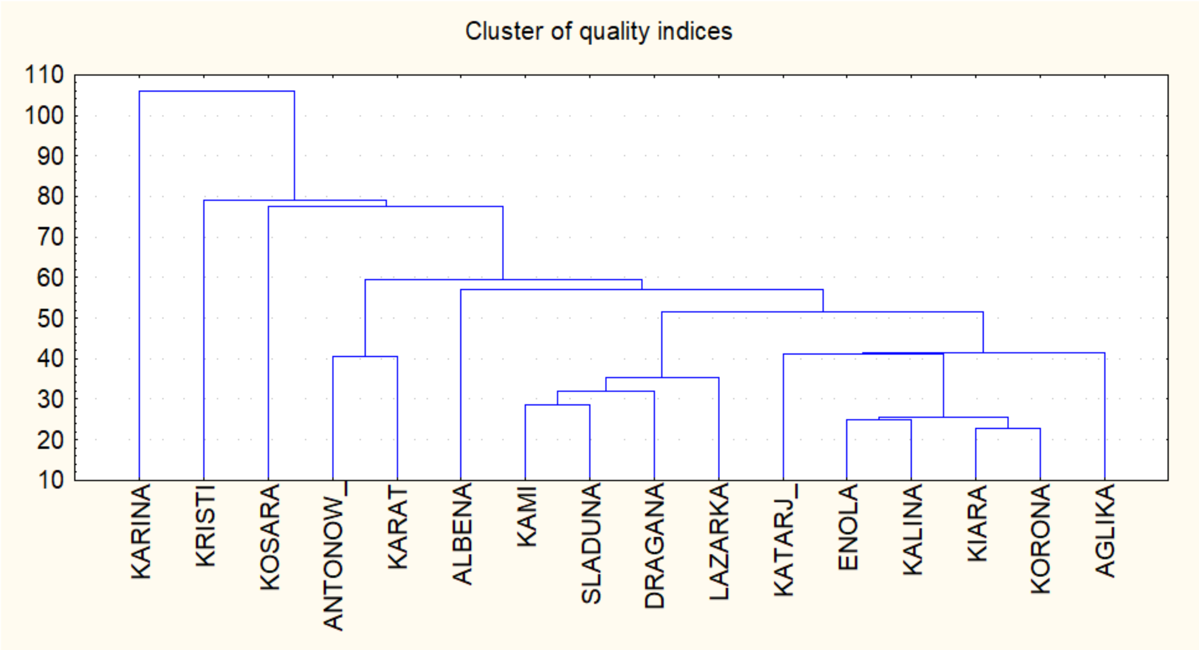

Figure 2. Cluster of quality indices

Cluster analysis was applied for grouping of the studied cultivars according to their qualitative parameters. The following main groups were formed: cultivars Aglika, Katarzhina, Enola, Kalina, Kiara and Korona fell within the first group; the second group included cultivars Kami, Sladuna, Dragana, Albena and Lazarka; the third group – Kossara, Antonovka and Karat, and the fourth group – Karina and Kristi.

The applied statistical models allowed a complex evaluation on the level of adaptability of the studied cultivars and their classification. The cultivars, which adapted to the changeable climatic conditions according to the investigated parameters, were the following: Dragana, Aglika, Karina, Korona and Albena. Cultivars Kami, Lazarka, Kiara, Katarzhina and Kristi demonstrated high susceptibility.

Conclusions

1. According to all parameters as a complex, cultivars Dragana, Aglika, Karina, Korona and Albena showed high level of adaptability. Cultivars Kami, Lazarka, Kiara, Katarzhina and Kristi possessed high susceptibility.

2. According to the parameter productivity, cultivars Dragana, Karat, Karina, Kossara, Kalina and Korona demonstrated high ecological plasticity and stability. Culttivars Aglika, Antonovka, Kiara and Enola showed susceptible reaction.

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