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STABILITY OF QUALITY PARAMETERS OF WINTER WHEAT IN DIFFERENT ENVIRONMENTAL CONDITIONS

STABILNOST PARAMETARA KVALITETE OZIME PŠENICE U RAZLIČITIM OKOLINSKIM UVJETIMA

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ABSTRACT

Breeding program should focus on high protein content although generally there is a negative correlation between protein content and yield. To obtain information about the reaction of winter wheat genotypes to different environmental conditions, experiments were set up with 18 winter wheat genotypes in four replications at four locations with different soil types in two seasons. Protein content, wet gluten content and sedimentation value were analyzed. The genotype Divana had a high mean protein content accompained with a high positive interaction between genotype and environment. The genotypes Golubica, Mihaela and Renata formed an adaptive group with moderate positive interaction. Distribution of genotypes points in the AMMI II biplot revealed that the genotype Sana scattered closest to the origin, indicating minimal interaction of this genotype with environments. Wet gluten content ranged from 18.3 % (genotype Aida in Pozega 2009) to 39.3 % (genotype Golubica in Osijek 2010). The highest sedimentation value was obtained at location Osijek 2010 (genotypes Renata, Golubica, and Divana). Investigated quality parameters (protein content, wet gluten content, sedimentation value) were highly correlated. This information about stability of quality parameters is helpful in selecting proper genotypes for wheat breeders, growers, millers and bakers for their end products with desired quality characteristics, which should be combined with good rheological and agronomic traits.

Key words: environment, wheat, quality

SAŽETAK

Program oplemenjivanja se usmjerava na visok sadržaj proteina iako općenito postoji negativna korelacija između sadržaja proteina i prinosa. Za

dobivanje informacija o reakciji genotipova ozime pšenice u različitim uvjetima okoliša, pokusi su postavljeni sa 18 genotipova ozime pšenice u četiri ponavljanja na četiri lokacije s različitim tipovima tla u dvije sezone. Analizirani su sadržaj proteina, vlažni gluten i sedimentacijska vrijednost brašna. Genotip Divana je imao visoki prosječni sadržaj proteina popraćen visokom pozitivnom interakcijom genotipa i okoline. Genotipovi Golubica, Mihaela i Renata su formirali adaptivnu grupu sa srednje pozitivnom interakcijom. Raspodjela genotipova u AMMI II biplotu otkrila je da je genotip Sana najbliže ishodištu, što pokazuje minimalnu interakciju ovog genotipa s okolinama. Vlažni gluten se kretao od 18,3% (genotip Aida u Požegi 2009) do 39,3% (genotip Golubica u Osijeku 2010.). Najveća sedimentacijska vrijednost zabilježena je na lokaciji Osijek 2010 (genotipovi Renata, Golubica, i Divana). Ispitivani parametri kvalitete (protein, vlažni gluten, sedimentacijska vrijednost) vrlo su usko povezani. Informacije u vezi stabilnosti nekih parametara kvalitete mogu pomoći oplmenjivačima, proizvođačima, mlinarima i pekarima u odabiru odgovarajućih genotipova pšenice, da se dobiju krajnji proizvodi sa željenim osobinama kvalitete, koji bi trebali biti u kombinaciji s dobrim reološkim i agronomskim svojstvima.

Ključne riječi: okolina, pšenica, kvaliteta

INTRODUCTION

It is difficult to compare values reported for the protein content of grain grown in different locations or in different years. Anyway, breeding programm should focus on high protein content although generally exist the negative correlation between protein content and grain yield. Most wheat is purchased on a protein basis, as this dictates the potential end use(s) of the flour. Gluten, "cohesive, viscoelastic, proteinaceous material prepared as a by-product of the starch isolation from wheat flour" and the storage and dough-forming protein of wheat flour, is the key to the unique ability of wheat to suit the production of leavened products (Pasha et al., 2007). Drezner et al. (2007) report that trials over the years and several locations are important in selecting the best genotypes. AMMI analysis is useful in the adaptation and selection of certain genotypes in different locations (Gauch, 1997).

Table 1 . Analysis of variance for the AMMI model

Tablica 1. Analiza varijance za AMMI model

Source	DF	S^2
Genotype (G)	17	97.50***
Environment (E)	7	129.16***
G*E	119	29.80***
AMMI component 1	23	12.11***
AMMI component 2	21	6.98**
AMMI component 3	19	3.50ns
AMMI component 4	17	3.38*
G*E residual	39	3.83

***,**,*=significant at *P*<0.001, 00.1 and 00.5, respectively; ns=not significant (*P*>0.05)

The aim of this study was to observe the stability (depending on protein content) of 18 winter wheat genotypes at four locations with different soil types in two growing seasons. End-use quality of analysed cultivars was also evaluated by wet gluten content and sedimentation value. The aim of this research was to determine the three quality characteristics of the Croatian wheat that may provide some directions to the breeders about stability of this traits in different environmental conditions.

MATERIAL AND METHODS

The survey was conducted during 2008/09 and 2009/10 using 18 genotypes of winter wheat cultivars (Felix, Zitarka, Seka, Ilirija, Srpanjka, Katarina, Mihaela, Aida, Lela, Divana, Alka, Golubica, Renata, Lucija, Zlata, Pipi, Sana, Soissons). The experiment was set up as completely randomized block in four replications at four different locations with different soil types (Tovarnik-near Vukovar, 45°10'N, 19°09'E, Osijek, 45°27' N, 18°48'E, Pozega, 45°20', 17°41'E, Slavonski Brod, 45°10'N, 18°01'E). The fields were located in the main wheat growing region in Croatia, and represented different types of soil (Tovarnik-black earth, Osijek-eutric cambisol, Pozega-pseudogley, Slavonski Brod-amphigley). The climate conditions during growing season significantly differed in the amount of rainfall and average temperatures at different locations and years (2008/09: Osijek=368.6 mm, 10.8°C; Pozega=528.1 mm, 10.2°C; Slavonski Brod=507.9 mm, 10.6°C; Tovarnik=430.6 mm, 11.2°C, 2009/10:

Osijek=846.0 mm, 10.3°C; Pozega=829.5 mm, 9.9 °C; Slavonski Brod=863.5 mm, 10.2 °C; Tovarnik=759.3 mm, 10.7°C). The area of one experimental plot was 7.56 m^2. After the harvest the following traits were analyzed: protein content, wet gluten content and sedimentation value. Analysis of variance was calculated using the GLM procedure of SAS 9.1. Stat Softwer at the level of significance α=0.05. Software IRRISTAT 5.0 (for Windows © Irristat, 2005) was used for AMMI models.

RESULTS AND DISCUSSION

Protein content

Analysis of variance showed high genetic variability among the genotypes. Highly significant differences for environments indicated their influences on protein content at different environments. AMMI I model shows the genotype and environment main effects on the abscissa and IPCA1 scores on the ordinate. AMMI I biplot gave a model fit of 93.1 %. AMMI I biplot for grain yield of the 18 genotypes at 8 environmental conditions is presented in Fig 1. The genotype Divana had high mean protein content accompained with high positive interaction. The genotypes Golubica, Mihaela and Renata formed an adaptive group with moderate positive interaction and highly moderate mean for protein content. Protein quality is important for baking purposes. Strong elastic gluten indicates it is good for breadmaking; weak and slack gluten is better used in biscuits and cakes (Horvat et al, 2008). For those genotypes interaction is high positive at Osijek 2009/10 and Tovarnik 2009/10, and high negative at Slavonski Brod 2008/09 and Pozega 2008/09. As it was expected location Pozega 2008/09 had on average, the lowest value of protein content because of the negative characteristics of acid soil content.

Location Pozega 2009/10 had on average higher protein content which can be due to higher precipitation in that growing season. Genotypes Lela and Ilirija had average means with moderate negative interaction. Genotype Zitarka had a moderate negative interaction, the genotypes it exhibited IPCA scores close to zero, thus found to be stable. Low G*E interaction of a genotype indicates stability of the genotype and also further partitions into interaction effects due to individual environments. Genotypes Soissons and Alka had low mean with moderate negative interaction. Among the environmental conditions, high mean

had Osijek 2009/10, with high positive interaction. Pozega 2008/09 and Slavonski Brod 2009/10 showed very low mean effect and negative moderate interaction, while Tovarnik 2008/09 had low mean and positive low interaction. The low protein content environments represented areas where crop failure is common due to drainage problems with pseudogley which belongs to the group of plastic and acid soils. The highest protein content was recorded at location Osijek in 2010 (17.57 %, genotype Divana), while the smallest protein content had geno-type Soissons (11.09 %) at Slavonski Brod in 2010.

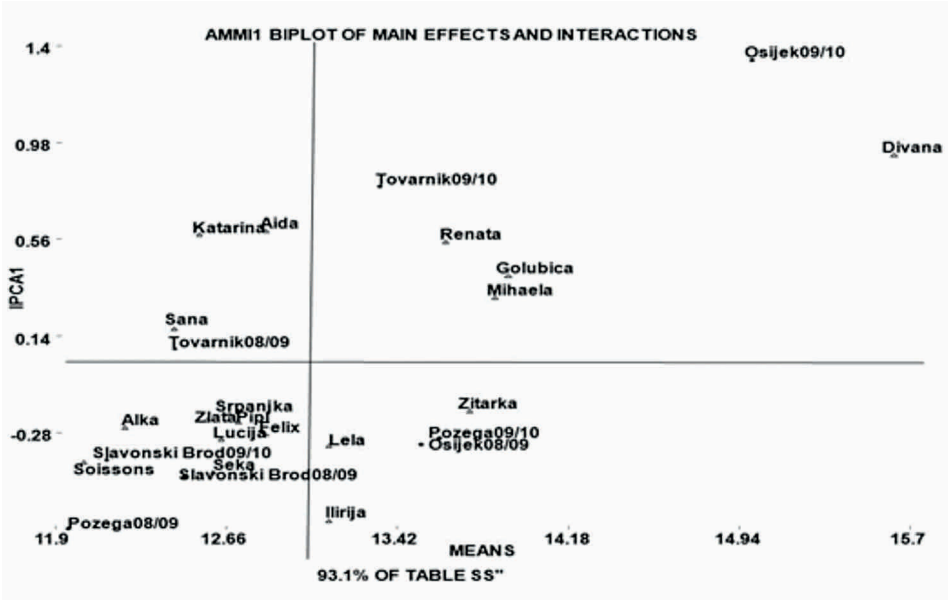

Fig 1. Protein content grouped by genotypes and environments

Fig 1. Sadržaj proteina grupiran po genotipovima i okolinama

On average all genotypes in 2009 and 2010 at location Osijek had 13.35 % and 15.00 % , protein content, at Tovarnik 12.43 % and 13.34 %, at Pozega 11.96 % and 13.26 %, at Slavonski Brod 12.47 % and 12.13%. Fig 2 gives the AMMI II biplot for protein content. Distribution of genotypes points in the AMMI II biplot revealed that genotype Sana scattered closest to the origin,

indicating minimal interaction of this genotype with environments. Baric et al. (2004) consider that the genotypes that give a smaller contribution to the interaction of genotype*environment are more stable in their properties than genotypes with greater contribution to the above-mentioned interaction. The remaining genotypes which scattered away from the origin in the biplot indicated that these genotypes were more sensitive to the environmental influence.

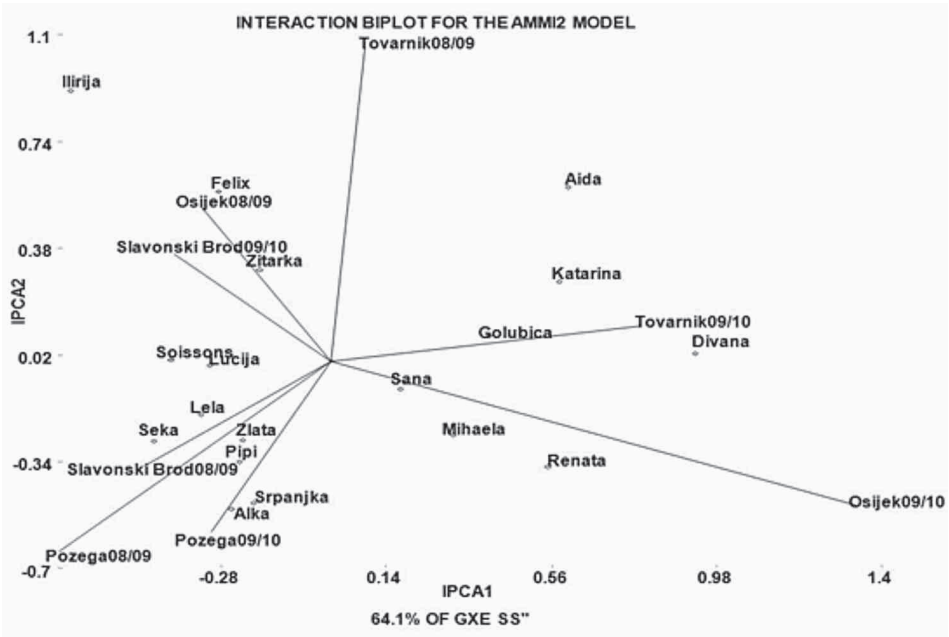

Fig 2. Stability of protein content grouped by genotypes and environments

Fig 2. Stabilnost sadržaja proteina grupiranog po genotipovima i okolinama

Parallel vectors with the same direction (Slavonski Brod 2008/09, Pozega 2008/09 and Pozega 2009/10, Slavonski Brod 2009/10 and Osijek 2008/09) indicate high positive correlations, while opposite directions (Slavonski Brod

2008/09, Pozega 2008/09 and Pozega 2009/10 in comparison with Tovarnik 2008/09 and Slavonski Brod 2009/10 and Osijek 2008/09 in comparison with Osijek09/10) indicate strong negative correlations for GEI.

Table 2. Wet gluten content (%) of analysed genotypes at different locations

Tablica 2. Sadržaj vlažnog ljepka (%) ispitivanih genotipova na različitim lokacijama

Genotype	Osijek 08/09	Pozega 08/09	Tovarnik 08/09	Slavonski Brod08/09	Osijek 09/10	Pozega 09/10	Tovarnik 09/10	Slavonski Brod09/10
Golubica	36	26	30	29	39	37	34	30
Divana	35	26	30	28	39	34	36	27
Zitarka	33	25	30	28	35	33	33	28
Mihaela	31	23	28	24	36	32	32	26
Lela	29	23	25	25	34	31	28	25
Ilirija	29	20	26	22	32	35	29	26
Katarina	29	21	24	24	33	28	28	24
Renata	29	22	24	25	35	30	28	24
Lucija	28	21	27	23	29	23	25	21
Felix	28	19	24	22	31	27	26	23
Pipi	27	20	23	23	30	27	26	22
Soissons	27	20	23	22	30	26	25	23
Sana	27	22	25	24	38	32	31	24
Srpanjka	27	21	21	21	33	34	26	23
Zlata	26	19	21	22	30	26	27	22
Seka	26	23	23	23	30	28	29	23
Aida	26	18	23	22	32	27	26	20
Alka	25	20	22	22	31	25	26	18
Average	29	22	25	24	33	30	29	24

This interaction effect is stronger in a case where vector is longer (Osijek 2009/10, Tovarnik 2008/09, Pozega 2008/09). Spearman coefficient revealed high positive correlation between protein content and wet gluten content, which was expected (data not shown). Gluten proteins are the major storage protein fraction in the mature wheat grain (Tosi et al., 2011).

Wheat proteins contribute to dough properties, bread loaf volume, and crumb structure (Magdić et al. 2006.), as well as in pasta production, where gluten proteins generate the desired cooking quality. In general high protein content genotypes are accompanied by high wet gluten content and sedimentation value. This is not unexpected, since all three parameters were in high statistically significant correlations (data not shown).

Table 3. Sedimentation value (cm^3) of analaysed genotypes at different locations

Tablica 3. Sedimentacijska vrijednost (cm^3) analiziranih genotipova na različitim lokacijama

Genotype	Osijek 08/09	Pozega 08/09	Tovarnik 08/09	Slavonski Brod08/09	Osijek 09/10	Pozega 09/10	Tovarnik 09/10	Slavonski Brod09/10
Divana	72	64	71	53	68	53	70	64
Golubica	72	60	61	54	60	43	68	56
Renata	72	62	59	50	43	42	62	42
Lela	71	62	53	43	46	46	62	45
Mihaela	71	68	67	48	55	40	62	40
Felix	68	54	55	48	41	39	58	41
Alka	66	49	45	27	35	40	54	37
Katarina	65	47	47	33	40	34	59	38
Seka	65	47	47	36	38	40	44	36
Zlata	65	50	48	35	37	35	49	36
Srpanjka	64	53	46	32	33	36	44	34
Ilirija	63	60	50	50	64	40	71	54
Zitarka	61	52	45	44	44	36	58	41
Pipi	60	45	38	34	36	39	59	38
Lucija	55	42	46	33	40	36	46	38
Sana	48	36	35	23	31	29	36	31
Aida	45	31	37	27	36	29	46	33
Soissons	40	34	29	30	33	31	53	34
Average	62	51	49	39	43	38	56	41

CONCLUSION

For more specific definition of genotypes end-use quality it is necessary to evaluate their dough rheological properties. This research work will have a

practical application and will be useful snd helpful to wheat breeders, growers, millers and bakers in their intended uses as every consumer demands a specific wheat quality.

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