PERFORMANCE OF SOME ROMANIAN WINTER WHEAT CULTIVARS UNDER ORGANIC AGRICULTURE CONDITIONS II. BREAD MAKING QUALITY INDICES

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Abstract
In order to explore genetic possibilities for producing wheat suitable to bread-making industry requirements, we tested 16 Romanian winter wheat cultivars in yield tests organized in South Romania at Fundulea, during 2019-2022. Grain protein concentration was generally low, only line FDL Amurg fulfilling on average, but not every year, the requirements for Grade 1 (in Romania, the requirements for organic wheat are the same as for conventional wheat, although the protein content is generally lower under organic conditions). Most tested cultivars belonged to Grade 3, with average grain protein content below 11%. A significant part of grain protein variation was associated with grain yield variation, but two genotypes (FDL Amurg and Voinic) showed positive deviations from the regression yield – grain protein content. Zeleny sedimentation and the alveograph W index were strongly correlated with grain protein percentage, suggesting that, in order to produce high quality wheat under organic agriculture, improving grain protein concentration, genetically or by crop management, is most important.

Key words**:**organic agriculture, wheat cultivars, grain protein content, Zeleny sedimentation, alveograph W index

INTRODUCTION

One of the most difficult challenges for wheat production in organic agriculture is obtaining high breadmaking quality, without using chemical fertilizers and therefore under reduced nitrogen availability (Hildermann et al., 2009).

Many research results demonstrated that both agricultural systems and cultivars have significant effects on breadmaking quality. Organic agriculture has been in most cases associated with lower grain protein content (Carr et al., 2006; Rossi et al., 2006; Mader et al., 2007; Mazzoncini et al. 2007; Krejčířová et al., 2007; Hildermann et al., 2009; Bilsborrow et al., 2013). On the other hand, many crop management measures have been suggested in order to reduce the negative effects of low grain protein contents on breadmaking quality (David et al., 2012; Ali et al., 2020).

Research results obtained in Romania showed that on average wheat produced in organic agriculture had a grain protein concentration about 30% lower, a gluten strength 23% lower and an estimated bread volume 44% lower than wheat produced under conventional crop management (Neacşu et al., 2010). These authors concluded that differences between cultivars regarding quality indices were too small to counteract the effect of agricultural systems. However, recent progress in wheat breeding made us to update research using the newest wheat cultivars. As Toncea (2011) noticed, cultivars may have a higher positive

economic impact than other crop management measures for organic agriculture.

MATERIALS AND METHODS

Samples used for quality analyses were collected from organic yield trials at Fundulea(jud. Călăraşi) by the Agroecological Center for research, innovation and technological transfer of the National Agricultural Research and Development Institute – Fundulea(44°30' N, 24°10' longitude E, 68 m a.s.l.). Details regarding the testing conditions are presented in the accompanying paper „Performance of some Romanian winter wheat cultivars under organic agriculture conditions. I. Grain yield (Marinciu et al., 2022).

From the many indices that describe wheat breadmaking quality we chose for this paper grain protein content, Zeleny sedimentation index and the alveograph index W which estimates dough strength. All traits were determined with a FOSS Infratec 1241 Grain Analyzer.

RESULTS AND DISCUSSIONS

As seen from ANOVA, most of the observed variation for the analysed quality indices was due to the differences between years, but differences between cultivars also explained a significant part of the total variation (Table 1)

Grain protein percentage had generally low values because of limited nitrogen availability related to the absence of chemical N fertilizers (Table 2). Most cultivars had, on average and in most years protein content corresponding to the lowest grade, according to the official grading system adopted in Romania (CNGSC, 2017). Only the breeding line FDL Amurg was on average but in only two of the testing years classified as Grade 1. Four other cultivars (Voinic, Dacia, Izvor and A15) were classified on average as Grade 2. None of the best cultivars for grain protein content had high yields. This fact suggests that besides the genetic possibilities for increasing the protein content to the level required by the breadmaking industry, crop management measures are necessary in organic agriculture to ensure higher nitrogen availability. Analysis of the relationship between grain protein percentage and grain yield showed that the yield differences between cultivars explained a significant part of protein concentration variation – R^2=0,302 (Figure 1). Cultivars with highest yields in organic agriculture had a lower grain protein content. On the other hand, cultivars Dacia and especially A15, which had high grain protein percentage were among the less yielding cultivars. Exceptions were the cultivar Voinic and mostly the breeding line FDL Amurg, which had yields close to the average level of the trial, being at the same time among the cultivars with the highest grain protein concentration

Tabel 1. ANOVA for analysed breadmaking quality indices of wheat cultivars tested in organic agriculture.

		% grain protein		Sedimentation index		Dough strength (W)	
Source of variation	*DF*	*MS*	*F*	*MS*	*F*	*MS*	*F*
Cultivars	15	1,214	3,94**	59,115	4,02***	2062,936	4,20***
Years	2	16,669	54,04***	956,078	65,06***	12703,510	25,89***
Cultivars*Years	30	0,308		14,695		490,766	
Total	47						

*** Highly significant P<0.001

Table 2. Grain protein concentration of wheat cultivars tested in organic agriculture

Cultivar	2019	2020	2021	**Average**	**Grading***
FDL AMURG	12.8	12.7	10.5	**12**	**1**
VOINIC	12.2	10.8	10.4	**11.2**	**2**
DACIA	11.7	10.3	11.2	**11**	**2**
IZVOR	11.5	11.8	9.6	**11**	**2**
A 15	12.6	10.8	9.6	**11**	**2**
LITERA	11.5	12	8.8	**10.7**	**3**
GLOSA	11.9	10.9	9.2	**10.7**	**3**
PITAR	11.7	11	9.2	**10.6**	**3**
ADELINA	11.7	10.7	9.4	**10.6**	**3**
MIRANDA	11.2	10	9.6	**10.3**	**3**
SEMNAL	11.2	10	9.4	**10.2**	**3**
URSITA	10.9	10.4	8.9	**10**	**3**
CARO	11.3	9.6	8.9	**9.9**	**3**
ALEX	10.7	10.4	8.6	**9.9**	**3**
FDL ABUND	10.4	9.5	9.1	**9.7**	**3**
UNITAR	10.4	9.2	9.1	**9.6**	**3**

***) according to**SR 13548 **GRÂU COMUN (*TRITICUM AESTIVUM* L.).**

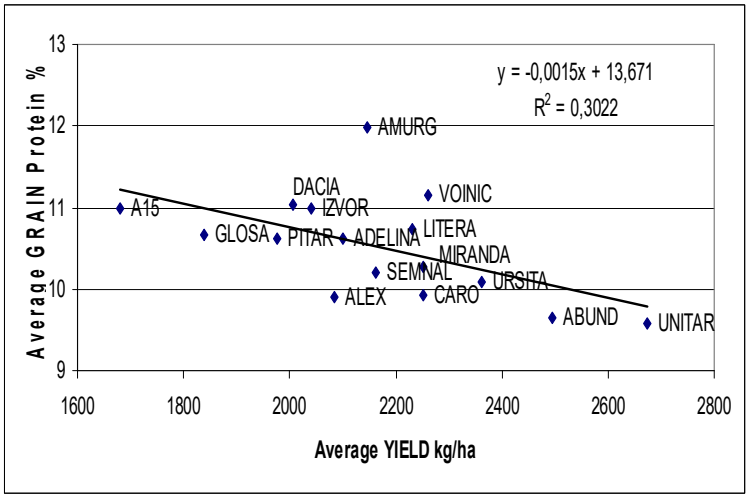

Figure 1. Relationship between the average grain yield and average grain protein percentage in wheat cultivars tested under organic agriculture system (2019-2021)

Both cultivars had important positive deviations from the regression line that describes the general relationship between yield and protein percentage (Table 3). The line FDL AMURG had on average a grain protein content more than 1% higher, and the cultivar VOINIC more than 0.75% higher than expected based on the regression. This could be a reason for recommending these cultivars to organic farmers, in order to produce wheat with satisfactory breadmaking quality, unless efficient crop management practices for increasing nitrogen availability to a level that could sufficiently increase protein content in all cultivars to the required values.

In any case, the two cultivars identified in this study as having the highest positive deviations from the regression yield-

protein content can be recommended as parents in breeding new cultivars for organic agriculture.

Table 3. Grain protein deviations from the regression yield – protein % .

Cultivar	*2019*	*2020*	*2021*	**Average**
FDL AMURG	1 .00	1.84	0.68	**1.17**
VOINIC	1.09	0.21	0.98	**0.76**
LITERA	-0.33	1.9	-0.78	**0.26**
ADELINA	0.41	-0.06	0.22	**0.19**
IZVOR	0.01	0.47	0.04	**0.17**
PITAR	0.38	0.01	0.12	**0.17**
GLOSA	0.04	-0.07	0.24	**0.07**
DACIA	-0.25	-1.05	1.36	**0.02**
A15	-0.12	-0.31	0.22	**-0.07**
SEMNAL	-0.2	-0.38	0.08	**-0.17**
URSITA	-0.17	0.03	-0.7	**-0.28**
MIRANDA FDL	-0.51	-0.33	-0.12	**-0.32**
FDL ABUND	-0.25	-0.58	-0.3	**-0.38**
CARO	-0.08	-0.63	-0.51	**-0.4**
ALEX	-0.58	-0.36	-0.64	**-0.53**
UNITAR	-0.45	-0.7	-0.88	**-0.68**

Taking into account the fact that the cultivars identified in this study as superior in organic agriculture were also noticed in other studies under conventional agriculture (Marinciu et al., 2018), we were interested to find how the grain protein concentrations determined under organic agriculture correlate with the ones determined in conventional agriculture. For this purpose we used data obtained for the same cultivars in the breeding field situated nearby using chemical nitrogen fertilizers, as recommended in conventional agriculture. The correlation between protein percentage measured in the two agriculture systems was not significant, but the cultivars with high deviations from regression had a similar behavior in both cases (Figure 2). This fact suggests that identification of genotypes with high deviations from the negative relationship between yield and grain protein content can be useful for breeding in both systems, but selection for high protein content should be made in each system separately. The regression line describing the relationship between grain protein content in the conventional and organic systems had a subunitary slope (b= 0.44), suggesting that genetic progress obtained for protein concentration in conventional breeding programs is only partially recovered in organic agriculture.

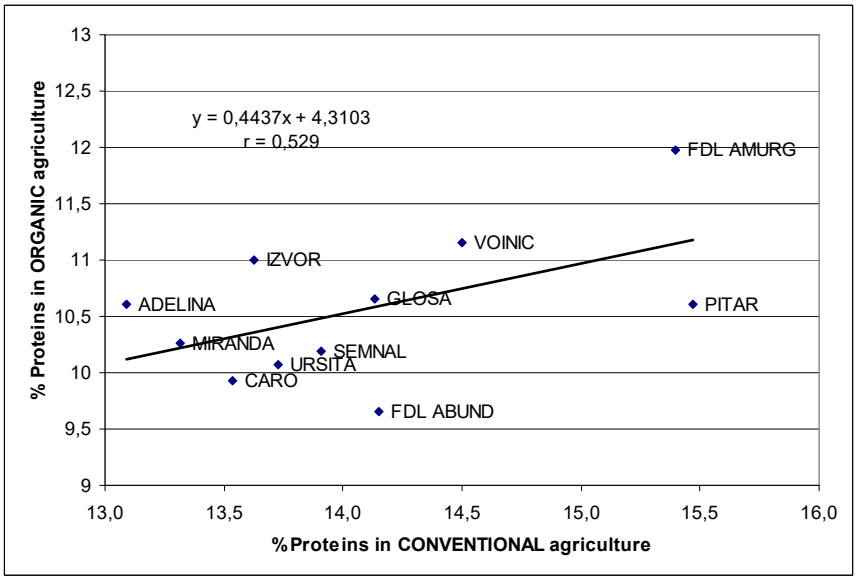

Figure 2. Relationship between grain protein concentrations determined for the same cultivars grown in conventional and organic systems in nearby field

Table 4. Zeleny sedimentation index of cultivars tested in organic agriculture

Cultivar	2019	2020	2021	1.1. Average
FDL AMURG	40 .9	40.2	22.5	**34.5**
VOINIC	37	29.2	23.5	**29.9**
A 15	37.9	26.5	16	**26.8**
IZVOR	30	33	15.7	**26.2**
DACIA	30.3	20.3	26.7	**25.8**
GLOSA	34.7	27.3	14.1	**25.4**
PITAR	32.2	28.1	13.8	**24.7**
LITERA	28.8	31.8	11.5	**24**
ADELINA	32.3	25.1	14.7	**24**
MIRANDA FDL	29.6	21.2	15.2	**22**
SEMNAL	28.4	21.4	15.6	**21.8**
CARO	31.7	20.2	11.8	**21.2**
URSITA	28.8	22.2	9.3	**20.1**
FDL ABUND	24.5	19	13.8	**19.1**
ALEX	22.7	21.9	10.2	**18.3**
UNITAR	22.4	16.2	13.5	**17.4**

Sedimentation index had low values, between 17.4 and 34.5 ml averaged over 3 years (Table 4). It can be noticed that the classification order largely corresponds to the classification for grain protein concentration.

Correlation between Zeleny sedimentation index and grain protein content was very high with R^2=0,94 (Figure 3). This fact suggests that at the low grain protein concentrations observed in the organic system, differences in protein accumulation become more important than differences in protein quality in determining other flour qualitative indices.

The same is true for the alveograph W index which had low values, generally under market requirements (Table 5) and was very closely correlated with grain protein concentration (Figure 4).

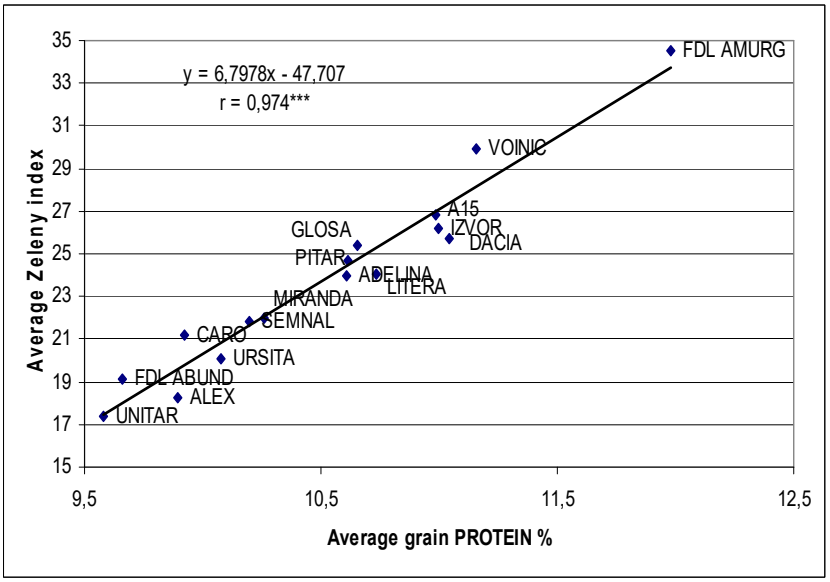

Figure 3. Relationship between the average grain protein concentration and Zeleny index in cultivars tested in organic agriculture (2019-2021)

Table 5. Alveograph dough strength (W) of wheat cultivars tested in organic agriculture

Cultivar	2019	2020	2021	**1.2. Average**
FDL AMURG	249.1	250.3	182.8	**227.4**
A 15	250.5	195.6	165.9	**204**
VOINIC	209.1	197.6	178.1	**195**
DACIA	200.2	162.7	218.5	**193.8**
IZVOR	184.8	229.8	137.5	**184**
LITERA	186.9	227.4	99.7	**171.3**
PITAR	194.7	194.5	123.4	**170.9**
GLOSA	195.8	183.2	130.2	**169.7**
ADELINA	188.5	187.8	131.5	**169.3**
FDL ABUND	167.2	149.1	133.4	**149.9**
ALEX	169.4	175.9	101	**148.7**
URSITA	161.5	174.4	108.6	**148.2**
SEMNAL	168.7	156.7	114.6	**146.6**
MIRANDA	160	147.9	127.8	**145.3**
CARO	156.3	158.4	110.1	**141.6**
UNITAR	152.2	135	118.8	**135.3**

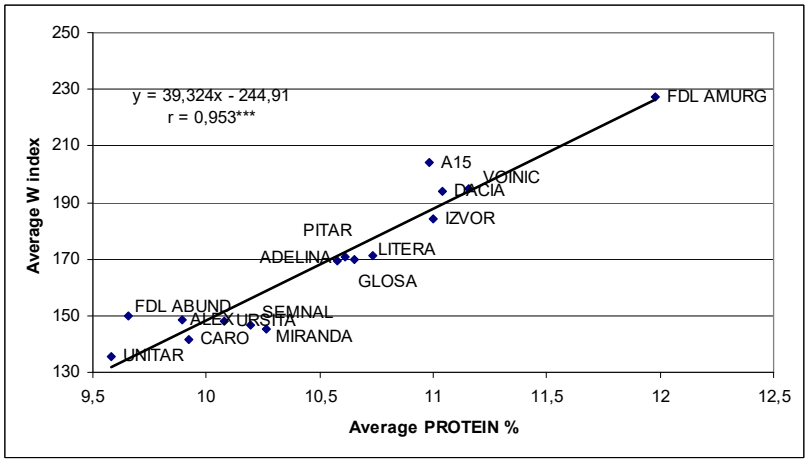

Figure 4. Relationship between the average grain protein percentage and the average alveograph W index of wheat cultivars tested in organic agriculture (2019-2021)

CONCLUSIONS

Obtaining wheat production with superior breadmaking quality in organic agriculture is difficult, mainly because of the lower nitrogen availability, which determines lower grain protein concentrations. Producing organic wheat of high quality in most weather conditions would need an increase of grain protein content, using both crop management measures and cultivars showing positive deviations from the negative relationship between yield and grain protein.

ACKNOWLEDGEMENTS

Results presented in this paper were partially obtained in the frame of the European research project ECOBREED („Increasing the efficiency and competitiveness of organic crop breeding)", H2020 - Grant agreement ID: 771367, financed by the European Union.

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