PERFORMANCE OF SOME ROMANIAN WINTER WHEAT CULTIVARS UNDER ORGANIC AGRICULTURE CONDITIONS I. GRAIN YIELD

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Abstract
In order to identify wheat cultivars most suitable for cultivation in organic agriculture, we tested 16 Romanian winter wheat cultivars in yield tests organized in South Romania at Fundulea and Valu lui Traian during 2019-2022. Most of the yield variation was due to the variation of environmental conditions, but cultivars also had a significant effect. Older cultivars yielded less than modern ones, and highest average grain yields were obtained in the most recently registered cultivars, Ursita and FDL Abund. Genetic progress for yield achieved in breeding programs performed in conventional agriculture conditions was also reflected in the cultivars' performance under organic agriculture.

***Key words**: organic agriculture, wheat cultivars, grain yield*

INTRODUCTION

Concerns about the impact of traditional agriculture on the environment and human health resulted in the development of organic agriculture, despite of generally lower yields, which raise questions about its capacity to produce enough food for the increasing world population (Murphy et al., 2007).

In Romania, according to statistic data, in 2021 agricultural area used for organic production was 468887 ha, of which about 28.6% was occupied by cereals (Dunăreanu and Bonea, 2022). The share of cereals, and therefore of wheat, was smaller in the organic system than in the conventional one.

Many experimental results showed that yields under organic agriculture are lower than those under the conventional one (Carr et al., 2006; Hildermann et al., 2009; Seufert and Ramankutty, 2017; Grausgruber et al., 2022), which is related to a reduced biomass accumulation (Petcu et al., 2011). In Romania, Dunăreanu and Bonea (2022) obtained on average over the testing period, 35% lower yields under organic agriculture, than under conventional one. There are many causes of these smaller yields, one of these being insufficient adaptation of cultivars to the specific conditions. This is why Toncea (2011) stated that wheat cultivars adapted to organic agriculture may have a higher positive economic impact than other crop management practices. According to the same author, best cultivars for yield and bread making quality, which could be recommended for organic farmers, are: Glosa, Exotic, Izvor, Delabrad, Ciprian, Gruia, Faur, Apache, Briana, Dor and Miranda (Toncea, 2011).

Taking into consideration the continuos genetic progress and the fact that organic

agriculture could contribute to mitigation of climate change (Muller and Aubert, 2014), the present paper aims at exploring possibilities of improving the wheat cultivar structure in Romanian organic farms.

MATERIALS AND METHODS

The yield trials analyzed in this paper were conducted in two locations of South Romania, i.e., at Fundulea (jud. Călăraşi) and Valu lui Traian (jud. Constanţa).

At **Fundulea**, the trials were conducted by the Agroecological Center for research, inovation and technology transfer of the National Agricultural Research and Development Institute – Fundulea. The land of the institute is located in the Eastern part of the Romanian plain, in the zone separating the Vlasiei plain from Southern Bărăgan, on the Mostiştea river (44°30’ N, 24°10’ E; 68 m a.s.l.). The land is under organic management since 2011. Climate is continental with annual average temperature 10°C. The soil is a chernozem with pH 5.7, Humus: 3.4%; PAL: 28 ppm P; KAL: 203 ppm K.

At **Valu lui Traian**, the trials were conducted by the Agricultural Research and Development Station Valu lui Traian located at between Podişul Dorobanţului and Podişul Topraisarului (44º11´30" N, 28º30´5" E; 70 m a.s.l.). The land is under organic management since 2015-2016. The climate is moderate continental, with a specific given by the vicinity of the Black Sea, which increases the air humidity, mitigating the temperature contrasts. The soil is a vermic chernozem, formed on loess, with 3.5% humus content, and pH 7.4-7.8.

During the last years many winter wheat cultivars were tested under organic agriculture. At Fundulea, several Romanian cultivars were included in a set of 80 European cultivars tested in the frame of the European research project ECOBREED, and at Valu lui Traian 25 cultivars were tested each year. Sixteen Romanian cultivars released were common in all trials and were included in the present analysis (Table 1). Crop management measures applied are presented in Table 2.

Results of yield trials with wheat cultivars under organic system conditions presented in this paper refer to the years 2018 to 2022. In 2020 the trial at Valu lui Traian was lost because of extreme drought.

Table 1. The wheat cultivars tested in yield trials under organic agriculture conditions

Nr.	Cultivar	Genealogy	Originating Institution	Year when released
1	A15	Selection from Tenmarq	ICAR	1933
2	DACIA	Bucuresti1/Skorospelka3	NARDI Fundulea	1971
3	ALEX	Flamura80/Fundulea29	ARDS Lovrin	1994
4	GLOSA	F135U2-1/F508U1-1BUCUR	NARDI Fundulea	2005
5	IZVOR	KARL/F201R2-111//F508U1-1	NARDI Fundulea	2008
6	LITERA	ERYT26221/F96869G1-1//GLOSA	NARDI Fundulea	2010
7	MIRANDA FDL	ERYT26221/F96869G1-1//GLOSA	NARDI Fundulea	2011
8	PITAR	02555GP2/00099GP2	NARDI Fundulea	2015
9	ADELINA		ARDS Şimnic	2013
10	SEMNAL	05511GP4/LITERA	NARDI Fundulea	2017
11	VOINIC	OTILIA/MIRANDA//OTILIA/02870G	NARDI Fundulea	2020
12	URSITA	00628G34-1/2*GLOSA	NARDI Fundulea	2021
13	FDL ABUND	00628G34-2001/2*OTILIA	NARDI Fundulea	2022
14	UNITAR	M1 IZVOR/M1 00628G34	NARDI Fundulea	Under testing
15	FDL AMURG	MURGA/03124G//06213GP4	NARDI Fundulea	Under testing
16	CARO		ARDS caracal	Under testing

Table 2. Crop management measures

	Fundulea	Valu lui Traian
Yield trial design	Randomised blocks	Balanced square lattice
Harvest plot area	5 m^2	7 m^2
Preceding crop	soybeans	soybeans
Fertilizers	0.25 kg/ha NATURAMIN, every year in early spring 375 kg/ha BIO-FER-NATUR /01.11.2021	
Sowing density	550 germinating seeds/m^2	550 germinating seeds/m^2
Soil preparation	Disc, Chisel, Combinator	Ploughing 20 cm, Disc + combinator
Planting date	15-28 October	20 October-8 November

Table 3. Weather conditions of the testing years at Fundulea

Year	October		November		December		January		February		March		April		Ma		June		July	
	AvgT	Rain	AvgT	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain
2018-2019	13.4	10.8	5.2	23.0	-0.1	43	-1.2	53.8	3.8	21.4	9.3	22.4	11.2	51.4	17.2	124.2	23.6	74.6	23.0	87.4
2019-2020	12.8	38	10.2	33.2	4.0	16.2	0.9	2.0	5.2	16.6	8.3	29.8	12.3	14.0	17.0	58.0	21.7	68.4	25.1	34.2
2020-2021	14.7	28.6	6.1	20.0	3.9	77.6	1.6	77.0	3.2	16.2	5.1	59	9.7	31.0	17.2	57.6	21.1	135	25.3	21.2
2021-2022	10.2	56.4	7.7	33.8	2.6	37.6	2.1	4.8	4.7	5.4	4.4	12.3	12.1	47.6	17,9	30.1	22.6	59.6	25	29.2

Table 4. Weather conditions of the testing years at Valu lui Traian

Year	October		November		December		January		February		March		April		Ma		June		July	
	AvgT	Rain	AvgT	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain	Avg.T	Rain
2018-2019	15.4	4.2	6.4	51	1.1	31	1.2	38.1	3.8	15.5	8.9	17	10.2	44.8	17.5	46	25.7	2.7	23.5	38
2020-2021	16.1	18.6	6.2	23.2	6.18	69.6	3.4	98.6	20.2	20.2	4.7	70.8	9.3	75.8	16.3	82.0	20.3	118.0	24.3	33.8
2021-2022	11.1	101.6	8.6	39.8	4.12	83.4	2.04	13.4	4.3	28.2	2.8	31.2	11.3	31.0	16.1	21.2	21.2	33.6	24.1	25.4

RESULTS AND DISCUSSIONS

ANOVA for grain yield of wheat cultivars tested in organic agriculture shows that most of the variation in yield was due to environmental conditions of the two locations during the testing years (Table 5). The effect of the cultivars was also just significant when tested against the cultivar*environment interaction.

Average yields of wheat cultivars tested under organic system were low, as a result of many unfavorable conditions that differentiate this system from the conventional one. Although data allowing an exact comparison between the two systems were not available, we made an approximate comparison between cultivar yield trials performed not far away under the two different agricultural systems including fertilization and chemical weed control (Table 6). According to the approximate data in the table, average yield of the cultivars tested in organic agriculture were between 29 and 87% of the yield of the same cultivars grown in nearby plots with conventional crop management. Obviously, these yield differences cannot be due entirely to the agricultural systems, because many studies showed that grain yields under organic agriculture are generally 14-40% lower than under conventional agriculture (Mäder et al., 2007; Seufert et al., 2012; Seufert and Ramankutti, 2017). Results obtained at Fundulea, especially in 2020, were clearly affected by other factors than those associated with the agricultural system.

Yields obtained by the 16 cultivars in the 7 testing environments varied from 1261 kg/ha for cultivar Izvor in 2020 at Fundulea, to over 5900 kg/ha for cultivar Unitar in 2021 at Valu lui Traian. Averaged over all

conditions the cultivars' yield varied from 2533 kg/ha for A15, to 3631 kg/ha for cultivar Ursita. Yield stability, characterized by the coefficient of variation coefficient (CV%) varied from 33.6 for cultivar Miranda FDL to over 52% for cultivar Glosa. It is interesting to note that cultivar Miranda FDL was also identified by Dunăreanu and Bonea (2022) as having a superior yield stability in organic agriculture. All tested cultivars had lower coefficients of variation than Glosa (most widely grown, both in conventional and organic agriculture), and four of them gave also higher yields.

Table 5. ANOVA for grain yield of wheat cultivars tested under organic agriculture

Souce of variation	*DF*	*MS*	*F*	*P value*
Cultivars	15	502060	1.78*	0.05
Environment (Years*Locations)	6	22828722	80.81***	< 0.001
Error	90	282230		
Total	111			

Table 6. Average yield of wheat cultivars tested under organic agriculture as compared with yield obtained in trials performed in nearby plots under conventional crop management

	Average yield (kg/ha)		% organic/conventional
Experient	**Under organic agriculture**	**Under conventional agriculture**	
Fundulea 2019	2561	5634	45.4
Fundulea 2020	1752	6000	29.2
Fundulea 2021	2167	5849	37.0
Fundulea 2022	3937	5689	69.2
Valu Traian 2019	2644	6894	38.4
Valu Traian 2021	4974	5683	87.5
Valu Traian 2022	4197	6357	66.0

Table 7. Yields of cultivars tested under organic agriculture in 7 environments

Cultivar	Fundulea 2019	Fundulea 2020	Fundulea 2021	Fundulea 2022	V.Traian 2019	V.Traian 2021	V.Traian 2022	Average	*CV%*	Difference from GLOSA
URSITA	2886	1897	2305	4786	2773	5077	**5689**	3631	41.6	+334*
FDL ABUND	**3240**	2131	2114	**4851**	2823	4920	4619	3528	35.5	+232
UNITAR	3051	**2220**	**2749**	3359	**3012**	**5953**	4243	3512	35.3	+216
VOINIC	2877	1748	2159	4109	2692	4457	5413	3351	39.9	+54
GLOSA	2295	1550	1668	4355	2433	5820	4951	3296	52.1	0
LITERA	2309	2117	2270	4220	2692	5577	3535	3246	39.5	-50
ALEX	2726	1650	1877	3107	2917	5273	4810	3194	43.1	-102
FDL AMURG	2292	1616	2527	2698	2612	5673	4928	3192	47.0	-104
CARO	2651	2017	2085	3540	2722	4980	4224	3174	35.2	-122
SEMNAL	2620	1902	1964	4209	2683	5583	3066	3147	42.1	-149
IZVOR	2535	1261	2323	**4867**	2428	4053	4174	3092	41.6	-204
DACIA	2178	1300	2542	4527	2187	4430	4025	3027	42.4	-269
ADELINA	2701	1691	1907	3905	2727	4350	3755	3005	34.1	-291
MIRANDA FDL	2375	1945	2437	3699	2703	4872	2753	2969	33.6	-327^{0}
PITAR	2681	1543	1708	3279	2400	5765	3061	2920	48.3	-376^{0}
A15	1559	1441	2039	3474	2507	2802	3907	2533	36.9	-763^{00}
Average over cultivars	2561	1752	2167	3937	2644	4974	4197	3176	40.5	

A largely debated subject regarding the choice of wheat cultivars for organic agriculture is about advantages and disadvantages of old cultivars in comparison with modern ones. Some authors stated that old cultivars could be more suitable for organic agriculture because of their superior capacity for

symbiosis with arbuscular mycorrhiza that favor plant nutrition under unfavorable conditions, because they have better competitiveness with weeds and have higher grain protein content (Stalenga and Jończyk, 2008). Old cultivars are supposed to be more robust and therefore might better face climate changes, including under organic agriculture (Migliorini et al., 2016; Carranza-Gallego et al., 2018).

On the other hand many researches demonstrated the yield superiority of modern cultivars in comparison with old cultivars, including in organic agriculture (Hildermann, 2009; Carr et al., 2006; Seufert and Ramankutty, 2017; Grausgruber et al., 2022).

Results of our study demonstrated that cultivar A15, the oldest of the tested cultivars, gave the lowest yields in 4 out of 7 analyzed conditions and the lowest average yields over all conditions. The cultivar Dacia, that was next in age, also gave an average yield lower than average. These results were confirmed by the results of the European research project ECOBREED, where the lowest yields were observed in the old cultivars (Bánkúti 1201, A15, Slovenská 200 and Radošínska Karola from Hungary, Romania and Slovakia, respectively) (Grausgruber et al., 2022).

The highest average grain yields in our study were obtained in the most recently released cultivars Ursita and FDL Abund, which outyielded the cultivar Glosa, recommended based on previous research findings for organic farms (Toncea, 2011). This demonstrates that the genetic progress in yield, obtained by breeding programs working under conventional agriculture, was also reflected, at least partially under organic agriculture.

It is worth mentioning that in studies performed in the frame of the European research project ECOBREED cultivar URSITA was found to have also other characteristics that are important for organic agriculture, such as resistance to many bunt races, including the ones prevalent in Romania (Pfatrisch et al., 2022) and a higher capacity to exudate compounds with allelopatic effects on some weeds (Hussain et al., 2022).

CONCLUSIONS

Multi-year testing of several Romanian winter wheat cultivars under organic agriculture in two research centers of South Romania, showed that modern cultivars gave higher grain yield as compared with old cultivars. Most recently released cultivars (Ursita and FDL Abund) can be recommended for organic farmers in Romania.

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REFERENCES

Carr P.M., Kandel H.J., Porter P.M., Horsley R.D., Zwinger S.F. 2006. Wheat Cultivar Performance on Certified Organic Fields in Minnesota and North Dakota. Crop Science 46 (5):1963-1971.

Carranza-Gallego G., Guzmán G.I., García-Ruíz R., González de Molina M., Aguilera E. 2018. Contribution of old wheat varieties to climate change mitigation under contrasting managements and rainfed Mediterranean conditions. Journal of Cleaner Production 195: 111-121

Dunăreanu I. C. and Bonea D. 2022. Grain yield and hectolitre weight of some wheat cultivars in organic and conventional production systems. Romanian Agricultural Research 39:1-9.

Grausgruber H., Megyeri M., Hauptvogel P., Fusková M., Marinciu C.M., Şerban G., Bauer N., Mayer M., Veskrna O., Jockovic B., Titan P., Meglič V. 2022. Multi-environment trials of the

ECOBREED wheat diversity panel. In: Vereinigung der Pflanzenzüchter und Saat-gutkaufleute Österreichs (Ed.), 72.Jahrestagung 2021, 22-24 November, Raumberg-Gumpenstein, pp. 43-52. University of Natural Resources and Life Sciences, Vienna, Austria.

Hildermann I., Thommen A., Dubois D., Boller T, Wiemkenc A. and Mader P. 2009. Yield and baking quality of winter wheat cultivars in different farming systems of the DOK long-term trial. Journal of the Science of Food and Agriculture 89: 2477–2491.

Hussain M.I., Vieites-Álvarez Y., Reigosa M. J. and Sánchez-Moreiras A.M. 2022 . Enhanced exudation of BOA, HMBOA, HBOA and DIBOA by wheat seedlings in proximity to common purslane (*Portulaca oleracea*) and annual ryegrass (*Lolium rigidum*). In: Vereinigung der Pflanzenzüchter und Saat-gutkaufleute Österreichs (Ed.), 72. Jahrestagung 2021, 22-24 November, Raumberg-Gumpenstein, pp. 77-78. University of Natural Resources and Life Sciences, Vienna, Austria.

Mäder P., Hahn D., Dubois D., Gunst L., Alfoldi T., Bergmann H., Oehme M., Amado R., Schneider H., Graf U., Velimirov A., Fließbach A. and Niggli U. 2007. Wheat quality in organic and conventional farming: results of a 21 year field experiment. Journal of the Science of Food and Agriculture 87:1826–1835.

Migliorini P., Spagnolo S., Torri L., Arnoulet M., Lazzerini G. and Ceccarelli S. 2016.Agronomic and Quality Characteristics of Old, Modern and Mixture Wheat Varieties and Landraces for Organic Bread Chain in Diverse Environments of Northern Italy. European Journal of Agronomy 79:131-41. doi:10.1016/J.EJA.2016.05.011.

Muller A. and Aubert C. 2014. The Potential of Organic Agriculture to Mitigate the Influence of Agriculture on Global Warming—A Review. Chapter 13. In: S. Bellon, S. Penvern (eds.), Organic Farming, Prototype for Sustainable Agricultures, pp. 239-259. Springer, Dordrecht. DOI 10.1007/978-94-007-7927-3_13.

Murphy K.M., Garland-Campbell K.A., Lyon S.R., and Jones S.S. 2007. Evidence of varietal adaptation to organic farming systems. Field Crops Research 102:172-177.

Petcu E., Toncea I., Mustăţea P., Petcu V. 2011. Effect of organic and conventional farming systems on some physiological indicators of winter wheat. Romanian Agricultural Research 28: 131-135.

Pfatrisch K., Sternbauer M., Dumalasova V., Marinciu C.,Grausgruber H. (2022) Evaluation of ECOBREED winter wheat germplasm for common bunt resistance. In: Vereinigung der Pflanzenzüchter und Saat-gutkaufleute Österreichs (Ed.), 72. Jahrestagung 2021, 22-24 November, Raumberg-Gumpenstein, pp. 67-71. University of Natural Resources and Life Sciences, Vienna, Austria.

Seufert V., Ramankutty N. 2017. Many shades of gray-The context-dependent performance of organic agriculture. Science Advances 3 (3):e160263.doi: 10.1126/sciadv.1602638

Seufert V., Ramankutty N., Foley J.A. 2012. Comparing the yields of organic and conventional agriculture. Nature 485:229–232.

Stalenga J. and Jończyk K. 2008.Yielding and Selected Leaf Diseases of Old Winter Wheat Cultivars in the Organic System. 16th IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008.https://orgprints.org/id/eprint/12407/

*Toncea I. 2011. Identificarea şi cultivarea în sistem ecologic a soiurilor de grâu de toamnă (*Triticum aestivum*) pentru panificaţie (Project financed by the World Bank and the Ministry of Agriculture through the Grant Agreementnr.141540/21.04.2008). In:* Genetica și fiziologia rezistenței plantelor. *21 iunie 2011, Chişinău:164.*