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DIFFERENT GENOTYPES OF ALTERNATIVE SMALL GRAINS IN ORGANIC FARMING

Dušan Dj. KOVAČEVIĆ[*1], Svetlana ROLJEVIĆ[2], Željko DOLIJANOVIĆ[1], Snežana DJORDJEVIĆ[1], Vesna MILIĆ[3]

[1]University of Belgrade, Faculty of Agriculture, Belgrade, R. Serbia
[2]Institute of Agricultural Economics, Belgrade, R. Serbia
[3]University of East Sarajevo, Faculty of Agriculture, East Sarajevo, R. Bosnia and Herzegovina

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The main objectives were to examine different genotypes of alternative small grains important for food technology in organic farming conditions on morphological and productive characteristics. Four genotypes of different alternative small grains were included in the trial. Three of them were chosen for specific usage in food technology compact wheat Bambi - *Triticum aestivum* L. ssp. *compactum,* spelt Nirvana *(Triticum aestivum* L. ssp. *spelta)*, durum wheat Durumko- (*Triticum durum* L.), and one which leads as a genotype for intensive conventional common wheat production in Serbia - NS 40S (*Triticum aestivum* L. ssp. *vulgare*).

Plots were fertilized with biohumus "Royal ofert" (30 t ha^{-1}) applied in autumn with basic tillage and microbial fertilizer "Slavol" ad as in spring foliar treatment in full tillering (5 l ha^{-1}).

Alternative small grains durum wheat and compact wheat except splet gives lower grain yield in organic condition compared with comercial cultivar for high-input NS-40S.

Key words: alternative small grains, genotypes, organic farming, yield

INTRODUCTION

Currently, different directions in which agriculture is conceived, are existing, weather it is represented as industrial, so called very intense, or conventional one followed also by many environmental trends based on strict principles of environmental inputs. Conventional agriculture

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Corresponding author: Dušan Dj. Kovačević, University of Belgrade, Faculty of Agriculture, Institute of Field and Vegetable crops, dulekov@agrif.bg.ac.rs; +381 11 2615-315 ext. 356, fax: +381 11 3161-987

has a duty to ensure maximum production in terms of quantity and quality at the lowest cost. For these purposes, a variety of cultural practices are available, sometimes with many negative long-term effects in agroecosystems, in addition to the expected positive effects (KOVACEVIC *et al*., 2010).

Organic farming is one of the most interesting current trends in agriculture entirely based on ecological principles and the absence of agricultural chemicals use (pesticides, fertilizers, antibiotics, hormones, GMOs, etc. The Republic of Serbia has significant natural resources and favorable conditions for agricultural production, which can meet the basic requirements for the establishment of organic farming, due to less contamination of soil and water, and to less use of pesticides and other chemicals. Organic production is characterized by a certain transition period of conversion, greater biodiversity, changed agricultural practices and the necessary certification. (KOVACEVIC and LAZIC, 2012).

However, when it comes to organic field production it is necessary to choose field types of plants without normal use (alternative), suitable for this type of production (PEARSON *et al*., 2004; BAVEC, and BAVEC, 2007; MALESEVIC *et al*., 2010). The highest yielding cultivars with best quality in conventional systems are not the highest yielding cultivars with the best quality in organic systems, would suggest the need for breeding and selection under organic conditions (MURPHY *et al.,* 2007). Some of these grains may be of local significance or of limited markets, and some are interesting on the so oriented farms (KOVACEVIC *et al*., 2011).

The main objectives were to examine different genotypes of alternative small grains important for food technology in organic farming conditions on morphological and productive characteristics.

MATERIALS AND METHODS

Investigation of different genotypes alternatives types of small grains in organic condition was conducted on Radmilovac experimental station of the Faculty of Agriculture in Belgrade during vegetation seasons 2006/07 and 2006/08.

A factor in this study, is represented by different genotypes of winter wheat, of which three are, so called, alternative grains - wheat varieties of different types of special purpose (Bambi, Nirvana, Durumko) and one ordinary baking soft wheat cultivar NS 40S bred primarily for conventional intensive production.

The basic characteristics of the genotypes of different types of wheat are as follows:

G_1 - NS 40S, medium early baking genotype of common wheat *Triticum aestivum* ssp. *vulgare* has been selected primarily for conventional intensive production leading cultivar for conventional production in Serbia NS 40S - good resistance to winter frost, drought tolerant, high yield potential, high-quality Class B_1-B_2.

G_2 – Bambi, late varieties of compact wheat *Triticum aestivum* ssp. *compactum*, winter frost resisted with a booted grain. Bambi is intended exclusively for preparing tea and hard biscuits.

G_3 – Nirvana, late varieties of spelt wheat *Triticum spelta*, winter frost resisted with a booted grain. This genotype of wheat is used for making special bread that is digested much faster than one made of the regular wheat.

G_4 – Durumko, winter - spring durum wheat *Triticum durum*. Genotype durumko is intended exclusively for making pasta, spaghetti, macaroni, etc. Since it is optional can be sown from early October to mid - February.

The experiment, in addition to control (F_0), has examined two variants with factor (F):
F_1- fertilization by biohumus and microbiological fertilizer during recharging (30 t ha^{-1} + 5 l ha^{-1} Slavol).
F_2 - fertilization of a microbial inoculant - 5 1 ha $^{-1}$ prep. "Slavol" (*Bacillus megaterium* - 10^6 cm^{-3}, *Bacillus licheniformis* $10^6 cm^{-3}$, *Bacillus suptilis* - 10^6 cm^{-3}, *Azotobacter chtoococcum* - 10 ^{6} cm^{-3}, *Azotobacter vinelandi*- 10^6 cm^{-3}, *Derxia* sp. $10^6 cm^{-3}$. Auxin activity that corresponds to the activities of indole - 3 - acetic acid (IAA) in the range of 0.01-0.1 mg L^{-1}.

Sowing was done at the end of the second week of October. In both years for planting the original seed of the Institute for Small Grains/Institute of Field and Vegetable Crops in Novi Sad has been used.

The experiment was conducted under 4-yr crop rotations that included dismissal of crops in the following order: maize - winter wheat - spring barley + red clover - red clover, where legumes red clover was nitrogen source. The previous crop every year to winter wheat was maize.

After the harvest, the grain yield was measured by elemental plots immediately after threshing and reduced to a moisture level of 14%. Samples were taken among 10 plants in four replications for measuring productive characteristics of the plant (stem height, spike length, number of spikes, number of grains in spike, harvest index) and yield per hectare.

Statistical analysis of data for all traits was performed using analysis of variance for factorial experiments at two different growing seasons. For individual comparisons, we used the LSD test. Correlation analysis was performed by Statistica 6.0 package to determine the relationship among the characters according to Pearson method.

Meteorological conditions

Meteorological conditions during the study period at the experimental field "Radmilovac" in the period 2006/07-2007/08 are shown in the table below.

Meteorological conditions during the study period had a significant influence on the formation of high yields of wheat. The data in Table 1, shows that the first year examination 2006/07 period was much worse comparing to the second one. It is characterized by low rainfall during the winter months and more modest amounts in the spring period. The lack of moisture in the soil especially in April and increased rainfall in June, had an influence on the reduction of yield in that year. The second year of trials had more favorable temperature conditions and a better distribution of rainfall per month for important critical period for moisture corn compared to the initial year.

Table 1. Mean monthly temperature (^0C) and monthly precipitation summ (mm) in Belgrade

Year	Temp/ Precipitation	Months										Average/ summ
		X	XI	XII	I	II	III	IV	V	VI	VII	
2006/07	^0C	16.1	9.6	4.7	7.9	7.8	10.8	14.7	19.8	24.4	26.9	14.3
	mm	21	25	48	36	53	100	4	79	108	18	492.0
2007/08	^0C	12.1	5.6	1.5	3.4	6.6	9.8	14.2	19.3	23.0	23.6	11.9
	mm	104	131	34	42	10	79	35	61	45	64	605.0

RESULTS AND DISCUSSION

Breeding programs dedicated to organic agriculture would focus on traits including improved nitrogen and nutrient efficiency, adaption to soil microbes, improved competitiveness against weeds and resistance to insects and diseases currently controlled with chemical pesticides with the incorporation of these traits into high yielding cultivars, organic agriculture will be better equipped to realize its full potential as a viable alternative to conventional agriculture (MURPHY *et.al.,* 2007; PRZYSTALSKI *et al*., 2008). The transition to new technologies with lower investments, as the case in the organic production of winter wheat and other grain alternative is unthinkable without the new varieties. The initial approach and criteria in the ideo/types varieties design for such a change to the conditions must be different from the present.

New varieties must have a greater resistance to abiotic and biotic stress conditions, more efficient uptake of mineral nutrients and better exploit of the existing environmental conditions. Since the problems of weeds in organic crop production are more pronounced if it is the initial criteria, it is certain that sorts incurred by this means should be selected, based on other grounds (BERENJI, 2009).

Many alternative grains may well be successful in our environmental conditions as indicated by our research. Each genotype has a morphological characteristic, the need for different vegetation factors, usage, etc. like any other commercial crop. Placing the individual genotypes in terms of organic cultivation technology, we have examined their response through measurement of morphological and productive traits. Test results of morphological and productive characteristics of different wheat genotypes are shown in Tables 2 to 7.

Table 2. Steam height, cm

Year/	2006/07			Average	2007/08			Average	Average
Genotype	F_0	F_1	F_2	G	F_0	F_1	F_2	G	
G_1	60.66	65.81	62.60	63.03[a]	61.86	66.60	68.15	65.54[a]	64.28
G_2	59.46	73.64	65.73	66.28[a]	73.57	75.76	76.94	75.43[b]	70.85
G_3	75.80	75.31	87.79	79.64[b]	86.13	91.56	87.42	88.37[c]	84.00
G_4	66.05	65.52	68.06	66.58[a]	71.88	63.45	65.67	65.89[a]	66.23
Average F	65.49[a]	70.10[ba]	71.05[b]	68.88	72.53[a]	74.35[a]	74.55[a]	73.81	71.34

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

On average, tree height varied from 64.28 cm (G_1) to 84.0 cm (G_3). The fertilizer increased the height of the tree, especially in the unfavorable weather conditions in the first year of investigation (table 2).

Spike length depended on the investigation genotype in both years, and the fertilizer, has no affected on this characteristic (table 3). Best class occurs by spelt wheat (variety Nirvana) and the shortest compact wheat.

Number of spikelets was trait that most minimally varied depending on the investigation factors. In both years, the largest number of spikelets was obtained by compact wheat, but in this species, as with other genotypes it was not significantly changed depending on the applied fertilizer (table 4).

Separate breeding for high and low fertilizer inputs may be required when genotype-by-fertilizer interaction involving rank-change occurs entailing additional resource commitments (SINEBO *et al*., 2002)

Table 3. Spike length, cm

Year/ Genotype	2006/07 F_0	2006/07 F_1	2006/07 F_2	Average G	2007/08 F_0	2007/08 F_1	2007/08 F_2	Average G	Average
G_1	6.75	8.00	7.74	7.49[a]	8.07	9.19	7.83	8.26[a]	7.87
G_2	3.92	4.03	3.91	3.96[b]	3.93	4.09	3.82	3.95[b]	3.95
G_3	11.97	9.97	11.94	11.19[c]	11.96	12.22	12.82	12.34[c]	11.76
G_4	6.57	7.15	7.76	7.15[a]	7.57	7.44	8.09	7.70[a]	7.42
Average F	7.30[a]	7.20[a]	7.83[a]	7.44	7.89[a]	8.16[a]	8.14[a]	8.06	7.75

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Table 4. Number of spikelet

Year/ Genotype	2006/07 F_0	2006/07 F_1	2006/07 F_2	Average G	2007/08 F_0	2007/08 F_1	2007/08 F_2	Average G	Average
G_1	15.40	18.00	18.03	17.14[a]	17.86	19.70	18.40	18.66[a]	17.90
G_2	20.90	22.13	20.73	21.26[b]	19.60	21.43	20.93	20.66[ba]	20.96
G_3	18.20	15.10	18.26	17.19[a]	19.03	19.10	20.16	19.43[a]	18.31
G_4	18.00	19.06	19.06	18.71[ba]	18.00	18.60	19.06	18.56[a]	18.63
Average F	18.13[a]	18.58[a]	19.02[a]	18.42	18.62[a]	19.71[a]	19.64[a]	19.32	18.87

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Table 5. Number of grains per spike

Year/ Genotype	2006/07 F_0	2006/07 F_1	2006/07 F_2	Average G	2007/08 F_0	2007/08 F_1	2007/08 F_2	Average G	Average
G_1	34.70	37.13	38.73	36.86[a]	47.10	57.93	43.60	49.54[b]	43.20
G_2	49.30	63.56	50.56	54.48[b]	53.60	66.33	59.20	59.71[a]	57.09
G_3	30.90	22.63	32.20	28.58[ba]	32.43	33.73	39.06	35.08[c]	31.83
G_4	31.80	40.83	41.73	38.12[a]	46.50	41.33	51.76	46.53[bd]	42.32
Average F	36.67[a]	41.04[a]	40.81[a]	39.51	44.91[a]	49.83[a]	48.41[a]	47.71	43.61

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Number of grains per spike was statistically significantly varied depending on the genotype. Due to this effect of genotype statistical significance in interaction with other factors investigated was found (table 8). Differences between individual genotype were highly significant in the investigation for both years. If we look at the average number of grains per spike for a two-year period (Table 5), we find it smallest at spelled wheat (31.83).

Harvest index depended on genotype, showing the highest value obtained from spelt and lowest with compact wheat in both years of investigation. Fertilization with organic and microbial fertilizers compared to the control led to a small increase in the value of harvest index, but significant differences obtained were not statistically significant (table 6).

Table 6. Harvest index, %

Year/	2006/07			Average	2007/08			Average	Average
Genotype	F_0	F_1	F_2	G	F_0	F_1	F_2	G	
G_1	46.08	45.22	44.34	45.22[a]	46.12	46.32	45.00	45.82[a]	45.52
G_2	42.51	41.49	40.80	41.62[b]	41.44	40.11	40.80	40.78[b]	41.20
G_3	46.26	46.93	46.25	46.48[a]	46.99	47.10	47.01	47.03[a]	46.76
G_4	42.18	45.09	42.84	43.37[ab]	44.98	44.79	45.46	45.08[a]	44.22
Average F	44.26[a]	44.69[a]	43.56[a]	44.17	44.88[a]	44.58[a]	44.57[a]	44.68	44.42

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Factorial analysis of variance have showed that grain yields significantly depend on the chosen fertilizer. Combined application of organic fertilizer in the fall and microbial in the spring, the highest average yields of alternative wheat were obtained regularly. The yield obtained by this variant, compared to the other two variants of fertilization were highly significant.

From the genotypes, the highest yields were obtained by growing commercial varieties NS-40S, especially in terms of combined application of organic and microbial fertilizers in the second, a better year of study (table 7). Spelt wheat is second genotype by its yield, with a note that the yield of this genotype in the control plots were always the lowest.

Table 7. Grain yield, t ha^{-1}

Year/	2006/07			Average	2007/08			Average	Average
Genotype	F_0	F_1	F_2	G	F_0	F_1	F_2	G	
G_1	3.13	3.91	3.38	3.47[a]	4.63	6.53	5.65	5.60[a]	4.54
G_2	2.25	2.59	2.96	2.60[b]	3.49	5.40	4.44	4.44[b]	3.52
G_3	3.47	4.33	2.81	3.54[a]	3.75	6.10	4.84	4.89[c]	4.22
G_4	2.52	3.35	2.62	2.83[b]	3.78	5.22	3.97	4.32[b]	3.57
Average F	2.84[b]	3.55[a]	2.94[b]	3.11	3.91[b]	5.81[a]	4.73[c]	4.81	3.96

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Table 8. The statistical significance of differences of the traits (F test and LSD test)

Characteristics	Year	2006/07			2007/08		
	Factor	G	F	GF	G	F	GF
Steam height	F test	***	**	*	***	ns	ns
	LSD 0.05	4.24	3.67	7.35	5.56	4.81	9.63
	0.01	5.82	5.04	10.07	7.62	6.60	13.20
Spike length	F test	***	Ns	*	***	ns	ns
	LSD 0.05	0.75	0.65	1.30	1.03	0.89	1.78
	0.01	1.03	0.89	1.79	1.41	1.22	2.44
Number of spikelet	F test	**	Ns	ns	ns	ns	ns
	LSD 0.05	1.54	1.33	2.67	1.84	1.59	3.19
	0.01	2.11	1.83	3.66	2.52	2.18	4.37
Number of grains per spike	F test	**	Ns	*	**	ns	*
	LSD 0.05	5.88	5.09	10.19	6.15	5.33	10.66
	0.01	8.06	6.98	13.97	8.44	7.31	14.61
Harvest index	F test	*	Ns	ns	**	ns	ns
	LSD 0.05	2.77	2.40	4.81	2.32	2.01	4.02
	0.01	3.81	3.30	6.59	3.18	2.75	5.51
Grain yield	F test	*	*	ns	***	***	*
	LSD 0.05	0.608	0.526	1.053	0.194	0.168	0.336
	0.01	0.834	0.722	1.444	0.266	0.230	0.461

^{ns}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

Pearson's correlation coefficient indicates that there is a statistically significant positive correlation between spike length and stem height and harvest index between investigation and all factors. On the other hand, there is no statistically significant correlation between grain yield and stem height and grain yield and spike length (p > 0.05), as shown in table 9.

Tabela 9. Corelation matrix of the observed traits (average 2006/07-2007/08)

Variable	Grain yield	Steam height	Spike lenght	Harvest index
Grain yield	-	0.13^{ns}	0.28^{ns}	0.35^{*}
Steam height		-	0.53^{**}	0.36^{*}
Spike lenght			-	0.83^{**}
Harvest index				-

^{nsz}=P>0.05 *=P<0.05 **=P<0.01

Environmental factors through different years strongly influenced the yield of small grains, even though there was also a significant genotype effects shown by analysis of variance. Productivity is a function of the variety of adaptability to environmental conditions, thus it is very important to varieties creating able to provide consistently high yields in a wide range of environmental factors. This large difference in variance between environmental influences and genotypic clearly demonstrates the importance of impact of meteorological conditions on yield of winter wheat tested small grains genotypes. Phenotypic variability of the major yield components (steam height, length of spike, number of spikelet) is primarily caused by differences between the genotypes of the cultivars, while the variation of their products (number of grain per spike and grain yield) depends mainly on the interaction between genotype and environmental factors.

CONCLUSION

The investigation different genotypes of alternative small grains for food technology and their effects on morphological and productive characteristics in organic farming condition leads to the conclusion:

The importance of genotype response to growing conditions on environmental grounds is very large, the choice of the genotype is important as the level of implementation of other cultural practices.

Any difference in the average grain yield depending on genotype, except between compact and durum wheat are highly significant. A high correlation between steam height and grain yield and grain yield and spike length was found.

An alternative crop make a positive contribution by increasing diversity on the farms income base, spreading out the risks reducing weakness in the farm system or broadening the base operations.

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RAZLIČITI GENOTIPOVI ALTERNATIVNIH STRNIH ŽITA U ORGANSKOJ PROIZVODNJI

Dušan Dj. KOVAČEVIĆ[1], Svetlana ROLJEVIĆ[2], Željko DOLIJANOVIĆ[1],
Snežana DJORDJEVIĆ[1], Vesna MILIĆ[3]

[1]Univerzitet u Beogradu, Poljoprivredni fakultet, Zemun, R. Srbija
[2]Institut za ekonomiku poljoprivrede, Beograd, R. Srbija
[3]Univerzitet u Istočnom Sarajevu, Poljoprivredni fakultet, Istočno Sarajevo, R.BiH

Izvod

Organska poljoprivreda je jedan od interesantnih aktuelnih pravaca zasnovan na ekološkim principima i na odsustvu primene agrohemikalija. Za organsku proizvodnju alternatinih strnih žita izuzetno je važan izbor vrste odnosno sorte. Posebno su za ovu proizvodnju značajni genotipovi selekcionisani za posebne namene. Za preporuku su oni genotipovi koji su na osnovu produktivnih osobina adaptibilniji na skromnije uslove u ovom tipu proizvodnje i otporniji na bolesti i štetočine.

Na osnovu naših istraživanja pšenica krupnik (*Triticum spelta*) je dala najbolje rezultate u poredjenju sa ostalim alternativnim vrstama, odnosno slične rezultate kao sorta za komercijalnu upotrebu NS 40 S. Medjutim, i druga dva ispitivana genotipa pokazuju da mogu biti interesantni za organsku proizvodnju s obzirom da poseduju specifična kvalitativna svojstva.

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