

## AGRO-ECOLOGICAL CONDITIONS AND MORPHO-PRODUCTIVE PROPERTIES OF SPELT WHEAT

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**Abstract:** Experiments were conducted during 2011-2012, at three localities in Serbia (Valjevo, Nova Varoš and Nova Pazova). The seed of spelt wheat cultivar *Nirvana* was used, having been selected at the Institute of Field and Vegetable Crops in Novi Sad. The objective of the research was to assess the effect of agro-ecological conditions on morphological and productive properties of spelt wheat grown on different types of soils. The effect of the locality was significantly expressed in all tested morphological properties of spelt wheat (plant height, number of spikelets, number of grains per spikelet), while meteorological conditions (year) affected spike length and grain mass per spike significantly. The average grain yield from all three localities was 3.20 t ha<sup>-1</sup>. A considerably higher yield was achieved on chernozem, locality Nova Pazova (3.89 t ha<sup>-1</sup>). The comparison of the grain yields from Valjevo (eutric cambisol) and Nova Varoš (grey forest soil) did not show any significant differences.

**Key words:** spelt wheat, agro-ecological conditions, morphological properties, yield

### Introduction

The majority of the world wheat production comprises *Triticum aestivum* and durum (*T. durum*) cultivars. Nowadays, there is a growing interest in some old wheat species. These species are now rather limitedly used in human diet, unlike in animal diet where they are used as alternatives to oats and barley. Spelt wheat (*Triticum aestivum* ssp. *spelta* L.) is the oldest known wheat species came as a result of spontaneous crossings of wild grasses. At the end of the twentieth century, after studying the nutritional characteristics of spelt wheat grains (*Abdel-Aal et al., 1995*), this species had a significant role in field crop production. Reviving of spelt wheat production has started in the hilly and mountainous regions of Central

Europe and North America. This tendency can be related to the development of ecological agriculture and a high nutritional value of this cereal. Moreover, there is evidence of its positive effect on human health (*Campbell 1997; Majewska et al., 2007; Sulewska et al., 2008*).

Serbia has considerable agricultural resources that are a basis for possible improving plant production for about 50%, which is very important not only for meeting domestic demand but also for improving the export of agricultural products (*Filipović, 2005*). The realisation of organic production comprises various production programs with different forms of supply, complying with the program on »environmental quality of foods«. That is in function of a tendency for food safety, which gives an advantage to Serbian supply on agricultural products (*Popović et al., 2013*). To support these tendencies, there are some studies on the quality and status of oat and wheat seeds selected in Serbia, with distinctive production properties of satisfying quality (*Janković et al., 2012; Rakić et al., 2012a,b*). The nutritional value of spelt wheat grains shows it can be used in production of quality and healthy food (*Dražić et al., 2010*). Spelt is a wheat species that has not been grown in Serbia for long time. Since there is a growing demand for flour of this cereal (*Zielinski et al., 2008*), the objective of this research was to assess the effect of agro-ecological conditions on the morphological properties and yield of spelt wheat.

## Materials and Methods

In two-year research (2011-2012) *Nirvana* spelt wheat seed was used. The experiments were conducted at three localities: in Valjevo (western Serbia); Nova Varoš (south-western Serbia) and Nova Pazova (Srem) and on different types of soils – on eutric cambisol in Valjevo, grey forest soil in Nova Varoš, and chernozem in Nova Pazova. Based on agrochemical soil analysis, it was established that the most fertile soil was on the location of Nova Pazova, while on the other two locations, the contents of the main nutrients (N, P, K) were significantly lower (Table 1).

**Table 1. Agrochemical properties of soil\***

Soil	pH		CaCO <sub>3</sub> ,	Humus,	Azot,	Easy available forms	
	nKCl	H <sub>2</sub> O	%	%	%	P <sub>2</sub> O <sub>5</sub> mg/100g	K <sub>2</sub> O mg/100g
Chernozem	8,4	7,2	8.9	4,3	0,26	13.20	24,20
Grey forest soil	5.6	4.5	1.7	2.1	0.10	1.12	6.68
Eutric cambisol	6.0	5.3	1.3	2.6	0.10	1.16	9.94

\* Agrochemical analyses of soil samples from the experimental fields were performed in the laboratory of PSS Tamiš in Pančevo, in year 2012.

Potatoes are used as a pre-crop at all three localities. Sowing was done manually in late October. During the vegetation period, crop tending and crop protection measures were not applied. Prior to early June harvest, sampling was conducted in order to determine the following morphological properties: stem height, spike length, number of spikelets, number of grains per spike, and grain mass. After the harvest, the morphological properties were analysed, and grain yields per unit area were calculated based on the grain mass of the spike samples. At each locality, a sample was based on 200 randomly selected plants. In order to assess the significance of environmental conditions (locality and year) for the morphological properties and grain yield of spelt wheat, the analysis of variance for two-factorial experiments was used (ANOVA MANOVA, Stat 5).

**Meteorological conditions.** Data on monthly precipitation and air temperatures in 2011/12 were retrieved from the Republic Hydro-meteorological Service of Serbia. The annual heat distribution varied with the localities, months and years. In 2011, the average temperatures recorded on all three localities were lower than the ones recorded in 2012 (Figure 1a).

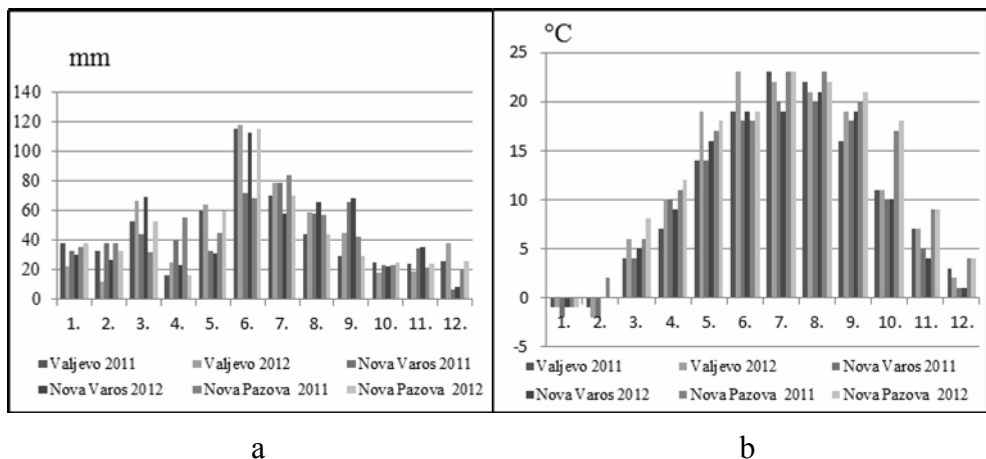


Figure 1a, b. Precipitation, mm (a-left) and temperature, °C (b-right), Serbia (2011-2012)

As for the monthly distribution of precipitation, it varied with all localities, with pronounced maximum of 115 mm in June. In 2011, the total annual amounts of precipitation recorded at all three localities were smaller than the ones recorded in 2012 (Figure 1b).

## Results and Discussion

Based on the obtained results and the assessment of significance, it was determined that the agro-ecological conditions significantly affected the morphological and productive properties of the spelt wheat grain. The effect of the

locality was significantly expressed in all the properties of spelt wheat, and meteorological conditions (year) significantly affected only spike length and grain mass per spike (Table 2).

The average values for plant height, number of spikelets, grains per spike and average yields did not differ, except for spike length and grain mass per spike. In 2012, spike length and grain mass were considerably higher at all the localities. A considerable higher yield was obtained in Nova Pazova, on chernozem (3.89 t ha<sup>-1</sup>). Comparing the grain yields from Valjevo (eutric cambisol) and Nova Varoš (grey forest soil) no differences in yields were determined (Table 3). The results achieved on naturally less fertile soils of the hilly and mountainous regions of Serbia shows alternative cereals can also be grown in less favourable conditions for field crops farming (*Glamočlija et. al., 2010*).

**Table 2. Analysis of variance for morphological and productive properties**

Properties of spelt wheat	Source of variation	df	MS	F	Test LSD	
					0.05	0.01
Plant height	Locality, A	2	393.502	69.943**	2.21	3.02
	Year, B	1	17.025	3.026 <sup>NS</sup>	1.81	2.46
	Interaction, AB	2	2.366	0.421 <sup>NS</sup>	3.13	4.27
	Error	20	5.626			
Spike length	Locality, A	2	6.401	17.194**	0.57	0.78
	Year, B	1	2.133	5.73*	0.46	0.63
	Interaction, AB	2	0.17	0.530 <sup>NS</sup>	0.80	1.10
	Error	20	0.372			
Number of spikelets per spike	Locality, A	2	9.733	7.565**	1.06	1.44
	Year, B	1	0.300	0.233 <sup>NS</sup>	0.86	1.18
	Interaction, AB	2	0.000	0.000 <sup>NS</sup>	1.50	2.04
	Error	20	1.287			
Number of grains per spike	Locality, A	2	13.300	14.353**	0.90	1.22
	Year, B	1	1.633	1.763 <sup>NS</sup>	0.73	1.00
	Interaction, AB	2	2.033	2.194 <sup>NS</sup>	1.27	1.73
	Error	20	0.927			
Grain mass per spike	Locality, A	2	1.087	263.569**	0.06	0.08
	Year, B	1	0.022	5.434*	0.05	0.07
	Interaction, AB	2	0.000	0.049 <sup>NS</sup>	0.08	0.12
	Error	20	0.004			
Yield	Locality, A	2	3.633	362.799**	0.09	0.13
	Year, B	1	0.010	0.971 <sup>NS</sup>	0.08	0.10
	Interaction, AB	2	0.007	0.678 <sup>NS</sup>	0.13	0.18
	Error	20	0.010			

<sup>NS</sup> not significant, \* 5% level, \*\* 1% level

When it comes to the localities, the highest values of the investigated morphological properties were obtained on the chernozem-type soil (Nova Pazova); slightly lower values were obtained on eutric cambisol (Valjevo), and the lowest on grey forest soil (Nova Varoš). This indicates that a soil type has a big influence on these properties. It is important to point out these properties did not show significant differences between grey forest soil and eutric cambisol. Compared to the data from a previous study (*Andruszczak et. al., 2011*), the results obtained on less fertile soils are also satisfactory and since spelt wheat is tolerant to adverse agro-ecological conditions and pathogens and it does not need intensive cropping practices used for other wheat species.

**Table 3. Effect of agro-ecological conditions on the investigated morphological properties and yield of spelt wheat**

Parameter	Locality, A			LSD <sub>A</sub>		Year, B		LSD <sub>B</sub>	
	Valjevo	Nova Varoš	Nova Pazova	<sup>0.05</sup>	<sup>0.01</sup>	2011	2012	<sup>0.05</sup>	<sup>0.01</sup>
Plant height, cm	95.17 <sup>b</sup>	89.95 <sup>c</sup>	102.44 <sup>a</sup>	2.21	3.02	95.10	96.61	1.81	2.46
Spike length, cm	10.62 <sup>b</sup>	9.84 <sup>c</sup>	11.44 <sup>a</sup>	0.57	0.78	10.37 <sup>b</sup>	10.90 <sup>a</sup>	0.46	0.63
Number of spikelets per spike	18.90 <sup>a</sup>	17.30 <sup>b</sup>	19.10 <sup>a</sup>	1.06	1.44	18.53	18.33	0.86	1.18
Number of grains per spike	24.50 <sup>a</sup>	22.80 <sup>b</sup>	25.00 <sup>a</sup>	0.90	1.22	24.33	23.87	0.73	1.00
Grain mass per spike, g	1.44 <sup>b</sup>	1.07 <sup>c</sup>	1.73 <sup>a</sup>	0.06	0.08	1.38 <sup>b</sup>	1.44 <sup>a</sup>	0.05	0.07
Yield, t ha <sup>-1</sup>	2.87 <sup>b</sup>	2.83 <sup>b</sup>	3.89 <sup>a</sup>	0.09	0.13	3.18	3.22	0.08	0.10

a,b,c values within the "locality" column, and a-b within the "year" column not followed by the same superscript letter are significantly different (P<0.05)

## Conclusion

The effect the agro-ecological conditions had on spelt wheat was significant. The effect of the localities was expressed in all morphological properties of spelt wheat (plant height, number of spikelets, number of grains per spikelet), while the meteorological conditions (year) significantly affected spike length and grain mass per spike. The crops grown on chernozem therefore had

higher values of the investigated properties, compared to the ones grown on eutric cambisol and grey forest soil. The grain yields obtained in the two-year research and compared to the ones in the best agricultural regions in Serbia show that hilly and mountainous regions have favourable agro-ecological conditions for spelt wheat.

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## Agroekološki uslovi i morfološko-produktivna svojstva krupnika

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## Rezime

Ispitivanja su sprovedena tokom 2011-2012 godine, na tri lokaliteta u Srbiji (Valjevo, Nova Varoš i Nova Pazova). Korišćeno je seme krupnika sorte *Nirvana*, selekcionisana u Institutu za ratarstvo i povrtarstvo, Novi Sad. Cilj istraživanja je bio da se oceni uticaj agroekoloških uslova na morfološke i produktivne osobine pod različitim tipovima plodnosti zemljišta. Uticaj lokaliteta značajno se ispoljio kod svih ispitivanih morfoloških osobina krupnika (visina biljke, broj klasića, broj zrna u klasiću), a meteorološki uslovi (godina) su značajno uticali na dužinu klasa i masu zrna u klasu. Prosečan prinos zrna krupnika na sva tri lokaliteta iznosio je 3,20 t ha<sup>-1</sup>. Značajno veći prinos ostvaren je na černozevu, lokalitet Nova Pazova (3,89 t ha<sup>-1</sup>). Poređenjem prinosa zrna na lokalitetima Valjevo (gajnjača) i Nova Varoš (sivo šumsko zemljište) nisu utvrđene značajne razlike.

## References

- ABDEL-AAL S., HUCL P. and SOSULSKI F. W. (1995): Compositional and nutritional characteristics of spring einkorn and spelt wheats. *Cereal Chemistry*, 72, 621-624.
- ANDRUSZCZAK S., KWIECIŃSKA-POPPE E., KRASKA P., PAŁYS E. (2011): Yield of winter cultivars of spelt wheat (*Triticum aestivum* ssp. *spelta* L.)

- cultivated under diversified conditions of mineral fertilization and chemical protection. *Acta Scientiarum polonorum, Agricultura*, 10,4, 5-14.
- CAMPBELL K.G. (1997): Spelt: agronomy, genetics and breeding. *Plant Breeding Rev.*, 15, 188-213.
- DRAŽIĆ S., GLAMOČLIJA Đ., OLJAČA S., DOLIJANOVIĆ Ž., JEVDIČIĆ R., ĐEKIĆ V., KRIVOKUĆA-ĐOKIĆ D. (2010): Uticaj agroekoloških uslova i primenjenih agromera na lekovite osobine heljde. Zbornik izvoda, IV inovacije u ratarskoj i povrtarskoj proizvodnji, Poljoprivredni fakultet, Beograd.
- FILIPOVIĆ V., GLAMOČLIJA Đ. and JEVDIČIĆ R. (2005): The Application of Eco-fertilizers in the Buckwheat Crop (*F.esculentum* Moench.). XL Croatian Symposium on Agriculture with International Participation, Opatija, Thematic proceedings, 145-146, Opatija.
- GLAMOČLIJA Đ., STALETIĆ M., IKANOVIĆ J., ĐEKIĆ V. i DAVIDOVIĆ M. (2010): Possibilities alternative grain production in the highlands area of central Serbia. International Scientific Meeting: Multifunctional Agriculture and Rural Development (V), II Book, 71-77.
- JANKOVIĆ S., RAKIĆ S., IKANOVIĆ J., DRAŽIĆ G., MALIĆ N. (2012): Possibility of growing rye on degraded soil of open pit mines in the process of biological recultivation. Third International Scientific Symposium „Agrosym 2012“, Jahorina, 15-17. 11.2012. godine, 225-229.
- MAJEWSKA K., DĄBKOWSKA E., ŻUK-GOŁASZEWSKA K., TYBURSKI J. (2007): Wartość wypiekowa mąki otrzymanej z ziarna wybranych odmian orkiszu (*Triticum spelta* L.) [Baking quality of flour obtained from grains of chosen spelt varieties (*Triticum spelta* L.)]. *Żywność – Nauka – Technologia – Jakość*, 2, 51, 60-71 [in Polish].
- POPOVIĆ V., SIKORA V., BERENJI J., GLAMOČLIJA Đ., MARIĆ V (2013): Uticaj ekoloških faktora na produktivnost semena heljde u konvencionalnom i organskom sistemu gajenja. Zbornik naučnih radova Institut PKB, Beograd, 19, 1-2, 155-164.
- RAKIĆ S., JANKOVIĆ S., DEMIN M., BUCALO D., MASLOVARIĆ M. (2012a): Quality and condition of wheat grain (*Triticum spp.*) during storage. *Biotechnology in animal husbandry*, 28, 3, 595-602.
- RAKIĆ S., JANKOVIĆ S., KRIVOKAPIĆ M., JOVANOVIĆ R., IKANOVIĆ J. (2012b): Grain Quality and Status of Oats (*Avena sativa* L.) During Storage. *Biotechnology in animal husbandry*, 28, 4, 863-871.
- SULEWSKA H., KOZIARA W., PANASIEWICZ K., PTASZYŃSKA G., MROZOWSKA M. (2008): Skład chemiczny ziarna oraz plon białka dmian ozimych orkiszu pszennego w zależności od wybranych czynników agrotechnicznych [Chemical composition of grain and protein yield of spelt cultivars depending on selected agrotechnical factors]. *J. Res. Appl. Agric. Engin.* 53, 4, 92-95 [in Polish].

ZIELINSKI H., CEGLINSKA A. and MICHALSKA A. (2008): Bioactive compounds in spelt bread. *European Food Resources and Tehnology*, 226, 537-544.

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