

IMPACT OF AGRO-ECOLOGICAL CONDITIONS ON PROTEIN SYNTHESIS IN HEXAPLOID WHEAT - SPELT (*Triticum Spelta*)

Jela Ikanović¹, Vera Popović², Snežana Janković³, Gordana Dražić⁴, Slobodanka Pavlović⁵, Mladen Tatić², Ljubiša Kolarić¹, Vladimir Sikora², Ljubiša Živanović¹

¹University of Belgrade, Faculty of Agriculture, 6 Nemanjina St., Belgrade-Zemun, Serbia

²Institute of Field and Vegetable Crops Novi Sad, 30 Maksima Gorkog St., Novi Sad, Serbia

³Institute for Science Application in Agriculture, 68b Blvd. despota Stefana, Belgrade, Serbia

⁴Singidunum University, Faculty of Applied Ecology "Futura", Belgrade, Serbia

⁵Independent University of Banja Luka, Faculty of Ecology, V. Mladenovića St., R.of Srpska, B&H

Corresponding author: E-mail: jela@agrif.bg.ac.rs; bravera@eunet.rs;

Communication

Abstract: Technological quality of wheat is defined by physical and chemical indicators of quality and its baking properties. To make wheat a commodity, there are certain requirements to be met, defined by minimum values of trade quality indicators. As hexaploid wheat, spelt (*Triticum spelta* L.) belongs to a group of alternative cereal grains high in gluten, and its flour is therefore used for making most pastries. Due to its high nutritional value, spelt flour is used to enhance the quality or flavour of wheat bread and other bakery products. Two-year research was conducted during 2011 and 2012 to investigate protein content in crops grown on the Eutric Cambisol soil type. The research was conducted on two spelt cultivars: Hungarian *Ekö 10* and Serbian *NS Nirvana*. The results showed that *NS Nirvana* averaged a statistically significantly higher proteins content (16.76%) than Hungarian cultivar *Ekö 10* (15.65%). Climatic factors, temperatures, the intensity of light and duration of seed filling had an impact on the investigated parameter.

Key words: alternative cereal grain, spelt, climatic factors, protein content, correlation.

Introduction

Wheat is one of the most important crop cultures grown in Serbia, on approximately 500,000 ha; with an average yield of 3,700 kg/ha (*Statistical Yearbook of Serbia, 2012*). It has been used for thousands of years to provide food

for humans. For livestock feeding, wheat kernels can be used as concentrated livestock feed, whereas whole plant can be used as fodder (*Krnjaja et al., 2014*).

The group of alternative cereal grains comprises some old and nearly forgotten wheat cultivars, such as spelt, emmer (*Triticum dicoccum* Schrank), einkorn (*Triticum monococcum* L.), club wheat (*Triticum compactum* Host.) and khorasan wheat (*Triticum turanicum*). Spelt occupies an important place in this group, due to its biological, dietary and medicinal properties. Spelt (*Triticum spelta* L.) as hexaploid wheat belongs to a group of alternative cereal grains of the genus *Triticum*, with fragile spikes and chaffy kernels. The biological properties and chemical composition of spelt make it suitable for growing in our areas as well (*Pavićević, 1988; Glamočlija, 2004; Jankovic et al., 2013; 2015*). During harvest, spelt spikes fall apart into spikelets, which mostly contain two, and sometimes even three kernels (caryopsis). The kernels are closely covered with chaff, and in non-breed populations it is hard to separate the chaff from the kernels (*Pavicevic, 1988; Ugrenovic, 2013*). The chaff usually makes up 25%-35% of total kernel weight (*Medović, 2003*).

The nutritional value of kernels, as mentioned by *Ruibal-Mendueta et al. (2002)*, reflects in a high level of total protein (up to 19%) with increased essential amino acids. It comprises a lot of dietary fibres, vitamin B complex, and mucopolysaccharides that stimulates an immune response, and it also comprises increased levels of oil and mineral salts. Spelt kernels are high in gluten, and its flour is used for making most of pastries (*Pržulj et al., 2012*). Due to a high nutritional value, spelt flour is used as a quality and flavour enhancer for wheat bread and other bread and bakery products (*Galova and Knodlochova, 2000*).

Spelt is an alternative to wheat in making bread, to barley and oats in animal feed and to barley in beer brewing. It is mostly used as a substitute for wheat flour to make bread, pasta, biscuits, crackers, muesli for breakfast, puff pastry, pancakes, and waffles; partially de-husked spelt can be used for brewing and making gin and vodka, but also as a substitute for unglazed rice (*Pržulj et al., 2012*). Kernels of this cereal grain are easy to digest and therefore recommended to the sick and convalescent, but also to children and the elderly. Besides high dietary and nutritional value, one should also mention medicinal properties of kernels and whole plants of spelt (*Ikanović, 2013; Ugrenović, 2013*).

To make wheat a commodity, there are certain requirements to be met, defined by minimum values of trade quality indicators. These requirements are differently regulated worldwide. Indirect indicators comprise physical, chemical and rheological indicators of quality, namely all the indicators that indirectly imply technological quality of wheat. Direct indicators define what kind of end-product can be made from such wheat, thus including testing of its baking properties (*Živančev, 2014*).

The composition of wheat comprises the following chemical compounds: starch, proteins, dietary fibres and fat (*Goesaert et al., 2005*). Protein levels in

kernels are chemical indicators of spelt quality. Proteins make the second most abundant group of compounds in wheat kernels, right after starch. The share of proteins in kernels usually ranges from 8 to 15% (Shewry, 2009). The protein level is one of the most important chemical indicators according to which wheat is classified into quality classes (SRPS E.B1 200). Milling of hard wheat with high protein levels (from 11 to 14%) gives a suitable ingredient for the baking industry (Halverson and Lawrence, 1988).

The goal of this research was to investigate the impact of years on protein synthesis in spelt kernels (*Triticum spelta* L.) on the brown forest-type soil. Furthermore, the goal was also to point out the ecological potential of this alternative cereal grain as a key protein source of nutrients and the most versatile ingredients of life. Spelt is also an element of biodiversity; it is tolerant to adverse climatic factors and successfully uses favourable elements from the environment.

Material and Methods

The research on the impact of the year on protein synthesis in kernels of two spelt wheat cultivars (*Triticum spelta* L.): Hungarian (*Ekö 10*) and Serbian Novi Sad cultivar (*Nirvana*) were conducted on an experimental field of the Faculty of Agriculture in Banja Luka (Serb Republic) during 2010/2011 and 2011/2012, in early March (in the both years of research), and set up in a form in a randomized block design with three repetitions.

This spelt wheat was produced by using cropping practices commonly applied in wheat (*Triticum vulgare* L.) production. Sowing was done in the optimal period – in the first decade of November in both years of the research, on a basic plot size of 10 m² with potato as the preceding crop. Plant density for spelt varieties was 500,000 plants ha⁻¹. Harvest was carried out at full maturity of the crops. The harvest was conducted manually.

For analysing technological quality of the spelt kernels, the samples were taken after de-husking of the kernels, by sowing periods. The percentage of protein was calculated on a dry matter basis, according to the Kjeldahl method at the Laboratory of the Faculty of Agriculture in Banja Luka.

The field trial was set on brown forest soil (eutric cambisol, according to FAO classification of soil). The soil had low levels of humus (1.38%) and total nitrogen (0.114%), and was poor in easily available phosphorus (5 mg in 100 g soil) and potassium (11.8 mg in 100 g soil). Due to a pronounced acid reaction (pH 6.1 in H₂O), it had high levels of available Fe, Cu, Mn and Zn as well as Pb derived from the rock it is formed on (Glamočlija et al., 2015; Jankovic et al., 2015).

The domestic NS cultivar *Nirvana* was created at the Institute of Field and Vegetable Crops in Novi Sad, by re-selecting a local population. This cultivar has been on the National List of Varieties in the Republic of Serbia since 2004. *Nirvana* belongs to a group of late cultivars, tolerant to winter. It is characterised

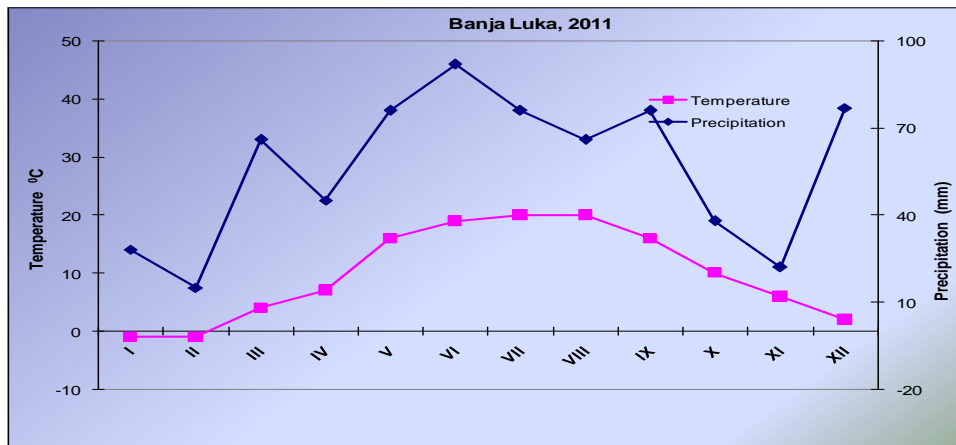
by high adaptability and tolerance to different soil and agro-ecological conditions. Its requirements for nitrogen are not so high, so it achieves the best results on soil of moderate fertility. However, its high stem makes spelt prone to lodging when soil is too fertile, as well as in intensive nitrogen use. The genetic cropping potential of this cultivar is over 4,000 kg ha⁻¹ (Mladenović and Denčić, 2010). According to the research of Bodroža-Solarov et al. (2010a), its chaff averages 22.7% of total weight. High levels of protein, mineral salts and gluten, and a quite specific ratio between gliadin and glutenin make its flour be used for making special bakery products of high nutritional value.

Field data were analysed by using descriptive and analytical statistics, with the help of *STATISTICA 12 for Windows* software package. All estimations of significance were based on the LSD test (significance levels 0.5% and 0.1%). Relative dependence was determined with a correlation analysis and the obtained coefficients for the significance levels of 0.5% and 0.1%. The results are shown in tables and graphs.

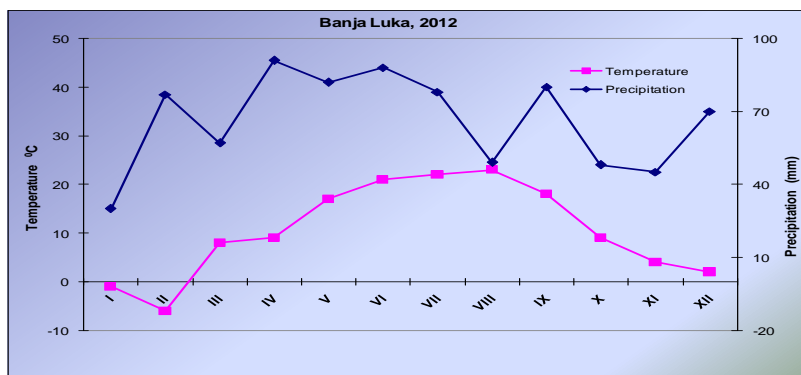
Results and Discussion

Meteorological conditions

In this research, meteorological data were retrieved from a weather station in Banja Luka, Graph 1 and 2.



Graph 1. Monthly precipitation (mm) and average temperatures (°C), Banja Luka, 2010/2011



Graph 2. Monthly precipitation (mm) and average temperatures ($^{\circ}\text{C}$), Banja Luka, 2011/2012

Meteorological conditions are changeable and unpredictable (Popovic, 2010), having a major impact on plant growth (Popović et al., 2013a; Ikanović et al., 2014; Mandić et al., 2015). In the years of the research, the average monthly temperature of air was 10.17°C , being higher in 2012 (10.50°C) than in 2011 (9.83°C). The average monthly precipitation in the years of the research was 736 mm, varied from 677 mm in 2011 to 795 mm in 2012 (Graph 1). Climatic factors had a significant impact on wheat quality, Table 1, Graph 3.

Protein content in spelt seed

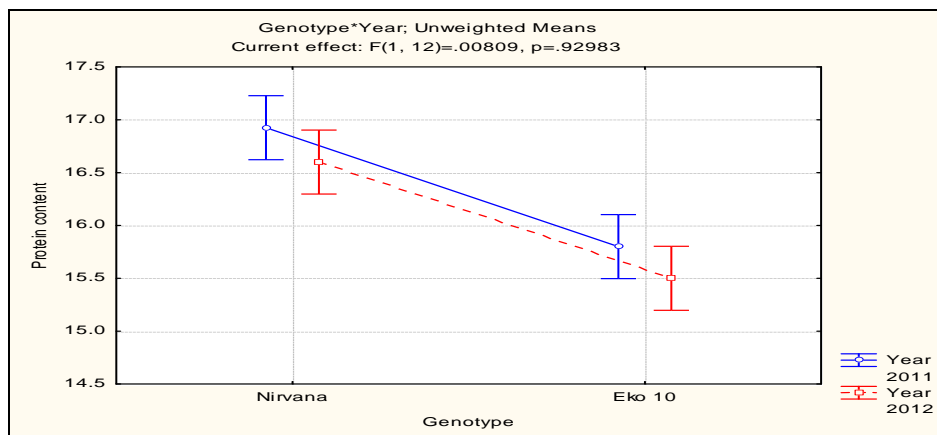
The results show that NS cultivar *Nirvana* had, on average, a statistically highly significantly higher protein content (16.76%) than *Ekö 10* (15.65%). The genotype and year had a statistically significant impact on the investigated property, Table 1.

Observed by year, the NS cultivar *Nirvana* had statistically highly significantly higher protein content than the Hungarian cultivar *Ekö 10*. *Nirvana* had 1.13% higher protein content (16.93%) than *Ekö 10* in 2011, and 1.10% higher (16.60%) in 2012, Table 1, Graph 3 and 4.

Table 1. Protein content (%) in spelt grain

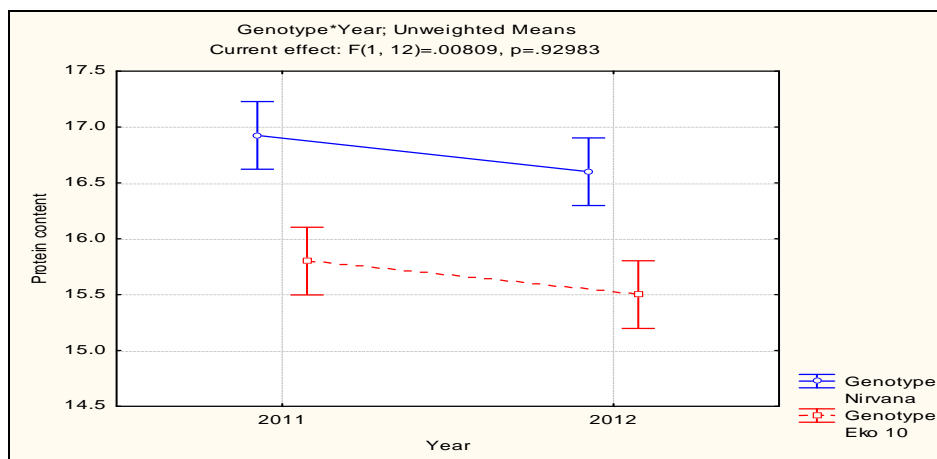
Year (A)	Genotype (B)		Average (B)	Std. Dev.	Std. Error	No. repl.
	Nirvana	Ekö 10				
Protein content, %						
2011	16.93	15.80	16.36	0.66	0.23	8
2012	16.60	15.50	16.05	0.64	0.23	8
Average, A	16.76	15.65	16.21	0.65	0.16	16

Indicator	LSD-test	G	Y	G x Y
Protein	0.05	0.31	0.30	0.43
Content	0.01	0.43	0.43	0.61



Graph 3. Impact of genotypes on protein content in spelt seed, *Nirvana* and *Ekö 10* (%)

The years of the research had a significant impact on protein content in the spelt grain. In 2012, both cultivars had on average statistically significantly lower values of this property, 16.05% lower than in 2011 (16.36%). Their difference of 0.31% between the years was recorded. The standard deviation for protein content averaged 0.65, Table 1 and 2, Graph 4.



Graph 4. Impact of years on protein content in spelt seed, *Nirvana* and *Ekö 10* (%), 2011-2012

Climatic factors, such as precipitation, temperatures, light intensity and duration of seed filling had an impact on protein content.

Protein content was negative non significant correlation with temperature and precipitation, table 2.

Table 2. Correlations in tested parameter

Parameter	Protein content	Temperature	Precipitation
Protein content	1,00	-0,25 ^{ns}	-0,25 ^{ns}
^{ns} – non significant			

According to *Malešević et al. (2008)*, climatic conditions prolong the filling, resulting in well-filled seed low in protein. In contrast to this research, *Zhao et al. (2009)* determined that artificially caused draught did not cause an increase in wheat protein. In hot and arid areas, such as plains in the USA and regions of the Mediterranean, wheat is normally high in protein (*Živančev, 2014*). Technological quality of wheat is defined by physical and chemical indicators of quality and its baking properties (*Malešević et al. 2008*). To make wheat a commodity, there are certain requirements to be met, defined by minimum values of trade quality indicators.

Conclusions

Spelt (*Triticum spelta* L.) is an alternative cereal grain, a key source of nutrients and the most versatile ingredients of life. Spelt is also an important element of biodiversity and it is tolerant to adverse climatic conditions.

The results of this research show that NS *Nirvana* averaged statistically significantly higher protein content (16.76%) than Hungarian cultivar *Ekö 10* (15.65%). The years of research also had a statistically significant impact on protein content in spelt seed. In 2012, the tested cultivars averaged statistically significantly lower protein content (16.05%) than in 2011. The difference between the years was 0.31%.

Climatic conditions, such as: precipitation, temperatures, the intensity of light and duration of seed filling had an impact on the investigated parameter, namely protein synthesis. Protein content was negative non-significant correlation with temperature and precipitation.

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Uticaj agroekoloških uslova na sintezu proteina hehaploidne pšenice krupnik - *Triticum Spelta L.*

Jela Ikanović, Vera M. Popović, Snežana Janković, Gordana Dražić, Slobodanka Pavlović, Mladen Tatić, Ljubiša Kolarić, Vladimir Sikora, Ljubiša Živanović

Rezime

Tehnološki kvalitet pšenice definisan je fizičkim i hemijskim pokazateljima kvaliteta i pecivnim osobinama. Da bi pšenica bila predmet trgovine potrebno je da zadovoljava određene uslove koji su definisani minimalnim vrednostima pokazatelja prometnog kvaliteta. Heksaploidna pšenica krupnik (*Triticum spelta L.*) pripada grupi alternativnih žita koja ima visok sadržaj glutena, te se od njegovog brašna uspešno pravi većina peciva. Zahvaljujući visokoj hranljivoj vrednosti brašno krupnika koristi se kao poboljšavač kvaliteta i ukusa pšeničnog hleba i drugih hlebno-pekarskih proizvoda.

Dvogodišnja istraživanja izvedena su tokom 2011. i 2012. godine u cilju ispitivanja sadržaja proteina na zemljištu tipa gajnjača. Ispitivane su dve sotre krupnika: mađarske sorta *Ekö 10* i srpska NS sorta *Nirvana*. Rezultati su pokazali da je NS sorta *Nirvana* imala u proseku statistički značajno veći sadržaj proteina (16.76 %) u odnosu na mađarsku sortu *Ekö 10* (15.65 %). Klimatski faktori temperatura, intenzitet svetlosti i dužina trajanja faze nalivanja zrna imali su uticaj na ovaj ispitivani parametar.

References

- BODROŽA-SOLAROV M., BALAŽ F., BAGI F., FILIPČEV B., ŠIMURINA O., MASTILOVIĆ J. (2010a): Effect of hulls on grain mould infestation in *Triticum aestivum ssp. spelta* from organic trial. 45th Croatian and 5th International Symposium on Agriculture, Agroecology and Ecological Agriculture, Croatia, 51-54.
- GALOVA Z., KNODLOCHOVA H. (2000): Nutritivna svojstva sorti spelta pšenice, Journal "Žito hleb", 27, 135-142.
- GLAMOČLIJA Đ. (2004): Posebno ratarstvo, žita i zrnene mahunarke / Special farming, cereal grains and grain legumes. "Draganić", Belgrade
- GOESAERT H., BRIJS K., VERAVERBEKE W.S., COURTIN C.M., GEBRUERS K., DELCOUR J. A. (2005): Wheat flour constituents: how they impact bread quality, and how to impact their functionality. Trends in Food Science and Technology, 16, 12-30.

- IKANOVIĆ J., POPOVIĆ V., JANKOVIĆ S., ŽIVANOVIĆ LJ., RAKIĆ S., DONČIĆ D. (2014): Khorasan wheat population researching (*Triticum Turgidum*, sp. Turanicum (McKEY) in the minimum tillage conditions. *Genetika*, Belgrade, 46 (1), 105-115.
- JANKOVIĆ S., IKANOVIĆ J., POPOVIĆ V., RAKIĆ S., KUZEVSKI J. (2013): Agro-ecological conditions and morpho-productive properties of spelt wheat. *Biotechnology in Animal Husbandry*, 29 (3), 547-554.
- JANKOVIC S., IKANOVIC J., POPOVIC V., RAKIC S., PAVLOVIC S., UGRENOVIC V., SIMIC D., DONCIC D. (2015): Morphological and productive traits of spelt wheat – *Triticum spelta* L. "Agriculture and Forestry", Podgorica, ISSN: 0554-5579; <http://www.agricultforest.ac.me>, 61, 2, 173-182.
- KRNJAJA V., LEVIC J., STANKOVIC S., PETROVIC T., MANDIC V., TOMIC Z., OBRADOVIC A. (2014): Presence of deoxynivalenol in winter wheat treated with fungicides. *Biotechnology in animal husbandry* *Biotechnology in Animal Husbandry*, 30, 1, 167-173.
- MALEŠEVIĆ M., JOVIĆEVIĆ Z., ŠTATKIĆ S., DOLAPČEV S., STOJŠIN V. (2008): A return to higher and more stable yields. *Proceedings. Institute "PKB Agroekonomik"*, 14 (1-2), 13-19.
- MANDIĆ V., SIMIĆ A., KRNJAJA V., BIJELIĆ Z., TOMIĆ Z., STANOJKOVIĆ A., RUZIĆ MUSLIĆ D. (2015): Effect of foliar fertilization on soybean grain yield. *Biotechnology in Animal Husbandry*, 31, 1, 133-143.
- MLADENOVIĆ G., DENČIĆ S. (2010): *Nirvana - Triticum spelta* L. *spelt wheat cultivar*. 6th Scientific and Professional Symposium of the Serbian Association of Plant Breeders and Seed Producers, Vršac, 100.
- MEDOVIĆ A. (2003): Čurug spelt wheat from the 4th century - in a tight grip of field bindweed and black-bindweed. *Work of the Museum of Vojvodina* 51, 147-157.
- PAVIĆEVIĆ LJ. (1988): Origin of wheat, its breeding and beginnings of wheat production in our country. *Montenegrin Academy of Sciences and Arts. Gazette of the Natural Sciences Department*, 6, 1988, 19-36.
- POPOVIC V. (2010): Influence of Agro-cultural and agro-ecological practices on seed production of wheat, maize and soybean. Ph.D. dissertation, University of Belgrade, Faculty of Agriculture, 1-145, 62-65.
- POPOVIC V., SIKORA V., GLAMOČLIJA Đ., IKANOVIĆ J., FILIPOVIĆ V., TABAKOVIC M., SIMIĆ D. (2013): Influence of agro-ecological conditions and foliar fertilization on yield and yield components of buckwheat in conventional and organic cropping system. *Biotechnology in Animal Husbandry*, 29, 3, 537-546.
- PRAVILNIK O METODAMA FIZIČKIH I HEMIJSKIH ANALIZA za kontrolu kvaliteta žita, mlinskih i pekarskih proizvoda, testenina i brzo smrznutih testa (1988).

- PRŽULJ P., MOMČILOVIĆ V., DENČIĆ S., KOBILJSKI B. (2012): Alternative small grains grown for the purpose of organic farming. 46th Conference of Serbian Agronomists, Zlatibor, 123-145.
- REENTO H. J., MÜCK U. (1999): Alte und neue Dünkelsorten. Institut. F. bio. Dyn. Forschung Darmstadt.
- RUIBAL-MENDIETA N. L., DELACROIX D. L., MUERENS M. (2002): A comparative analysis of free, bound and total lipid content on spelt and winter wheat wholemeal. *Journal of Cereal Science*, 35, 337-342.
- SHEWRY P. R. (2009): Wheat. *Journal of Experimental Botany*, 60, 6, 1537–1553.
- SRPS E.B1. 200 Pšenica kao sirovina za mlinsku industriju–opšti uslovi kvaliteta/ Quality specification of cereal grain (wheat) for milling industry - General requirements (1978) [In Serbian].
- STATISTICA (Data Analysis Software System), version 10. StatSoft, Inc, Tulsa, OK, USA (2011) (www.statsoft.com).
- STATISTICAL YEARBOOK OF SERBIA (2012): Statistical Office of the R. of Serbia, Belgrade, p.410.
- UGRENOVIĆ V. (2013): Uticaj vremena setve i gustine useva na ontogenezu, prinos i kvalitet zrna krupnika (*Triticum spelta* L.) Ph.D. dissertation, University of Belgrade, Faculty of Agriculture, 1-125.
- ZHAO C.X., HE M.R., WANG Z.L., WANG Y.F., LIN Q. (2009): Effects of different water availability at post–anthesis stage on grain nutrition and quality in strong–gluten winter wheat. *Comptes Rendus Biologies*, 332 (8), 759–764.
- ŽIVANČEV D. (2014): Analiza uticaja genetskih, mikroklimatskih i ekoloških faktora na sastav glutena i tehnološki kvalitet sorti pšenice. Ph.D. dissertation. University of Novi Sad, Faculty of Technology.

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