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MORPHOLOGICAL AND PRODUCTIVE TRAITS OF SPELT WHEAT –*Triticum spelta* L.

SUMMARY

Spelt [*Triticum spelta* (L.)] is a wheat species that is becoming increasingly popular in the production of safe food, and also due to rising possibilities for ecological farming of this alternative crop. Two-year research on possibilities of growing spelt was carried out during 2011 and 2012, on the experimental field of the Institute of Agriculture in Banja Luka (Republic of Srpska). The subject-matter of the research was two spelt cultivars: Hungarian cultivar *Ekö-10* and Serbian Novi Sad cultivar *Nirvana*. The trials were set up in the form of a randomised block design with three repetitions. The trials investigated the following morphological and productive traits: plant height, spike length and 1000-grain weight. The results show that the cultivars have a large genetic potential. Statistically, *Nirvana* had significantly higher plants (150.66 cm), longer spikes (8.37 cm) and higher1000-grain weight (46.39 g) than cultivar *Ekö-10* that had lower values in the both years of research. Identifying correlations enabled better understanding of interrelations among the traits and their balancing, in order to increase yield per unit area. The conditions of the trial site were proved favourable for growing spelt.

Keywords: spelt, morphological and productive traits, genetic potential, correlations,

INTRODUCTION

Nowadays the consumption of alternative crops is increasing abruptly, mainly due to their nutritional and functional traits that have positive impact on human health. During a long history of growing in less favourable agro ecological and soil conditions, these grains have developed a natural system of sustainability and tolerance to abiotic stress that is nowadays sincreasingly expressed as a result of global climate change (Popovic, 2010). Spelt (*Triticum*

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spelta L., i.e. *Triticum aestivum spp. Spelta* (L) Thell.) is one of the oldest grain species. In the mid-20th century, growing of spelt completely ceased, due to the introduction of some more productive genotypes of other grains (Glamoclija, 2012). In the mid-1970s, spelt became popular again after studies on the nutritional value of its kernel that has been becoming increasingly popular in the production of safe food, and also due to rising possibilities for ecological farming of this crop. The reviving of spelt production began in hilly-mountainous areas in Switzerland, Germany and Austria, and later on in other countries of Central and Western Europe, as well as in North America. In our country the interest in this grain started to rise in the late 20th century, and until recently spelt has been grown in hilly-mountainous areas in Serbia (Glamoclija, 2012).

Spelt belongs to the group of hexaploids (n=2), to as ub group with a fragile spike and chaffy kernels, not suitable for use in the human diet unless chaffs are separated from the kernel prior to milling. De-hulling is performed with special machines, like in the processing of the barley kernel. Only de-hulled kernels can be used in the human diet. Spelt can be used in many ways in the diet for humans and domestic animals. There are significantly higher levels of gluten proteins in the spelt kernel than in the kernel of common wheat, ranging 45–55%. Gluten contains gliadin that provides elasticity and stickiness and glutenin that provides har dinessand stability. People allergic to gluten from other grains can eat bread made from spelt flour, which also contains this protein but does not cause allergies (Ikanovic et al., 2014).

Milled spelt kernels can be used for making various pastries and bread, such as a special type of bread made by mixing spelt with other flours (wheat and rye). This type of bread has higher dietary and nutritional values than wheat bread, as the kernel contains important amino acids in perfectly balanced ratio, as well as carbohydrates, oils, B-group vitamins and vitamin E and K, numerous mineral salts of iron, calcium, magnesium and others. Moreover, the kernel is used for *spelt (Dinkel) groats*, *spelt flakes*, *instant coffee*, while there are also some candies with added spelt flour on the market. The kernel is generally easy to digest and good for the sick and convales cents, as well as for children and the elderly (Glamoclija et al., 2015).

Since spelt is more tolerant to adverse agro-ecological conditions and pathogens, it does not require intensive cropping practices used for soft and hard wheat. Hard leathery chaff protects the kernel from air pollution and pests, making spelt suitable for ecological (organic) farming (Glamoclija et al., 2015).

Hristov et al. (2010) point out that, increating new cultivars, we do not use enough of positive traits of rare cultivars and populations and their relative swith high genetic variability, which we are extra ordinary rich in. Plant breeding is about accumulating a number of desirable genes and combining them into one genotype (Pavićević, 1985, 1988). The starting point of the breeding philosophy is that there is a good genotype for all environmental conditions or it can be created (Mladenovic et al., 1998, 2008, 2011).

Figure 1. Cultivar Spelt *Nirvana*. a) Emergence b) Flowering (Photo by: Ugrenovic 2012)

The nutritional value of spelt kernels indicates that they can be used to produce quality and safe food (Drazic et al., 2010, Jankovic et al., 2013). They are less demanding in terms of agro ecological conditions, but also less tolerant to drought (Ugrenovic, 2013). Spelt kernels contain significantly higher levels of gluten proteins than common wheat, ranging 45–55%. Gluten consists of gliadin that provides elasticity and stickiness and glutenin that provides hardiness and stability (Molnar, 2012). Hidegard (2007) points out that the spelt kernel contains significantly higher levels of leucine, methionine and phenylalanine than the kernel of common wheat. Phenylalanine produces dopamine and two hormones (noradrenaline and adrenaline) responsible for creating a good mood and regulating blood sugar levels. Tryptophan stimulates synthesising of serotonin, a hormone that impact mood and mental health. Hence, using spelt preventively in the diet keeps the human body from diseases and improves the immune system. Spelt is very rich in minerals, microelements and vitamins. Compared to common wheat, spelt has higher levels of vitamins B1, B2 and niacin, as Glamoclija et al. (2015) point out.

Figure 2. Cultivar Spelt *Nirvana*. Hulled and de-hulled spelt kernel (Ugrenovic, 2012)

The aim of this paper was to indicate a new old ecological potential of Nirvana and Ekö-10 cultivars. Spelt is the element of biodiversity that opposes to unfavourable climatic conditions or makes use of favourable environmental conditions. Due to these traits, this cultivar is snatched from oblivion and re-grown on several hectares in the Republic of Srpska, with a tendency to increase.

MATERIAL AND METHODS

The subject-matter of this study is two-year research (during 2011 and 2012) on the variability of morphological and productive traits of the alternative grain spelt, grown on brown forest soil with no NPK applied. Two spelt cultivars were investigated: Hungarian cultivar - Ekö-10 and Serbian cultivar of Institute of Field and Vegetable Crops, Novi Sad - Nirvana. The trials were conducted on the experimental field of the Institute of Agriculture in Banja Luka (Republic of Srpska) in early March (in the both years of research), and set up in a form in a randomized block design with three repetitions. The trials investigated the following morphological and productive traits: plant height, spike length and 1000-kernel weight. The specimens of 10 spikes from each experimental plot were taken prior to harvest and measured, where as 1000-kernel weight were measured after harvest. The harvest was conducted manually.

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 (Glamoclija et al., 2015).

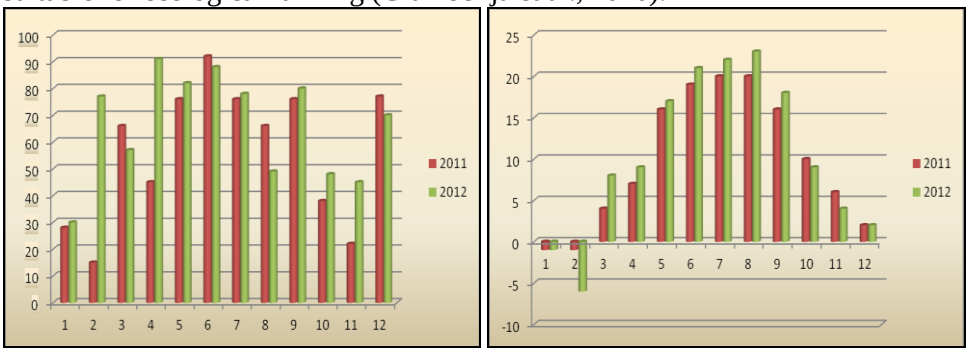
Field data were analysed by using descriptive and analytical statistics, with the help of STATISTICA 12 for Windows software package. All estimations of significance were based on the LSD test (significance levels 0.5% and 0.1%). Relative dependence was determined with a correlation analysis and the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

Weather conditions

Weather conditions in a particular area canvary. Hence, it is important to monitor the variation of external factors, to know their impact on physiological processes that determine the quality of the seed and critical stages from the aspect of yields and quality (Popovic, 2010), as well asto know the time of application of certain cropping measures. Weather data were retrieved from the weather station in Banja Luka. During the period of vegetation in 2012, the average monthly temperature of air was 10.50 ^{o}C, which is 0.67^{o}C higher than in 2011. The total amount of precipitation in 2011 was 819 mm, being 24 mm higher from the total precipitation in 2012 (Graph 1a, and 1b).

Spelt is more tolerant to unfavourable environmental conditions and to pathogens and does not require intensive cropping practices that apply for soft

(common) wheat. Hard, leathery chaff protects the kernel better from air pollution and pests, whereas a waxy layer on the stem and leaves prevents from the occurrence of pathogenic fungi that cause diseases. Since it is more adapted to unfavourable biotic and abiotic conditions than common wheat, spelt is suitable for ecological farming (Glamoclija et al., 2010).



Graph.1. Total monthly precipitation (mm) and average temperature (^{o}C), Banja Luka, 2011–2012

RESULTS AND DISCUSSION

Seed traits of wheat cultivars can be grouped by various parameters: biological, genetic, technological and other. The traits of biological nature are characterised by polymorphism in ecotypes, varieties and sub-varieties. Genetic traits vary depending on the number of genes that control their expression (Sabovljevic et al., 2010).

Plant height. The average plant height of spelt was 150.66 cm. The investigated factors (cultivar and year) had agreat impact on plant height, $p < 0.5$. Statistically, Serbian cultivar *Nirvana* had higher plants (155.25cm) than Hungarian cultivar *Ekö-10* (146.08). On average, the standard deviation of the plant heights was 6.6507 (Table 1 and 2, Graph 2).

Glamoclija et al. (2013) emphasize that in some previous studies on this type of wheat, plant height and 1000-kernel weight have greatly varied due to genetic, climatic and edaphic factors and applied cropping practices, ranging in a quite wide interval. The same authors indicate that in previous studies plant height has amounted to about 110 cm, spike length 11 cm and grain weight 1.06–1.78g. The results have shown that weather conditions, the amount and distribution of precipitation play a significant role, affecting the investigated traits. Ugrenovic (2013) in his studies states that climatic conditions have the highest impact on the number of emerged plants, number of stems, mortality of tillers, number of spikes, degree of lodging and harvest index, where as the time of sowing has the biggest influence on plant height and the yield of green biomass. The time of sowing and crop density equally affect the number of grains per spike and grain weight.

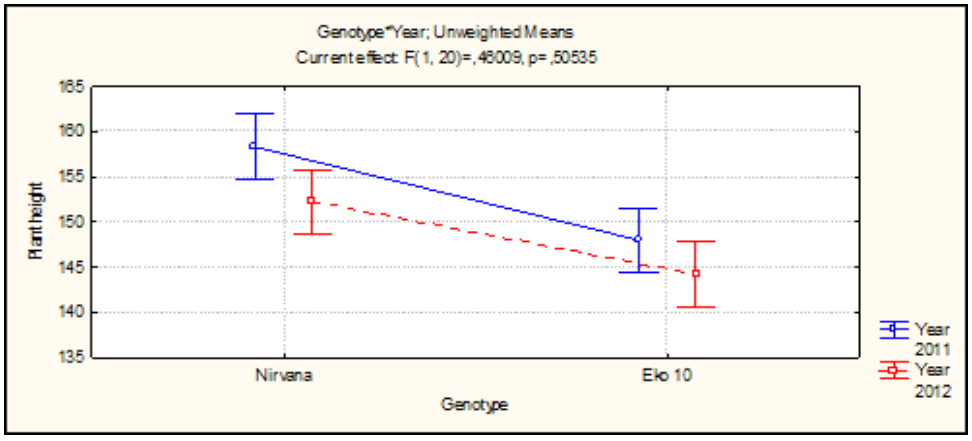
Table1. Plant height (cm),spike length and 1000-kernel weight, 2011–2012

Cultivar	***Nirvana***	***Ekö-10***	***Average***	**Std. dev**	**Std. err**
Plant height(cm), df =20.00					
2011	158.33	148.00	153.16	6.9652	2.0107
2012	152.16	144.16	148.16	5.5075	1.5898
Average	155.25*	146.08	150.66	6.6507	1.3575
Spike length(cm)					
2011	8.90	8.03	8.46	0.4830	0.1394
2012	8.53	8.01	8.28	0.4654	0.1343
Average	8.72	8.02	8.37	0.4741	0.0967
1000- grain weight (g)					
2011	46.73	45.30	46.02	0.8156	0.2354
2012	46.05	45.15	45.60	0.8011	0.2312
Average	46.39	45.22	45.81	0.8187	0.1671

Parameter	G		Y		G x Y	
LSD Test	0.5	0.1	0.5	0.1	0.5	0.1
Plant height	3.5878	4.8933	3.5878	4.8933	5.0740	6.9202
Spike length	0.2621	0.3575	0.2621	0.3575	0.3707	0.5056
1000- grain weight	0.4579	0.6246	0.4579	0.6246	0.6476	0.8833

Table 2.Univariate tests of significance for plant height

Effect	**SS**	**Degr. of freedom**	**MS**	**F**	**p**
Intercept	544810.7	1	544810.7	30693.56	0.000000
Genotype	504.2	1	504.2	28.40	0.000032
Year	150.0	1	150.0	8.45	0.008717
G x Y	8.2	1	8.2	0.46	0.505353
Error	355.0	20	17.8		

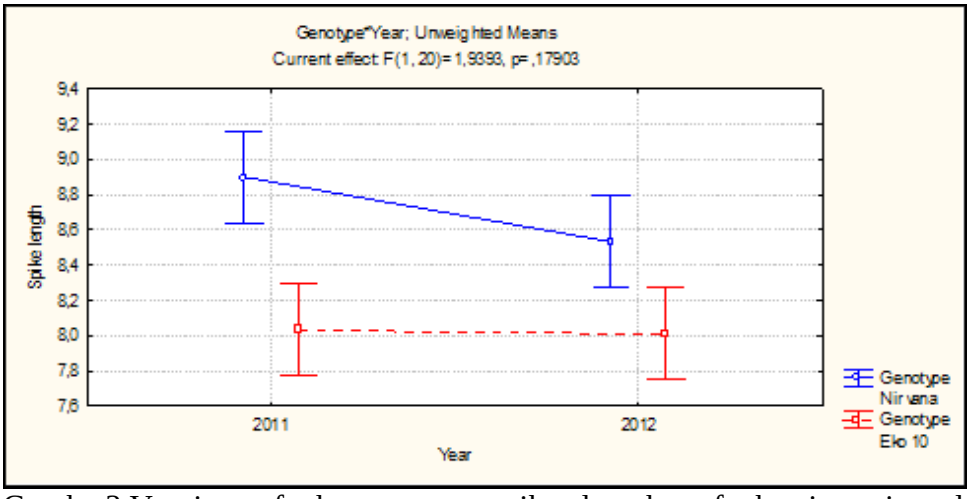


Graph 2.Varying of the average plant height sof the investigated genotypes (cm), 2011–2012

Spike length. Spike length is a significant factor of spelt cropping. The spike plays an important role as a direct bearer of yielding and kernels, but it also takes part in the process of photosynthesis, creating of organic matter and grain filling due to its large surface (Đekić et al., 2012). The average spike length was 8.37 cm, ranging from 8.72 (*Nirvana*) to 8.02 (*Ekö-10*). The average standard deviation for spike length was 0.4741 (Table 1, Graph 3). Genotype was the factor that had the biggest impact on this trait (Table 3).

Table 3.Univariate tests of significance for spike length

Effect	**SS**	Degr. of Freedom	**MS**	**F**	**p**
Intercept	1681.700	1	1681.700	17748.82	0.000000
Genotype	2.870	1	2.870	30.29	0.000022
Year	0.220	1	0.220	2.33	0.142863
G x Y	0.184	1	0.184	1.94	0.179033
Error	1.895	20	0.095		

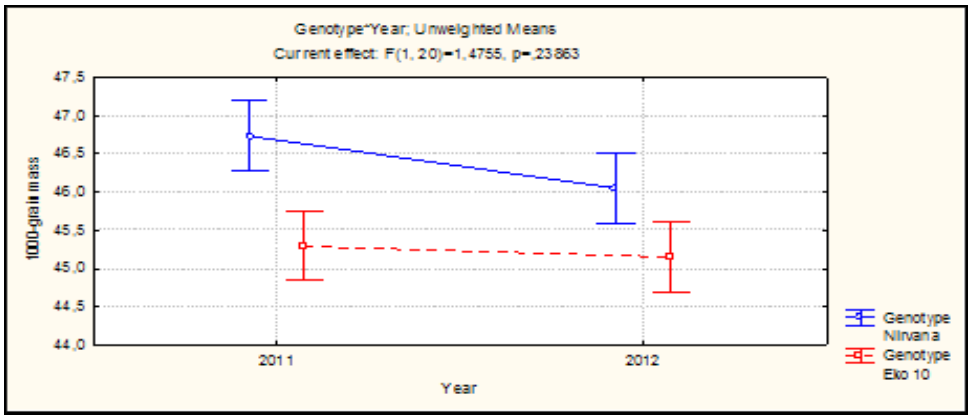


Graph 3.Varying of the average spike lengths of the investigated genotypes (cm), 2011–2012

1000-grain weight. Genotype determines the size of a grain and, therefore, the absolute 1000-grain weight. In spelt, 1000-grain weight varies greatly, due to genetic, climatic and edaphic factors and cropping practices, ranging in a quite wide interval. The average 1000-grain weight was 45.81g. *Nirvana* had statistically higher 1000-grain weight (46.39) than *Ekö-10* (45.22g). On average, the standard deviation of spike length amounted to 0.8187 and standard error amounted to 0.1671 (Table 1, Graph 4). This trait was mostly influenced by genotype, where as the interaction between year and genotype did not have a statistically significant impact (Table 4).

Table 4. Univariate tests of significance for 1000- grain weight

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	50361.68	1	50361.68	174161.4	0.000000
Genotype	8.17	1	8.17	28.2	0.000034
Year	1.04	1	1.04	3.6	0.072228
G x Y	0.43	1	0.43	1.5	0.238627
Error	5.78	20	0.29		



Graph 4.Varying of the average 1000-kernel weights (g) of the investigated genotypes, 2011–2012

Jankovic et al. (2013) in their study state that impact of site was significantly expressed in all the investigated morphological traits (plant height, number of spiklets, number of grains per spike) of Serbian spelt cultivar *Nirvana*, while weather conditions in the years of research had a significant impact on spike length and grain weight per spike.

Correlation of the investigated factors

The research investigated the interdependence of the traits. A strong positive correlation was found between plant height and spike length, as well as between plant height and 1000-grain weight (Table 3).

Table 3.Coefficients of correlations between of investigated traits

Parameter	Plant height	Spike length	1000- grain weight
Plant height	1.00	0.72**	0.77**
Spike length	0.72**	1.00	0.64*
*and**: significant at 0.5 and significant at 0.1			

A positive correlation was found between spike length and 1000-grain weight (Table 3). Identifying correlations allows us to have better understanding of interrelations among the traits and their balancing in order to improve yield per unit area in some future research

CONCLUSION

The results show that the investigated spelt cultivars have a large cropping potential. Weather conditions during the vegetation period had a statistically significant impact on morphological and productive traits. During the two-year research, the average plant height ranged from 146.08 cm to 156.08 cm, where as the average spike length was 8.37, ranging from 8.72 (Nirvana) to 8.02 (Ekö-10). Moreover, Nirvana had a significantly higher 1000 - grain weight (46.39 g) than cultivar Ekö-10 (45.22 g).

Taking into account the correlations between the investigated traits of two different spelt cultivars, the authors found there was a statistically significant interdependence between the investigated parameters. Hence, some future research should be focused on understanding the interdependence of these relationships and their balancing, in order to increase yields per unit area. The intensification of spelt production is therefore becoming increasingly important in the production of quality and safe food in the South East Europe.

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