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THE ACHIEVED LEVEL AND FUTURE DIRECTIONS OF GRAIN CROPS BREEDING PROGRAM AT THE AGRICULTURAL INSTITUTE OF THE REPUBLIC OF SRPSKA, BANJA LUKA

SUMMARY

This scientific paper presents long-term results of breeding program that resulted in registration of several grain crops varieties and in creating more promising lines of cereals that are in the process of recognition. Under the conditions of present abiotic stress it is extremely difficult to create variety of any plant species that possesses all desirable agronomic and technological characteristics and this particularly affects the quality parameters which are influenced by production conditions. The highest negative effects of abiotic stresses are manifested in the agricultural, respectively food production. The predicted climate change scenario will be reflected in significant deviations of average climatic factors from perennial values, and a significant reduction of rainfalls, their poor distribution, increased temperatures in spring and autumn, risk of drought and land degradation. These facts emphasize the necessity to create more tolerant varieties of grain crops, as well as introduction of corrective factors associated to variety, technology and production conditions with good communication between science and profession.

Keywords: wheat, grain crops, breeding, yield.

INTRODUCTION

Grain crops represent main raw materials in human nutrition. They are also an important element in crop rotation and an integral part of agricultural strategy of every country. Therefore, in such a context, they represent an unavoidable segment of studies and enhancement of main traits. Plant selection and breeding is one of the oldest human occupations. More than thousand years ago man commenced with breeding and selection of those plant that could ensure sufficient foods. The contemporary plant breeding based on scientific foundations exists for around 100 years and during the second part of the last century yield of several plant species (wheat 14.5t/ha, barley 11.4 t/ha) achieved recording volumes thank to the science and plant breeding Frey and Borojević (1981). Many analyses indicate that plant breeding is the cheapest way to increase productivity of agricultural production Jošt (2005).

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Generally, in breeding plant species, the variety is a primary production factor in terms of yield and quality. Therefore creation of new and better varieties is a task of the utmost importance Denčić et al. (2011).

Increase in grain crop production, primarily of wheat, mainly depends on creation of new varieties that have high genetic potential and satisfactory quality per area unit, as well as on application of production technology, especially since it is well known that land area represents one of the limiting production factors (there is only 0.28 ha of arable land per capita in the world, with the tendency of decrease). Varieties exist in certain environmental conditions, and therefore it is necessary to establish a relation between the variety and the environment that would ensure the highest prosperity for the varieties Protić, Janković, Đurić (1997). Such relation is resembled in adaptability and stability of varieties, i.e. in the variety as a whole, arising from the variety's genetic composition Eberhart and Russell (1996). High adaptability of wheat is provided by three different genomes originating from three different plant species, as follows: *Aegilops speltoides*, *Triticum urartu* and *Aegilops tauschii*. Spontaneous hybridizations resulted in the contemporary wheat, which due to its nutritional values is on the top of human nutrition pyramid, since humans can survive eating only whole grain bread and naturally by consuming water. Which genetic composition is to be used by a breeder depends on the breeding objective, i.e. on which agro-ecological conditions is the variety intended for, as well as on the market demands, and somewhere even on cultivation tradition Borojević (1978). In addition to wheat, barley is also grown worldwide and its highest economic significance is linked to the malt and beer industry. Even though 28% of world production is linked to this industry, around 67% is used in animal feeding and around 5% for human nutrition, Pržulj et al. (2011). Regarding the triticale, oat and rye, being the alternative cereals, it can be noticed that in the last decade there has been a real increase in area under these cereals in our region. Its expansion is incentivized by inputs related to such production, primarily lower investment costs and lower requirements in terms of land, since they have better adaption to more acid and less fertile lands, as well as by the real demand from the milling-bakery industry Mandić et al. (2009).

MATERIAL AND METHODS

The material for this study was varieties of winter grain crops (wheat, barley, triticale, rye) and spring oats developed by the Agricultural Institute of the Republic of Srpska during last ten years, which were recognized by the Variety Commission of Serbia and Bosnia and Herzegovina on the basis of two-year and three-year-long researches on several locations. The size of the main plot for micro-trials was 5m² and for the net of macro-trials was 100-500m². The entire growing technology was at the level of an average production technology (sowing time, seed volume, nitrogen volume, etc...). Regarding the value of these varieties and of the lines, the average yield was tested in comparison to standard cultivars for each species, followed by testing the protein content and

variance ratio. The results are shown as two-year and three-year results for newly recognized varieties and as one-year results for varieties in macro-trials with the use of several varieties that are leaders in production on the territory of the Republic of Srpska.

RESULTS AND DISCUSSION

Oskar

According to the biannual results of the Variety Commission, the variety of winter triticale -Oskar achieved the average grain yield of 8.952 kg ha⁻¹, which is for 1.335kg more than the standard. The highest yield of this variety was achieved under the conditions of intensive production in Sremska Mitrovica with 9.509 kg ha⁻¹, in Novi Sad with 9.077 kg ha⁻¹, in Kragujevac with 8.452 kg ha⁻¹ and in Zaječar with 9.516 kg ha⁻¹. During the extremely dry year of 2002, the highest yield was achieved on the locality of Banja Luka with 7.546 kg ha⁻¹. Under the micro-trials on the locality of the Economy of the Agricultural Institute, where the three-year comparative experiments were conducted, this variety achieved yield of 8.805 kg ha⁻¹. This variety has been in seed production for already seven years. It has also shown excellent production characteristics on various production areas throughout the entire Bosnia and Herzegovina, thus the producers are very satisfied with this variety.

Tab.1. Grain yield of the variety Oskar and standard in 2005 (kg ha⁻¹)

Variety	Localities						Average
	Kragujevac	N.Sad	Pančevo	S.Mitrovica	Sombor	Zaječar	
Oskar	8452	9077	7960	9509	8700	9516	8869
KG-20	8088	8046	7680	6850	5800	8740	7534

In order for a new line – variety to have a high genetic potential and at the same time to be a stable production potential, it needs to possess as many positive agro-economic characteristics as possible, such as the resistance to low temperature, resistance to lodging, tolerance to relevant diseases, as larger grain size as possible and good grain shape, higher number of grains in an ear (over 40), early maturity, etc... As regards the heading time, Oscar is a rather early cultivar, which in our conditions starts heading at the beginning of May, and possesses excellent resistance to low temperatures. The stem height is around 115cm with rather long (around 15 cm) semi-shattered ears, with absolute mass of around 44g, excellent volumetric weight of around 72kg and protein content of around 15%.

Tab.2. Grain yield of triticale varieties tested by localities in 2006

No.	Institute	variety	yield	locality	Rank
1.	BL	BL T 8	5722	Aleksandrovac	2
2.	BL	Oskar	6025	Aleksandrovac	1
3.	NS	Odisej	5367	Aleksandrovac	3
4.	KG	Favorit	5325	Skelani	4

The lines of the Agricultural Institute of Banja Luka achieved excellent results on the Aleksandrovac locality and were mainly ranked on the top positions. It is important that the regionally leading triticale varieties were also used in these trials.

Oktavija

According to the one-year results of the Variety Commission, the line BL R-31, i.e. the variety of winter rye Oktavija achieved an average grain yield of 6.730 kg ha^{-1} , which is for 498kg higher than the standard. This variety achieved the highest yield under the conditions of intensive production in Sremski Karlovci with 9.535 kg ha^{-1} and in Sombor with 7.200 kg ha^{-1} (Table 3). During the extremely variable 2007, the highest yield was achieved under the conditions of Banja Luka with 7.816 kg ha^{-1} . During the three-year micro-trials at the location of the Economy of the Agricultural Institute, the achieved yield was 8.235 kg ha^{-1} .

Tab.3. Grain yield of the variety Oktavija and standard tested by localities, 2007

Variety	Localities						Average
	Kragujevac	N.Sad	Pančevo	S.Mitrovica	Sombor	Zaječar	
Oktav.	4564	6498	5761	9535	7200	6824	6730
Rasa	4736	7020	5585	8205	6160	5688	6232

During the second year (2008) of researches by the Variety Commission on the localities in Serbia, the Oktavija variety achieved significantly better results, i.e. for 12.8% more than the standard variety Raša, which can be seen in the table 4.

Tab.4. Grain yield results of the variety Oktavija and standard, tested in 2008 by the Commission for variety registration

Variety	Localities						Average
	Kragujevac	N.Sad	Pančevo	S.Mitrovica	Sombor	Zaječar	
Oktav.	4696	9076	7866	6616	3644	6344	6374
Rasa	4860	7688	7322	5542	2852	5636	5650

Pursuant to such two-year results, the variety Oktavija was officially recognized and introduced into the assortment of grain crops for various purposes, whereof one purpose is for organic production. It possesses excellent resistance to low temperature. The stem height is around 165 cm with rather long (around 12 cm) semi-shattered ears. This line is resembled with extremely large grain size with the absolute mass of around 44 g and excellent volumetric weight of around 80 kg. The flag leaf is semi-upright and remains in such position until the end of milk stage of maturity, when it gradually falls into the horizontal position. The ear is with long parallel glumes, having the upright position at the bottom part of the ear, which bends gradually with the maturity, reaching a completely bend position at the full maturity stage.

Nova Bosanka

According to the three-year average, the observed winter wheat Nova Bosanka achieved the grain yield of 6,918.62 kg ha⁻¹, which is for 479.33 kg ha⁻¹ or for 7.45% higher than the standard variety Tina. Such difference is highly significant. In the three-year average, the variance ratio is higher for 0.09%. On the basis of our results from the comparative trials at the Economy locality of the Agricultural Institute in Banka Luka, this variety achieved the average three-year yield of 8.020 kg ha⁻¹. The research conducted at that time also analyzed the impact of variety and locality factors to the yield, recording a significantly high and high impact of the observed line.

Tab.4 . Grain yield of the variety Nova Bosanka and standard (kg/ha) tested by years and localities

Variety	2006 /07		2007/2008		2008/09		Average
	Butmir	Živinice	Butmir	Živinice	Butmir	Živinice	
N.Bosanka	6.928	6.680 ⁺	7.000 ⁺	6.880 ⁺	7.000 ⁺	7.020 ⁺⁺	6.970
Tina	6.540	6.216	6.420	6.340	6.620	6.500	6.560
Average	6.852	6.352	6.610	6.540	6.750	6.720	6.725
LSD _{0,05}	401,2	403,27	484,1	367,30	287,1	227,68	
LSD _{0,05}	563,2	566,05	679,6	515,57	403,0	319,59	
CV (%)	4,24	4,60	5,31	4,07	3,08	2,45	

In the third year of researching (2008/2009) the grain yield was 7.010 kg ha⁻¹, which is for 166 kg ha⁻¹ or for 2.43% higher than in the first year of researches (2006/2007) and for 30 kg ha⁻¹ or for 0.44% higher than in the second year of researches (2007/2008). Such a difference is not statistically justified and could be deemed as a statistical error.

Kosta

According to the researching conducted by the Variety Commission from Sarajevo and on the basis of three-year results, the variety of winter two-rowed barley Kosta was recognized. The variety was bred under the code BL 1/11. The average three-year grain yield on the locality Butmir amounted to 7.097 kg ha⁻¹, and on the locality Odžak 6.982 kg ha⁻¹, which is for 114 kg ha⁻¹ or for 3.06% less than the Butmir locality. The observed cultivar achieved yield that was for 133 kg ha⁻¹ higher than the average for this locality. Additional four cultivars were observed at this locality, respectively their values contributed to determination of locality's average.

The three-year average of the observed winter barley Kosta achieved the grain yield of 7.040 kg ha⁻¹, which is for 414 kg ha⁻¹ or for 6.24% higher than the standard cultivar Sladoran. Such a difference is highly significant. As regards the heading, Kosta is an early barley variety, which under our agro-ecological conditions forms ears during the first decade of May and also possesses excellent resistance to low temperature. The stem height is around 70 cm with long (around 7-8cm) semi-shattered ears.

Tab.5 . Grain yield of the variety Kosta and standard (kg ha⁻¹)

Variety	2008/09		2009/10		2010/11		Average
	Butmir	Odžak	Butmir	Odžak	Butmir	Odžak	
Kosta	6820	6760	7428	7208	7044	6980	7040
Sladoran	6532	6144	6956	6780	6924	6424	6626
LSD	227,6		236,8		352,5		340,7
	356,1		253,3		388,1		454,6
	376,6		390,9		583,3		
	589,3		419,1		642,2		
CV %	1,93	3,13	2,07	2,24	2,87	3,29	

* tested by years and localities

This variety is characterized by the medium-size round grains with the absolute mass of around 42g and excellent volumetric weight of around 75kg. Flag leaf is semi-upright and remains in such position until the end of milk stage of maturity, when it gradually falls into the horizontal position. The ear is with long parallel and during the heading phase purple glumes, having the upright position at the bottom part of the ear, which bends gradually with the maturity, reaching a completely bend position at the full maturity stage. Very important characteristic is a well formed grain with lower content of proteins, which depends on accumulation of dry matter in the grain, coming from leaf and stem. Protein content is around 10% of the grain dry matter. The protein content has negative correlation with the extract content. It is generally known that beer barleys require protein content of 9–11% of the grain dry matter for production of high quality malt.

As regards to wheat, during the most recent years the breeding programs have dedicated a particular attention to development of lines with higher grain quality, respectively with higher protein content. As a result of previously conducted researches, we hereby point out the line of winter wheat BL R-O1, which during the last three years of researches had protein content over 14%. This line also possesses excellent other characteristics relevant for this variety and therefore it shall apply to the variety commission during this year for its recognition. The table no 6 shows results regarding the protein content, which were achieved on the locality Banja Luka during 2011.

Tab.6 . Protein content (%) of the tested wheat varieties and lines

No.	Variety-line label	Protein (%)	No.	Variety-line label	Protein (%)
1.	Pobeda	9,16	8.	BL R- 01	14,04
2.	N.Bosanka	9,72	9.	BL 10-08	13,49
3.	Balaton	9,35	10.	BL 1- 06	11,62
4.	Renesansa	10,21	11.	Bijela pšenica	12,22
5.	Orion	11,87	12.	BL 1-11	12,29
6.	Renan	10,90	13.	BL 2-09	10,37
7.	Mihelica	11,17	14.	NS 40-S	9,80

Tab.7 . Grain yield of the winter triticale line tested by localities in 2011

<i>WINTER TRITICALE</i>						
Code	Variety	Localities				Average
		Kikinda	Novi Sad	S.Mitrovica	Sombor	
107	Odisej	8786	10594	8878	11593	9963
108	BL T-55	7408	11524	10196	12141	10317
CV (%)		6,32	3,22	10,98	6,14	6,86

Tab. 8. Grain yield of the spring oats tested by localities in 2011

<i>SPRING OATS</i>						
Code	Variety	Localities				Average
		Kikinda	Kruševac	Novi Sad	S.Mitrovica	
12	Slavuj	8108	6787	7240	8840	7534
13	BL Z-101	8247	6454	9273	8270	7709
Average		8267	6706	8299	9412	7930

Tab.9. Results of the macro trial on wheat at the location Dušanovo-municipality Gradiška

Variety	AM ¹	HT ²	t/ha	Variety	AM	HT	t/ha
Bosanka	34,7	80.5	6,38	Renesansa	43.5	80.1	6,17
Nova Bosanka	46.3	77.8	6,17	Simonida	42.0	79.9	6,79
Orion	37.4	77.5	5,96	Balaton	44.9	77.9	6,37
Kristina	41.9	80.9	6,81	Autan	43.9	76.1	6,82
Prijedorčanka	42.5	80.5	6,15	Merkur	40.6	80.9	5,73
Marija	40.0	78.2	6,91	Carica	45.9	80.3	5,53
Mihelica	44.5	77.6	6,37	Vizeljka	44.5	78.05	6,59
Sana	41.9	76.4	6,50	Lepoklasa	44,2	79.3	6,37
Prima	46.3	76.4	7,20	Talas	39,1	82.1	5,33
Zvezdana	43.7	79.3	6,55	Oskar	44,1	76.4	5,77
Pobeda	45.2	80.1	6,36	Viktor	41.2	70.8	5,53
Etida	42.6	77.2	6,37	Odisej	51.2	76.1	5,52
Dragana	48.0	79.3	6,13	Goran	48.5	74.0	5,13
Arija	43.3	77.4	7,04	Oktavija	39,8	75.8	5,04
NS 40 S	39.0	75.2	6,59	Oziris	52	73	5,45

¹ (gr)/1000-kernel weight² (kg)/Hectoliter mass

Testing, respectively examinations, conducted by the Variety Commission in Serbia lasts for two years on four locations, whilst in Bosnia and Herzegovina it takes three years on three locations. One line of the winter triticale **BL – T 55** was submitted to the Variety Commission in Belgrade for the first year of examination, whilst in Sarajevo, upon the three-year researches on three locations and on the basis of achieved results, the variety of winter barley was recognized

under the commercial name "Kosta". At the beginning of 2011, one line of spring oat applied for recognition in Serbia (Belgrade) under the code **BL -Z 101**. This line meets all requirements for commencement of recognition process. The tables 7. and 8. show results achieved by the submitted lines.

The macro-trial 2010/11 was conducted under the organization of the Extension Service on the locality Dušanovo, Gradiška Municipality, where the leading production varieties of Bosnia and Herzegovina were sown (wheat, barley, triticale and durum wheat) from different selection houses. The production technology was adequate even for the conditions of extreme drought, respectively deficient rainfalls and with high daily temperatures. The results are given in table in respect to the main traits.

CONCLUSIONS

With recognition of several grain crop varieties of the Agricultural Institute of the Republic of Srpska in Banja Luka, the production assortment of our region has become richer for several good varieties, which are characterized by excellent production traits, such as high genetic potential of grains, excellent resistance to low temperature, resistance to lodging, satisfactory tolerance to relevant diseases, excellent weight, satisfactory technological traits, good adaptability and yield stability. The varieties described in this paper have found their place in production of grain crops by our producers and have become recognizable in our production conditions.

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**DOSTIGNUTI NIVO I DALJNI PRAVCI OPLEMENJIVANJA
STRNIH ŽITA NA POLJOPRIVREDNOM INSTITUTU
REPUBLIKE SRPSKE, BANJA LUKA**

SAŽETAK

U ovom radu su prikazani višegodišnji rezultati oplemenjivačkog rada koji su rezultirali priznavanjem nekoliko sorti strnih žita, zatim kreiranjem više perspektivnih linija strnih žita koje su u procesu priznavanja. U uslovima sa sve prisutnijim abiotičkim stresovima izuzetno je teško stvoriti sortu bilo koje biljne vrste koja posjeduje sve poželjne agronomske i tehnološke osobine, a što se posebno odražava na parametre kvaliteta koji su pod značajnim uticajem uslova proizvodnje. Najveći negativni efekti abiotičkih stresova manifestuju se na poljoprivredu, odnosno proizvodnju hrane. Predviđeni scenario klimatskih promjena odraziće se u značajnijem odstupanju klimatskih faktora od prosječnih višegodišnjih vrijednosti, i to kao značajno smanjenje padavina, njihov loš raspored, povećanje temperatura kako proljetnih tako i jesenjih, rizika od suše kao i degradacije zemljišta. Ove činjenice nameću potrebu za stvaranjem tolerantnijih sorti strnih žita kao i uvođenje korektivnih faktora koji povezuju sortu, tehnologiju i uslove proizvodnje uz dobru komunikaciju nauke i struke.

Ključne riječi: pšenica, žita, oplemenjivanje, prinos.