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DOSTIGNUĆA U OPLEMENJIVANJU PŠENICE Bc INSTITUTA ZA OPLEMENJIVANJE I PROIZVODNJU BILJA ZAGREB U HRVATSKOJ*

ACHIEVEMENTS IN WHEAT BREEDING OF THE Bc INSTITUTE FOR BREEDING AND PRODUCTION OF FIELD CROPS- ZAGREB IN CROATIA**

S. Tomasović, P. Javor, R. Mlinar, B. Sesar

SAŽETAK

Oplemenjivanje ozime pšenice u Bc Institutu - Zagreb ima vrlo dugu tradiciju. Rad na oplemenjivanju ozime pšenice započet je u tadašnjem Zavodu za ratarstvo u Botincu davne 1947. godine pod vodstvom dr. sc. Josipa Potočanca, koji je zasnovao model Bc pšenica baziran na povećanom broju biljaka po jedinici površine kombiniranjem svojstava talijanskih sorti s američkima. S izvjesnim promjenama taj su model kasnije prihvatili oplemenjivači Bc Instituta: Javor P., S. Tomasović i R. Mlinar. U 1971. godini priznate su sorte Zlatna Dolina i Sanja. To je bio veliki napredak u usporedbi sa sortama stvorenima prije njih. Sorta Zlatna Dolina bila je 15% većeg uroda u širokoj proizvodnji nego tada vodeća talijanska sorta Libellula (Martinić-Jerčić, 1990.). Poslije Zlatne Doline priznato je 70 visokorodnih sorti ozime pšenice od kojih je jedna sorta ozimog duruma stvorena u Bc Institutu - Zagreb. Mnoge od tih sorti prihvatili su proizvođači pšenice u zemlji i izvan zemlje gdje je priznato 16 sorata (Italija, Mađarska, Čehoslovačka, Bugarska, Slovenija). Oplemenjivanje ozime pšenice je složen posao. U Bc Institutu-Zagreb to se odvija u sklopu nekoliko programa, čiji je osnovni cilj stvaranje polupatuljastih i srednje visokih sorata s povećanjem kakvoće zrna i brašna. Oplemenjivači: Javor, Tomasović i Mlinar postavili su za cilj postići urod zrna od 15 t/ha (12-15 t/ha), jer već u 1983. i 1984. godini sa Zg-sortama pšenice ostvareni su urodi od 10 t/ha i više u širokoj proizvodnji, održavanje visoke stabilnosti uroda putem oplemenjivanja na najznačajnije bolesti pšenice (crna žitna hrđa, pepelnica, Septoria spp. i Fusarium spp.), te daljnje povećanje

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kakvoće zrna i brašna za naše uvjete proizvodnje. Stalnim poboljšanjem našeg oplemenjivačkog programa stvorene su nove sorte. Naše nove Bc sorte ozime pšenice sve se više nalaze na žitnim poljima širom zemlje i zauzimaju značajan udio u proizvodnji u Hrvatskoj.

Među njima posebno se ističu Sana i Marija, koje, rekli bismo daju pečat u proizvodnji pšenice u zemlji. Radi visokog kapaciteta rodnosti i dobre kakvoće zrna i brašna obe sorte vrlo dobro udovoljavaju strogim zahtjevima tržišta. Sorte koje ulaze u proizvodnju iz najnovijeg ciklusa oplemenjivanja pšenice Bc Instituta - Zagreb su sljedeće: Darka, Rina, Davorka, Melita, Sandra, Olga, Sutla, Tina, Rugvica, Patria, Plodna, Mladenka, Pakra, Vitina, Ida i dr. Navedene sorte postižu urod iznad 8 t/ha suhog zrna, dok im je genetski potencijal rodnosti mnogo veći i iznosi više od 10 t/ha. Kod najnovijih Bc sorata i linija ozime pšenice postignut je značajan napredak u poboljšanju kakvoće zrna i brašna. Tako neke sorte, odnosno linije pripadaju I., a neke u II. kvalitetni razred. Odlikuju se dobrim farinološkim svojstvima. Vrijednosti ekstenzograma su također dosta povoljne. Značajan doprinos istraživanju problematike povišenja uroda pšenice po klasu dalo je otkriće gena, koji kontroliraju granatost (Ramifera), četverorednost (Tetrastichon), te normalnu formu klasa kod pšenice Triticum aestivum L. (Rm, Ts i Nr geni) (genotipovi s vrlo dugim klasovima – 33 klasića u klasu) (M. i Svetka Korić, Tomasović).

Rad na kolekciji genetske osnove za oplemenjivanje ozime durum pšenice (Triticum durum Desf.) u Bc-Institutu - Zagreb, u Zavodu za strne žitarice u Botincu, započet je prije 1985. godine. Činjenica je, da veliki dio površina u Hrvatskoj (Istra, Dalmacija) ima mediteransku klimu, i da neke susjedne zemlje s oštrijim zimama nego što su naše imaju svoje vlastite sorte durum pšenice, što nas je ohrabrilo da započnemo sa stvaranjem vlastitih sorti (linija) za potrebe Republike Hrvatske. Sakupljeno je više od 2 500 genotipova (sorte i linije), od kojih veliki dio ima germplazmu s dobrim svojstvima za korištenje u oplemenjivačkom programu (otpornost na zimu, dobra fertilnost klasa, niska stabljika, debljina stabljike, veličina i položaj listova, bolja otpornost na gljivične bolesti, duljina vegetacije). Sljedeće Bc TD linije ozime durum pšenice s dobrim gospodarskim svojstvima prijavljene za registraciju Komisiji za priznavanje sorata Republike Hrvatske su: Bc TD 3201/92 i Bc TD 3200/92 (Tomasović, Javor, Sesar). Kasnije u 1997. godini linija Bc TD 3201/92 je priznata kao prva sorta ozime durum pšenice u Hrvatskoj pod imenom Primadur.

Ključne riječi: obična pšenica, durum pšenica, oplemenjivanje, genetski potencijal rodnosti, stabilnost uroda, gljivične bolesti pšenice, kvalitetna svojstva zrna i brašna.

ABSTRACT

Breeding of winter wheat in the Zagreb Bc Institute has a very long tradition. The work on breeding winter wheat was initiated in the then Farm Department in Botinec as early as 1947, under the guidance of Dr. Josip Potočanac, who developed a model of Bc-wheats which is based on increasing the number of plants per unit area after the model of Italian wheat varieties combining their traits with the American. With certain changes, this model was accepted by the breeders fron the Bc Institute; Javor, Tomasović and Mlinar.

In 1971 the varieties Zlatna Dolina and Sanja were released. That was a great progress in comparison with the varieties developed prior to those. The variety Zlatna Dolina was 15% more yielding in wide production than the leading Italian variety Libellula (Martinić-Jerčić, 1990). After Zlatna Dolina 70 high-yielding wheat varieties (one variety of winter durum wheat) developed by the Bc Institute have been registered. Many of these varieties have been accepted by wheat growers both at home and a broad, where 16 varieties have been registered so far (in Italy, Hungary, former Czechoslovak Republic, Bulgaria, Slovenia).

Breeding of winter wheat is a very complex work. In the Bc Institute-Zagreb it is being done in several programs the basic objective of which is development of semi-dwarf and moderately tall varieties with increased kernel and flour quality. The breeders' team: Javor, Tomasović and Mlinar set an objective to achieve yields of 15 t/ha (12-15 t/ha), because already in 1983 and 1984 yields of 10 t/ha and more of ZG-wheat varieties were produced in wide production, to maintain high yield stability breeding for resistance to the most important wheat diseases (black stem rust, powdery mildew, Septoria spp., Fusarium spp.) and to further increase kernels and flour quality.

With permanent improvement of our breeding work new varieties have been developed. The new Bc varieties of winter wheat are increasingly grown throughout the country and are regaining significant share in the nation's production. Among them, Sana and Marija are especially distinguished and one might say that they have made their mark in the nation's production. Because of their high yield and improved kernel and flour quality both Sana and Marija satisfy strict criteria of the market.

Bc varieties from the latest cycle of breeding that are entering production are the following: Darka, Rina, Davorka, Melita, Sandra, Olga, Tina, Rugvica, Patria, Plodna, Mladenka, Pakra, Vitina, Ida.They produce yield well above 8 t/ha of dry grain, while their yielding potential is much higher, i.e. more than 10 t/ha. Certain amount of progress has been made in the latest Bc varieties

and lines in terms of kernel and flour quality. They often belong to quality class I, and some to class II. They exhibit good farinological properties. Extensograph values are also relatively good.

Remarkable contribution to the investigation of higher yield per spike was made with the discovery of genes that control branching (Ramifera) furrowing (Tetrastichon) and normal spike form of Triticum aestivum L. wheat (Rm, Ts and Nr genes) (genotypes with very long spikes - 33 spikelets in a spike) (M. and Svetka Korić, Tomasović).

Work on collection of genetic basis for breeding winter durum wheat (Triticum durum Desf.) in the Bc Institute-Zagreb, in Department of Cereal Crops in Botinec, was initiated before 1985. The fact, that a large party of the Republic of Croatia (Istria, Dalmatia) has Mediterranean climate, and that some neighbouring countries with more severe winters than ours, have their own durum wheat varieties, we were encouraged to start developing our own durum wheat varieties (lines) for the needs of the Republic of Croatia. More than 2500 lines and varieties have been collected, part of which have germplasm with good properties for using in breeding projects (winter-hardiness, good spike fertility, low stature, culm strength, size and position of leaves, better resistance to fungal diseases, vegetation length). The following Bc (ZG) TD lines of durum winter wheat with good economic traits have been submitted for registration to the national Committee of the Republic of Croatia: Bc TD 3201/92 and Bc TD 3200/92 (Tomasović, Javor, Sesar). Later, in 1997 the line BC TD 3201/92 was released as the first winter durum variety in Croatia named Primadur.

Key words: common wheat (Triticum aestivum L. em Thell.), durum wheat (Triticum durum Desf.), breeding, genetic yielding potential, yield stability, fungal wheat diseases, qualitative traits of kernel and flour.

INTRODUCTION

Wheat breeding in Croatia was initiated soon after the first attempts in the world in incorporating traits of parents into their progeny by crossing. In 1911, a paper by prof. dr. Gustav Bohutinsky was published in "Gospodarska smotra" under the title "Crossing squarehead x Banatska brkulja". The most yielding variety between two world wars was the Croatian variety U_1 (Osječka šišulja) developed by prof. dr. Mirko Korić. As a leading variety it was widely accepted in production until the new Italian varieties were introduced.

Breeding of winter wheat in Bc Institute for breeding and production of field crops - Zagreb was initiated in 1947 by dr. Josip Potočanac. After many investigations into Italian wheat varieties, which were in productionn in Croatia after 1956 and because of several crucial failures among which the most important was insuficient winter hardiness, he established new model of wheat variety, by combining, at first good traits of Italian and American varieties. From this concept two famous wheat varieties were released, Zlatna Dolina and Sanja. Zlatna Dolina received international appreciation and was 15% more yielding in wide production than the leading Italian variety Libellula (Martinić-Jerčić, 1990). Stability of their high yielding was expanded as the next step in breeding wheat over resistance on the most important fungal diseases: powdery mildew, stem rust, Septoria spp. and Fusarium spp. This model of wheat variety was accepted, with certain changes and improvements, by breeders who continued that breeding work: Javor P., Tomasović S. and Mlinar R. It is evident, that this orientation in breeding was correct, because 70 varieties (one variety of winter durum wheat) were released. Out of this number 16 were recognised in foreign countries (Hungary, Italy, Czechoslovakia, Bulgaria and Slovenia).

BREEDING PROGRAMME

Breeding new winter wheat varieties and genetic investigations in the Bc Institute for breeding and production of field crops – Zagreb is the program for advancing wheat production in Croatia. In the Bc Institute – Zagreb it is done within several programs (Table 1). The basic objective is development of semi-dwarf and moderately tall varieties with increased productivity, wide adaptability through resistance to main fungal diseases, earliness and improved kernel and flour quality. The Bc Institute – Zagreb possess a large gene pool of different genetic material with various wheat properties. From the broad genetic variability offer crossing, breeding is made by using modified Pedigree method with discontinual individual selection.

Nowadays the aim of the breeding program is further raising of yielding capacity by increasing the number of spikeletes in a spike in the same crop density common to the well known Bc varieties Baranjka and Super Zlatna.

A remarkable contribution to the higher production of kernels per spike was the discovery of genes that control branching (Ramifera), four-rowing (Tetrastichon), and normal spike form of Triticum aestivum L.em. Thell wheat (RM, Ts and Nr genes). These genes, discovered and determined by dr. Svetka

Korić, (Korić, 1972) enable us to prolong spikes and increase the number of kernels. Branching genes are frequently used for developing highly productive normal form of spikes. The highest production per spike was 103 kernels The achieved size of the normal cylindric wheat spike with high number of kernels is influenced by pleiotropic effect of these genes in relation to higher 1000 kernel weight and increased number of kernels per spike.

Table 1. Number of recognized winter wheat varieties of the Bc Institute for breeding and production of field crops - Zagreb

Breeding program	Number of varieties	Authors (number of recognized varieties)
General	8	Potočanac, J., I. Golovčenko, (3) Potočanac J., M. Špekuljak, (5)
For resistance to stem rust	3	Potočanac, J., M. Engelman (2) Engelman, M., R. Mlinar et al. (1)
For resistance to powdery mildew	28	Potočanac J., P. Javor, (15) Javor, P. et al. (13)
For resistance to Septoria spp	10	Mlinar, R. et al. (10)
For resistance to Fusarium spp.	12	Tomasović S. et al. (12)
Improvement of yield and grain quality	4	Kump Marija, L. Ivčević, (1) Matijašević, M. et al. (3)
Improvement of a sink capacity	4	Korić Svetka, M.Korić (1) Svetka Korić (1), S. Korić, S.Tomasović (2)
Sowing date and quality	1	Martinić-Jerčić Z., P. Bakula, (1)
Total	70	

The new lines have more than 20 fertile spikelets, some of them even 27. Among the genotypes developed on the basis of higher production per spike there are some with 33 spikelets in a spike (data on such a large number of spikelets have not been found in the literature). It is known that the famous variety Zlatna dolina had about 16 spikelets and 1000 - kernel weight about 35 g.

Further improvement of relevant properties (1000 kernel weight, kernel and flour quality) is pursued within the current three programs whose main task is to achieve yields of 15 t/ha. Namely, in 1983 and later top yield of some of our varieties in good years was over 10 t/ha in field production.

RESULTS OF WHEAT BREEDING IN THE Bc INSTITUTE – ZAGREB

Bc wheat varieties posses high yielding potential and are suited to different agroecological growing conditions which has made them spread both at home and in the neighbouring countries. After Zlatna dolina and Sanja the varieties produced by the Bc Institute – Zagreb dominated over 70% of the wheat fields of Croatia in 1984 and 50% today. In 1980-ies cultivars of the Bc Institute – Zagreb dominated over 70% of the wheat fields in Croatia. Now it is 50%. Zlatna dolina, Sanja, Super Zlatna, Baranjka, Lonja, Zagrepčanka, Adriana, Korona, Marija, Mihelca, Plodna, Anita, Olga, Tina, Davorka and Mladenka were recognized in foreign countries (Potočanac and Javor; Javor; Tomasović; Mlinar).

In the period from 1983 to 1986 Bc wheat varieties predominated in areas under wheat in the Republic of Croatia. Until 1985, there was a steady increase in seed production of Bc wheat varieties when they accounted 96% of the harvested area in the country. After that period the production fell to 50% but a new trend of growth has been observed. (Table 2).

Table 2. Seed production of winter wheat in the Republic of Croatia and the share of the Bc Institute in the total seed production for the period from 1983 to 1984

Production year	Production in tons	Share %
1983.	37.262	95
1984.	30.582	93
1985.	32.068	96
1986.	34.747	76
1987.	57.372	60
1988.	34.090	61
1989.	29.186	59
1990.	41.734	53
1991.	11.841	-
1992.	14.552	-
1993.	18.199	-
1994.	18.077	-

It is evident from table 2 that the highest amount of seed was produced in 1987. Despite war conditions (1991 – 1994) permanent growth of marketed seeds of Bc wheat varieties could be observed for that period which meant a significant contribution of the Bc Institute – Zagreb to the nation's seed production.

Table 3. Grain yield and some relevant agronomic traits of some new winter wheat cultivars developed by the Bc Institute Zagreb, in small-scale trials, Zagreb-Botinec, 1991-1993.

Cultivar	Grain yield kg/ha		Relat. to Sana Sana= 100% Stand.	1000 kernel weight (g)	Test weight (kg)	Plant height (cm)	Lodging (%)	Vegetat. length ± days Sana	Disease attack			
	Cultivar	Sana							Powd. mildew (0-9)	Leaf rust Cobbs scale	Sept. spp. (0-9)	Fusar. spp. (0-5)
Darka	8858	8892	99,62	47,0	77,2	73	0	–1	1-2	OR	2	0
Davorka	9202	9168	100,37	45,0	78,0	77	0	–2	3	OR	0	1
Melita	8862	8892	99,66	42,0	77,0	77	0	–1	1	OR	0	0
Olga	8000	7600	105,26	49,5	78,9	82	2-3	+2	3-4	OR	2-3	0
Rina	9740	8892	109,53	43,5	76,0	75	0	–1	0-1	OR	1	0
Rugvica	9850	9152	107,62	46,5	78,5	79	0	+3	4	TR	2	0
Sandra	8232	7878	104,49	47,0	78,4	84	5	+2	3-4	OR	3	0
Sutla	9236	9152	100,91	43,5	77,8	80	4	+4	4-5	OR	2-3	0
Tina	8124	8290	97,99	46,5	75,5	72	0	0	2	TR	2	0
Ida	8836	8444	104,64	47,5	77,0	80	0	0	1	OR	0	0

Within the new Bc varieties of winter wheat Korona and Marija are specially distinctive. Owing to their high yielding capacity and the results achieved in agricultural production both at home and abroad, the above varieties serve as standards for the Committee for registration of new wheat varieties (Korona-standard in the Committee of the Republic of Croatia; Marija- standard in the Committee of the Republic of Slovenia). Because of their high yield and improved kernel and flour quality both Korona and Marija satisfy strict criteria of the market. Following Marija and Korona, a prominent place in the wide agricultural production is taken by Alena, Adriana and a new variety Ida, which is an excellent raw material for confectionary industry.

Bc wheat varieties and advanced lines from the latest cycle of breeding that are entering production are the following: Darka, Rina, Melita, Davorka,

Sandra, Sutla, Olga, Rugvica, Tina, Mladenka, Patia, Pakra, Plodna, Vitina, Mihelca, ZG 4160/91, ZG 4166/91, ZG 31/91, ZG 18/91 and others (Tables 3, 4). On normal years and planted at optimal date (October 10-25) they produced a yield well above 8 t/ha^{-1} of dry grain which in micro-trials is about 10 t/ha^{-1}. Line ZG 4160/91 produced 10720 kg/ha^{-1}, which is 7,15% (716 kg) above the standard variety, Korona.

Certain progress has been made in the latest Bc varieties and lines in terms of kernel and flour quality. Higher level of protein content and sedimentation value have also been achieved and some varieties or lines often belong to quality class I and II (Table 5). New varieties and lines exhibit good farinological properties of which water absorption should be emphasized. Extensograph values are also relatively good. As for indices of seed quality, increase in 1000-kernel weight is highly pronounced, i. e. 40-50 g and more, in some materials even 50 g and more as compared to the varieties from earlier breeding programs. The old variety, Zlatna dolina, had the average 1000-kernel weight of 30-35 g. Table 3 shows that the new varieties are characterized by a high level of resistance to the most important fungal diseases affecting wheat. They have a moderately tall stem of good strength and exhibit very good resistance to lodging. By maturity they belong to mid-early types.

Table 4. Grain yield and some relevant agronomic traits of some new winter wheat lines developed by the Bc Institute Zagreb. In small-scale trails. Zagreb-Botinec 1991-1993

Line	Grain yield kg/ha		Relative to Sana	1000 kernel	Test weight	Plant height	Lodg. %	Vegetat. length	Sedim. value	Disease attack			
	Line	Sana	Sana = 100% Standard	weight (g)	(kg)	(cm)		± days Sana	(ml)	Powd. mild. (0-9)	Leaf rust Cobbs scale	Sept. spp. (0-9)	Fusar. spp. (0-5)
ZG 4160/91	10 720	10 004	107.15	44.0–51.5	78.0	80	0	0	24	1–2	OR	0	1
ZG 4166/91	10 460	10 004	104.56	40.0–46.0	78.4	77	0	0	37	1–2	OR	0	1
ZG 3037/91	10 244	10 004	102.12	44.0	78.2	78	0	0	36	2	OR	0	1
ZG 100/91	8 236	7 792	105.70	41.7–47.5	75.4	75–77	0	–2	35–43	2–3	OR	0	0
ZG 18/91	7 800	7 688	101.46	42.0–43.5	76.0	73–76	0	0	35–50	0–1	OR–TR	0–1	0–1
ZG 31/91	8 548	8 068	105.95	40.2–48.5	74.8	67–72	0	+2	36-42	0	25 MS	0–1	0–1
ZG 3311/92	9 624	9 448	101.86	45.0–52.5	76.8	82-88	5	–2	35-40	2–3	OR-TR	0–1	0–1

Work on collecting genetic basis for breeding hard winter wheat (Triticum durum Desf.) in the Bc Institute – Zagreb, in Department of Cereal Crops in Botinec was initiated before 1985. The fact, that a large part of the Republic of Croatia (Istra, Dalmatia) has a Mediterraniean climate, encouraged us to start

breeding durum wheat varieties (lines) for the needs of the Republic of Croatia. More than 2500 lines and varieties have been collected, part of which have germplasm with good properties for using in breeding projects (winter hardiness, good spike fertility, low stature, culm strength, size and position of leaves, better resistance to fungal diseases, vegetation length) Two Bc (ZG) TD lines of durum winter wheat with good economic traits have been submitted for registration to the National Committee of the Republic of Croatia: Bc TD 3201/92 and Bc TD 3200/92 (Table 6, 7) (Tomasović, Javor, Sesar).

Table 5. Quality indices of some new winter wheat cultivars developed by the Bc Institute for breeding and production of field crops - Zagreb

Cultivar	Protein %	Sediment. value (ml)	Quality class	Farinograph			Extenzograph		
				Water absorption	Quality number	Quality group	Exten sib. (mm)	Resistance (EJ)	Ratio (OR)
Darka	12.9	34.7	II	57.0	58.5	B1	166	230	1.38
Davorka	13.3	30.8	II	50.8	53.9	B2	187	355	1.89
Melita	12.4	33.8	II	55.5	55.1	B1	171	190	1.11
Olga	11.5	43.0	I-II	59.3	65.0	B1	147	245	1.32
Rina	12.0	38.0	II	50.0	35.4	C1	116	340	2.93
Rugvica	11.6	22.9	III	52.0	50.6	B2	116	340	2.93
Sandra	14.0	47.8	I	57.7	67.3	B1	139	215	1.54
Sutla	12.2	31.8	II	62.0	47.4	B2	129	470	3.64
Tina	13.8	64.4	I	53.8	63.8	B1	180	320	1.78

Table 6. Performance of the new lines of durum winter wheat (Triticum durum Desf.) in comparative micro - trials (Zagreb-Botinec. 1994)

No. line	Grain yield (kg/ha)	Relative to Stand.=100%	Plant height (cm)	Lodging (%)	Veget. length ±days to Stand.	Grain quality	
						1000 Kernel (g) weight	HI - weight (kg)
1. Bc TD 3201/92	5 036	126.02	88	0	–2	45.25	76.28
2. Bc TD 3200/92	4 760	119.11	85	0	+2	46.00	77.20
3. L-5066/93 (STAND.)	3 996	100.00	81	0	0	48.50	77.48

LSD 5% = 975.89 kg/ha
1% = 1299.56 kg/ha

Table 7. Resistance of the new Bc TD lines of durum wheat (Triticum durum Desf.) to the most important wheat diseases in comparative micrt-trials (Zagreb-Botinec, 1994)

No. line	Disease attack											
	E. graminis inf.		Septoria spp. natur inf		S. nodorum artif. inf.		Fusarium spp. natur. inf.		Fus. monilif. var. subglut. artif. inf.		Puccinia recondita natur. inf.	
	natur. 0-9	artif. 0-9	leaf 0-9	spike %	leaf (0-9)	spike	0-5	%	0-5	%	%	type
1. Bc TD 3201/92	2	5	0	0	6-7	0	0	0	0-1	1	0	R
2. Bc TD 3200/92	2	5	0	0	6-7	0	0	0	0-1	1	0	R
3. L-5066/93 (STAND.)	2	5	0	0	5	7	0-1	1	0-1	1-3	0	R

Rating rust after Cobb (%, type)

Scale (0-5):
0 = no infection
5 = more than 75% of infected spikes

Scale (0-9):
0 = no infection
9 = the highest disesase severity

Later, in 1997 the line Bc TD 3201/92 was released under the name Primadur.

CONCLUSIONS

To summerize the achievements in breeding of Bc varieties of winter wheat, which are the result of a continuous breeding work, the following conclusions can be made:

- Wheat varieties and lines with yielding capacity well above 10 t/ha^{-1} have been developed whose yield has been achieved owing to an improved genetic basis and wide adaptability to different agroecological growing conditions.
- High yield stability of the new Bc varieties and lines has been maintained through genetic resistance to the economically most important fungal diseases.
- As compared to some older varieties, a significant progress has been made in wheat breeding in terms of improved kernel and flour quality. Varieties and lines with markedly improved relations of yield and kernel and flour quality have been developed. Higher percentage of total proteins and increased sedimentation values have been achieved.

- The new varieties and the latest lines are distinguished by very good farinological characteristics, especially good water absorption, which very important for higher bread keeping quality and hence baking industry. Extensograph values for the new varieties and lines are also improved in comparison to the older varieties.
- As for kernel quality the latest varieties and lines display a marked progress, especially in higher 1000-kernel weight relative to older varieties.
- Spike length has been extended and it is reflected in a bigger number of spikelets per spike (33) increased number of kernels per spikelet (3-5) and total number of kernel per spike (103).
- Stem strength has been increased resulting in good lodging resistance.
- Bc Institute - Zagreb has made a large contribution to the production of seed of winter wheat in Croatia, which rank among the best in the world.
- Until 1985 there was a steady increase in seed production of Bc wheat varieties when they amounted to 96% of the harvested area in the country. After that period the production fell to 50% and a new trend of growth has been observed.
- Except for common wheat in 1985 we started breeding work on hard winter wheat (Triticum durum Desf.). In breeding we pay a special attention on the most important properties for our agroecological conditions like: winter hardiness, spike fertility, semidwarf stature, culm strength, size and position of leaves, length of vegetation period, etc. In choice of parents, special attention is given to genotypes with better resistance to fungal diseases, especially to Fusarium spp. and Septoria spp. The best durum lines (Bc TD 3201/92 and BC TD 3200/92) have been submitted for registration to the National Committee of The Republic of Croatia. In 1977 the line Bc TD 3201/92 was released as the first winter durum variety in Croatia under the name Primadur.

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Adresa autora - *Author's address*:

Dr. sc. Slobodan Tomasović, oplemenjivač
Dr. sc. Petar Javor, oplemenjivač
Mr. sc. Rade Mlinar, oplemenjivač
Mr. sc. Branko Sesar, sjemenar

Bc Institut za oplemenjivanje
i proizvodnju bilja – Zagreb, d.d.
Marulićev trg 5/I, Zagreb,
Zavod za strne žitarice - Botinec.