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WHEAT BREEDING AND FOOD PRODUCTION

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Abstract

The progress achieved in wheat breeding is analyzed in the function of food production as well as the possibility of further work on increasing the yield and quality, resistance to diseases and more economical usage of mineral nutrients. The great success is achieved in the increase of genetic potential for grain yield and quality improvement, while in nutritive values the slight improvement is accomplished. In the program of creating the new wheat cultivars it was constantly worked on including the genes for resistance against the main pathogenic organisms attacking the wheat where the cultivars of high degree of genetic resistance to leaf rust (*Puccinia recondita*) and powdery mildew (*Erysiphe graminis*) were produced. During the last years the greatest attention is paid to breeding of the cultivars having the more strong ability to use mineral nutrition from soil and using it more economically for grain production.

Key words: *Wheat (Triticum aestivum), breeding, yield, quality, resistance.*

Introduction

Cereals being at the first place in the world by produced of human food. Food components they are containing, human organism accepts easily. From the total produced plants' proteins in the world the greater part belongs to cereals (52%) while the remaining (48%) belongs to all other plants. They will probably keep such position in future, moreover due to their production potential and the possibility of growing in different environments. The cereal production improvements until recently had meant grain quantity increase regardless of technologic and nutritive traits. The next step was grain technological traits improvement. For these reasons today the main objective of cereals breeding is to improve the nutritive values, first of all the protein content in grain, and simultaneously the increase of genetic potential for yield and improvement of other agronomic traits.

The great contribution of genetics and breeding in creation of new cultivars can be seen from the fact that owing to them, yield of cereals is increased in this century for about 1% per year (Fray, 1971; Mac Key, 1980). The researches in Serbia & Montenegro have showed as well that new wheat cultivars, under the same agronomic conditions can have 50-70% bigger grain yield than the old ones (Borojević, 1990). The wheat breeding and improved agronomy practice increased total production in Serbia & Montenegro, that started 1956/57, increased the wheat production per area unit 3.6 times (Mišić, 1987). The further breeding progress is possible as there are the germplasm for traits that are significant for successful plant growing in different conditions, and their transfer to any genotype is possible and to improve it genetically by conventional breeding methods and recurrent selection. Nowadays certainly that transfer of gene from other cultivars and biotechnology methods are used, such as di-haploids, molecular markers and transformations, that can be used for transfer of genes that control the particular traits (Bedo, 1994).

The breeding for high yield alone is not a difficult task. The breeding for high yield and grain quality is more complex problem and finally the breeding for yield, quality and nutritive value simultaneously makes the breeding process complex by geometric progression. In addition the need for effective weed and pest control, protection from diseases as well as the need of rationalized use of mineral nutrients make the complex problem that modern wheat breeding is to solve.

In this paper the wheat breeding at the Institute of Field and Vegetable Crops in Novi Sad is presented from the three aspects of creating the cultivars for healthy food production: /i/ breeding for yield and quality, /ii/ breeding for diseases resistance, and /iii/ breeding for efficient mineral nutrient utilization.

Breeding for yield and quality

The contribution of the particular cultivars in different periods of wheat growing is obtained by the results of macro trials analysis (Denčić et al., 1993). To the end of fifties the leading cultivar in the Voivodina Province Province (Serbia granary) was Bankut-1205. It was the cultivar of high plant, sensitive to lodging, well resistant to low temperatures and of good quality. As the result of

the tendency for intensification in agriculture and production increase, the Italian cultivars were introduced. These cultivars of short stature, productive spike and of early maturity, were used as the model where the genes for low temperature resistance, genes for better grain and flour quality, as well as the genes for resistance to diseases were input (Borojević, 1990; Mišić and Mladenov, 1995a). The best Italian cultivar was San Pastore, which over yielded Bankut-1205 for about 35% (Table 1). The cultivar San Pastore was the first foreign cultivar with the effects on Yugoslav yield increase and it was in production for 12 years (1957-1970).

In the period from 1963-1967 the famous Russian cultivar Bezostaja –1 entered into the production. Although it had not a high yield potential, it was in the production more than 10 years. The reason for that was excellent quality, what the Italian cultivars were lacking. By introducing this cultivar into a program of crossing the progress in the breeding the winter wheat for quality was achieved. From these hybrid combinations the cultivars-lines were obtained with balanced quality indexes. In that way, by application of different methods of hybridizing the divergent parents, the genes were successfully combined, that control all important agronomic traits and the cultivars with a yield potential over 10 t/ha were released and of satisfactory to excellent quality (Mišić and Mladenov, 1995b). In that period one Italian cultivar more occurred and that was Libellula. It was, in distinction from Bezostaje-1, with higher yield from San Pastore cultivar for about 20%. That period was denoting releasing of the first Yugoslav cultivars (Bačka, Hibrid 013, etc) which due to lower yield were not mass-produced.

In the seventies the Novi Sad cultivar Sava released. The next yield increase was achieved with this cultivar, its yield was higher than Libellula for about 15%. The Sava was from the middle to the end of the seventies the leading cultivar and it remained in production by 1980.

The further success in wheat production was achieved by the cultivars the Novosadska rana 1 and Novosadska rana 2, which by their genetic yield potential were on the level of the Sava cultivar, however they had better quality and shorter vegetation. They took over the primate in production, and they were the leading cultivars for further few years not only in Voivodina Province but also in other parts of Serbia & Montenegro. The significant progress was made concerning the quality. The Novi Sad cultivars Partizanka, Dunav and Nova Banatka due to excellent quality and higher yields completely pushed away the cultivar Bezostaja-1.

In the middle of the eighties the cultivars Yugoslavia and Balkan took over the primate in production from the Novosadska rana 2, and these are the cultivars with successful combination of high genetic yield potential and very good to excellent quality. In the period from 1985 to 1990 many of the cultivars were released. Some of them as Partizanka niska, Somborka, Žitnica and other were present in production, therefore the dominance of one or small number of cultivars was decreased in this period. From that period the winter wheat production in any region engaged few cultivars (5-6), of the same yield potential, but complementing each other by length of vegetation resistance to diseases, quality etc. In this way opposition to environment limiting factors is provided, whereby obtaining the high yield stability (Mladenov, 1996).

At the beginning of the nineties the primate in Voivodina Province had the cultivars Evropa, Lasta and Francuska better in respect to yield potential than cultivars Yugoslavia but worse in respect to quality. During the last years new Novi Sad cultivars have released which representatives are: Pobeda, Novosadska rana-5, Evropa-90, Kremna, which according to the results in macro trials showed that they are going to spread in production. At majority of these cultivars the genes for high yield, good resistance to low temperature, lodging and diseases were successfully recombined with very good to excellent quality.

When it is said wheat quality it usually means bread organoleptic traits. However such evaluation isn't complying with nutritive values where analytic evaluation of quantity and quality of proteins, amino acids, vitamins, lipids and mineral matter are taken into consideration (Gaal et al., 1992). The chemical composition of wheat grain is such that outer grain cover (pericarp, seed vessel and aleuron) is richer in respect to protein (amino acids), lipids and pentosans in relation to endosperm which consists mostly of starch and usually is used for preparing the white, the most requested and the most expensive bread in Serbia & Montenegro. Therefore it is well known long ago, that bread has been made from the whole grain which is, from the nutritive point of view, much better than the bread from endosperm.

Although all constituent parts of the grain are important, yet according to general significance in life, proteins have the main role there as well. In respect to proteins the especially significant issue is the composition and content of particular amino acids being of vital importance for life. In general wheat has deficit of very important amino acids such as lysine, treionine, methionine and cistine and possesses the sufficient quantities of glutaminic acids and proline (Pilch, 1994).

In further period it will be worked on yield increase and improvement of technological and nutritive quality, as by increasing protein production for example from 13% to 15% at average grain yield of 4 t ha^{-1} it will be obtained 80 kg ha^{-1} protein more and protein of high nutritive value which could be kept easily and long without deterioration.

Table 1. Results of wheat macrotrials in Vojvodina in period 1957-2005.

Cultivar	Period	Yield (t ha^{-1})	In relation to leading cultivar (%)	Quality class	Bred-making quality
Bankut 1205	1957-1960	3.00	100	II	good
San Pastore		4.05	135	III	poor
San Pastore	1963-1967	3.96	100	III	poor
Bezostaja-1		4.07	103	I	excellent
Libellula		4.80	121	III	poor
Libellula	1970-1974	4.93	100	III	poor
Sava		5.69	115	III	poor
Bezostaja-1		4.68	95	I	excellent
Sava	1975-1978	6.08	100	III	poor
Drina		6.21	102	III	poor
NS rana-1		6.17	102	II(I)	good
NS rana-2		6.07	100	II(I)	good
Partizanka		5.81	96	I	excellent
Sremica		5.79	95	I	excellent
NS rana 2	1980-1984	5.87	100	II(I)	good
Jugoslavija		6.08	104	I	very good
Partizanka		5.77	98	I	excellent
Balkan		5.93	101	I	excellent
Jugoslavija	1985-1987	6.34	100	I	very good
Partizanka niska		6.25	99	I	very good
Somborka		6.36	100	I	very good
Jednota		6.43	101	I	very good
Žitnica		6.52	103	II(I)	good
Lasta		6.77	107	(III)II	good
Rodna		6.41	101	I	excellent
Jugoslavija	1988-1990	6.31	100	I	very good
Evropa		6.70	106	II(I)	good
Francuska		6.68	106	II	good
Lasta		6.97	111	III(II)	good
Tanjugovka		6.37	101	I	excellent
Evropa	1991-1992	6.01	100	II(I)	good
Rodna		5.46	91	I	excellent
Rana niska		5.78	96	II(I)	very good
Evropa	1993-1998	5.76	100	II(I)	good
Pobeda		6.03	105	I	excellent
NS rana-5		5.64	98	I(II)	very good
Proteinka		5.54	96	I	excellent
Pobeda	1999-2005	6.01	100	I	excellent
Renesansa		6.04	100	I	excellent
Pesma		6.10	101	I	excellent
Ljiljana		6.10	101	I	very good
Sonata		6.17	103	III	poor
Dragana		6.15	102	II	good

Breeding for diseases resistance

There are numerous diseases occurring in wheat. Some of them cause the economically significant losses therefore they have to be prevented chemically. All measure of protection could be divided into three groups: chemical, agronomic and growing of resistant cultivars. The creation and growing the resistant cultivars is of the greatest significance, as in that way the most efficient and ecologically safe prevention is achieved. The base for successful wheat breeding of resistant cultivar is knowledge of parasites virulency, knowledge of different wheat genotypes resistance and knowledge of resistance way of inheritance.

In the program of breeding the new wheat cultivars it was worked constantly on transfer of genes for resistance against the main pathogenic organisms attacking the wheat in Serbia & Montenegro. At the Institute of Field and Vegetable Crops in Novi Sad the emphasis of the work was on the resistance to leaf rust (*Puccinia recondita*) and powdery mildew (*Erysiphe graminis*). The investigation of virulency of the causes of mildew, leaf and stem rust were the objectives of many researches. It was found out that population of Erysiphe graminis tritici consists of many physiological races of different virulency (Stojanović et al., 1973; Iliev, 1994). The similar results were obtained in researches of the population *Puccinia*

recondita tritici (Bošković, 1985). Opposite to previous parasites *Puccinia graminis tritici* consisted from smaller number of races (Špehar et al., 1978) but from different biotypes as well (Andrejević and Stojanović, 1982). The existence of many races represents the disadvantageous factor in wheat selection to resistance. So far that the race composition in nature is changing, new races are formed, virulent for the resistant cultivar up to then. Therefore it is necessary to follow permanently the changes in parasites population.

Phytopathologists determined the genes for leaf rust and powdery mildew effective only in certain stage of growing. By testing wheat genotypes from the international nurseries and Yugoslav breeding material the sources of resistance are chosen (Kostić et al., 1985, Bošković, 1985) which breeders use for crossing. Several American cultivars from Kansas (e. g. Redcoat and Selkirk), are used as the source of genes for resistance to leaf rust (Lr3, Lr4-8), stem rust (Sr2, Sr6, Sr7b, Sr17) as well as the genes for resistance to powdery mildew (Pm1, Pm2, Pm3). Especially important is the contribution of the Russian cultivars Bezostaja-1 (introducing the genes Lr3 and Sr5), Aurora and Kavkaz (introducing the genes Lr3, Lr26, Sr5, Sr31, Yr9, Pm8).

Knowing that the high resistance to few kind of pathogens can not be achieved, either to all prevailing races of one kind of pathogens, it was tended to achieve a good field resistance, i.e. weak and late pathogens attack. It was achieved by combination of few genes for resistance with low effects, than by individual genes with strong effects such as Lr9 and Sr11.
The majority of Novi Sad cultivars are not sensitive to rusts and powdery mildew, although they differ according to resistance degree (Table 2). By crossing the divergent parents the new genetic basis are formed for resistance to leaf (*Puccinia recondita tritici)* and stem rust (*Puccinia graminis tritici*). So the cultivars Partizanka, Yugoslavia, Rodna and other have very good field resistance to leaf and stem rust. Such resistance to leaf rust is kept by Partizanka and Yugoslavia for over 20 years (Mišić et al., 1987). The similar reactions are of the new cultivars, Novosadska rana 5, Pesma, Pobeda, Ljiljana and Dragana. The high degree of genetic resistance to leaf rust have the cultivars Rana niska, Varadinka, Somborka, Stepa, Prima, Kremna, and Ljiljana. The good resistance to stem rust was showed by the cultivars Balkan and Yugoslavia. The high degree of resistance to causes of powdery mildew have the cultivars Sloga, Yugoslavia Renesansa, Pobeda and Dragana..

The transfer of genes for resistance against the main pathogenic organisms is the permanent task at each crop breeding. This is important as today the pesticides are used easily even for those pathogens where the good genetic resistance could be achieved. Exaggerated use of pesticides, causes not only the harmful residues in the products we use as food but also water and soil pollution, what can lead us together with the pollution from industry, to a real ecological catastrophes. In order to provide high, stable, qualitative and healthy food the work on formation of resistant cultivars should be intensified and expended on all significant parasites (Jevtić et al., 1997; Miedaner, 1997). The economic and ecological aspect of growing the resistant cultivars is in the saving pesticides and environment.

Breeding for efficient using of mineral nutrients

While breeding had the great success in genetic changes of the parts of plant above soil, the breeding of root system yet starts, although the absorption of mineral elements and water from soil depends on it (Muchow and Carberry, 1993). It is established that there are differences between cultivars of one class in the development of root system, as well as the difference in absorption and using of the mineral nutrients. Today when production expenses are increasing, especially of nitrogen nutrients, it is necessary to determine the genetic differences between the cultivars and to breed the cultivars with active root system in different types of soil, with higher nitrogen harvest index and cultivars which are going to use the absorbed nutrients more economically for the production of the main product-grain.

One of the most efficient measures for yield increase and wheat quality improvement is mineral nutrition's (Ortiz-Monasterio et al., 1997). Mineral nutrition's improve the wheat yield that can be increased 2-2.5 times (Malešević et. al., 1996). However, the surplus of unused nutrients, mostly as nitrate, can come to the surface and underground waters and cause their pollution. One part of nitrogen becomes N_2O by denitrification in soil, as gaseous product can go into atmosphere and influence negatively the ozone stratum of stratosphere. There are the data that intensive nutrition of the crops, by nitrogen, reduces pH values of soil and thereby causes favorable movements of some metals in soil and their absorption by plant.

Particular biochemical and physiological processes are used as criteria for evaluation of cultivar specificity in plant mineral nutrition. The special attention is paid to the activity of ferments engaged in absorption and metabolism of particular elements of mineral nitrate reductase. The differences between the cultivars are determined, in their activity during use and translocation of reduced form of nitrogen from the vegetative organs into grain. High yielding cultivars had higher content and more intensive translocation of nitrogen as well as greater activity of nitrate reductase. Therefore the selection of wheat should be directed towards better use of already absorbed nitrogen, i.e. better expressed translocation from vegetative organs into organs and greater activity of nitrate reductase (Rao et al., 1977). The activity of this ferment depends on the nutrition conditions (optimum activity 70-80 $kgNha^{-1}$), cultivar and temperature (Mahnovskaja et. al., 1980). With nitrogen increase the activity is reduced (Shumnyi and Tokarev, 1976),

Referring to this, the task of the wheat breeders is to breed the new cultivars able to take mineral nitrogen from soil in greater extent. These cultivars should have the increased efficiency of absorption and assimilation of nitrates. It understands breeding the cultivars with increased absorption activity of the root system.

Table 2. Risk degree range of leaf rust (Pucc. recondita tritici) and powdery mildew (Erysiphe graminis tritici) atack in Novi Sad winter wheat cultivars.

Cultivar	Risk degree		Cultivar	Risk degree	
	leaf rust	powdery mildew		leaf rust	powdery mildew
Balkan	7	5	Sremka	2	5
Rodna	1	6	Jugoslavija	2	3
Rana niska	2	6	NS rana-2	9	8
Proteinka	6	6	Somborka	3	7
Pobeda	5	4	Jarebica	8	9
Danica	2	5	Stepa	3	5
Košuta	7	5	Sloga	2	2
Milica	2	6	Fortuna	9	9
Srna	4	5	Alfa	3	2
Partizanka	1	7	Rusija	8	4
Slavija	9	6	Divna	4	6
NS rana-5	3	6	Luna	3	6
Evropa	9	8	Struna	4	6
Evropa 90	8	8	Kremna	3	6
Francuska	9	8	Prima	2	6
Lasta	3	3	Pobeda	2	6
Italija	9	8	Renesansa	2	5
Dična	5	5	Pesma	2	5
Varadinka	2	6	Ljiljana	2	6

Artifical infection in the field
Risk degree: 1 = low ; 10 = high

Table 3. Cultivar specificity in the technology of growing of Novi Sad wheat cultivars

Cultivar	Sowing date [1)]	No. of vlable seed/m. sq. [2)]	No. of spikes/m.sq [3)]	N dose for top-dressing (kg ha^{-1}) [4)]	No. of top-dressings
Balkan	1-10. X	450-500	650	60	1
Pobeda	1-25. X	450-500	700	75	1-2
Proteinka	1-10. X	550-650	650	90	1-2
Rana niska	10-31. X	550-650	750	90	1-2
Partizanka	1-15. X	450-500	700	60	1
Košuta	1-15. X	450-500	650	60	1
Rodna	5-15. X	500-550	650	60	1
NS rana-5	10-25. X	500-550	650	75	1-2
Evropa 90	1-25. X	500-550	750	60	1
Kremna	1-25. X	550-600	800	75	1-2
Stepa	1-10. X	500-550	700	60	1
Prima	10-31. X	600-650	850	90	1-2
Dična	10-25. X	500-550	700	60	1
Jugoslavija	1-25. X	450-550	600	60	1
Somborka	10-25. X	550-650	700	90	1-2
Pesma	5-25. X	550-650	800	75	1-2
Zlatka	5-25. X	550-600	800	90	1-2
Renesansa	5-25. X	500-550	750	60	1
Pobeda	5-25. X	450-500	700	60	1
Ljiljana	5-31. X	450-500	650	60	1
Nevesinjka	10.X-31.X	450-550	600	60	1

[1)] Sowing date in wheat-growing regions of Serbia & Montenegro.
[2)] Seeding rate in kg ha^{-1} is calculated on the basis of 1000-seed mass and viability: the recommended number of seeds pertains to the optimum sowing date.
[3)] The optimum number of spikes to secure a high grain yield.
[4)] An accurate calculation of nitrogen dose is based on nitrate level in soil, the provisional doses given above are valid for the average NO_3-N level of 90 kg ha^{-1} in the soil layer 0-90 cm

As the result, one of the most current trends in wheat breeding was created, such as creating of the cultivars that need less expenses for their successful growing (low input wheat cultivars) and they are used in the sustainable agriculture (Ceccarelli, 1996). Sustainable agriculture is defined as the trend in the agriculture organization with the main objectives: farm profitability, yield stability, food quality and safety, environmental quality and safety, and erosion control (Berker, 1991). In sustainable agriculture the cultivars should be created for the existing environmental factors, contrary to the previous work, that some agroecological factors are changed by adding the expensive inputs such as: large quantities of mineral nutrients, herbicides, fungicides etc (Atlin and Frey, 1989; Ceccarelli, 1996). Relating to that, the main objectives of breeding are greater resistance to biotic and abiotic stresses and therefore better efficiency in mineral nutrient absorption (Dhugga and Waines, 1989; Pržulj et al., 1998). In order to form such cultivars it is necessary to include the certain genetic changes such as; increase of the harvest index, the changes in the assimilative source and increase of the root system efficiency.

Sustainable agriculture, and thereby the cultivars for such production are the question of the future and the first results are to be expected for a few years. However, it is interesting to analyze to which extent are present cultivars adapted to the production with lower input (Table 3). Low input cultivars as Evropa-90, Rodna, Pobeda, Ljiljana and Dragana represent the first step in further work on forming the cultivars used in sustainable agriculture.

The vegetarian food in human nutrition will remain significant in future as well, but it is a great risk of its contamination with pesticides, fertilizers, moulds, cowwheat, storage pests, microorganisms and parasites, in the production and process, marketing, storage and the use itself. The residues of pesticides and their derives, nitrates, phosphates, mycotoxines and other toxic and carcinogenic or mutagenic factors threaten the human population. Problems referring to many of the factors which directly or indirectly threaten human health and human environment can be solved. Therefore it is very important to breed, such cultivars adequate for production of sufficient quantities, nutritive valuable and health safe food, which can taken human nutrition, the place of the main food and have a significant role in the health improvement.

References

1.Andrejić, M., S. Stojanović. 1982. Biotipovi fizioloških rasa Puccinia graminis tritici u jugoistočnom delu SFRJ od 1975 do 1980. godine. Savremena poljoprivreda, 3-4: 183-189.

2.Atlin, G.N., K.J. Frey. 1989. Breeding crop cultivars for low-input agriculture. American Journal of Alternative Agriculture, 4:53-58.

3.Bedo, Z. 1994. Improvement in the genetic basis for breadmaking quality in wheat (*Triticum aestivum*L.). EUCARPIA, Prospectives of cereal breeding in Europe, 4-7 Septembe 1994, Switzerland, 95-96.

4.Borojević, S. 1990. Genetski napredak u povećanju prinosa pšenice. Savremena poljoprivreda, 38, 25-47.

5.Bošković, M. 1985. Ispitivanje virulentnosti Puccinia recondita f. sp. tritici i testiranje materijala pšenice na specifičnu otpornost. Zaštita bilja, 174: 345-356.

6.Ceccarelli, S. 1996. Adaptation to low/high input cultivation. Euphytica, 92:203-214.

7.Denčić, S., T. Mišić, M. Malešević, Z. Jerković, L. Panković, R. Jevtić. 1993. Rezultati ogleda sa novosadskim sortama pšenice. Zbornik radova, Institut za ratarstvo i povrtarstvo Novi Sad, 21: 213-219.

8.Dhugga, K.S., J.G. Waines. 1989. Analysis of nitrogen accumulation and use in bread and durum wheat. Crop Sci. 29: 1232-1239.

9.Frey, K. J. 1971. Improving crop yields trough plant breeding. Moving off the yield Plateau. Amer. Soc. Agron. spec. Publ. 20, 15-58.

10.Gaal, F.F., N.L. Rehak, M.P. Egeto. 1992. Sadržaj nekih toksičnih i esencijalnih elemenata u pšenici, brašnu i mekinjama. Hrana i ishrana, 33(1/2):23-26.

11.Iliev, I. 1994. Dynamics of occurrence of powdery mildew in some Bulgarian winter wheat cultivars. EUCARPIA, Prospectives of cereal breeding in Europe, 4-7 Septembe 1994, Switzerland, 121-122.

12.Jevtić, R., N. Mladenov, N. Hristov, Z, Martinović, M. Milovanović. 1997. Uticaj lokaliteta i genotipa na pojavu bolesti zrna pšenice. II JUSEM, Aranđelovac, 1-5. jun 1997. Zbornik izvoda: 6.

13.Kostić, B., M. Pribaković. 1985. Učestalost i virulentnost fizioloških rasa Eryisiphe graminis f. sp. tritici u jugoistočnom delu zemlje od 1978 do 1982. godine. Zaštita bilja, 1:5-12.

14.Mac Key, J. 1980. Genetic potencials for improved yields. Proc. Workshop Agric. Potentiality Directed by Nutritional Needs., Akademiai Kiado, Budapest, 121-143.

15.Mahnovskaja, M.L., V.I. Babenko. 1980. Karakter usvojenia raznih form azota prorastkami visokoproduktivnih genotipov ozimoj pšenici pri različnih temperaturah. Fiziol. rast., 27(2): 287-295.

16.Malešević, M., LJ. Starčević, D. Bogdanović, D. Mihajlović. 1996. The change in the protein content in wheat kernel depending on the temperatures and nitrogen nutrition level. Cereal and flour production and processing, Monograph, 91-104. Novi Sad.

17.Miedaner, T. 1997. Breeding wheat and rye for resistance to Fusarium diseases. Plant Breeding. 116:201-220.

18.Mišić, T. 1987. Uslovi i mogućnosti proizvodnje 6 miliona tona pšenice. Uslovi i mogićnosti proizvodnje 6 miliona tona pšenice, Novi Sad, 9-13.
19.Mišić, T., N. Mladenov. 1995a. Oplemenjivanje pšenice na otpornost prema poleganju. Zbornik radova XXIX seminar agronoma, Institut za ratarstvo i povrtarstvo Novi Sad, 23: 115-130.
20.Mišić, T.,N. Mladenov, 1995b. Results in winter wheat breeding for yield and quality. The First Balkan Symposium on Breeding and Cultivation of Wheat, Sunflower and Legumes Crops, Inst. Wheat and Sunflower "Dobroudja".
21.Mladenov, N. 1996: Investigation of genetic and phenotypic variability of wheat lines and cultivars under different agroecological conditions. Ph. D. Thesis. University of Belgrade. Faculty of Agriculture, Belgrade-Zemun.
22.Muchow, R.C., P.S. Carberry. 1993. Designing improved crop plants for the semi-arid tropics: An agronomist's Viewpoint. In F. Penning de Vries of al. (ed) Systems approaches for agricultural development. Kluwer Academic Publ. Dordrect, Netherlands. 37-61.
23.Ortiz-Monasterio, J.I., K.D. Sayre, S. Rajaram, M. McMahon. 1997. Genetic progress in wheat yield and nitrogen use efficiency under four nitrogen rates. Crop Sci. 37:898-904.
24.Pilch, J. 1994. High protein and lysine wheat-like Triticale revertants and their utility for wheat breeding. EUCARPIA, Prospectives of cereal breeding in Europe, 4-7 Septembe 1994, Switzerland, 45-46.
25.Pržulj, N., S. Dragović, M. Malešević, V. Momčilović, N. Mladenov. 1998. Comparative performanse of winter and spring malting barleys in semiarid growing conditions. Euphytica (In press).
26.Rao, K.P., D.W. Rains, C.O. Qualset, R.C. Huflaker. 1977. Nitrogen nutrition and grain protein in two spring wheat genotypes differing in nitrate reductase activity. Crop Sci., 17(2): 283-286.
27.Shumnyi, V.K., B.I. Tokarev. 1976. Sortovoja specifičnost aktivnost nitratreduktaze v pšenice. Sibirski vestnik seljskohozjajstvenih nauki, No 2, 33-38.
28.Stojanović, S., B. Kostić, M. Andrejić. 1973. Fiziološke rase Eryisiphe graminis tritici. Savremena poljoprivreda, 7-8: 85-93.
29.Špehar, V., V. Vlahović. 1978. Petogodišnja ispitivanja fizioloških rasa Eryisiphe graminis u zapadnom području Jugoslavije (1968-1972). Poljoprivredna znanstvena smotra, 45: 83-90.