ITEMS FROM PAKISTAN

AGRONOMIC RESEARCH STATION
Bahawalpur, Pakistan.

Wheat following the cotton and rice-based cropping system in Pakistan.

Muhammad Sarwar Cheema, Liaquat Ali, and Muhammad Akhtar.

Four million hectares of wheat are planted after cotton and rice in Pakistan. Little research has been done on the aronomy of wheat following these crops on a cropping pattern basis. Both of these crops delay wheat planting, and it is estimated that 40–50 kg of wheat grain is lost for every day that planting is delayed past 20 November. Current recommendations for land preparation, fertilizer use, weed control, and varieties are based on planting wheat following a fallow. Team work is direly needed to develop more useful recommendations for planting wheat following cotton- and rice-cropping patterns.

Cotton and rice in Pakistan are grown on 2.93 million and 2.38 million hectares, respectively, whereas wheat is planted on an area of 8.463 million hectares (Fedreal Bureau of Statistics, January 2001). We estimate that 70 % of the cotton- and 80 % of the rice-planted area is followed by wheat. This area equals approximately 4 million hectares of wheat or 50 % of wheat area sown in Pakistan.

Sowing date. The sowing of wheat is delayed by both the cotton and rice harvests in Pakistan. The proper time of wheat sowing is influenced by the cotton variety and maturity. The decision to have an extra picking of cotton and an additional collection of cotton sticks for fuel can be a valuable bonus for the farmer. For rice, the type and variety are also important factors in any decision to delay the planting of wheat. Only two types of rice, coarse and fine, commonly are grown in Pakistan. The coarse-type rice variety IRRI-6, which is a high-yielding, nonphotosensitive rice, is harvested from late October to mid November and wheat can be planted in November, the normal sowing time. Basmati is a fine-type rice often harvested between the end of November into December. In addition, farmers cut, dry, and thresh the rice in the same fields, therefore, land preparation for wheat is often delayed for 15–20 days. Wheat can be planted in December or January. The optimal date for planting wheat is 20 November. On average, 40 kg/ha (160,000 t/4-million ha) of grain is lost for every day planting is delayed after this date. Earlier plantings have lower yields because of frost damage during flowering. Delayed planting after cotton and rice substantially reduces yield potential, especially with wheat planted after Basmati rice. This situation can be improved by using early-maturing cotton and rice varieties, establishing a quicker turnaround time, and using wheat varieties that yield better when planted late.

Land and seedbed preparation. In cotton–wheat areas, seedbed preparation is relatively easy. Following the removal of cotton debris, the soil is relatively friable and can be prepared for wheat quickly. In the rice-growing areas, the situation is different. Approximately one-half of the rice in Pakistan is grown on puddled clay and clay-loam soils. The farmers are faced with a hard, structureless mass of soil to prepare for wheat planting. This preparation takes time and, where soils are heavy in texture, final seedbed preparation may be very poor. Fortunately, the other half of the rice-growing area is medium textured. Associated with the unfavorable soils are the plow pans, developed by puddling and needed to restrict water percolation in rice. For wheat, these pans may limit rooting and subsequent moisture and nutrient availability. They also increase waterlogging in wheat and increase problems with seedbed preparation. If the plow pan is broken, wheat yields may increase, but more water will be required for the rice crop and the soil may not be able to physically support the animals or implements needed to till the puddle soil for rice. As with cotton, there also is the problem of crop residues facing the farmer when he prepares the land for wheat. Little information is available on these issues. More studies are needed to identify and evaluate the best implements for land preparation for their cost and time benefits and their ability to handle residues. A study of the effects of deep tillage on total annual productivity also would be interesting.

Seeding rate and methods of planting. Most farmers broadcast seed for wheat sowing following cotton and rice. The seeding rate usually is 150 kg/ha. More study is needed on using higher seeding rates and to compare broadcast versus

machine drilling when wheat is planted late. Poor plant stands are common in the rice–wheat areas, largely because of poor land preparation. A higher seeding rate may compensate for this problem. Studies should also be initiated on no-till planting of wheat into rice as a means to reduce turnaround time.

Fertilizer use. As with the previous agronomic practices, fertilizer studies in Pakistan have been on wheat following fallow, but rarely on wheat following cotton or rice. Response times for nitrogen and phosphorus in cotton–wheat and rice–wheat cropping patterns for different soils must be determined. Reports of response to potash and micronutrients in wheat following rice are available, but more studies are needed in this area on a cropping-pattern basis.

Weed control. Weeds are influenced greatly by the previous crop and cropping pattern. Common weeds in the cotton–wheat rotation include *Chenopodium album*, *C. murale*, and *Convolvulus arvensis*. In the rice-wheat rotation, *Phalaris minor* and *Avena fatua*, along with *C. album*, are the major weeds causing economic losses in wheat. Herbicides could be used to control these weeds. Any phenoxyacetic acid herbicide will control broadleaf weeds, although *C. arvensis* will regrow after some time. The substituted ureas, Tribunil, Dicuran, Dosanex, or Isoproturon can be used for *Phalaris* or *Avena.* Suffix, Mataven, or Difenzoquat may be better herbicides but are more costly than broadleaf herbicides. In Pakistan, herbicide use is in its infancy and few scientists and very few farmers are experts in their proper application. Other methods are needed for weed control. Many farmers rotate land when weeds become a problem. Berseem, *Trifolium alexandrinum*, is used in place of wheat as a winter fodder when weeds are a problem, however, this is not a viable option except in areas where berseem is a cash crop. Preirrigation is another way of reducing weed populations. The weeds are plowed under just before planting. The major problem here is the delay in planting associated with irrigation, and so this obviously is not a solution for growers of Basmati rice. Many farmers irrigate their rice fields before harvest to germinate weed seeds and not delay wheat sowing.

Yield gap. A substantial yield gap has been observed between yield at the experiment stations and in farmers' fields in each province. This gap is primarily from a lack of finances on the part of a majority of farmers for implementing modern technology for wheat production. Thus, there is great hope for improving wheat production and yield in the country.

ITEMS FROM ROMANIA

S.C.A. — AGRICULTURAL RESEARCH STATION
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Breeding procedure applied for improvement of winter wheat varieties at ARS Turda.

V. Moldovan, Maria Moldovan, and Rozalia Kadar.

Wheat breeders rely on classical methods to produce new, improved varieties. Reliance on classical-breeding procedures seems to be sound from a theoretical point-of-view, because genetic variation available in common wheat and related species has not yet been exhausted. As long as such usable variability exists, the opportunity for further significant increases genetic progress in wheat by breeding will exist. Classical breeding consists of two important steps. First, crosses are planed to achieve reasonable odds for desired genetic recombinants. Second, the selection process presumably is designed for success in identifying agronomically superior phenotypes within the hybrid populations.

Therefore, classical breeding has numerous variations that are dictated largely by the philosophy of the breeder, the wheat crop specificity, the breeding objectives and priorities, and different economic constraints. The most productive wheat-breeding programs rely upon numbers, both in hybrid population sizes and number of hybrid combinations. The number of crosses can be relatively large, and it reflects, in part, the inability of breeder to predict with certainty the worth of specific hybrid combinations on the basis of known attributes of the parental varieties. Nevertheless, our experience has shown that a smaller number of well-planned crosses may provide better hybrid material than a large number of poorly planed crosses. The size of a manageable hybrid population is estimated from the number of traits that are considered as breeding objectives with which the breeder is concerned. Establishing realistic priorities at a reason-

able number is very important, because each added objective reduces the rate of expected genetic progress for each of the others. Changes in priorities also can affect the achieving desired genetic progress.

Wheat breeding procedure at ARS Turda. The objectives that are emphasized in our wheat-breeding program have been reported previously (Ann Wheat Newslet **45**:119). We now report on the wheat-breeding procgram used at ARS, Turda, as one way to produce new, improved varieties. This breeding and selection procedure can be summarized as follows:

1. **Three to four hundred of crosses are made annually.** Our experience has shown that we can maintain adequately as many as 400 hybrid combinations with available land, experimental equipment, financial resources, and personnel. Careful consideration is given to the choice of parents from an available core collection, which is annually refreshed with new accessions. Intercrosses of parental varieties or breeders' lines are almost exclusively made by hand during heading in the field. The majority of crosses involve two parents (A x B), but every year a number of three-way crosses ((A x B) x C) and single backcrosses ((A x B) x A) or ((A x B) x B) are made. Because genetic variability and diversity can be increased by multiple crosses (((A x B) x C) x D) and convergent methods ((A x B) x (A x C)), they also are taken into consideration. Lately, recrossing selected lines within a hybrid population has been used in a manner similar to recurrent selection.
2. **Grow F_1 hybrids in the field.** The F_1s are evaluated for agronomic and disease resistance traits. The few that are of poor quality are discarded, reflecting the inability to predict the worth of progeny from known attributes of the parental varieties used in the crosses.
3. **Hybrid populations are used as bulks through the F_2 generation.** Bulked hybrids are grown in the field near the normal rate of seeding in order to evaluate them under conditions that approximate plant competition in commercial production. Based on agronomic and disease-resistance evaluations, some populations of no value are discarded. From the most promising F_2 hybrid populations, we use head selection. In a limited number of crosses of special interest, the first selection is delayed until the F_3, F_4, or F_5 generation. However, F_2 selection is most common for us. Head selections are made essentially with attention on such attributes as maturity, plant height, disease reaction, and plant type. The number of heads selected per population averages 50 to 100, although in some valuable populations it can be 100 to 300. Larger numbers exceed our capability for adequate evaluation.
4. **The head-row nursery is usually comprised of 25,000 to 30,000 entries, including reselections.** For the most part, these nurseries are represented by F_3 progenies from selected heads. This process of selection is repeated, within superior rows, generation after generation, until row progenies are sufficiently uniform and stable. In our program, no more than 2 or 3 reselections are made, so the last generation of selection is F_4–F_5. Simply inherited, observable and measurable morphological traits can be readily monitored in the selection process to assure reasonable uniformity and nonsegregation. This is easy in hybrid combinations with parents that are similar in plant type, maturity, plant height, and other readily observable traits. However, varieties selected in an early generation are likely to conserve a substantial amount of heterogeneity, especially for complex traits such as the yield. This heterogeneity can contribute to yield performance as well as to stability of performance in an array of environments. After this screening process, in which apparent agronomic value and disease resistance are assessed, the best lines, approximately 5 %, are advanced.
5. **Preliminary observation plots, without replications, include those approximately 750 to 1500 lines retained as selections from the head-row nursery.** Lines remain in observation plots for only 1 year, in which they are more comprehensive evaluated. At maturity, heads of each plot are harvested for a sprouting test in artificial conditions in a mist cabinet. Sufficient grain is available for small-scale, bread-making quality tests. Lines also will be entered in a special disease nursery where they will be evaluated using artificial epidemics. Based upon of these complex evaluations, approximately 25–30 % promising lines are retained.
6. **Observation yield trials are organized as randomized, block-design experiments with three replications.** The number of trials is limited to the 250–300 promising lines retained from preliminary observation plots. They remain in observation yield trial for 1 year and continue to be evaluated for agronomic performance, disease resistance, and bread-making quality. At this stage, we have the first opportunity to precisely quantify yield performance and compare them with the check varieties. On this basis, only truly superior lines are advanced. The number of lines does not exceed 100–150 annually.
7. **Competition yield trials, which are randomized block design experiments with more than three replications, are organized 1–3 years and comprise those 100–150 lines retained from observation**

yield trials. Evaluation for agronomic performance, disease resistance, and a large-scale, bread-making quality analysis are continued. Each year doubtful lines are discarded. After 1 to 3 years of evaluation, valuable lines (10–15 annually) may be introduced in regional yield trials at nine Agricultural Research Stations, which are located in different ecological areas. Performance and stability evaluations, simultaneous with local evaluation and seed increase, are continued. Those lines of value are advanced into the Official Yield Trials.

8. **Official Yield Trials at the State Institute for Variety Testing and Registration (ISTIS) give an indispensable and independent assessment of new lines over a wider range of environments.** After 3 years of testing for agronomic and technological value (VAT) and distinctness, homogeneity, and stability (DOS), the new lines that have sufficient merit have been entered in the Romanian Official Catalogue of Varieties, named, and released to growers. Continued station and regional performance trials are concurrent with foundation seed increase.

Outlook. Consistent with the assumptions that the useful genetic variability in wheat has not been exhausted and such variability for yield is mostly additive and can be fixed in true-breeding lines, we use variations of classical-breeding procedures to manipulate this variability for varietal improvement.

Our breeding procedure does not differ widely from the pedigree-selection method. In particular, it differs in the volume of breeding material that is managed in the system. We do not pretend that this system is the best in all circumstances, nor do we suggest that it could be applied with equal success to others wheat-breeding programs.

Using the system presented here, we have developed and released for commercial production, nine improved varieties of winter wheat since 1971 (Table 1). Five of these still maintain good acceptance and popularity and are listed in The Romanian Official Catalogue of Varieties for 2002.

Table 1. Winter wheat varieties developed by the ARS–Turda breeding program (1971–2000). Those varieties in bold print are listed in The Romanian Official Catalogue of Varieties.

Variety name	Pedigree	Year of release
Turda 195	ICA440C / Skorospelka 3b	1971
Silvana	Bezostaia 1 / Harach 11-5964	1975
Potaissa	Bezostaia 1 / Stamm 6111	1976
Transilvania	**US(60)43 / Aurora // T141-65**	**1981**
Turda 81	Bezostaia 2 / Sava	1984
Ariesan	**Rubin / 2*T141-65**	**1985**
Apullum	**Odesskaia 75 / Bezostaia 1**	**1992**
Turda 95	**199 I 1-2 / T6-80**	**1995**
Turda 2000	**Apullum / Ariesan**	**2000**

Since 1971, an average of one new variety every 3 years has been released to wheat producers from our program. Of these nine varieties, seven were from single crosses, Transilvania was selected from a three-way cross, and Ariesan had its origin in an backcross. Note that Turda 2000 is the result of a single cross made between two of our own varieties (Apullum/Ariesan). The genetic progress achieved in previous breeding cycles can be used for continued improvement of wheat genotypes in a manner similar to that for broad-sense recurrent selection.

The variety Ariesan, released in 1985, is most extensively grown in central and northeastern Romania. We believe that a breeding procedure where some heterogeneity is conserved into wheat varieties, especially for complex traits such as the yield, that buffers against environmental change contribute yield stability are factors favoring the long life and wide acceptance of Turda varieties among the wheat growers of central Romania. At the same time, such varieties could be variable for a number of resistance genes, thus simulating a multiline variety.

We follow a liberal variety-release policy. The five varieties listed in The Romanian Official Catalogue of Varieties represent 15 % of the total wheat varieties cultivated in Romania. They constitute nearly one-fourth of the total Romania wheat acreage. It is in our own best interest that our varieties are replaced with another of our improved varieties. For this reason, keeping pace with the advances in wheat productivity achieved in the other programs is important. Thus, our wheat-breeding program also encompasses genetic studies, disease-resistance investigations, end-use quality studies, and breeding methodology. All are involved in the task of improvement of winter wheat varieties.

ITEMS FROM THE RUSSIAN FEDERATION

AGRICULTURAL RESEARCH INSTITUTE FOR THE SOUTH-EAST REGIONS
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The effect of Lr genes on grain yield and quality parameters in 2001.

S.A. Voronina, S.N. Sibikeev, and V.A. Krupnov.

We investigated the influence of *Lr* genes on the agronomic performance of a set of NILs of spring bread wheat. The growing conditions of the first half of the growing season in 2001 were very wet, and a moderate epidemic of leaf rust developed. The second half was hot and droughty and the grain-filling period lacked any precipitation. In these conditions, the *Lr*-sib lines had the highest grain yield as compared with the *lr*-sibs, for *Lr14a + Lr23* (4.16 t and 3.32 t), *Lr19* (3.32 t and 3.00 t), *Lr14a* (3.17 t and 2.41 t), and *Lr9 + Lr19* (3.84 t and 3.48 t), respectively. For SDS evaluation, the *Lr*-sib lines equaled the *lr*-sib lines varying between 91.3–100. A mixograph analysis was produced for each NIL with *Lr14a + Lr23* and *Lr9 + Lr19* combinations. No significant difference between *Lr* and *lr* sibs were found.

The efficiency of Lr genes and gene combinations in 2001.

S.N. Sibikeev, S.A. Voronina, and V.A. Krupnov.

In a moderate epidemic of leaf rust in 2001, the different *Lr* genes and gene combinations were tested in the Department of Genetics ARISER. The following infection types were found:

IT = 3	*Lr19*;
IT = $2^{+}3$	*Lr23*, *Lr25*, *Lr26*;
IT = 11^{+}	*LrT.d (S57)*; and
IT = 0;	*Lr16 + Lr3*, *Lr23 + Lr26*, *Lr19 + Lr9*, *Lr19 + Lr23*, *Lr19 + Lr24*, *Lr19 + Lr25*, *Lr19 + Lr26*, *Lr19 + LrT.d (S57)*, *Lr19 + LrT.d (Sz)*, *Lr23+ LrT.d (S57)*, *LrT.dc*, *LrT.dcs*, and *Lr6R*.

where *LrT.d (S57)* and *LrT.d (Sz)* are derived from *T. durum* cultivar Saratovskaya 57 and Saratovskaya zolotistaya, respectively; *LrT.dc* and *LrT.dcs* are derived from *T. turgidum* subsps. *dicoccum* and *dicoccoides*, respectively; and *Lr6R* is derived from *Ag. intermedium* chromosome $6Ag^{i}$. The progression of the leaf rust epidemic in the June was depressed by hot and dry weather in the July. The maximum leaf rust severity on susceptible cultivars was 35–40 %.

A comparison of Ustilago tritici populations from the former USSR and abroad.

V. A. Krupnov and A.E. Druzhin.

Nielsen and Thomas (1996) identified about 44 races loose smut revealed in Canada and other countries. The identification of races was made on the 19 differential cultivars. Krivchenko et al. (1987) identified 71 races on nine cultivars from the former USSR. Different techniques for identification were used by each authors.

Table 1. Percent of virulence to loose smut races on the common cultivars (differentials) in different *Ustilago tritici* populations from the world and the former USSR. The number of races is specified in parentheses. For the former USSR, races 24, 25, 36, and 40 in the Russian population and 11, 19, and 30 from the Russian population were excluded as they had no genes virulent to one of the 19 differentials.

Population	Kota	Reward	Mindum
World (40)*	43	78	10
Former USSR (33)**	45	69	18

Nielsen, 1987	Krivchenko etc., 1987
Used only teliospores for inoculation of one spike or was propagated on a universal-susceptible cultivar differential D 13.	Inoculation by a mix teliospores, collected from several spikes of one cultivar.
Teliospore concentration – 1 g/L H_2O	Teliospore concentration – 0.1–1 g/L H_2O
Inoculation by syringe and hypodermic needle.	Inoculation by a vacuum method.
Inoculated two spikes.	Inoculated 5–8 spikes.
Tested 30 plants or more.	Tested not less than 150–200 seeds.
Races identified in the field using the scale: R = R = resistant (sporulating plants 0–10 %), S = susceptible (sporulating plants more than 10 %)	The races identified in laboratory and field. Reaction types of cultivars included three types: 0 = no mycelium in any part of the embryo or only at a low level in the scutella (less than 10 % of the embryos examined) and completely absent from plumular buds. In a field no or less than 1 % sporu lating plants. 1 = mycelium in embryos but confined to the scutella, of which up to 100 % may be infected; most plumular buds are free of mycelium or less than 10 % infected. In a field, sporulating plants less than 10 %. 2 = mycelium in nearly all embryos and in both scutella and plumular buds. In a field, a cultivar with this reaction will have a high level of sporulating plants (minimum 10 %).

Included in the R class are reaction types 0 and 1 reduces the population of loose smut races in the former USSR to 33 (Table 1, p. 116). The differentials have three common cultivars (Mindum, Kota, and Reward) and a comparison of their reaction to race pathogens is interesting (Table 1). The similarity in reaction of loose smut populations, which were detected in the Russian and foreign cultivars, may be explained by the prevalence of similar *Ut* genes.

Optimizing estimates of breeding material for resistance to loose smut.

A.E. Druzhin and A.Yu. Buyenkov.

We studied breeding material with resistance to loose smut using different techniques to estimate the effect of the pathogen and establish classes based on the degree of resistance (Table 2, p. 118).

The division of cultivars and lines for these types of reaction is based on results of estimating mycelium in seed and the quantity sporulating spikes in a field. Neither of these techniques take into account morphological and physiological changes that are observed in infected plants (e.g., destruction of ovary at inoculation, reduction in germination, quantity of seed/spike, or reduction of 1,000-kernel weight). These are the so-called latent losses. For our long-term assessments, latent losses in some cultivars included the classes R and MR (Nielsen and Thomas 1996) and 0, II, III (Krivchenko 1987). These losses can be rather large and depend on the presence in a cultivar of other *Ut* genes, their expression in a genotype, and their reaction to races of the pathogen (Table 3, p. 118). Some cultivars and lines from the R and MR groups have low seed germination than those from the MS, S, and HS groups. Taking this into account, the percent of defeat from loose smut, in our opinion, it is necessary to make determinations from quantity of seed sown and health of plants at heading and not from the quantity of healthy and sporulating plants. When choosing the donor of resistance genes for loose smut, you need to consider the level of the latent losses from the *Ut* gene.

Table 2. Methods of estimating resistance to loose smut.

Krivchenko 1987					Nielsen and Thomas 1996		
% of infected							
embryo		plants			% plants		
buds	scutella		Symbol	Class	infected	Symbol	Class
0	0	0	0	Highly resistant	0–10	R	Resistant
0	< 20	0–5	I	Moderately resistant	11–30	MR	Moderately resistant
< 20	< 100	6–25	II	Moderately susceptible	31-50	MS	Moderately susceptible
< 40	< 100	26–50	III	Medium susceptible	51–70	S	Susceptible
> 40	100	> 50	IV	Highly susceptible	> 70	HS	Highly susceptible

Table 3. Reaction of cultivars and lines on race 23 of loose smut. The race was identified on a set of Soviet cultivars and differentials in Saratov in 2000.

	Reduction in relation to the control, %					
Cultivar/line	germination	seed/spike	1,000-kernel weight	% of plants sporulating	Type of reaction	
L 2040	50.8	10.9	8.7	5.3	R	II
L 18-94	9.8	18.1	16.7	0.0	R	0–I
Zhygulevskaya	61.6	61.6	22.9	7.7	R	II
L 2359	85.6	1.7	11.1	0.0	R	0–I
Saratovskaya 46	90.4	3.2	6.7	2.0	R	I
L 2776-01	85.9	37.5	3.9	0.0	R	0–I
L 2772-01	48.2	19.9	4.4	5.8	R	II
L 1152-00	95.5	3.2	4.8	0.0	R	0–I
Yuogo- vostotchnaya 2	23.4	3.2	2.1	11.6	MR	II
Saratovskaya 60	44.0	2.4	1.6	12.3	MR	II
Saratovskaya 29	17.0	12.3	4.9	37.5	MS	III
L 505	68.6	—	—	75.0	HS	IV
L 528	65.3	—	—	100.0	HS	IV

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The use of winter wheat varieties in the selection of spring wheat varieties for the far eastern Russian Federation.

Ivan M. Shindin.

Problems associated with the selection of initial breeding material for use in spring wheat breeding are very real. Although there is a large spring wheat germ plasm collection, it is not enough for the breeding of cultivars. Disease resistance, drought tolerance, and grain quality must be combined with high yield potential, but this combination is rarely implemented. Practice shows that it is better to use forms with the maximum number of traits for new varieties, which is

why the best winter wheat varieties with higher biological potential for productivity, lodging resistance, and disease tolerance are of interest to spring wheat breeders.

The Primorskey Agricultural Experimental Station (now the Primorskey Research Agricultural Institute) started using winter wheat varieties for the selection of spring wheat cultivars in the 1960s under A.V. Zaitseva. As a result, Primorskaya 18 and Okeanskaya cultivars were developed. Although they did not find a commercial use, they did become valuable starting material for breeding spring wheat cultivars. Those hybridizations of winter wheat cultivars, however, were made without regard to their agrobiological use in far eastern Russia. In addition, methods of hybridization of winter and spring wheat cultivars and the nature of inheritance of developmental type, vegetative period, plant height, and productivity were not studied.

The Far Eastern Research Institute of Agriculture, Khabarovsk, and the Primorskey Research Institute of Agriculture, Ussuryisk, have studied 450 winter wheat cultivars. Valuable varieties selected as initial breeding material included such cultivars as Bezostaya 1, Skorospelka 35, Rannyaya 12, and Krasnodarskaya 39, which where bred at the Krasnodar Research Institute of Agriculture, and the U.S. cultivars Arthur, Redcoat, Kenosha, Sturdy, Soout 66, and Trader, which are resistant to *P. graminis*. Aurora, Kavkaz, Predgornaya 2, and Priboy (Russia); Ruslaka, Rumeliya, and Trapezitsa (Bulgaria); and Timwin, Redcoat, and Sturdy (U.S.) are tolerant to *P. triticina*. No cultivars resistant to *F. graminiarum*, the most harmful wheat disease in the far east, were bred, although Odesskaya 16, Odesskaya 26, Odesskaya 51, and Belotserkovskaya 198 (Ukraine); Kishenyovskaya 4 (Moldovia); Rumelia (Bulgaria); Libellula (Italy); and Redcoat, Timwin, Soutt 66, Sturdy, and Parker (U.S.) showed a high level of resistance (mark 4). Odesskaya 26, Odesskaya 51, Rumelia, Timwin, Sturdy, and Libeilula have complex resistance to *P. triticina*, *P. graminis*, and *E. graminearum*.

In far eastern Russia, the weight of grains/spike is an important indicator of productivity. The kernel weight of the majority of the winter wheat cultivars studied was 1 g, regardless of weather conditions. Predgornaya 2, Skorospelka 35, Kavkaz, Moldavanka, Mironovskaya 808, and Polesskaya 70 had weights of 1.23–1.44 g, which is 40–65 % higher than that of spring wheat cultivars. Ear length, weight of kernels/spike, and 1,000-kernel weight were indicators of a more productive spike, and were 7–8 cm, 25–30 grains, and 28–35 g, respectively, in spring wheat cultivars and 9–10 cm, 35–40 grains, and 38–45 g, respectively, in winter wheats.

As a result of selection for these traits, complex, valuable, medium-maturity cultivars with high or moderate resistance to diseases, strong stems, good grain quality, high yield potential, and relative yield stability were bred, including Bezostaya 1, Skorospelka, Predgornaya 2, Polesskaya 70, Mironovskaya 808, Scout 66, and Timwin. All of these cultivar have been used in hybridizations with spring wheat cultivars.

Inheritance studies of different characters has shown that the vegetative period of winter–spring hybrid F_1s does not differ from that of the spring-type parents with the exception of hybrids with spring wheats Primorskaya 18 and Okeanskaya, which have winter wheat cultivar genes in their pedigrees. The vegetative period of those hybrids was 5–10 days longer than that of hybrids obtained by crossing a winter wheat and a 'pure' spring wheat cultivar.

Dihybrid (16 spring types/1 winter type) and trihybrid (54 spring types/1 winter type) schemes were used to split the F_2. The largest percent of winter types (15–21 %) was found in those populations in which a spring type was developed from a winter-spring hybrid. In the F_3, we found great diversity in spring and winter types and vegetative period. The number of spring lines was different and varied from 26–60 % depending on the cross combination, which is why spring forms should be selected in the F_3 and following generations.

We determined that winter–spring F_1 hybrids inheriting the trait of productivity by heterosis, which was two times more frequent than in hybrids from crosses of two spring wheat cultivars. Heterosis more often was determined by the weight of grains/spike and plant productivity (80 and 95 %, respectively). Heterosis reached 40–63 % in 'Aurora/Primorskaya 14' and 'Aurora/Amurskaya 75' crosses and 50–85 % in 'Kavkaz/Dalnevostochnaya', 'Kavkaz/Primorskaya 14', and 'Aurora/Amurskays 75'. Selection under different agricultural conditions may account for the difference between spring and winter wheat cultivars, because it did not allow for the exchange of genetic information, except in rare cases.

Analyses of hybrid populations indicate that the developmental process in winter–spring and spring–winter populations is richer than in 'pure' spring populations. A high level of variability for all traits was observed, including

diversity in plant height, up to 45 cm; plant productivity, up to seven stems; ear length, up to 5 cm; the number of spiklets/spike, up to 9; the number of grains/spike, up to 28; l,000-kernel weight, up to 35.8 g; grain/spike, up to 1.3; and grains/plant weight, up to 6–7, Of these traits, the most highly variable traits were plant productivity and plant effectiveness, a difference of 6–7 times. This variability made a good basis for the selection of commercial spring wheats.

As a result of hybridization of winter and spring wheat cultivars, various lines were studied in different phases of the selection process. Bezostaya l, Kavkaz, Aurora, Skorospelka 35, Polesskaya 70, and Moldovanka are found in the pedigrees of many of these lines. High yield potential and resistance to lodging under the climatic conditions of far eastern Russia (about 6 t/ha) also are present. In a good summer, they have a yield advantage of 1–1.5 t/ha. In a dry summer, their yield is similar to that of standard cultivars. On average, these cultivars have a 20–25 % yield higher than standard cultivars.

The spring wheat cultivar Primorskaya 21, bred with the winter wheat Bezostaya 1, is characterized by high yield, lodging resistance, and resistance to *P. graminis* and *U. tritici*. Another spring wheat cultivar, Primorskaya 39, is also a product of a winter wheat, but was developed not a hybridization but by transformation of winter wheat cultivar Ilyichyovka into a spring wheat following individual selection. The spring wheat cultivars Primorskaya 21 and Primorskaya 39 are grown in the great growing area of the Primorskey Territory, which is situated in the far eastern part of Russia. In our opinion, the method of hybridization of winter wheat cultivars and spring wheat cultivars has great potential for further improving spring wheat cultivars for far eastern Russia.

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Virulence of Puccinia triticina in the Russian Federation in 2000.

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Wheat leaf rust is an important disease in the Russian Federation. Wheat is grown in many regions of Russia under a wide range of environmental conditions. Mean crop losses can vary from 10–12 % to 50 % on leaf rust-susceptible cultivars in epidemics years. Success in selecting resistant varieties of wheat in connected to the constant control of the pathogens population structure, determining new virulence pathotypes, and monitoring virulence frequencies.

Collections of leaf rust uredospores were made from wheat in the Central, Volgo-Vyatka, and north Caucasian regions. Uredospores from each collection were increased in the seedling-susceptible wheat cultivars Mironovskaya and Hakasskaya. Spores from a single uredium were directly inoculated on 5–6-day-old plants of a differential host series of NILs of Thatcher with single resistance genes *Lr1*, *Lr2a*, *Lr2b*, *Lr2c*, *Lr3a*, *Lr3bg*, *Lr3ka*, *Lr9*, *Lr10*, *Lr11*, *Lr14a*, *Lr14b*, *Lr15*, *Lr16*, *Lr17*, *Lr18*, *Lr19*, *Lr20*, *Lr21*, *Lr23*, *Lr24*, *Lr25*, *Lr26*, *Lr27 + Lr31*, *Lr28*, *Lr29*, *Lr32*, *Lr36*, and *Lr38*. Plants were sprayed with

Table 1. Percent of isolates of *Puccinia triticina* virulent on single-gene differential lines.

	Percent of isoltes virulent on Lr gene		
Gene	Central	Vyatka	North Caucasian
Lr1	97	42	36
Lr2a	12	2,5	16
Lr2b	51	25	40
Lr2c	26	45	50
Lr3a	100	100	100
Lr3bg	100	100	100
Lr3ka	38	38	62
Lr9	0	0	0
Lr10	98	67	81
Lr11	100	100	100
Lr14a	98	72	74
Lr14b	97	100	96
Lr15	31	0	17
Lr16	67	62	65
Lr17	100	100	100
Lr18	100	100	100
Lr19	3,2	0	6,0
Lr20	28	28	24
Lr21	100	100	97
Lr23	15	25	48
Lr24	0	0	0
Lr25	8	10	20
Lr26	16	0	4
Lr27 + Lr31	12	7	21
Lr28	1,6	0	5,0
Lr29	0	0	0
Lr32	41	77	59
Lr36	72	100	85
Lr38	0	0	0
Total	61	40	81

Table 2. Frequency (as percentage) of the dominant and several other pathotypes of *Puccinia triticina* among the 121 phenotyphes collected in three regions of the Russian Federation.

	Regions		
Virulence on lines with *Lr* genes:	Central	Volgo-Vyatka	North Caucasian
1,2c,3a,3bg,10,11,14a,14b,17,18,21,36	0	7.5	0
3a,3bg,10,11,14b,17,18,21,32,36	0	5.0	5.0
1,3a,3bg,10,11,14a,14b,17,18,21,36	4.8	7.5	0
2c,3a,3bg,10,11,14b,16,17,18,21,36	0	2.5	1.2
1,3a,3bg,10,11,14a,14b,17,18,21,32,36	6.4	5.0	1.2
3a,3bg,3ka,10,11,14a,14b,15,16,17,18,21	1.6	0	1.2
1,2b,2c,3a,3bg,10,11,14a,14b,17,18,21,36	4.8	0	0
1,2c,3a,3bg,10,11,14a,14b,17,18,20,21,36	1.6	2.5	0
1,2c,3a,3bg,10,11,14a,14b,17,18,21,32,36	1.6	7.5	0
1,3a,3bg,3ka,10,11,14a,14b,15,16,17,18,21	4.8	0	0
1,3a,3bg,10,11,14a,14b,16,17,18,20,21,32,36	4.8	0	2.5
1,2b,3a,3bg,10,11,14a,14b,16,17,18,21,26,32,36	6.4	0	0
1,2b,2c,3a,3bg,3ka,10,11,14a,14b,16,17,18,20,21,23,32	6.4	0	0
1,2a,2c,3a,3bg,3ka,11,14a,14b,15,17,18,19,21,26,32	0	0	1.2
1,2a,2b,2c,3a,3bg,11,14a,14b,15,16,17,18,19,21,26,32,36	0	0	1.2
1,2a,2b,3a,3bg,10,11,14a,14b,15,16,17,18,19,20,21,26,36	1.6	0	0
2a,2b,2c,3a,3bg,3ka,10,11,14a,14b,16,17,18,19,21,25,32,36	0	0	1.2
1,2a,2b,2c,3a,3bg,3ka,10,11,14a,14b,16,17,18,19,21,23,32,36	0	0	1.2
1,2a,2b,3a,3bg,10,11,14a,14b,15,16,17,18,19,20,21,26,32,36	1.6	0	0
2b,2c,3a,3bg,3ka,10,11,14a,14b,15,16,17,18,19,20,21,25,27+31,36	0	0	1.2
Total	46.4	37.5	17.1

suspension of spores and placed in dew chamber overnight at 18°C. Spore suspensions of each isolate were applied to the first leaf of seedlings. Infection types are recorded after 12 days using the scale developed by Stakman and Levine.

Race composition and frequencies of virulence on each of the differential lines differs among collections from the three regions (Tables 1, p. 120, and 2). The total number of phenotypes in the three agroecological areas was 121.

Central region. Thirty-seven virulence/avirulence phenotypes on 29 host lines were found among the 61 single-uredinial isolates. Twenty-five virulence genes were found (*Lr1*, *Lr2a*, *Lr2b*, *Lr2c*, *Lr3a*, *Lr3bg*, *Lr3ka*, *Lr10*, *Lr11*, *Lr14a*, *Lr14b*, *Lr15*, *Lr16*, *Lr17*, *Lr18*, *Lr19*, *Lr20*, *Lr21*, *Lr23*, *Lr25*, *Lr26*, *Lr27 + Lr31*, *Lr28*, *Lr32*, and *Lr36*) and four virulence genes were not (*Lr9*, *Lr24*, *Lr29*, and *Lr38*).

Volgo-Vyatka region. Twenty-nine virulence/avirulence phenotypes were found on host lines among 40 single uredinial isolates. Twenty-one virulence genes were found (*Lr1*, *Lr2a*, *Lr2b*, *Lr2c*, *Lr3a*, *Lr3bg*, *Lr3ka*, *Lr10*, *Lr11*, *Lr14a*, *Lr14b*, *Lr16*, *Lr17*, *Lr18*, *Lr20*, *Lr21*, *Lr23*, *Lr25*, *Lr27 + Lr31*, *Lr32*, and *Lr36*) and eight genes were not (*Lr9*, *Lr15*, *Lr19*, *Lr24*, *Lr26*, *Lr28*, *Lr29*, and *Lr38*).

North Caucasian region. Sixty-four virulence/avirulence phenotypes were found among 81 single uredinial isolates. Twenty-five virulence genes were discovered (*Lr1*, *Lr2a*, *Lr2b*, *Lr2c*, *Lr3a*, *Lr3bg*, *Lr3ka*, *Lr10*, *Lr11*, *Lr14a*, *Lr14b*, *Lr15*, *Lr16*, *Lr17*, *Lr18*, *Lr19*, *Lr20*, *Lr21*, *Lr23*, *Lr25*, *Lr26*, *Lr27 + Lr31*, *Lr28*, *Lr32*, and *Lr36*) and four genes were not (*Lr9*, *Lr24*, *Lr29*, and *Lr38*).

Virulence to *Lr3a*, *Lr3bg*, *Lr11*, *Lr17*, and *Lr21* was very high and often 100 % in all regions. Virulence to *Lr1* was relatively high in Central region but low in Volgo-Vyatka and North Caucasian regions. Virulence to *Lr3ka*, *Lr23*, *Lr25*, and *Lr27 + Lr31* was high in North Caucasian region and low in two other regions. *Lr26* virulence was low in Central region and relative high in North Caucasian region. Virulence to *Lr19* was low in Central and in North Caucasian regions. Virulence to *Lr19* was first detected in 1998 after the release of a new cultivar with high resistance to leaf

Table 1. Influence of sowing time on the development of different varieties of wheat.

Variety	Growing-point differentiation after sowing on:							Heading after sowing on:							
	1 Aug	11 Aug	21 Aug	26 Aug	1 Sep	11 Sep	26 Sep	1 Oct	1 Aug	11 Aug	21 Aug	26 Aug	1 Sep	11 Sep	21 Sep	1 Oct
Winter type																
Lutescens 329	10 Apr	30 Apr	30 Apr	3 May	6 May	8 May	11 May	13 May	23 Jun	23 Jun	23 Jun	26 Jun	28 Jun	29 Jun	1 Jul	2 Jul
Mironovskaya 808	25 Apr	25 Apr	25 Apr	25 Apr	27 Apr	29 Apr	3 May	4 May	18 Jun	18 Jun	18 Jun	18 Jun	23 Jun	25 Jun	27 Jun	29 Jun
Bezostaya 1	19 Apr	19 Apr	19 Apr	19 Apr	19 Apr	24 Apr	25 Apr	27 Apr	15 Jun	15 Jun	15 Jun	15 Jun	15 Jun	15 Jun	20 Jun	22 Jun
Alternative type																
Khlumetskaya 12	18 Sep	26 Oct	25 Apr	25 Apr	28 Apr	29 Apr	4 May	6 May	21 Jun	21 Jun	21 Jun	21 Jun	25 Jun	27 Jun	29 Jun	30 Jun
Spring type																
Lutescens 62	18 Aug	29 Aug	10 Sep	19 Aug	10 Oct	—	—	22 Apr	—	—	—	—	—	—	—	26 Jun

rust race L-503. After new virulent race are detected, many new combinations of virulence to *Lr19* were identified in the Central and North Caucasian regions. Virulence to *Lr9*, *Lr24*, *Lr29*, and *Lr38* were absent and fully effective in all regions. Host-resistance genes *Lr9*, *Lr24*, *Lr29*, and *Lr38* are important sources of resistance.

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Biological determination of the time for optimum autumn sowing of different wheats (winter and alternative).

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The biologically optimum time for planting different varieties of winter wheat is the latest point in the autumn when the plants reach a phase of readiness for the formation of rudimentary spikes and will undergo spike formation at the earliest possible date in the spring. At this sowing time, spike formation in the spring occurs under the most favorable conditions (a large reserve of nutrients, low temperatures, and before the days have become long) and over a longer period ensuring the formation of large spikes. Optimum autumn sowing time of different varieties depends on their photoperiodic responce; the more marked this reponce, the earlier a variety should be sown and, conversely, the less marked the responce, the later the variety should be sown.

Wheat yields depend, to a considerable extent, on time of sowing. The largest yield can be obtained when sowing time is optimum. Yield reduction is severe when new, highly productive varieties are planted at the wrong time. Optimum sowing times currently are determined empirically and their biological nature has not been established. Why different wheat varieties have different optimum sowing times in the same climatic zone is still unclear.

Different wheat varieties were sown at different times under field and controlled (greenhouse, hotbed, and controlled-climate chamber) conditions. Observations were made on the differentiation of the growing point. Our studies (Table 1) showed that the sowing time has a strong influence over the onset of rudimentary-spike formation and heading. In plants of all the early sown wheat varieties (up to a definite day for each variety) including the most winter hardy variety (Lutescens 329), which were sown at three different times through 21 August, growing-point differentiation and heading were observed simultaneously. The same phenomenon was observed for all sowing times through 26 August in the moderately winter hardy varieties and through 1

September in the weakly winter hardy variety (Bezostaya 1). In later-sown plants, differentiation of the growing point and heading occurred later as the sowing time was delayed.

August-sown plants, which began spike formation simultaneously, received sufficient light energy in the autumn for the growing point and the entire plant to enter the reproductive phase. Plants sown at later times did not have this opportunity, so that in the spring, they continued to accumulate the necessary amount of nutrients and grow in order to reach the stage of readiness for the transition to the reproductive phase and formation of the rudimentary spikes.

The largest spikes were formed when the sowing times allowed the growing point to differentiate into spike rudiments, all other conditions being equal. The following data illustrate this point. The average weight of the grain from one spike of Mironovskaya 808 winter wheat was 1.18 g when sown on 11 August, 1.20 g when sown on 21 August, 1.24 g when sown on 26 August, 0.73 g when sown on 11 September, 0.64 g when sown on 21 September, and 0.47 g when sown on 1 October. Spike productivity was approximately the same for all four August sowing times. For other sowing times, the later planting date, the lower the grain yield per spike.

These changes in yield can be attributed to the fact that plants sown in August were the first to form rudimentary spikes under the most favorable spring conditions, having the largest reserve of nutrients accumulated since autumn. The period of spike formation was the longest for these plants. Plants sown at later times began this process considerably later and under less favorable conditions that include higher temperatures and longer days, poor water supply, and a smaller reserve of nutrients accumulated since autumn. These plants required a longer period (depending on the sowing time) for vegetative growth under long-day conditions in order to reach the stage of spike formation, for which there was a substantially fewer number of days. All this led to the formation of spikes with relatively lower productivity as a result of later sowing.

Not all sowing times that permitted plants to reach a phase of readiness for rudimentary-spike formation in autumn resulted in a high grain yield, although they potentially provided for formation of large spikes. When sown relatively early, plants did not overwinter well because of severe damage by diseases and pests, strong growth, and inadequate hardening.

During normal autumn climactic conditions, the highest yields were usually obtained from seeds planted at, or about, the latest time that permits plants to reach the stage of readiness for rudimentary-spike formation during the autumn and earliest heading in the spring. In terms of the whole plant, this roughly corresponded to the tillering stage for individual shoots and to the three-leaf stage and the beginning of development of the fourth leaf. For the winter wheat Mironovskaya 808, 26 August was the appropriate time (Table 1, p. 122).

Different varieties were considerably different in their optimum sowing time in the same climatic zone (near Moscow in this case), which was due to the biological characteristics of the varieties and their ontogeneses (more precisely, their photoperiodic reaction). The more pronounced the photoperiodic reaction of a variety, the more strongly it reacted to short days with delayed development, and the earlier it needed to be planted. Thus, the earliest optimum time for sowing of the frost-resistant varieties Lutescens 329 and Ul'yanovka was August 21, whereas the latest optimum time for the weakly frost-resistant variety Bezostaya 1 was 1 September. Even later optimum times were observed for the short-stemmed Mexican winter wheats, because of their weak photoperiodic reaction. The reaction was considerably more pronounced for frost-resistant rather than for those with weak photoperiodic response. Under the conditions of shorter days in autumn, frost-resistant varieties consequently had a considerably greater decrease in growth and development than the weakly frost-resistant varieties.

When sown at the same time, frost-resistant varieties required a longer time to reach that point when they were capable of beginning formation of rudimentary spikes than were the weakly frost-resistant varieties. Thus, Mil'turum 321 spring wheat, with a pronounced photoperiodic reaction, was sown at different times late in the summer; but was able to start ear formation only when planted no later than 16 August. The corresponding date for Lutescens 62, with a weak photoperiodic reaction, was 1 September (Table 1).

Thus, the optimum sowing time for a given variety in a specific climatic zone is largely dictated by its reaction to photoperiod. Knowing the photoperiodic reactions of a new and older varieties, one can, without conducting many years of experiments, determine the optimum sowing time for the new variety. Optimum sowing prevents the large losses in grain yield that occur when new varieties are sown at nonoptimum times and has a strong economic effect on agricultural production. Such data are important in practical breeding. One can create new varieties with a

preprogrammed optimum sowing time and a growing-season length that will ensure the highest yield under given climatic conditions.

Plants that differ in development type and vegetative periods will differ in their reaction to light during the vegetative phase and different amounts of light energy will be required for transition of the sprout to the light requirements of the longer vegetative phase (tillering). The longer the vegetative period, the more strongly expressed is the winter habit.

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New chemicals for morphogenic optimization of bread wheat in vitro.

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We studied the action of substances synthesized by the Chemistry Chair (Saratov State Agrarian University named after N.I. Vavilov) for use in induction-nutrient medium for increasing the regenerative ability of bread wheat callus in vitro. The new components, 1385, 1386, and 1387, from furfural branch, are produced under hemicellulose splitting and taken from agricultural timber-production wastes. Subtances 1386 and 1387 are optical isomers of 1385 ratsemat.

A semidwarf line that is an NIL of the *Rht-B1c* gene in the spring bread wheat background of Saratovskaya 29 and characterized by high morphogenetic activity of tissue culture in vitro was chosen for experiments (Djatchouk TI et al. 2001). After 10 days, 1385, 1386, and 1387 demonstrated growth-regulating activity (> 10 mg/l concentration) and they increase coleoptile length in GA-insensitive lines with the *Rht-B1c* gene. Material was put into induction nutrient medium at concentrations of 1 and 10 mg/l for in vitro cultivation of immature wheat embryos. Without 2,4-D, the plants lacked differentiation nor form callus. Compared with 1385 ratsemat and the 1386 optical isomer, 1387 increased plantlet formation frequency (from immature embryos) and reduced root growth. With 2,4-D (2 mg/l), 1385 negatively affected morphogenetic callus formation, but the others (1386 and 1387) did not have any effect on morphogenetic callus capacity at this concentration. Both the 1385 ratsemat and 1386 optical isomer positively influenced the regenerative ability, whereas 1387 did not effect callus formation with plantlets under initial nutritive medium. Therefore, the 1386 substance might be recommended for morphogenetic callus regenerative ability optimization as an immature embryo-cultivation medium as it raises callus regenerative ability to 52.7 % even at a concentration of 1 mg/l.

Publications.

Djatchouk TI, Tkachenko OV, and Lobachev Yu. 2001. *Rht* genes influence androgenesis and somatic embryogenesis in vitro in spring bread wheat. Ann Wheat Newslet **47**:148.

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Vital strategies and their role in supporting the functional stability of spring wheat.

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Attempts to classify plant organisms have been made for many years (Macleod 1894). Presently, phytobiologists prefer the classification of vital strategies (functional and ecocentric) proposed by Ramenskii (1938) and Grime (1979, 1988). According to this classification, all the plant organisms fall into three categories: competitors (C), stress tolerators (S),

and ruderals (R). C strategists are plants characterized by high competitiveness. They are usually dominant and act to edify plant communities. S strategists are capable of surviving in unfavorable conditions and are adapted to life in extreme conditions. R strategists are characterized by a high level of contribution to reproduction. They are plants of damaged habitats with short life cycles (annual plants). The C, S, and R strategies seldom occur in nature as pure types, but plants of mixed strategies frequently prevail. Grime and colleagues have now identified 19 strategy types and developed methods for their determination (Hodgson et al. 1999).

During selection for economically beneficial features, cultivated plants have to a large extent lost their competitive properties and stress tolerance and may be characterized as ruderal plants. The basic quality of these plants is their ability to quickly respond to improved growth conditions via increasing growth, development, and productivity. Because competitiveness is a function of the R and S strategies (Usmanov 1987), ruderality and stress-tolerance properties may be regarded as strategies crucial for ecological stability in an agroecosystem.

Spring wheat is characterized by a mixed strategy that in favorable conditions may show as R/SR, where R is the prevailing property. Under unfavorable conditions, wheat plants may demonstrate stress-tolerance traits by expressing genes of stability and redistributing energy and material input to increase stability at the expense of productivity.Under the long-term impact of an unfavorable factor (e.g., low positive temperature), wheat plants apparently implement an S/SR-type strategy, stress tolerance is a prevailing feature (in case the genotype has a sufficient, genetically conditioned potential for stress tolerance).

Depending on the variety, the proportion between ruderal and stress-tolerance properties is likely to fluctuate greatly. Indeed, within the huge amount of wheat varieties cultivated in various climatic zones of the world, there may be super ruderals, varieties with high production levels, and super stress-tolerators, varieties with high resistance to abiotic factors and relatively low productivity. The first type is comprised of varieties classified as intensive types, whose cultivation requires high energy input. Varieties of the second type are cultivated in areas with continental climates, for instance, in Siberia, North America, and Scandinavia.

Fig. 1 presents a scheme for the alterating plant properties (productivity and resistance) in a medium temperature environment and their connection with the type of vital strategy of wheat. At optimal temperatures for spring wheat cultivation (20–22°C), plants target growth to maximum yield to the highest extent (R_{max}). In this case, plants are characterized by minimal resistance (S_{min}). This strategy type is R/SR. Wheat plants have the largest resistance and least productivity at suboptimal (5–10°C) and superoptimal (30–35°C) temperatures. This strategy type is S/SR.

These ideas may be useful for selection work aimed at cultivating spring wheat varieties with well-expressed competitiveness and tolerance to stress, which will facilitate the elimination of weeds and reduce the risk of large decreases in yield over years of unfavorable climate and other growing conditions.

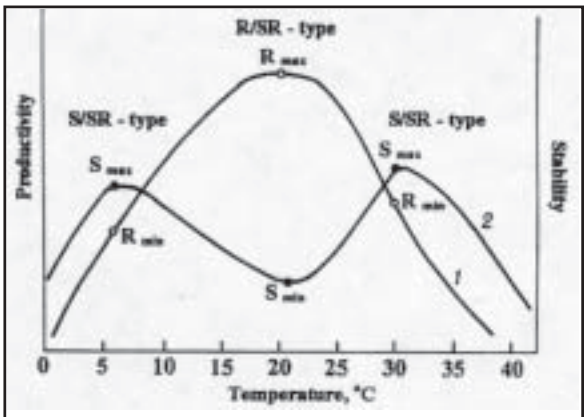

Fig. 1. The changes in resistance and productivity properties in a medium-temperature gradient as they relate with wheat vital strategy. R = productivity in an R strategy; S = stability in an S strategy.

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Growth of spring wheat as a function of mineral nitrogen and drought.

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We are interested in plant nutrition with various forms of mineral nitrogen under conditions of soil drought. Resistance to drought stress in wheat is increased by using NH_4^+ compared to NO_3^- (Spratt and Gasser 1970). The water potential in plants fed with NH_4^+ is reduced to a lesser extent than plants fed by nitrates in conditions of soil drought (Mihailovi et al. 1990). In optimal conditions, nitrates contribute to a higher amount of water in plant tissues than NH_4^+ (Kirkby and Mengel 1967; Krastina and Loseva 1975). We wanted to investigate the impact of various forms and doses of mineral nitrogen on the growth and certain physiological parameters of spring wheat cultivar Skala at the initial period of ontogenesis depending on the amount of soil moisture.

Materials and methods. Enamel tanks filled with to a capacity of 4 kg with dry sandy soil were used for the tests. A nutrient mixture incorporated macro- and microelements including nitrogen in the form of $(NH_4)_2SO_4$ or $Ca(NO_3)_2 \cdot 4H_2O$ + KNO_3 (Thomas et al. 1979). Nitrogen dose in either form in the soil was at 100, 400, and 800 mg/tank or 7.1, 28.5, and 57.1 mM, respectively. The plants were grown in a glass house until 4–5 leaves had developed. Different moisture regimes in the tanks were assured by watering at the amount of 25, 40, 60, 80, and 100 % of the total soil-water intake capacity (SWIC). In order to prevent nitrification, nitrapyrine at the amount of 1.5 % of nitrogen was added to the vessels with $(NH_4)SO_4$. Nitrates in plant tissues were determined by the method of Cataldo et al. (1975) and total reduced nitrogen by the micro-Kjedal method (Ermakov 1987). Plant samples were dried at 60°C to calculate the weight of the total water content in the plant tissues. The results are presented as the mean ± standard deviation.

Results and discussion. ***The impact of various degrees of soil moisture on water amount in the tissues and nitrates content in the plants.*** We found a distinct positive correlation between the increase in soil moisture (from 25 to 80% of SWIC and water amount in the surface part of the plants ($r = +0.94$) and nitrate content in leaves and stalks ($r = +0.97$). This dependence was discovered with an NO_3^- content in the soil equal to 400 mg/tank.

NO_3^- dose impacts water amount in the plants. An increase of nitrate concentration in the soil (from 100 to 400 mg) with optimal soil moisture (60 %) increases the amount of water in the tissues of surface organs. Water in the tissues decreases with a dose of 800 mg. In drought conditions (25 % of SWIC), water in the surface organs is half that for doses of 400 and 800 mg compared to those under optimal amounts of water (60 % of SWIC). With both soil moisture levels, a nitrogen dose of 800 mg produces a negative impact on the water amount in the tissues. Therefore, both low (100 mg) and high (800 mg) doses of NO_3^- in the soil reduce water in plant tissue. With the optimal water amounts of 60 % of SWIC, the highest water amount in plant tissues is observed with 400 mg NO_3^-.

NH_4^+ doses impact the amount of water in the plants. We observed that the amount of water in tissues of plants with NH_4^+ nutrition is lower than plants utilizing nitrates and the amount of water in the tissues depends less on nitrogen dose with both optimal water amount and its deficit. Soil drought reduces the amount of water in the plants by 23–28 % under all nitrogen doses. In fact, nitrates may reduce the amount by a factor of two. The unequal influence of NO_3^- and H_4^+ on water absorption by wheat is confirmed by calculating the amount of water in the plant surface part/gram of dry matter. This parameter in drought conditions decreases from 5.12 to 3.85 as level of NO_3^- in the soil increases and increases with a rise in NH_4^+ (from 3.58 to 4.55).

The impact of different NO_3^- amounts on nitrate content and their assimilation in surface organs. An increase in NO_3^- in the soil during drought reduces the amount of nitrates released from the roots and available to surface organs and their assimilation by the plants. Thus, an increase of nitrate content in the soil from 100 to 400 or 800 mg decreases the level in the leaves by 17 and 27 % and in the stems by 21 and 40 %, respectively. At the same time, NO_3^- assimilation, as evaluated by the content of total reduced nitrogen, drops in the leaves by 25 and 50 % and in the stems by 44 and 66 % at 400 and 800 mg, respectively. With NH_4^+ as an N source and insufficient water supply, the highest synthesis of nitric

compounds in the leaves and stems is observed with nitrogen doses of 400 mg, over twice that at 100 mg and decreases by 25–33 % when nitrogen is increased to 800 mg.

Accumulation of dry matter by wheat seedlings. The greatest total dry matter accumulated by plants (at the four-leaf stage) in a moisture deficit (25%) was observed at NO_3^- levels in the soil of 100 mg (134.1 ± 5.8 mg/plant). Increasing NO_3^- in the soil results in an abrupt drop of dry matter content of 90.3 ± 2.3 and 61.4 ± 1.6 mg/plant with the doses 400 and 800 mg, respectively. Using NH_4^+, the amount of dry matter accumulated by the plants is 112.8 ± 2.4, 134.2 ± 7.5, and 107.7 ± 4.1 mg/plant with nitrogen doses 100, 400, and 800 mg respectively. Thus, the highest degree of dry matter accumulation by wheat seedlings was observed with nitrate as the source of nitrogen and at a dose of 100 mg; with NH_4^+, the rate was 400 mg. Fluctuations in dry matter accumulation from different ammonium sources were expressed to a much lower degree than those with nitrate sources. A similar situation was found for water content in the tissues.

What accounts for the unequal influence of nitrates and ammonium on wheat growth in drought conditions ? We believe that the osmotic properties of nitrates and the different mechanisms for absorption and transportation of the nitrogen cation and anion to the surface organs may be the answer. Nitrates, being osmotically active ions (Veen and Kelinendorst 1986), may influence water absorption via a change in osmotic potential of the cells. Thus, an increase in NO_3^- in the soil (from 100–400 mg) sharply increases water and nitrate uptake by the plants in the conditions of optimal water availability. This dependence is disturbed, however, in a water deficit and high NO_3^-.

Transfer of both NH_4^+ and NO_3^- through the plasma membranes of the plant cells is by two transport systems. The first system functions at low nitrogen concentrations in the soil (up to 1 mM) (high-affinity transport system), the second system functions at high nitrogen concentrations (> 1 mM) (low-affinity transport system) (Goyal and Huffaker 1986; Cerezo et al. 2001). In our tests, we apparently observe the second transport system, which suppresses the sensitivity to nitrogen levels and the amount of water in the plants depending on the form of nitrogen. The majority of nitrates absorbed by wheat is known to be transported to the surface organs, where their assimilation (more energy-beneficial as compared to the roots) takes place (Lips 1997). Extreme factors (drought, salt buildup, or low temperature) inhibit nitrate transport to the surface organs (Glyanko 1995; Lips 1997). Because of these factors and as a consequence to nitrate-reductase inactivation in the roots during drought (Larsson et al. 1989; Il'chykov and Scher 1991), NO_3^- accumulates in the roots blocking synthesis of organic N-containing compounds required for plant growth.

Incorporation of absorbed NH_4^+ in metabolism is known to take place completely in the roots. Thus, amides (glutamine and asparagine) are largely synthesized, and a portion is used for the root growth another portion is transported to the surface organs. NH_4^+ assimilation in the roots is accompanied by abscisic acid synthesis (Lips 1997), which is transferred along xylem to the surface organs together with amides, where it can influence transpiration reduction via influence on stomata functions (Farkhutdinov et al. 1982). Soil drought may be assumed to produce lower (as compared to a nitrate nitrogen source) negative impact on NH_4^+ absorption and its incorporation into roots and the transfer of N-compounds to the surface plant parts. Evidently, this can account for the positive influence on plant growth of high NH_4^+ levels in the soil both with optimal and insufficient availability of water for the plant.

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The study of a nuclear acid ligand bound with the plant-stress protein CSP 310.

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Plants adapted to unfavorable temperatures by different biochemical mechanisms. In particular, the synthesis of some groups of stress proteins increases under the influence of low temperatures (Abromeit et al. 1992; Crosatti et al. 1994; Houde et al. 1992). A large number of these proteins are regulated on the transcriptional level, but some are known to be regulated on translational and even posttranslational levels. The posttranslational level of regulation for bacterial cold-shock proteins (CSPs) was established by Chapot-Chartier et al. (1997) Craig et al. (1998), and Fang et al. (1997). Of the stress proteins with specific function that are localized in mitochondria, such as alternative CN-resistant oxidase (AOX) (Vanlerberghe and McIntosh 1992, 1997; Umbach and Siedow 1993) and the plant-uncoupling, mitochondrial protein (PUMP) (Jezek et al. 2000) are regulated not only at transcriptional but also at posttranslational levels. Thus, regulation at translation and posttranslational levels is widespread among stress proteins with specific functions, such as those that are known to be activate during short-time stress (Ladomery 1997).

Previously, we established that the plant cold-stress protein CSP 310, which is found in cereals (Kolesnichenko et al. 1996), causes uncoupling of oxidation and phosphorylation only during cold stress when this protein rapidly increases in amount (Borovskii et al. 1999). Although this protein was found to be synthesized constituently in plant cells, it did not cause significant uncoupling of oxidation and phosphorylation in nonstressed plants (Kolesnichenko et al. 2001a). Upon further investigation by native electrophoresis gel and ethidium bromide staining, we showed that CSP 310 differs in stressed and nonstressed winter rye shoots. In nonstressed shoots, ethidium bromide stains a nucleic-acid (NA) ligand band; in stressed rye shoots, the band of this protein in unstained (Kolesnichenko et al. 2000). These two forms of CSP 310 were found to have different uncoupling activities. The stressed form strongly caused uncoupling in plant mitochondria; the constituently synthesized form lacked an uncoupling activity (Pobezhimova et al. 2001). This fact allows us to propose that the release of a nuclear-acid ligand from CSP 310 could be a mechanism of CSP 310 uncoupling action regulation (Kolesnichenko et al. 2001b). At the same time, the nature of NA ligand in CSP 310 was not established. The mechanism of ligand release from CSP 310 during cold stress was not established either. Thus, the aim of the present work is to determine the nature of this nuclear-acid ligand and if the binding of the NA ligand depends on the temperature and the nature of the ligand.

Materials and methods. Three-day-old etiolated shoots of the winter wheat cultivar Irkutskaya Ozimaya, the winter rye cultivar Chulpan, *X Triticosecale*, *Elymus sibiricus*, and maize cultivar VIR 32 were grown on moist paper at 26°C. CSP 310 from nonstressed and stressed seedling shoots was isolated as described previously (Kolesnichenko et al. 1996). Proteins, immunochemically related to winter rye, stress protein CSP 310 from nonstressed winter rye, winter wheat, *Elymus*, and maize seedling shoots were isolated using affinity chromatography on a column with BrCN-activated Sepharose with immobilized anti-CSP 310 antiserum as described previously (Kolesnichenko et al. 1999).

The isolation of the nuclear-acid ligand from purified CSP 310 and from proteins immunochemically related to stress protein CSP 310 was performed using the standard method of NA deproteinizing and isolation (Manniatis et al. 1982). To isolate the NA ligand, 1.6 mg of CSP 310 was dissolved in 500 ml of water and then 60 ml of 10X TE buffer (pH 8.0), 15 ml pronase E (20 mg/ml), and 35 ml of water were added to CSP 310 solution. Pronase E treatment was performed for 2 h at 37°C, after which the NA ligands were isolated by phenol-chloroform extraction and ethanol precipitation.

In experiments with incubation of CSP 310 with different NA yeast, HMW RNA (Serva) (10 mg/ml dissolved in 10 mM Tris-HCl, pH 8.0) and one-stranded DNA- oligonucleotide 5'–acactagcttacggtgatct, 20 b was used. The 10X incubation buffer was 10 mM Tris HCl (pH 8.0), 60 mM KCl, 5 mM $MgCl_2$, 1 mM DTT, 0.1 mg/ml BSA, and 12 % glycerol in ddH_2O. Experiments were performed in two variants; with the constituently synthesized and stress forms of CSP 310. In the first variant, the stressed form of CSP 310 (1.6 mg of protein in 1,000 ml) was incubated with a) 10X buffer (150 ml), HMW RNA (100 ml) or H_2O (250 ml); and b) 10X buffer (150 ml), 50 pM osDNA (5 ml) H_2O (345 ml). In the second variant, the constituently synthesized form of CSP 310 (1.7 mg of protein in 2,000 ml) was incubated with a) 10X buffer (250 ml), HMW RNA (100 ml) H_2O (150 ml) or b) 10X buffer (250 ml), 50 pM osDNA (5 ml), and H_2O (245 ml). In both variants, the incubation mixtures were divided in two parts and one part was incubated at 0°C for 2 h and the other part was incubated at 26°C for 2 h. Thus, there were a total of eight variants of the experiment. After incubation, CSP 310 was precipitated from the incubation mixture by 50 % ammonium sulfate saturation (8 h at 4°C). The precipitated CSP 310 was collected by centrifugation (20,000 g, 20 min) and washed four times with 50 % ammonium sulfate solution. After washing, CSP 310 was dissolved in 1 ml 10 mM Tris-HCl (pH 8.0) and dialyzed against 10 mM Tris-HCl (pH 8.0) for 24 h at 4°C. The dialyzed CSP 310 preparations were hydrolyzed with pronase E as described above, and the NA ligands obtained were analyzed by electrophoresis in 1.5 % agarose gels (Manniatis et al. 1982). NA ligands were visualized by ethidium bromide staining.

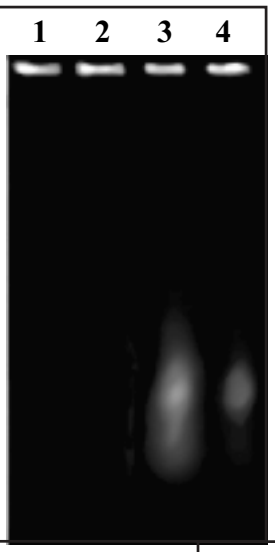

Fig. 2. Electrophoresis of nucleic acid preparations extracted from maize, *Elymus*, winter rye, and winter wheat CSP 310-like proteins obtained by affinity chromatography; lane 1, from maize; lane 2, from *Elymus*; lane 3, from winter rye; and lane 4, from winter wheat.

Results and discussion. We first tried to isolate the NA ligand from preparations immunochemically related to CSP 310 proteins from some cereal species obtained by affinity chromatography from nonstressed-seedling shoots. In this experiment, we used the standard method of NA deproteinizing and isolation (Manniatis et al. 1982). The electrophoresis of nucleic-acid preparations obtained from winter rye and winter wheat immunochemically related to CSP 310 proteins show the presence of NA ligands (Fig. 2). At the same time, these ligands were not detected in immunochemical proteins related to CSP 310 from maize and *Elymus* (Fig. 2). DNAse treatment failed to eliminate bands of extracted NA on the gel (Fig. 3.), so this NA ligand is not DNA. On the contrary, RNAse treatment eliminated bands of NA extracted on gel (Fig. 3). These results vindicate previous data on the presence of NA ligand in CSP 310 from winter rye (Kolesnichenko et al. 2000) and winter wheat (Kolesnichenko et al. 2001b). Indeed, CSP 310 was found among cytoplasmic proteins of winter rye and winter wheat, but was not found among maize and *Elymus* cytoplasmic proteins (Kolesnichenko et al. 1999). Based on these data, we concluded that in nonstressed winter rye and winter wheat shoots CSP 310 binds with an RNA ligand. The CSP 310-like proteins from maize and *Elymus* are not bound with any NA ligand.

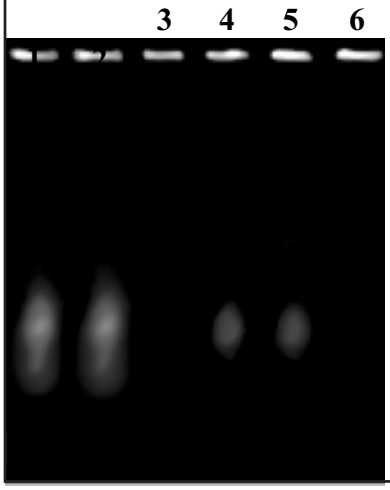

Fig. 3. Electrophoresis of nucleic acid preparations extracted from winter rye and winter wheat CSP 310-like proteins obtained by affinity chromatography; lane 1, from winter rye; lane 2, from winter rye after DNAse treatment; lane 3, from winter rye after RNAse treatment; lane 4, winter wheat CSP 310-like proteins; lane 5, from winter wheat after DNAse treatment; and lane 6, from winter wheat after RNAse treatment.

The temperature of protein preincubation has no influence on the presence of the RNA ligand in CSP 310. If CSP 310 extracted from nonstressed shoots was bound with RNA independently from the temperature of protein preincubation (26 or 0°C) (Fig. 4, p. 130, lanes 2 and 3) in CSP 310 from stressed (–1°C, 1 h) shoots, RNA was not detected (Fig. 4, p. 130, lanes 4 and 5). Thus, we can distinguish two forms of CSP 310, i.e., constituently synthesized (bound with RNA) and stress (not bound with RNA) forms. Experiments with

incubation of stress form CSP 310 with different NA (HMW RNA and random osDNA oligonucleotides) showed that the stress form of CSP 310 binds the HMW RNA both at 0 and 26°C (Fig. 4, lanes 6 and 7). At the same time, the stress form did not bind osDNA-oligonucleotides either at 0 or at 26°C (Fig. 4, lanes 8 and 9).

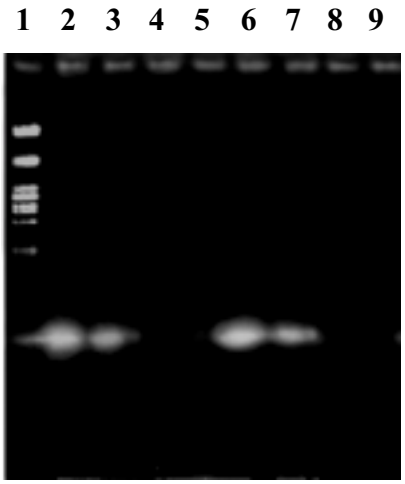

Fig. 4. Electrophoresis of nucleic acid preparations extracted from CSP 310. Lane 1, DNA standards (λ/*PstI*); lane 2, nucleic acid from the CSP 310 protein from non-stressed shoots (CSP 310 was preincubated at 0°C); lane 3, nucleic acid from CSP 310 protein from nonstressed shoots (CSP 310 was preincubated at 26°C); lane 4, nucleic acid from CSP 310 protein from stressed shoots (CSP 310 was preincubated at 0°C); lane 5, nucleic acid from CSP 310 protein from stressed shoots (CSP 310 was preincubated at 26°C); lane 6, nucleic acid from CSP 310 isolated from stressed shoots after incubation at 0°C with HMW RNA; lane 7, nucleic acid from CSP 310 isolated from stressed shoots after incubation at 26°C with HMW RNA; lane 8, nucleic acid from CSP 310 isolated from stressed shoots after incubation at 0°C with osDNA; lane 9, nucleic acid from CSP 310 isolated from stressed shoots after incubation at 26°C with osDNA.

Our data show that constituently synthesized CSP 310 in non-stressed winter cereals is a complex of protein with nuclear acid. This NA ligand is RNA. At the same time, CSP 310 in stressed plants is not so complex. The difference between the uncoupling actions of these two forms of CSP 310 allows us to suppose that this RNA ligand can be a regulator of its uncoupling activity (Pobezhimova et al. 2001). The CSP 310 RNA ligand was found in cytoplasmic proteins of winter rye and wheat immunochemically related to CSP 310, but not in CSP 310-like proteins of *Elymus* and maize. These data confirm previous data about the presence of CSP 310 among cytoplasmic proteins of species investigated (Kolesnichenko et al. 1999). Indeed, electrophoresis of native proteins followed by Western blotting detected CSP 310 only among native proteins of winter rye and wheat and only from CSP 310-like proteins of these species were we able to isolate RNA. This RNA was isolated from purified winter rye and *Triticosecale* CSP 310.

A study of the capacity of the stress form of CSP 310 to bind nuclear acids shows that CSP 310 binds HMW RNA but not osDNA oligonucleotides. These data allows us to suppose that CSP 310 can specifically bind RNA but not DNA and, therefore, can have RNA-binding sites in its structure. On the other hand, this RNA binding can take place because of conformational changes of native protein macromolecule. We note that the stress form of CSP 310 binds HMW RNA both at 0 and 26°C. This fact shows that the release of the RNA ligand during cold stress depends on the action of some mediators but not from the direct influence of low temperature. We can suppose that this mechanism of CSP 310-uncoupling activity regulation in winter rye and wheat can be a part of the integrated reaction of plant cells to low-temperature stress. In such cases, if the constituently synthesized form CSP 310 binds HMW RNA and can release it during low-temperature stress, it can participate in regulation of protein synthesis on translational level.

Based on the data obtained, we conclude that the constituently synthesized form of CSP 310 with low uncoupling activity binds with RNA ligand. During cold stress, this form of CSP 310 releases an RNA ligand and is transformed to the stress form of this protein with high uncoupling activity. This release does not depend on the direct action of the low temperature, because the stress form of CSP 310 can bind HMW RNA during incubation both at 26 and 0°C. CSP 310 can bind only HMW RNA but not osDNA oligonucleotides. CSP 310 can participate in regulation of protein synthesis on translational level.

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The influence of Ca^{+2} on the uncoupling function of the CSP 310 protein in winter wheat mitochondria.

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Cellular Ca^{+2} functions as an important cellular signal regulating most physiological processes in living organisms. This ion controls cell and mitochondrial reactions to various stress factors both in animals (Schefler 2000; McCormack et al. 1990; Kavanagh et al. 2000; Szabadkai et al. 2001) and plants (Khokhlova et al. 1993; Snedden and Fromm 1998) and controls such process as programmed cell death (Schefler 2000; Jones 2000; Kowaltowski 2000). Ca^{+2} has been established to have an important role in mediating the response of plant cells to different biotic and abiotic stimuli and trigger a large number of cellular processes that influence growth and the development (Jones and Mitchell 1989) that allow a

plant to tolerate different stress conditions (Snedden and Fromm 1998). Mitochondria have a number of transport mechanisms by which they take up and release Ca^{+2} across their inner membrane and, therefore, participate in the regulation of a number of Ca^{+2}-sensitive mechanisms in animal and plant cells (Schefler 2000; McCormack et al. 1990; Khokhlova et al. 1993; Snedden and Fromm 1998; Jones 2000; Kowaltowski 2000).

Recently, in cereals such as winter wheat and winter rye, a cold-stress protein CSP 310 that caused uncoupling of respiration and oxidative phosphorylation in cereal mitochondria during cold stress was found (Kolesnichenko et al. 1996; Voinikov et al. 1998). Studies of CSP 310 localization in vivo and in vitro showed increased amounts of this protein localized in mitochondria during cold stress (Kolesnichenko et al. 2000a and b). Previous researchers showed that Ca^{+2} ions regulated plant response to low-temperature stress (Khokhlova et al. 1993; Snedden and Fromm 1998). We were interested in determining if Ca^{+2} ions influence the CSP 310 function in cereal mitochondria.

One of the most important processes in which Ca^{+2} ion is involved in animal cells is apoptosis (Petit et al. 1997). During this process, mitochondria take up cytoplasmic Ca^{+2}, which causes PTP opening, collapse of mitochondrial membrane potential, release of cytochrome c followed by activation of caspases, DNA fragmentation, and, as a result, cell death (Petit et al. 1997; Smaili et al. 2000). This process in animal cells now is well studied. On the other hand, programmed cell death is known to be an important and integral part of the development of different plant tissues such as endosperm (Young and Gallie 2000), aleurone (Fath et al. 2000), and tracheary elements (Fukuda 2000). Unlike animals, however, programmed cell death in plants does not follow the apoptotic way with nuclear condensation, cytoplasmic blebbing, and the involvement of a macrophage to remove the corpse (Jones 2000). Though there are a lot of data on the participation of reactive oxygen species in both plant and animal PCD (Jabs 1999; Shirasu and Schulze-Lefert 2000), the main features of programmed cell death in plants are a high degree of vacuolarization and an abrupt loss of plasma membrane integrity, the activation of different nucleases and proteases, and the loss of organelles as a result of cellular autolysis (Jones 2000). Thus, programmed cell death in plants is programmed autolysis (Fath et al. 2000) or in some cases it may be programmed oncolysis (Jones 2000). Nevertheless, there are data on the participation of cytosolic Ca^{+2} in programmed cell death of many plant tissues (Groover and Jones 1999; Levine et al. 1996; He et al. 1996).

The addition of CSP 310 to isolated winter wheat mitochondria induces ascorbate-dependent and NADH-dependent lipid peroxidation systems unlike other known uncoupling proteins (Zykova et al. 2000; Kolesnichenko et al. 2001a). However, we have shown that the inhibition of CSP 310 by specific antiserum increases lipid peroxidation in isolated mitochondria (Kolesnichenko et al. 2001b) like other known uncoupling proteins (Kowaltowski 2000). Reactive oxygen species (ROS) are known to form participates in PTP openings (Petit et al. 1997; Smaili et al. 2000; Jabs 1999; Ridgley et al. 1999) and, therefore, programmed cell death. This process occurs more easily in mitochondria energized by complex I function. Stress protein CSP 310 affects mainly complex I of the mitochondrial respiratory chain (Fontaine et al. 1998). Because previously obtained data showed some similarity between PTP opening and CSP 310 function in cereal mitochondria, CSP 310 may influence the process of cytochrome c release from winter wheat mitochondria. The aim of this present work is to examine an influence of Ca^{+2} and CSP 310 on energetic activity and cytochrome c release in cold-resistant winter wheat mitochondria.

Materials and methods. Three-day-old etiolated shoots of the winter wheat cultivar Zalarinka were germinated on moist paper at 26°C. Mitochondria were extracted from control winter wheat shoots (germinated at 26°C) and stressed (–10°C for 1 h) winter wheat shoots by differential centrifugation as described previously (Davy de Virville et al. 1994). The isolated mitochondria were resuspended in 20 mM MOPS–KOH buffer (pH 7.4), 300 mM sucrose, 10 mM KCl, 5 mM EDTA, 1 mM $MgCl_2$, 4 mM ATP, 6 mM ADP, 10 mM malate, and 10 mM glutamate.

In the first set of experiments, mitochondria isolated from control winter wheat shoots were divided into two parts and resuspended in the above mentioned media with or without an addition of CSP 310 (0.5 mg/1 mg of mitochondrial protein) and added in paleographic cell with or without an addition of different concentration of $CaCl_2$ (1–50 μM). In the second set of experiments, mitochondria isolated from stressed winter wheat shoots were added in paleographic cell with or without an addition of different concentrations of $CaCl_2$ (1–50 μM). The activity of mitochondria was analyzed 3–5 min after isolation.

Mitochondrial activity was recorded polarographically at 27°C using a closed-type platinum electrode in a 1.4-ml cell (Estabrook 1967). The reaction mixture contained 125 mM KCl, 18 mM KH_2PO_4, 1 mM $MgCl_2$, and 5 mM EDTA, pH 7.4. An oxidative substrate of 10 mM malate in the presence of 10 mM glutamate was used. Polarograms were used to calculate the rates of phosphorylative respiration (state 3), nonphosphorylative respiration (state 4), respira-

tion control by Chance-Williams, and the ADP:O ratio (Estabrook 1967). The concentrations of mitochondrial protein and CSP 310 were analyzed according to the method of Lowry et al. (1951).

To isolate CSP 310, 3-day-old etiolated shoots of winter rye germinated at 26°C and stressed at –1°C for 1 h were used. The isolation and purification of CSP 310 were performed in according to previously described methods (Kolesnichenko et al. 1996).

Release of cytochrome c from winter wheat mitochondria was measured by a spectrophotometer (SF-46, LOMO, USSR) according Moore and Proudlove (1983) at 550 nm after mitochondria precipitation. To measure cytochrome c release, the following medium was used: 300 mM sucrose, 40 μM MOPS (pH 7.4), 10 mM KCl, 2 mM EDTA, 1 mM $MgCl_2$, 4 mM ATP, 6 mM ADP, 10 mM malate, and 10 mM glutamate (medium A). The reaction was initiated by adding 10 mM ascorbate and 0.1 mM TMPD. Cytochrome c amounts were calculated using the calibration curve 0.5–100 μM of cytochrome c as a standard.

Mitochondria isolated from control and stressed winter wheat shoots were incubated in either medium A + different $CaCl_2$ concentrations or medium A + different $CaCl_2$ concentrations + CSP 310 (1 mg/ml). Mitochondria were incubated at 0°C for 30 min and then were centrifuged at 20,000 X g for 3 min and the supernatant was used for cytochrome c measurement.

All the experiments were replicated six times. The data obtained were analyzed statistically by determining arithmetic means and standard errors.

Results and discussion. Ca^{+2} ions are known to be important for regulating most physiological processes and cells maintain a cytoplasmic concentration of this ion at very low levels. The cytosolic concentration of Ca^{+2} in mammals is about 7–10 M, and some researchers have used Ca^{+2} concentrations of 50–100 or 200 nM in their work (Smaili et al. 2000; Bowler and Fluhr 2000). Other data suggest that cytosolic Ca^{+2} concentration differs in plants and Ca^{+2} concentrations of 10 μM were used in the studies of Ca^{+2} influence on pea mitochondria (Vianello et al. 1995) and 0–30 μM in a study of Ca^{+2} influence on winter wheat mitochondria (Khokhlova et al. 1993). The concentration of Ca^{+2} in winter wheat roots in vivo was found to be about 1–2 μM/g f.w. (Minibayeva et al. 2000). In our study on the influence of Ca^{+2} on CSP 310 function in winter wheat mitochondria, we used Ca^{+2} concentrations 0-50 μM.

Mitochondria freshly isolated from winter wheat shoots had high energetic activity and a rather high degree of coupling of oxidation and phosphorylation. State-3 respiration without the addition of Ca^{+2} to the incubation medium was about 60 nM O_2/min/mg of mitochondrial protein and state-4 respiration was about 22 nM O_2/min/mg of mitochondrial protein at the same conditions (Fig. 5). The addition of different amounts of Ca^{+2} to the mitochondria-incubation media caused some changes in their activity. Low Ca^{+2} concentrations (1–5 μM) caused decreases in both state-3 and state-4 respiration to about 45–50 and 10–12 nM O_2/min/ mg of mitochondrial protein, respectively (Fig. 5). The increase in Ca^{+2} concentration (5–20 mkM) caused an increase in state-4 respiration up to 20–25 nM O_2/min/mg of mitochondrial protein, but state-3 respiration under these conditions was lower than in the variant without the addition of Ca^{+2} and was about 50–60 nM O_2/min/mg of mitochondrial protein (Fig. 5). The presence of the acute maxima of state-3 and state-4 respiration at 10 mkM of Ca^{+2} is interesting. Furthermore, an increase in Ca^{+2} concentration (5–20 μM) caused decreases in both state-3 and state-4 respiration from about 10–40 nM O_2/min/mg of mitochondrial protein, respectively (Fig. 5). Thus, different Ca^{+2} concentrations in mitochondrial incubation medium have diverse influences on mitochondrial energetic activity. If both low (1–5 μM) and high (25–50 μM) Ca^{+2} concentrations cause a

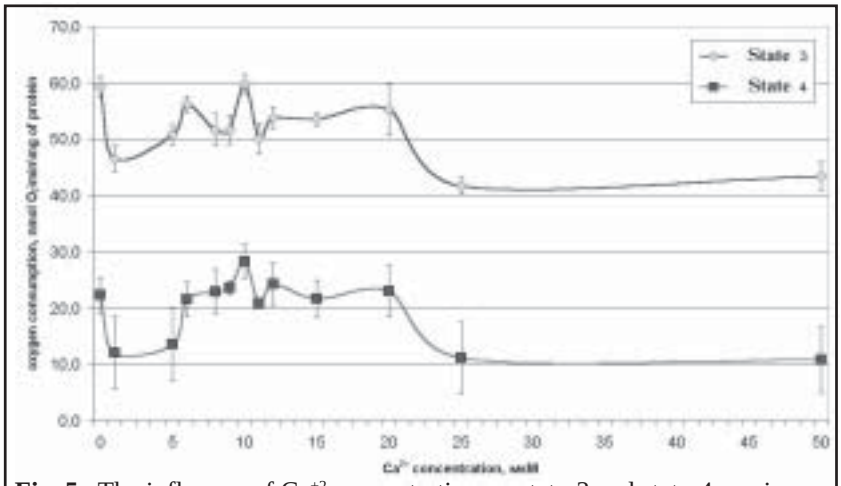

Fig. 5. The influence of Ca^{+2} concentration on state-3 and state-4 respiration of winter wheat mitochondria (mean ± standard deviation, n = 6).

decrease of state-3 and especially state-4 respiration, moderate Ca^{+2} concentrations did not have significant influence on their values.

The data obtained in our experiment on Ca^{+2} influence on mitochondria isolated from the super-cold-resistant, winter wheat Zalarinka differs from the data of Khokhlova and coworkers for mitochondria isolated from the medium-cold-resistant cultivar Mironovskaya 808 (Khokhlova et al.,1993). In their experiments without the addition of Ca^{+2}, the values of both state-3 (~ 30 nanoatom O_2/min/mg of protein) and state-4 (about 20 nanoatom O_2/min/mg of protein) respiration obtained for mitochondria isolated from nonhardened seedling shoots in the winter were significantly lower than in our experiments (~ 60 and 22 nM O_2/min/mg of protein for state-3 and state-4 respiration, respectively). In addition, in their experiments, peaks for both state-3 (up to 40 nanoatom O_2/min/mg of protein) and state-4 (up to 25 nanoatom O_2/min/mg of protein) respiration for mitochondria isolated in the winter from nonhardened wheat seedling shoots were detected. In our experiments, the maximum value for state-3 respiration in the variant without Ca^{+2} addition was observed. At 10 mkM Ca^{+2}, state-4 respiration was only slightly higher than in variant without added Ca^{+2}. On the other hand, at high Ca^{+2} concentrations both in our experiments and in experiments of Khokhlova with coworkers, the values of both state-3 and state-4 respiration were lower than without added Ca^{+2}. These data allow us to propose that there is less affinity to Ca^{+2} in mitochondria isolated from super-cold-resistant winter wheat Zalarinka.

A study of CSP 310 influence on mitochondrial energetic activity was made after 1 h of mitochondria incubation, because the maximum increase in CSP 310 content in stressed winter rye shoots is detected during the first hour of cold stress (Borovskii et al. 1999). Although the physiological concentration of CSP 310 in cereals is about 0.25–1.0 mg/mg mitochondrial protein (Pobezhimova et al., 2001), a concentration of CSP 310 equal to 0.5 mg/mg of mitochondrial protein was used in all experiments.

Incubating isolated winter wheat mitochondria in vitro with CSP 310 previously was shown to cause an increase in nonphosphorylative respiration and the uncoupling of oxidative phosphorylation (Voinikov et al. 1998). A study of the influence of Ca^{+2} concentration in the mitochondrial-incubation medium showed its strong influence on CSP 310-dependent changes in state-4 respiration (Fig. 6). In the presence of both low (1–5 μM) and high (25–50 μM) Ca^{+2} concentrations in the medium, the addition of CSP 310 caused an increase in state-4 respiration. On the other hand, at moderate Ca^{+2} concentrations in the medium, the addition of CSP 310 caused state-4 respiration to decrease (Fig. 6).

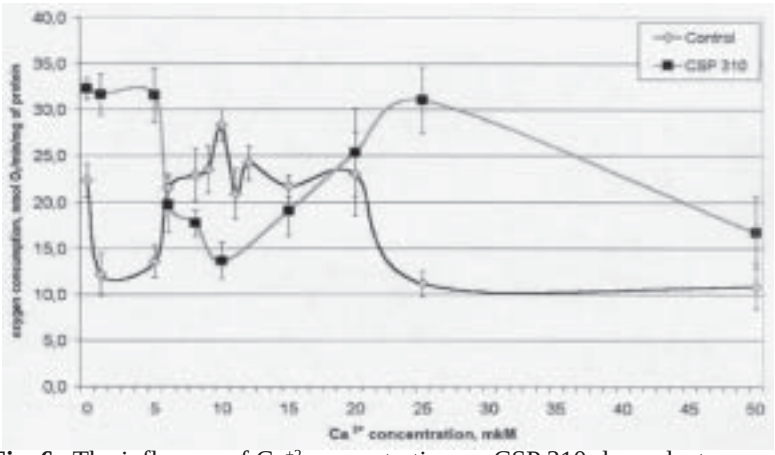

Fig. 6. The influence of Ca^{+2} concentration on CSP 310-dependent changes of state-4 respiration in winter wheat mitochondria (mean ± standard deviation, n = 6.

The influence of Ca^{+2} on the CSP 310 effect on state-3 respiration in winter wheat mitochondria is similar but slightly different. If CSP 310 did not have any influence on state-3 respiration in the absence of Ca^{+2} or at concentrations in the range of 15–20 μM and with both low (1–5 mkM) and high (25–50 mkM) Ca^{+2} concentrations in mitochondrial-incubation medium, the addition of CSP 310 would cause an increase in state-3 respiration. At moderate Ca^{+2} concentrations in the medium, the addition of CSP 310 caused the decrease of state 3 respiration (Fig. 7, p. 135). Of interest is the fact that at 7 μM of Ca^{+2} in the mitochondria-incubation medium, values for state-3 respiration with and without the addition of CSP 310 were similar.

Comparing the influence of cold stress (–1°C, 1 h) and CSP 310 on the respiratory-control coefficient in winter wheat mitochondria shows that they are similar at low (1–5 μM) and high (50 μM) Ca^{+2} concentrations in the mitochondria-incubation medium (Fig. 8, p. 135). Cold stress and the addition of CSP 310, however, had an opposite influence on the mitochondrial respiratory-control coefficient at moderate (5–25 μM) Ca^{+2} concentrations (Fig. 8). We note that cold stress had no influence on the respiratory-control coefficient at Ca^{+2} concentrations around 10 μM (Fig. 8). When we

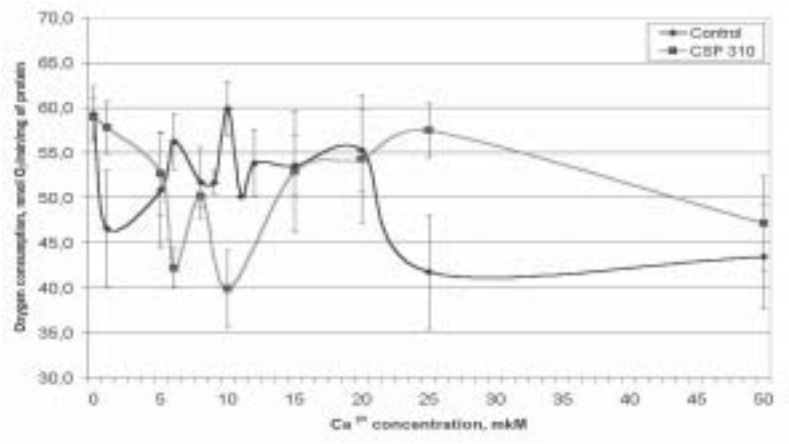

Fig. 7. The influence of Ca^{+2} concentration on CSP 310-dependent changes of state-3 respiration in winter wheat mitochondria (mean ± standard deviation, n = 6).

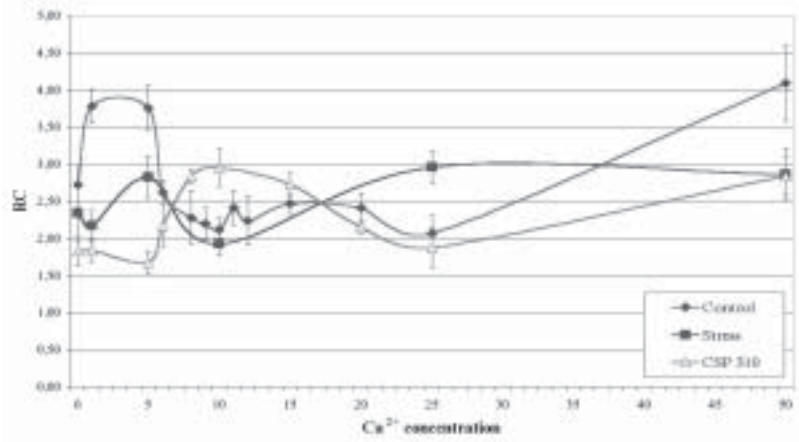

Fig. 8. The influence of Ca^{+2} concentration on low-temperature stress and CSP 310-dependent changes of respiratory control coefficient in winter wheat mitochondria (mean ± standard deviation, n = 6).

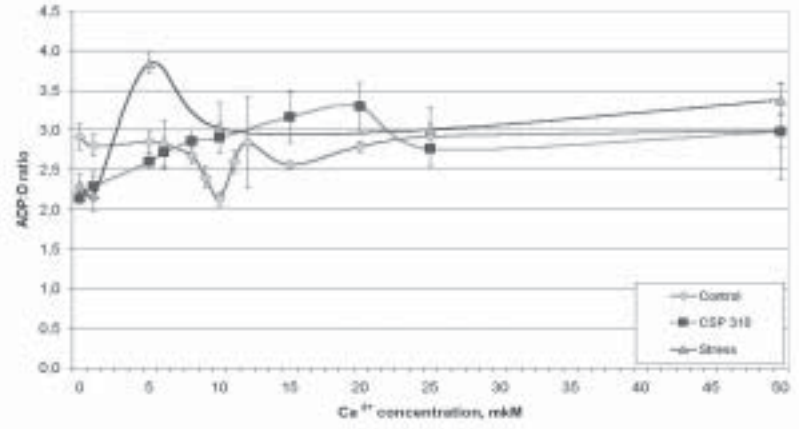

Fig. 9. The influence of Ca^{+2} concentration on low-temperature stress and CSP 310-dependent changes on the ADP:O ratio in winter wheat mitochondria (mean ± standard deviation, n = 6).

compare our data on RC coefficient in control and stressed shoots with the data of Khokhlova coworkers for winter wheat with medium levels of cold-resistance (Khokhlova et al. 1993), it is interesting to note that in our experiments, the curve for the control shoots was similar to the data obtained for mitochondria isolated from shoots hardened in summer conditions than from those of the control under winter conditions.

A study of the influence of CSP 310 on the ADP:O ratio in winter wheat mitochondria showed that it was similar to that of cold stress only at low Ca^{+2} concentrations in mitochondrial incubation medium (Fig. 9). At these Ca^{+2} concentrations, both the CSP 310 treatment and cold stress caused a decrease of the ADP:O ratio in winter wheat mitochondria. At other Ca^{+2} concentrations, the ADP:O ratio in the presence of CSP 310 in mitochondrial-incubation medium was equal to or even higher than that of in control mitochondria. A similar effect on ADP:O ratio at these Ca^{+2} concentrations (especially at 10 μM) had cold stress. At the same time, our cold stress experiments caused a 10 μM peak of ADP:O ratio above the theoretical maximum, which is similar to the data obtained for nonhardened, medium-resistant winter wheat (Khokhlova et al. 1993).

Taken together, the data obtained on the influence of Ca^{+2} on CSP 310 activity in winter wheat mitochondria shows that at low (0–5 μM) and high (50 μM) concentration, the influence of cold stress and CSP 310 treatment are similar; both cause a decrease in the respiratory-control coefficient, whereas at medium Ca^{+2} concentrations, their influence is contrary. We suspect that this fact is under the control of the cell on CSP 310 activity by Ca^{+2} concentration.

Because Ca^{+2} is implicated in the process of programmed cell death both in mammals (Smaili et al. 2000) and plants (Fath et al. 2000), and a main feature of this process is Ca^{+2}-depen-

dent cytochrome c release from mitochondria to cytoplasm (Jones 2000; Smaili et al. 2000), we studied the influence of low-temperature stress and CSP 310 on cytochrome c release from mitochondria at different Ca^{+2} concentrations in the mitochondria-incubation medium.

First, the Ca^{+2} concentration in mitochondria incubation medium had a significant influence on cytochrome c release from winter wheat mitochondria (Fig. 10). Cytochrome c release from winter wheat mitochondria was very low without the addition of Ca^{+2}; the addition of 1 μM of Ca^{+2} to mitochondria-incubation medium caused the release of about 1.8 μM of cytochrome c/mg of mitochondrial protein (Fig. 10). The increase of Ca^{+2} concentration to 5 μM caused a decrease of cytochrome c to 1 μM, and further increases in Ca^{+2} concentration to 10 μM and higher increased cytochrome c release to about 2 μM of cytochrome c/mg of mitochondrial protein (Fig. 10). Therefore, cytochrome c release in winter wheat mitochondria occurs in a Ca^{+2}-dependent manner and, consequently, winter wheat mitochondria could participate in programmed cell death like in mammals.

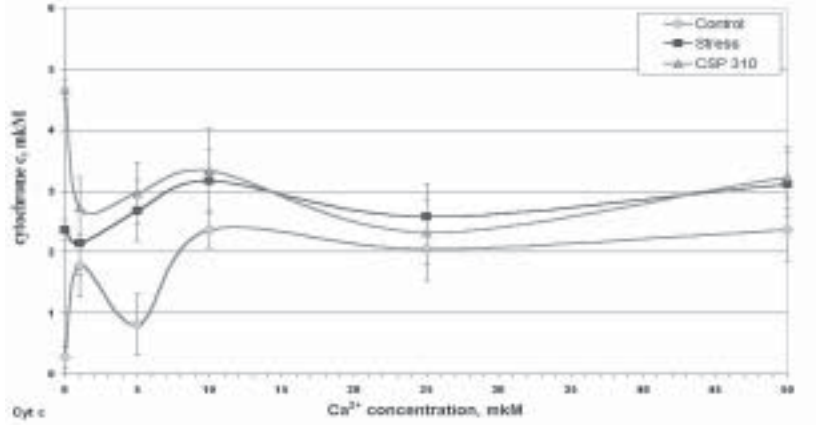

Fig. 10. The influence of Ca^{+2} concentration on low-temperature stress and CSP 310-dependent, cytochrome c release from winter wheat mitochondria (mean ± standard deviation, n = 6).

Our data show that cold stress (–1°C, 1 h) has an influence on cytochrome c release from mitochondria at some low Ca^{+2} concentrations (0 and 5 μM) (Fig. 10). All Ca^{+2} concentrations (even without the addition of Ca^{+2}), cytochrome c released from mitochondria was higher than 2 μM/mg of mitochondrial protein and at 10 μM of Ca^{+2} in mitochondria incubation-medium, cytochrome c release was nearly 3 μM. Therefore, cold stress causes similar effects on cytochrome c release in winter wheat mitochondria as in mammals, and we propose that winter wheat mitochondria participate in the process of programmed cell death caused by low-temperature stress.

CSP 310 dramatically influences the release of cytochrome c at low Ca^{+2} concentrations in winter wheat mitochondria (Fig. 10). The effect of the addition of CSP 310 to isolated winter wheat mitochondria on cytochrome c release at all Ca^{+2} concentrations was similar to the effect of cold stress. CSP 310 significantly increases cytochrome c release at low Ca^{+2} concentrations (0–10 μM) especially at 0 and 5 μM of Ca^{+2} in mitochondrial-incubation medium. From these data allow, we propose that CSP 310 participates in Ca^{+2}-dependent cytochrome c release from winter wheat mitochondria during cold stress and, therefore, participates in programmed cell death.

The similarity between the influence of CSP 310 on mitochondrial energetic activity and cytochrome c release in winter wheat mitochondria is interesting. Indeed, the most pronounced uncoupling effect of CSP 310 on respiratory control coefficient and the release of cytochrome c at low Ca^{+2} concentrations (0–5 μM) in our experiments were detected. Because cytochrome c release from mitochondria depends on PTP opening (Petit et al. 1997; Jabs 1999; Smaili et al. 2000), we can speculate that CSP 310 at some Ca^{+2} concentrations can interact with the outer membrane voltage-dependent anion channel (VDAC) and cause PTP opening.

Based on these data, we conclude that Ca^{+2} influences CSP 310 function in winter wheat mitochondria. CSP 310 causes a decrease of respiratory control coefficient at Ca^{+2} concentrations about 1–5 μM and 50 μM and the increase of respiratory control ratio at Ca^{+2} concentrations about 10–15 μM. The influence of CSP 310 and low-temperature stress on cytochrome c release from winter wheat mitochondria are very similar.

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Disulfide reductase activity and gluten quality in common wheat lines with intervarietal substitution for chromosomes of homoeologous groups 1 and 6.

S.V. Osipova, V.A. Trufanov, and T.A. Pshenichnikova.

Gluten content in common wheat is of great importance in breeding. A high content of storage protein is not a guarantee of high gluten quality, which depends substantially on the SS/SH status of these proteins (Bloksma 1975; Kretovich 1991). Wheat grains contain a specific system of enzymes belonging to the class of oxidoreductases that are responsible for the thiol-disulfide metabolism in proteins (Trufanov 1994; Trufanov et al. 1999). Studies of thiol:protein disulfide oxidoreductase (disulfide reductase, RED, EC 1.8.4.2) and thiol:oxygen oxidoreductase (thioloxidase, EC 1.8.3.2) activities in spring cultivars of wheat with different gluten quality have shown a correlation between activity and rheological properties of dough. The high genotypic variability of specific activity of thioloxidase and disulfide reductase was established in 18 common, spring wheat cultivars of different origins (Trufanov et al. 2000). Therefore, we were interested in investigating intervarietal substitution lines where a pair of chromosomes of a recipient cultivar are substituted for the homologues from a donor variety. In this paper, the results of study of disulfide reductase (RED) activity and some technological characteristics of grain in substitution lines involving chromosomes of homoeologous groups 1 and 6 of common wheat are presented. These chromosomes are known to have the genes for gluten formation (Wrigley and Shepherd 1973).

Materials and methods. Lines with substitutions for chromosomes 1A, 1B, 1D, 6A, 6B, and 6D were used (Maystrenko et al. 1998). The cultivar Diamant (DM), which has one of the highest grain-protein contents but poor technological properties, was the recipient, and the high-quality cultivar Novosibirskaya 67 (N67) was the donor parent. Disulfide reductase activity was determined according methods described earlier (Kichatinova et al. 1993; Trufanov 1994). The technological parameters studied are described in Trufanov et al. (2000). Figs. 11 and 12 show the average data of two independent replicates of experiment. The activity of disulfide reductase in each was determined three times in two biological and three analytical replicates. The data on specific activity and technological parameters are shown in percent of the recipient variety DM.

Results and discussion. According to modern concepts, the physical properties of the gluten-protein complex are determined considerably by the content of intra- and intermolecular SS-bonds in storage proteins. The formation, breaking, and isomerization are catalyzed by specific enzyme system of SS/SH metabolism. One of the key enzymes in

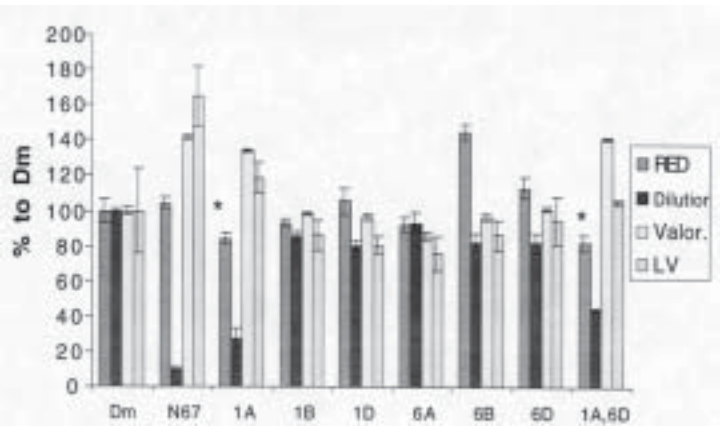

Fig. 11. Specific disulfide reductase (RED) activity, dilution, valorimeter, and loaf volume (LV) for the parental lines Diamant (Dm) and Novosibirskaya 67 (N67) and each of the group 1 and 6 and the 1A 6D double chromosome addition lines in relation to the Diamant parental line (* = P > 0.05).

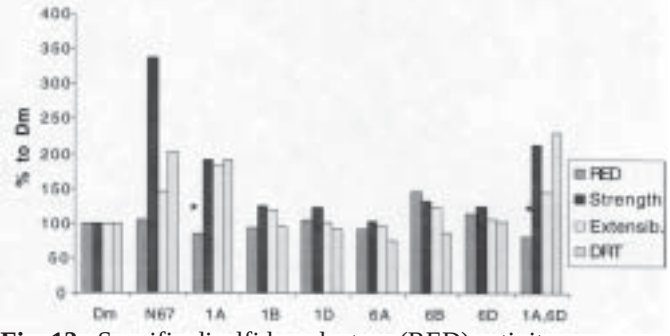

Fig. 12. Specific disulfide reductase (RED) activity, strength, extensibility, and dough-resistance time (DRT) for the parental lines Diamant (Dm) and Novosibirskaya 67 (N67) and each of the group 1 and 6 and the 1A 6D double chromosome addition lines in relation to the Diamant parental line (* = P > 0.05).

this system, RED catalyzes the reaction that reduces the disulfide bonds and participates in formation of SH/SS status of storage proteins. Figs. 11 and 12 show that the 1A substitution line and double 1A, 6D substitution line have better technological properties, higher flour strength and extensibility, dough resistance, valorimeter number, loaf volume, and a lower dough dilution. Overall, the technological properties have been improved compared to the recipient DM in lines with these substitutions. The RED activity also was significantly lower than in the recipient in these lines. The activity of RED negatively correlates with water-absorbing capacity, dough resistance, and valorimeter number Table 1.

The positive correlation with dough dilution observed may be connected with the participation of this enzyme in breaking SS-bonds in the gluten structural matrix. Introducing the favorable *Glu-A1a* allele into a cultivar genotype by intervarietal substitution is known to improve quality (Mansur et al. 1990). Our data show another result of substitution for 1A chromosome; changes in RED activity with improvement of separate technological properties. We have not found any data concerning the chromosome localization of genes for RED in cereals. The significant reduction of RED activity in lines DM/N67 1A and DM/N67 1A,6D may indicate that these two chromosomes participate directly in the genetic control of this enzyme or in regulation of its activity.

Table 1. Significant correlation coefficients of disulfide reductase activity (RED) with different quality characteristics (* = P > 0.05).

Quality characteristic	RED
Flour water-absorbing capacity	–0.759 *
Dough dilution	0.415
Dough resistance	–0.674 *
Valorimeter	–0.444

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Low-power laser irradiation as a possible morphogenesis inductor in wheat cultivar callus.

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The use of lasers has been growing steadily in the last 20 years, both in medical and biological research. The impact of laser irradiation on animal tissues and, particularly, on the human organism has been studied intensely (Devyatkov et al. 1987; Skobelkin 1997; Burlakova et al. 1998; Karu 1998; Rogatkin and Chernue 1999), whereas plants studies are relatively lacking. Plants, however, are better adjusted evolutionarily to the perception of light energy and its utilization in various physiological processes proven by the influence of irradiation on different biological units (Devyatkov et al. 1987; Skobelkin 1997; Karu et al. 1998; Bakeyeva et al. 1999; Grishko et al. 1999; Rogatkin and Chernue 1999). Numerous investigators confirm the stimulation of regenerative processes in animal and human tissues by laser irradiation (Burlakova et al. 1998). We assume a similar effect to be probable in plant tissues. The present work investigated the impact of low-power laser irradiation on morphogenesis and regeneration in the callus of wheat cultivars.

The following characteristics of cultivar tissue growth and development were determined: the number of morphogenic calli, secondary rhyzogenesis, and the number of regenerants. A helium-neon laser LG-75 with an irradiation wavelength of 632.8 nm and an intensity of 12 mV on the sample was used. The duration of the irridation was 5 min. Wheat calli of the variety Scala were used as plant material. Mature embryos with half of endosperm were used as explants. Callus induction was on a modified MS (Murashige/Scoog) medium with the addition of 2 % sucrose and 2 mg 2,4-D. Samples were irradiated on the second day after replanting on the first passage. The growth parameters were recorded for 100 calli in the test and for an equal number of control calli in three independent experiments. The number of morphogenic calli forming secondary differentiation zones, rhyzogenic zones, and the number of regenerants were calculated relative to the total amount of the samples under investigation. The reliability of differences between the average values compared was evaluated with a t-test. The dynamics of the formation of secondary differentiation zones in Scala calli during the course of the experiments is in Fig. 13.

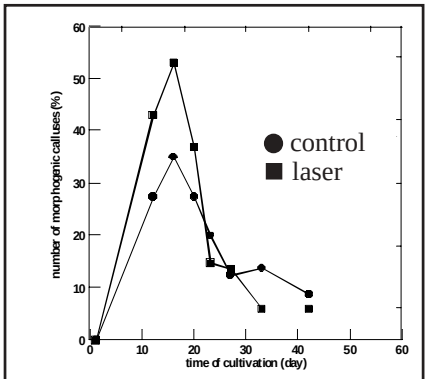

Fig. 13. The influence of low-power laster irridation on the dynamics of morphogenic calli formation in callus from the wheat cultivar Scala.

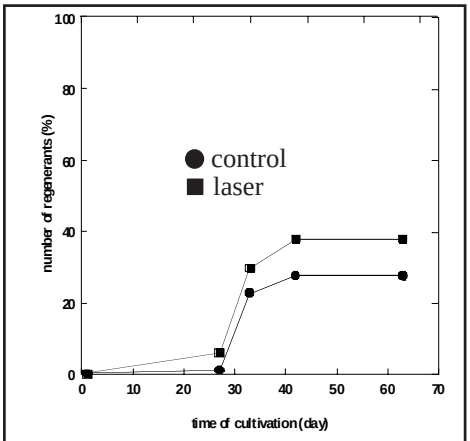

Fig. 14. The influence of low-power laster irridation on the number of regenerants in callus from the wheat cultivar Scala.

The type of dependence identified confirms the earlier established, wavelike character of morphogenic process dynamics in cultivar callus (Kuzevanov et al. 1990), both for the samples subjected to irradiation and for the control samples. The number of morphogenic calli in the samples subjected to laser treatment was systematically higher than in the control samples, on the average of 20 %, up to the time (20–25th day of cultivation) when regenerant formation began. At that time, the number of morphogenic calli in the control and test samples were equal. By the beginning of active formation of regenerants and roots from these calli, both were more numerous in the samples subjected to irradiation than in control. Especially from a biotechnological view point, the data demonstrate the dynamics of plant-regenerant formation from calli (Fig. 14).

Over the observation period, the number of the first regenerants in the samples subjected to irradiation exceeded the corresponding values in the control samples. The number of regenerants in the test averaged 38 %, whereas in the control sample it did not exceed 25 %. Over the course of the three experiments, the calli subjected to irradiation were distinctly difference compared to the corresponding values in the control samples ($P < 0.001$).

Laser irradiation may impact not only intensity, but also space and time coherence and, possibly, primarily polarization. Because the laser bundle is linearly polarized and coherent, its impact on cell structures is most likely to be anisotropic in character (i.e., the phenomenon of light-induced membrane hyperpolarization is known (Tazawa et al. 1986)). Laser irradiation may induce morphogenic processes. Evidence of a particular mutual location of cells and cell structures (so called polarity) is one of the principal conditions for the beginning of regenerative processes (Poleovoi 1989).

Based on our results, we can conclude that low-intensity coherent irradiation without changing the general dynamics of differentiation processes in wheat cultivar tissues, produces a stimulating effect on these processes by a noticeable increase of secondary differentiation zone number, root seedlings, and number of regenerants. These data make possible the use laser as a factor that can influence morphogenesis in the tissues of higher plants.

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Wheat racemase and the role of stereoisomers of N-malonyltryptophan during seed germination.

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Until recently, L-tryptophan (LTry) was presumed to be the main indole precursor of the key hormone of higher plants indolyl-3-acetic acid (IAA). In some plants, an enzyme system of IAA biosynthesis named D-tryptophan aminotransferase was reported to operate by using D-tryptophan (DTry) as a substrate (McQueen-Mason and Hamilton 1989). The formation of natural DTry is caused by the activity of another enzyme of tryptophan metabolism, a tryptophan racemase which converts LTry to DTry during several growing conditions (Law 1987). We assumed that when DTry appeared in plant tissues, it could be used simultaneously in IAA biosynthesis and in the formation of N-malonyl-D-tryptophan (MDTry) (Rekoslavskaya 1986), but not for synthesis of proteins. Rekoslavskaya et al. (1988) have shown that MDTry was accumulated in seeds and shoots of many plants during water lost.

Some researchers consider the process of formation of MDTry in plants to be an event of the IAA biosynthesis regulation system at the level of inactivation and reservation of the precursor. At the same time, the pathways of metabolism and the physiological role of this compound were not well studied.

The goal of the present study was to investigate activity of racemase in relation to the time course of germination and initial steps of growth and IAA biosynthesis. A second task was to assess configurations of MTry with respect to the biological activity of chemically synthesized enantiomers of MTry and to the growth of isolated embryos of *T. aestivum* and IAA level.

Materials and methods. The spring wheat cultivar Skala was used in this study. To determine the activity of tryptophan racemase, batches of 200 seedlings were harvested on the 3rd and 5th days after germination. Seedlings were ground in liquid nitrogen in a 0.66 M KH_2PO_4/Na_2HPO_4 buffer, pH 8.3, containing 20 μM pyridoxalphosphate, 1 mM Na EDTA, 4 mM $MgCl_2$, 1 mM phenylmethylsulfonylfluoride, 20 % glycerol, and 0.1 % mercaptoethanol. The homogenate was centrifuged at 4°C and 10,000 X g for 20 min. The fraction of pellet enriched with etioplasts was used as an enzyme source. The reaction mixture containing 5 μmoles of DTry or LTry and enzyme preparation (15–20 mg of protein) was incubated 1 h at 37°C. The quantities of DTry and LTry were determined according to the methods of Nagata et al. (1988) using D-amino acid oxydase or L-amino acid oxydase in separate experiments.

The total tryptophan transaminase and dehydrogenase activity was determined in etioplast fractions isolated according to methods published earlier (McQueen-Mason and Hamilton 1989). The amount of IAA was determined with HPLC with spectrofluorimetric detector in extracts isolated and purified according to Rekoslavskaya (1986). The amount of MTry was estimated after reaction with Ehrlich reagent and the extinction was measured at 564 nm. The synthesis of MDTry and MLTry was performed using the modified procedure reported by Satoh and Esashi (1884) for the synthesis of malonyl derivative of aminocyclopropane carboxylic acid.

Cultivation of embryos excised from dry seeds was on a modified Norstog nutrient medium deprived of casein hydrolysate and amino acids (Norstong 1973). Synthetic MLTry and MDTry were used as auxin precursors added to the agar medium. The configuration of the endogenous MTry was determined by chromatography on TLC Plates C18-Silica on glass plates (Sigma, USA). Each experiment was repeated twice at least. Data in tables are presented an average of two or three analytical repeats with calculated standard deviation.

Results and discussion. All MTry found in 2-day-old wheat embryos was identified as MDTry at 30 nmol/g. The amount of IAA determined by HPLC was 3.970.34 nmol/g fresh weight on the second day after germination. After the 5th day, the amount of IAA diminished to 0.690.19 nmol/g fresh weight. The most intensive growth of etiolated coleoptiles was between the 3rd and 4th days after germination and initial growth of seedlings when the coleoptile usually elongates very fast up to 5-6 cm in length. The activity of tryptophan racemase was determined in 3-, 5-, and 7-day-old wheat seedlings germinated in darkness (Table 2).

Table 2. The activity of conversion of L-tryptophan (L) to D-tryptophan (D) and D-tryptopan to L-tryptophan in etioplast fractions from etiolated wheat seedlings. Values presented are for nmol/mg of protein.

Days after germination	L –> D	D –> L
3	2,239	344
5	313	210
7	41	112

Obviously there was found a correlation between IAA content and activity of conversion of LTry to DTry during initial 2-3 days of germination of wheat seeds. In order to compare the conversion of DTry and LTry to IAA, the total activity of tryptophan transaminase and dehydrogenase was evaluated (Table 3).

Table 3. The activity of conversion of D-tryptophan (DTry) or L-tryptophan (LTry) to indole acetic acid (IAA) in fractions enriched with etioplasts. Values are expressed as pmol IAA/mg of protein/h.

Variant	Coleoptiles	Roots
LTry	3,429 ± 30	4,546 ± 155
DTry	1,542 ± 44	603 ± 59

Only the potential activity, not the real activity, of the enzymes was measured in the reaction mixture. We believe that coleoptiles and roots are able to convert both stereoisomers to IAA in vitro, perhaps DTry, and its stored form MDTry, might be used for IAA biosynthesis during germination by supporting the energetic heterotrophic growth.

In previous studies (McQueen-Mason and Hamilton 1988; Rekoslavskaya 1986), the concept of the role of MTry in the regulation of IAA biosynthesis implied the participation of MDTry, because it was not assumed the accumulation of MLTry in plants. Therefore, we made a comparison of synthetic MLTry and MDTry on the growth in vitro of isolated wheat embryos.

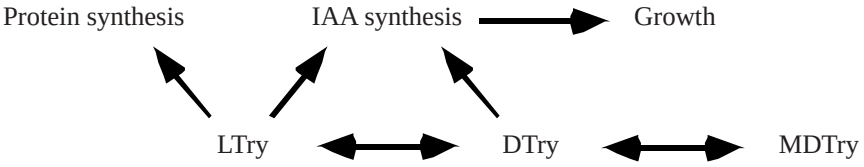
The synthetic 200 μM MDTry stimulated the formation of roots in almost 90 % of the embryos grown on the agar medium during 20 days. Unlike MDTry, MLTry retarded the growth of all parts of the embryos at all concentrations. On the media with 100 and 200 μM MLTry, about 60 % to 80 % of the embryos, respectively, perished or remained unsprouted. The concentration of IAA in embryos grown on the MDTry-containing medium (120 ng/g) was

considerably higher than that for the control and for growth on the MLTry-containing medium (10 and 40 ng/g, respectively).

The experimental material revealed a distinct correlation between the content of MDTry, IAA, and root-forming activity. The D enantiomer of MTry formed in the period of active root development in embryos of intact seedlings. We did not find MDTry in maturing wheat kernels. We concluded that racemization functions at the very early stages of germination and acts as a trigger stimulate fast, energetic germination to support auxin in the embryonic cells.

In native PAGE of purified D-tryptophan agarose-column enzyme preparations from etioplast fractions, we found the activity of tryptophan racemase as a band of 74 kD. While studying the kinetic parameters of wheat tryptophan racemase, we found that the Vmax and Km for etioplast racemase were 688 ± 26 nmol/h and 0.2 ± 0.1 mM for DTry and 2,588 ± 10 nmol/h and 0.6 ± 0.0 mM for LTry, respectively. We can assume that the shift of racemization in the L –> D direction was the consequence of the different stereospecificity of tryptophan racemase to DTry and to LTry.

Based on these data, we concluded that the formation of the endogenous MDTry in wheat embryos was probably one way of regulating IAA biosynthesis at the level of inactivation and reservation of the precursor. In this light, the chain of tryptophan transformations directed to IAA biosynthesis can be represented as follows.



Thus, LTry can be used for the synthesis of IAA and protein simultaneously. On germination, under the conditions of activation of protein synthesis and increasing requirement in auxin, the system for forming and reserving the nonproteinogenous precursor of IAA DTry (DTry) acts, perhaps, as an additional regulatory component, independent on the main nitrogen metabolism that determines the IAA status and growth potential of embryos.

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Quantitative characterization of the stomatal apparatus in monosomic lines of Chinese Spring wheat.

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By investigating monosomic wheat lines, numerous genetic effects of various characters were revealed and their chromosomal localizations of the corresponding genes established (Arbuzova and Maistrenko 1986; Goncharov 1992). Genes localized on chromosome 3A of winter wheat affect stoma resistance (Bobo et al. 1992). The relationship between the stomatal apparatus itself and individual chromosomes remains unexplored, although it attracts a fair amount of attention

Table 4. Indices of the stomatal assemblage (± S) on the upper surface of the preflag leaf in monosomic lines for each of the A, B, and D genomes of wheat variety Chinese Spring and the Chinese Spring control. Number of stomata is per mm^2; all other measurements are in microns. P ≤ 0.05, ** P ≤ 0.01, and *** P ≤ 0.001.

	Character				
				Size of stomata	
Line	Number of stomata	Distance between stomata	Distance between stomatal rows	length	width
1A	56.6 ± 1.4	7.2	11.0	4.34 ± 0.8***	2.58 ± 0.2***
2A	55.1 ± 2.5	6.4	12.9	4.40 ± 0.6***	2.58 ± 0.2***
3A	46.5 ± 1.0*	7.2	13.8	4.63 ± 0.5	2.58 ± 0.2***
4A	43.0 ± 1.3**	7.9	11.5	5.58 ± 0.4***	2.29 ± 0.2***
5A	39.6 ± 0.7***	15.5	10.3	4.63 ± 0.6	2.60 ± 0.4***
6A	55.1 ± 1.3	6.6	13.4	4.46 ± 0.4***	2.55 ± 0.3**
7A	49.6 ± 1.2	8.7	11.5	3.71 ± 0.6***	2.97 ± 0.2***
Mean	49.4 ± 0.0	9.2	12.1	4.49 ± 0.0	2.62 ± 0.0
1B	47.0 ± 1.2*	8.4	13.8	4.98 ± 0.4	2.70 ± 0.2***
2B	57.3 ± 1.5	8.0	11.6	4.69 ± 0.8	2.60 ± 0.4***
3B	53.6 ± 1.8	7.6	12.8	4.75 ± 0.6	2.88 ± 0.2***
4B	44.2 ± 1.1**	11.5	13.4	4.92 ± 0.4*	3.02 ± 0.2***
5B	42.4 ± 1.0***	10.7	12.7	5.22 ± 0.7***	2.71 ± 0.3***
6B	55.9 ± 1.8	8.9	10.2	4.52 ± 0.4**	2.19 ± 0.2***
7B	49.7 ± 1.0	8.0	15.0	4.69 ± 0.6	2.61 ± 0.4***
Mean	50.0 ± 0.0	9.0	12.8	4.82 ± 0.0	2.67 ± 0.0
1D	39.7 ± 1.0***	9.0	12.3	4.72 ± 0.6	2.60 ± 0.3***
2D	42.0 ± 1.6*	10.9	12.0	4.72 ± 1.1	2.74 ± 0.3***
3D	41.7 ± 1.6***	10.1	11.6	5.44 ± 0.5***	2.47 ± 0.3
4D	40.4 ± 1.0***	11.2	11.9	5.05 ± 0.6	2.56 ± 0.4**
5D	44.6 ± 1.5**	8.9	9.3	4.89 ± 1.4	2.62 ± 0.4***
6D	50.4 ± 1.2	12.1	8.1	4.08 ± 0.5***	2.25 ± 0.3***
7D	43.1 ± 1.9*	11.6	10.1	4.94 ± 0.7	2.60 ± 0.4**
Mean	43.1 ± 0.0	10.6	10.9	4.83 ± 0.0	2.54 ± 0.0
Control	55.7 ± 1.3	7.1	10.8	4.75 ± 0.5	2.44 ± 0.2

because it is associated with productivity and drought resistance (Sherifi 1991; Zhuravleva 1992; Wang and Clarke 1993a; Tupitsyn 1995).

This study was on monosomic lines of common wheat variety Chinese Spring. The effect of the absence of individual chromosomes on quantitative characters of the stomatal apparatus (number of stomata/unit leaf area, distance between stomata in a row, distance between the rows, and length and width of stomata) were investigated. Monosomic lines of Chinese Spring for each chromosome of the A, B, and D genomes were grown under identical conditions in a growth chamber. Disomic Chinese Spring also was grown as a control.

Prints were taken from leaves by a procedure that involved smears of chloroform-dissolved polymetyl methacrylate (Davidov 1991). Taking into account the considerable variability of stomata indices even within a single leaf blade (Wang and Clarke 1993b), prints were taken from the lower and upper sides of the middle part of the preflag leaf at boot stage. The prints were examined microscopically and the results are given in Tables 4 for the upper-leaf and 5 (p. 145) for the lower-leaf surfaces.

Number of stomata. Lines monosomic for chromosomes 2B, 1A, 6B, 2A, and 6A had the highest number of stomata on the upper-leaf surface and 5A, 1D, 4D, 3D, 2D, and 7D had the lowest number. On the lower side of the blade, lines

Table 5. Indices of the stomatal assemblage (± S) on the lower surface of the preflag leaf in monosomic lines for each of the A, B, and D genomes of wheat variety Chinese Spring and the Chinese Spring control. Number of stomata is per mm^2; all other measurements are in microns. P ≤ 0.05, ** P ≤ 0.01, and *** P ≤ 0.001.

	Character				
				Size of stomata	
Line	Number of <stomata	Distance between stomata	Distance between stomatal rows	length	width
1A	32.0 ± 0.3	18.3	15.4	4.24 ± 1.1***	2.42 ± 0.3***
2A	19.5 ± 0.3***	14.4	16.5	4.83 ± 0.4	2.89 ± 0.3
3A	27.5 ± 0.5	22.7	16.0	4.75 ± 0.5	2.43 ± 0.5***
4A	21.3 ± 0.3**	18.6	17.8	5.62 ± 0.8***	2.30 ± 0.3***
5A	11.7 ± 0.3***	21.5	25.0	4.39 ± 0.7***	2.68 ± 0.3
6A	28.4 ± 0.3	15.0	15.1	5.03 ± 0.4	2.68 ± 0.3
7A	29.0 ± 0.2	15.5	14.1	3.79 ± 0.4***	2.71 ± 0.2
Mean	24.2 ± 0.0	18.0	17.1	4.66 ± 0.0	2.58 ± 0.0
1B	24.6 ± 0.3	27.7	16.7	4.86 ± 0.4	2.94 ± 0.3***
2B	30.6 ± 0.3	20.9	12.7	4.84 ± 0.7	2.67 ± 0.3
3B	31.0 ± 0.4	16.3	12.6	4.47 ± 0.5***	3.25 ± 0.3***
4B	17.4 ± 0.3**	23.1	21.3	5.22 ± 0.5	2.62 ± 0.4
5B	25.0 ± 0.3	23.9	13.2	5.41 ± 0.5***	2.62 ± 0.3
6B	32.6 ± 0.3	15.6	13.3	5.04 ± 0.5	2.45 ± 0.3***
7B	49.7 ± 1.0	11.9	14.7	4.49 ± 0.5***	2.16 ± 0.4***
Mean	28.3 ± 0.0	9.0	14.9	4.90 ± 0.0	2.67 ± 0.0
1D	17.4 ± 0.3**	19.8	21.9	4.76 ± 0.66	2.77 ± 0.3***
2D	17.9 ± 0.2**	24.1	18.4	4.88 ± 0.5	2.39 ± 0.2
3D	16.2 ± 0.3***	26.6	18.2	4.43 ± 0.3***	2.68 ± 0.3
4D	16.5 ± 0.3***	25.4	20.6	4.63 ± 0.6**	2.56 ± 0.4*
5D	18.4 ± 0.4**	24.8	17.8	4.79 ± 0.7	2.64 ± 0.3
6D	25.7 ± 0.3	23.2	10.5	4.45 ± 0.5***	2.08 ± 0.3***
7D	17.6 ± 0.4**	24.9	16.6	4.68 ± 0.4**	2.50 ± 0.4***
Mean	18.5 ± 0.0	24.1	17.7	4.66 ± 0.0	2.51 ± 0.0
Control	28.1 ± 0.3	18.7	17.6	4.89 ± 0.5	2.65 ± 0.3

monosomic for chromosomes 7B, 6B, 1A, 3B, and 2B had the highest number of stomata and 5A, 4D, 7D, 2D, 3D, 3B, 5D, and 2A had the lowest number (Tables 4 and 5).

Generally, lines monosomic for A- and B-genome chromosomes differed little in the number of stomata on the upper-leaf surface (49 and 50 stomata/mm^2), whereas in the D-genome monosomics this index was 43 stomata/mm^2. The greatest value for the mean density of stomata on the lower-leaf surface was observed in monosomics for the B genome (28 stomata/mm^2), slightly greater than for the A genome (24 stomata/mm^2), with the least amount found in the D genome (18 stomata/mm^2).

Distance between stomata. Despite the fact that in some lines the distance between stomata varied from 2–27 μm, the mean value of this index on the upper-leaf surface was fairly stable; it was very similar for all genomes and varied from 9.0–10.6 μm. The greatest mean distance between stomata in a row was observed in monosomic line 5A (15.5 μm) and the least was in monosomic 2A (6.4 μm). On the lower-leaf surface, the mean distance between stomata was approximately half of that of the upper surface, varying from 18–24 μm. However, in all lines, including the control, stomata were lacking in considerable areas, sometimes 100 μm or greater. On the upper surface, such gaps were observed only in lines monosomic for chromosomes 6A and 4B.

Distance between the stomatal rows. On the upper-leaf surface, this index varied from 3–28 μm and averaged over the groups varied from 10.9–12.8 μm. On the lower surface, this character was more variable (5–65 μm), averaging from 14.9–17.7 μm.

Stoma length and width. On the upper-leaf surface, stoma length varied from 3.71 (monosomic 7A) to 5.44 μm (monosomic 3D). The values of this index averaged over the groups were very close, from 4.49–4.83 μm. Stoma width varied from 2.19 μm (monosomic 6B) to 3.02 μm (monosomic 4B). The value of this index averaged over the groups was less variable than that of width, from 2.54–2.67 μm. On the lower-leaf surface, the shortest stomata were found in the line monosomic for 7A (3.79 μm) and the longest was in monosomic line 4A (5.62 μm).
Stoma width on the lower leaf side varied from 2.08 μm (monosomic 6D) to 3.25 μm (monosomic 3B). The values averaged over the genome groups were similar, ranging from 2.51–2.67 μm. Although the ratios between the length and width of stomata in individual lines varied from 1.39–2.44 (lower-leaf surface, monosomic lines 7A and 4A), their mean values were 1.70–1.89.

Linear sizes of stomata were affected most by the absence of chromosome 7A. The mean stoma length in this line was less than that of the control by 21.9 and 22.5 % on the upper- and lower-leaf surfaces, respectively. The absence of chromosome 6D genes also affected the stoma length significantly. In this line, the mean stoma lengths were 14.1 and 9.0 % less than in the control on the upper and lower surfaces, respectively. By contrast, in momosomic 4A, an increase in mean stoma length by 17 % on the upper surface and 15% on the lower surface with respect to the control were observed.

Monosomy also can have the opposite effect, where the absence of a given chromosome may increase or decrease the value of a character in some cases (Tsil'ke and Tsil'ke 1973). The coefficient of variation is an important index of a character that measures the degree of variability. Distance between stomata on the lower-leaf surface had the greatest coefficient of variation, from 50.0 % in monosomic 5A to 154.5 % in monosomic 2B, which was explained by irregular positions of stomata within the rows. On the upper surface, the coefficient of variation of this index was much lower. Only in lines monosomic for chromosomes 6A (143.7 %) and 4B (139.4 %) was an irregular stoma distribution observe and did not exceed 60 % in the other lines. The coefficient of variation for distance between stoma rows did not exceed 50 % on either leaf surface. The number of stomata had an even lower coefficient of variation, below 40 % on the lower surface and below 15 % on the upper. The linear size of stomata were the least variable. The coefficient of variations were approximately equal on both sides and usually did not exceed 10 %.

Chromosome dosage, which effects gene dosage in various monosomic lines of Chinese Spring wheat, may cause considerable changes in the features of the stomatal apparatus. Absence of one dose of genes of the critical chromosome 5A exerted the greatest effect on the number of stomata and caused a decrease in their density by almost one-third on the upper-leaf surface and by more than a half on the lower, when compared with disomic Chinese Spring plants. The lack of some of the other chromosomes produced lesser effects, but also effected both the number of stomata and their linear sizes.

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Molecular forms of lipoxygenase from the grain of various cultivars of Triticum aestivum L.

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Lipoxygenases (Lpx, linoleate:oxygen oxidoreductase, EC 1.13.11.12) occur in plants as groups of enzymes catalyzing dioxidation of unsaturated fatty acids with forming superoxide radicals that may in vivo oxidize SH-groups of wheat storage proteins (Grechkin 1998). Best studied are soy seed lipoxygenases, where they amount to 2 % of protein and are represented by three isoforms (Axelrod et al. 1981). Durum wheat caryopses also contain three molecular forms of this enzyme with a molecular mass approximately of 100 kD (Hsieh and McDonald 1984). Thus, investigators are interested in lipoxygenase primarily because of its role in the in vivo formation of oxide radicals that may oxidize SH-groups of wheat storage proteins with the formation of inter- and intramolecular disulfide bonds stabilizing gluten protein complex. The influence of each lipoxygenase isoform is connected with SH-groups oxidation of storage proteins and improvement of certain gluten quality parameters (Shiiba et al. 1991). In this respect, we were interested in investigating the combination of molecular forms of lipoxygenase from various cultivars grains of wheat.

Materials and methods. Scala, Tulunskaja 12, Rollo, and Drott of cultivars grains of wheat were chosen for our investigations. The soluble, enzymatically active protein fraction of the wheat grain was extracted with a Tris buffer, pH 7.5, containing 5 mM EDTA, from standard ground flour in the proportion 1:2 (weight:volume). Subunit composition of the acquired fractions separated in SDS-PAGE according to the method of Laemmli (Laemmli 1970). Native salt-soluble proteins of the wheat grains of various cultivars were separated according to the method of Davis (1964) at the basic pH. Molecular forms of Lpx were identified immediately on gel slabs by specific coloring with sodium linoleate and iodine-starch reagent (Heydeck and Scewe 1985).

Results and discussion. Structural genes encoding lipoxygenase synthesis are known to be localized in chromosomes of homoeologous groups 4 and 5 (Li et al. 1999). The study of lipoxygenase activity in the grain of soft wheat varieties Saratovskaja 29 and Janetzkis Probat and their with intervarietal substitution lines of individual chromosome pairs 4A, 4B, 4D, 5A, 5B, and 5D indicated reliable differences in the effects of these chromosomes by the level of lipoxygenase activity in the recipient variety Saratovskaja 29 (Didenko et al. 2001). The results indicated genotypic differences in the expression of lipoxygenase structural genes and the important role in the demonstration of gene-regulator enzyme activity.

To establish variety-specificity in the level of lipoxygenase activity, we compared electrophoretic spectra of salt-soluble protein fraction of the caryopses of four varieties of spring soft wheat of different origin (Fig. 15). Specific coloring of protein spectra acquired by native PAGE-electrophoresis and iodine-starch reagents (Heydeck and Schewe 1985) allowed the identification from each variety of all three molecular forms of lipoxygenase with relative electrophoretic mobility 0.37, 0.32, and 0.24 marked *Lpx-1*, *Lpx-2*, and *Lpx-3*, respectively. In native state, the *Lpx-1* and *Lpx-3* isoforms significantly differ by their molecular surface charge and by relative electrophoretic mobility.

Fig. 15. Separation of lipoxygenase isoforms in native PAGE electrophoresis of soluble proteins of wheat cultivars (1) Scala, (2) Tulunskaia 12, (3) Rollo, and (4) Drott.

Subunit composition of salt-soluble proteins of individual caryopses of the four wheat varieties with electrophoretic fractioning in SDS-PAGE proved to be very heterogeneous (Fig. 16, p. 148). Nevertheless, subunit spectra for all the wheat varieties studied were similar and contained relatively high molecular polypeptides with molecular weights of 115, 105, 94, 85, and 75 kD.

The presence of three identical isoforms of native lipoxygenase and protein subunits with identical molecular weight in the grain of

genotypically different wheat varieties allows us to infer similarity in the expression of genes localized in chromosomes of homoeologous groups 4 and 5.

The results are to some extent contradictory with the data of Shiiba et al. (1991), who reported the presence in wheat caryopses of three lipoxygenase isoforms (L-1, L-2, and L-3) differing in the value of surface charge and affinity to various ion-exchangers, but characterized by the same mobility after SDS-PAGE electrophoresis (rf = 0.28) and a molecular weight of about 110 kD.

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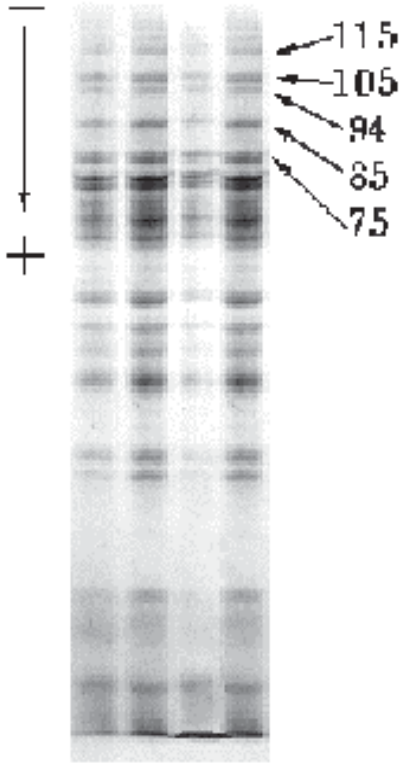

Fig. 16. SDS-PAGE electrophoresis of soluble proteins of wheat cultivars (1) Scala, (2) Tulunskaia 12, (3) Rollo, and (4) Drott.

Mineral nutrition and productivity of spring wheat on fluoride-polluted, gray forest soil.

L.V. Pomazkina and L.G. Kotova.

Technologic pollution is known to affect field crop metabolism and harvest. Plant response to the accumulation of pollutants in the soil depends on their toxicity, soil properties, and species of field crop (Kabata-Pendias and Pendias 1986; Il'yin 1991; Pomazkina et al. 1999a). This research is highly topical due to the pollution of arable soils in the Baikal Region by industrial exhaust from Russia's largest aluminum plants. Fluoride compounds classed as highly toxic prevail in the exhaust and their impact on mineral nutrition and productivity of spring wheat has not been studied sufficiently.

We hope to identify the impact of technologic pollution by water-soluble fluorides of gray forest soil on the productivity and mineral nutrition of spring wheat and fluorine accumulation. Greenhouse experiments were made on fluoride-polluted and unpolluted soils with similar properties. The humus content in unpolluted soil is 2.2 %, total N is 0.15, salt is 5.7, and base exchange is 24.4 mg-equiv/100 g. In polluted soil the humus content is 2.5 %, total N is 0.13 %, salt is 5.6, and base exchange is 24.4 mg-equiv/100 g. These soils have a very low content of dynamic macro-elements. The content of water-soluble fluorides in unpolluted soil correspond to the regional background, 5 mg/g of soil. In soil zones located in the area of local pollution by the aluminum plant, the water-soluble fluroride content is 60 mg/kg. The high level of pollution (220 mg/kg) was modeled by the additional introduction of NaF into the soil.

Experiments were conducted in a phytotron in the pots with 4 kg of soil. During the sowing season until the emergence of sprouts, air temperature was maintained at the level of 25°C and during the vegetative season, the daytime

temperature was 20°C and the night temperature was 18°C. During the 16-h light period, the degree of light amounted to 10,000 lux. Soil humidity was maintained by daily irrigation with distilled water and was calculated as 60 % of total moisture capacity. Experiments included a control (no fertilizer), an NPK treatment, and an NPK + NaF treatment. We used chemically pure salts of $Ca(H_2PO_4)_2$, KCl, and NH_4NO_3, which were introduced during filling of the pots. The dose of N, P, and K was 0.1 mg primary nutrient/kg of soil. The spring wheat Skala was planted as germinated sprouts at a rate of 14 plants/pot. The plants were harvested in the blooming phase. The experiments were replicated three times.

Total nitrogen in the plants was determined by the procedure, protein nitrogen with trichloroacetic acid, phosphorus by Alen's method with amidol, and potassium by flame emission photometer. Fluorine content was analyzed using arsenase by spectrophotocolorimetrical methods. Statistical data was processed by Microsoft Excel 2000.

Wheat productivity was more dependent on the amount of macro-elements in the soils than by pollution by water-soluble fluorides (Table 6). In unpolluted and polluted soils, the surface mass of wheat was low in the control plants and high in the NPK treatment. The efficiency of fertilizers was highest in unpolluted soil. In the soils with NaF, the surface mass was 40 % lower when compared to the background. This reduction may be connected not only with fluorine phytotoxicity, but with an increase in sodium content in the soil.

Table 6. Biomass and fluorine content in spring wheat at anthesis in polluted (A) and unpolluted (B) soils.

Soil type	F water-soluble (mg/kg)	Treatment	Biomass g/pot	Addition to control g/pot	F, mg/kg of dry matter	
					Surface	Roots
A	5	Control	4.2	—	55	56
		NPK	13.9	9.6	56	73
		LSD_{05}	0.4	11.0	20	
B	57	Control	4.0	—	88	110
		NPK	10.0	6.9	63	80
B	220	NPK + NaF	6.5	2.5	64	1,170
		LSD_{05}	2.1	15.0	25	

Fluorine content in the surface mass and roots of wheat grown in polluted soil was higher, particularly when no fertilizers were used. The comparatively low accumulation in plants supplied with NPK was apparently conditioned by a dilution effect due to high productivity. High fluorine content with NaF treatment was noticed only in the roots, which are characterized by their barrier function. Fluorine accumulation in the roots is known to produce a negative effect on plant metabolism (Vlasyuk 1969).

The absorption of certain macroelements by wheat on fluoride-polluted soils is demonstrated their proportion in the tissues (Table 7). During anthesis, the optimum N:P:K content in spring wheat is considered to be approximately

Table 7. Proportions of N, P, and K and nitrogen content in spring wheat plants in anthesis.

Soil	F water-soluble mg/kg	Treatment	Surface			Roots	
			N:P:K	N, mg/g of dry matter	Nonprotein N % of total	N:P:K	N, mg/g of dry matter
A	5	Control	40:11:49	15.8	31	35:9:56	8.8
		NPK	52:9:39	23.3	39	62:7:31	15.8
		LSD_{05}		2.5			3.2
B	57	Control	40:14:46	19.3	28	38:13:49	10.8
		NPK	59:9:32	26.9	44	68:5:27	19.5
	220	NPK + NaF	63:8:29	31.7	52	78:6:16	22.0
		LSD_{05}		3.3			3.0

50–57:7–9:36–43 (Tserling 1990). NPK treated plants showed approximately the same parameters in unpolluted soil. Tests on both soils showed a decrease in nitrogen, which is partially due to with its lack in the soil. In polluted soil in plants with an NPK treatment, the nitrogen share was higher, particularly in the variant with NaF (63 %). Similar changes in N:P:K proportions were observed in wheat roots.

The negative effect of soil pollution by fluorides also was observed in the increase of nitrogen required for the formation of 1 gram of dry matter in the above-ground parts and roots of wheat, particularly in the NaF-treated soil. The increase in the nitrogen content of these plants may be considered a nonspecific reaction caused by the toxicant and corresponds to an increase in nitrogen consumption by wheat in stress conditions (Al'tergot et al. 1974; Pomazkina et al. 1999a). Intensive nitrogen absorption by plants could be a consequence of increases in soil-nitrogen mineralization under technologic pollution of soils (Pomazkina et al. 1999b, 1999c).

An increase in the nonprotein-nitrogen fraction in wheat tissues also indicates nitrogen exchange on fluoride-polluted soils. For example, in the above-ground parts of the plants in the NPK treatment on polluted soil, nonprotein nitrogen amounted to 44 % of total nitrogen. With the NaF treatment, nonprotein nitrogen was 52 %, in contrast to 39 % in the plants on unpolluted soil. This decrease may be due to lower synthesis processes because of higher fluorine content in the roots.

The negative impact of technologic pollution of soils by fluorides was demonstrated in the disturbance of mineral nutrition and metabolism of spring wheat. We observed changes in the proportion of N:P:K in the tissues, largely because of increases in nitrogen. The increase in nonprotein nitrogen in the above-ground plant parts demonstrates an imbalance of synthesis-decomposition processes. The most significant changes responsible for the decrease in wheat productivity were identified when modeling high pollution levels. The disturbances revealed corresponded to fluorine accumulation in the roots.

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Genealogical analysis of spring bread wheat resistance to loose smut.

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Loose smut is the serious disease of common wheat that is widely distributed in all wheat-growing areas and considered to be important in arid and semi arid regions of eastern Europe and Russia including western and eastern Siberia.

The purpose of our work was to analyze resistance to loose smut in bread wheat by comparing groups of resistant and susceptible spring wheat cultivars from two regions, Russia and North America, using a genealogical approach.

The data on bread wheat cultivars were taken from the database of the Information and Analytical System GRIS3.5. The GRIS database contains passport information for more than 100,000 accessions; 650 are characterized as resistant, 225 as is moderately resistant, 426 as susceptible, and 97 accessions have contradictory estimations of resistance/susceptibility.

This information, assembled from the various publications, was received over time from different researchers. For the genealogical analysis of resistance, we created two groups (i) Russian-released spring wheat cultivars and perspective lines (336) and (ii) North American-released spring wheat cultivars (106). Each of these groups were divided on two subgroups; resistant and susceptible to loose smut. Among Russian accessions analyzed, 180 were resistant (the majority are listed in Table 5) and 156 were susceptible (Alenkaya; Altaiskaya 50, 81, and 92; Albidum 21, 24, 28, 29, 43, 233, 604, 1616, 1697, 2815, 2817, and 3700; Albosar; Albocaesium 65; Amurskaya 90 and 1495; Amurskaya Golokoloska; Angara 86; AS-29; Baganskaya 93; Balaganka; Barnaulskaya 83; Belyanka; Biryusinka; Blansar; Botanicheskaya 2; Caesium 111; Chelyabinskaya 12; Chernyava 13; Dalnevostochnaya 10; Dvulineinaya (1986); Dobrynya; Duvanskaya Krasnokoloska; Enita; Ershovskaya 32; Erythrospermum 5, 7-5, 8-5, 14, 36-5, 43-5, and 59; GDS 11; Irgina; Iren; Ivolga; Kamalinka; Kantegirskaya 89; Kerba; Kinelskaya 59, 60, and 97; Krasnokutka 5, Krasnoyarskaya 83, Krestyanka, Krokhinskaya, Kurganskaya 1, L-503, L-505, Leda, Leningradskaya 88, Line 36-74, 611-h-73, and 7-72; Lira; Lutescens 22-5, 25, 53-12, 62, 74, 121, 277, 508, 521, 1272, 2074, and 3221; Lyuba; Milogradovka; Milturum 321 and 553; Niva; Noe Selektsionnaya; Novosibirskaya 81 and 89; Obskaya 14; Omskaya 9; 12, 17, 18, 19, 20, 26, and 29, Ordynskaya, Oya, Piramida, Poltavka, PPG 23021-35, PPG 23311, Priamurskaya 93, Priirtyshskaya 86; Primorskaya 21; Priokskaya; Prizeiskaya; Rodina; Rosinka; Rosinka 2; Russa; Samsar; Saratovskaya 32, 38, 42, 46, 56, 62, 64, 66, and 210; Sarrubra; Sayanskaya 55; Selenga; Severyanka; Sibirka; Sibirka 1818; Sibiryachka 4; Simbirka; Skala; Skent 1; Smena; Sredneuralskaya 77; Strube; Tertsiya; Tulaikovskaya Stepnaya; Tulun 14, 15, and 32; Tulunskaya 10 and 12; Tyumenskaya 80; Tyumenskaya Rannyaya; Udarnitsa; Uralochka; Velutinum 15; Vetluzhanka; Voronezhskaya 6 and 12; Zemlyachka; Zhemchuzhina Zavolzhya; and Zlatozara). Among the North American spring wheat cultivars were 66 resistant (Table 4) and 40 susceptible varieties (AC Abbey, AC Eatonia, AC Intrepied, AC Majestic, AC Nanda, AC Phil, AC Reed, AC Taber, Biggar, Chester, Chinook, Columbus, Cutler, Cypress, Early Triumph, Genesis, GP-318, Huron, HY 320, Lake, Laura, Milton, Montana King, Oslo, Pasqua, Rescue, Reward, Sinton, SWS 52, and Vernon (Canada) and Ceres, Crim, HJ-98, Kota, Lathrop, Lee, Milam, Minnpro, Norm, and Verde (U.S.).

For each of the 442 accessions, we have constructed a genetic profile. In this profile we name the original ancestors that are included in family tree and their theoretical contributions in the genome of the cultivar. This contribution was estimated by calculating the coefficient of parentage between a cultivar and its ancestor. Two-way analysis of variance of the ancestor contributions for the design of unorganized replications was used in both groups. The source of resistance to loose smut was traced on expanded pedigrees with the help of an option from GRIS. The pedigrees of 336 Russian accessions were traced back to 218, and 106 North American cultivars back to 125 ancestors representing land races, local varieties, and material of unknown origin from the various countries of the world. For example, Table 1 (p. 152) shows the genetic profile for the Canadian spring wheat cultivar AC-ABBEY.

The genetic profile of one cultivar can be considered as a vector of the contributions to the 'final' ancestors in the genome of a cultivar, and the set of profiles of a set of cultivars represents a matrix of the ancestral contributions.

To reveal the distribution of the contributions of ancestors in subgroups of resistant and susceptible accessions, we made a two-way analysis of variance of the ancestor contributions. The factors investigated were subgroups of resistance (factor A) with two classes (resistance and susceptibility) and dominant ancestors (factor B) with number of classes b = 33 (Russian group) or b = 41 (North American group). Ancestors were considered dominant ancestors if the frequency was greater than 20 %. The ANOVA results were similar in both groups (Table 2, p. 153). The effects of the resistance/susceptibility (factor A) were not significant. The effects of ancestors (factor B), and also 'ancestor x subgroup' interaction (A x B) were all highly significant ($P < 0.005$). The fact that factor A was not significant specifies that in each group, resistant and susceptible varieties occur from the same ancestors. The significance of factor B indicates the existence of sets of the basic ancestors that are stable and region-specific. For example, among the Russian spring wheats varieties, the local variety Poltavka is very common, with an average contribution of 0.203 at a 63.8 % frequency of presence, whereas the contribution of a local variety Ostka Galicyjska was 0.042 with frequency of presence 69.4 %. In the group of North-American cultivars, the contribution of Ostka Galicyjska is the greatest (0.146), and it is present at all cultivars of this group.

Table 1. Genetic profile for the Canadian spring wheat cultivar AC-ABBEY (1998).

Name of ancestor	Country	Contribution
Hard Red Calcutta	India	0.2344
Ostka Galicyjska	Poland	0.1770
Crimean	Ukraine	0.1168
Iumillo	Italy	0.0993
LV-PRT (via S-615)	Portugal	0.0645
Kota	Russia	0.0264
Polyssu	Bazil	0.0193
Akakomugi	Japan	0.0193
Kenya-Standard	Kenya	0.0161
Yaroslav-emmer	Russia	0.0148
Turco	Brazil	0.0145
Red Egyptian	Egypt	0.0137
Kenya-BF-4-3-B-10-V-1	Kenya	0.0137
Rieti	Italy	0.0097
LV-Mediterranean		0.0059
Red Straw	Great Britain	0.0050
Ladoga	Russia	0.0032
Zeeuwse	the Netherlands	0.0024
Gehun	India	0.0018
Etawah	India	0.0016
Hybrid English	Great Britain	0.0010
Goldendrop	Great Britain	0.0010
Button	Kenya	0.0009
Gaza	Egypt	0.0007
Onega	Russia	0.0005
Kenya C-9906	Kenya	0.0005
Pusa 107	India	0.0005
T. timopheevii		0.0003
Rough Chaff White	Great Britain	0.0003
Daruma	Japan	0.0002
Kenya 9-M-1-A-3	Kenya	0.0002
Kenya U	Kenya	0.0002
LV-ENG (via Prince Albert)	Great Britain	0.0001
Redchaf	USA	0.0001
Indian G	India	0.0001
Red King	USA	0.0001
Barleta	Argentina	0.0001
Chinese Spring	China	0.0001
LV-URY (via Americano 25-E)	Uruguay	0.0001
LV-URY (via Pelon 33-C)	Uruguay	0.0001
Sicilian Squarehead	Italy	0.0001
Carosella	Italy	0.0001

A highly significant interaction (A x B) between resistance (A) and ancestors (B) indicates that the ratio of the ancestor contributions in a subgroup of resistant accessions differs from that in a subgroup of susceptible accessions. Thus, the average contribution of the major ancestors of North American spring wheat cultivars, Ostka Galicyjska, Hard Red Calcutta, and Crimean, are significantly higher in a resistant subgroup in comparison with a susceptible subgroup both for North American and Russian cultivars. The most important ancestors of Russian spring wheats Poltavka and Selivanovsky Rusak also differ significantly in subgroups of resistant and susceptible accessions. The average contribution of Poltavka is much higher among the susceptible subgroup, and Selivanovsky Rusak prevails in a subgroup of resistant accessions (Table 3, p. 153).

An analysis of the sources of resistance to loose smut was made with the aid of an option in the GRIS database that traces the transmission of a given gene allele or trait from ancestors to descendants on a pedigree tree. For a given cultivar, the program produces a list of ancestors with resistance to smut and a pedigree tree with ancestors marked for carrying resistance gene. For example, in Fig. 1 (p. 155) the expanded pedigrees of the spring wheats Thatcher, Saratovskaya 29, and Saratovskaya 35 has cultivars that are marked as resistant (Ut) or susceptible (ut) ancestors.

The results of the analysis of North American cultivars are shown in Table 4 (p. 159). By the tracing the resistance on expanded pedigrees, we can establish that a limited set of sources of resistance to loose smut is used in spring wheat breeding. Spring wheat cultivars from Canada and the U.S. received resistance mainly from three sources; the Polish local variety Ostka Galicyjska, the durum landrace Iumillo from Italy or Northern Africa, and a Ukrainian landrace Crimean brought by the Mennonites in 1873 from Crimea to North America). Two-thirds of the cultivars received resistance from three listed sources through Thatcher (Fig. 1a, p. 155) and its derivatives (Neepawa, Pembina, and Manitou). One source of resistance in approximately one-fourth of the pedigrees was Ostka Galicyjska. The resistance genes in this cultivar is from Marquis and its derivatives (Canus, Hope,

Table 2. Analysis of variance of the predominant ancestor contributions in subgroups of resistant and susceptible spring bread cultivars from two regions. * = significant at P < 0.005.

	Russia				North America			
Source	SS	df	ms	F	SS	df	ms	F
General	34.277	11,120			12.414	4,345		
Resistance (A)	0.007	1	0.0066	3.091	0.003	1	0.0031	1.827
Ancestors (B)	12.595	32	0.3936	184.111*	5.057	40	0.1264	74.470*
Interaction (A x B)	0.370	32	0.0116	5.415*	0.116	40	0.0029	1.705*
Error	21.305	11,055	0.0021		7.239	4,264	0.0017	

Table 3. Average contributions of predominant ancestors of Russian and North American spring wheats in subgroups of resistant and susceptible accessions. Values (inside one group) followed by different letters are significantly different at P = 0.05 by Duncan's multiple range test.

	Russia		Canada and the U.S.	
Name of ancestor	Resistant	Susceptible	Resistant	Susceptible
Poltavka	0.178 m	0.227 n	—	—
Hard-Red-Calcutta	0.060 l	0.032 h	0.166 q	0.139 o
Ostka Galicyjska	0.054 kl	0.030 fgh	0.161 pq	0.122 n
Selivanovsky Rusak	0.051 jkl	0.029 efgh	—	—
Crimean	0.045 ijk	0.024 cdefgh	0.099 m	0.073 l
Beloturka	0.026 defgh	0.032 gh	—	—
Iumillo	0.015 bcd	0.005 ab	0.050 k	0.039 ijk
Kenya C-9906	0.012 ab	0.008 ab	0.025 efghij	0.031 ghij
LV-UKR via Lutescens 17	0.012 ab	0.012 ab	—	—
Gehun	0.010 ab	0.008 ab	0.008 abcde	0.007 abcde
Ladoga	0.010 ab	0.009 ab	0.014 abcdefg	0.028 fghij
Mediterranean	0.009ab	0.008 ab	0.009 abcdef	0.012 abcdefg
Banatka	0.009 ab	0.010 ab	—	—
Akakamugi	0.007 ab	0.006 ab	0.020 abcdefgh	0.023 cdefghij
LV-Irkutsk via Balaganka	0.007ab	0.014 abc	—	—
Yaroslav emmer	0.005 ab	0.004 ab	0.036 hijk	0.018 abcdefgh
Barleta	0.004 ab	0.003 ab	0.006 abcde	0.006 abcd
Goldendrop	0.004 ab	0.005 ab	0.011 abcdef	0.014 abcdefg
Marroqui	0.004 ab	0.002 a	0.008 abcde	0.014 abcdefg
Rieti	0.004 ab	0.003 ab	0.010 abcdef	0.012 abcdefg
Khivinka	0.004 ab	0.010 ab	—	—
Daruma	0.002 a	0.002 a	0.002 a	0.003 ab
Polyssu	0.002 a	0.002 ab	0.022 bcdefghij	0.025 defghij
T. timopheevii	0.002 a	0.002 a	0.006 abcde	0.007 abcde
Redchaff	0.001 a	0.001 a	0.002 a	0.004 abc
Red Straw	0.001 a	0.001 a	0.010 abcdef	0.009 abcdef

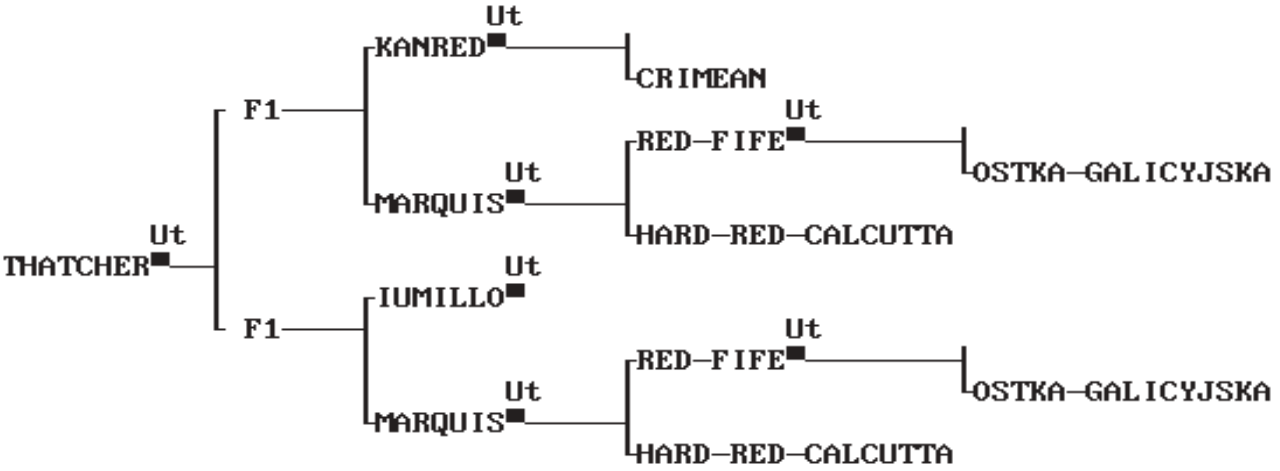
H-44, Red Bobs, and Regent). Some resistance donors were seldom used, including Selkirk (source of resistance Ostka Galicyjska and Crimean), Heines Kolben, Indiana Swamp, and Wisconsin 245.

For the majority of the Russian spring wheat varieties (Table 5, p. 156), the source of resistance were a local variety of the Saratov province Selivanovsky Rusak (*T. aestivum*) and the durum landrace Beloturka (Fig. 1b, p. 155). These varieties have Saratovskaya 29 and its derivatives (Irtyshanka 10 and Spektr) and also sister cultivars

Table 4. Donors of genes for resistance to loose smut for North American spring wheat cultivars. Cultivars listed in bold type are most frequently used as parents. Cultivars marked with an asterisk (*) indicate source of resistance is unknown.

Cultivar name	Resistant parent/ancestor	Hypothetical sources of resistance
AC Baltic, Belvedere	Garnet, Marquis, Peragis, Heines Kolben	Ostka Galicyjska, Saumur de Mars, LV-Seignora
AC Cadillac	Neepawa, Manitou, Red Bobs	Ostka Galicyjska, Iumillo, Crimean
AC Cora, AC Minto	Neepawa, Katepwa	Ostka Galicyjska, Iumillo, Crimean
AC Domain	Justin (Thatcher, Hope, Redman)	Ostka Galicyjska, Iumillo, Crimean
AC Foremost, **Katepwa**, Kenyon	Neepawa	Ostka Galicyjska, Iumillo, Crimean
AC Karma	Neepawa, HY-358	Ostka Galicyjska, Iumillo, Crimean
AC Michael	Neepawa, Park	Ostka Galicyjska, Iumillo, Crimean
Bluesky	Glenlea, Inia-66	Ostka Galicyjska, Iumillo, Crimean
Butte 86	Thatcher, Hope, Selkirk, Federation	Ostka Galicyjska, Iumillo, Crimean
Cache, **Garnet**, Improved Fife, **Marquis**, Preston	Red Fife	Ostka Galicyjska
Canthatch, GP 317, Leader, **Manitou**, **Neepawa**, **Park**, Sawtana	Thatcher	Ostka Galicyjska, Iumillo, Crimean
Canuck	Canthatch	Ostka Galicyjska, Iumillo, Crimean
Canus	Marquis, Kanred	Ostka Galicyjska, Crimean
Chaparral, Newana, Russel, Saunders	Thatcher, Hope	Ostka Galicyjska, Iumillo, Crimean
DC II-21-44	Marquis, Kanred, Iumillo	Ostka Galicyjska, Iumillo, Crimean
Dicklow *	—	—
Era, Kitt	Pembina, Thatcher, Hope	Ostka Galicyjska, Iumillo, Crimean
ES-4, GP 315, GP 316, HY 358	Glenlea	Ostka Galicyjska, Iumillo, Crimean
Glenlea	Pembina	Ostka Galicyjska, Iumillo, Crimean
H-44, **Hope**, Hope-Hussar, Kitchener	Marquis	Ostka Galicyjska
HY 377	7424-BW-5-B-4	—
II-39-42	Hope	Ostka Galicyjska
Norana	Thatcher, Federation	Ostka Galicyjska, Iumillo, Crimean
NS 3111	Hope, Marquis, Kanred, Iumillo	Ostka Galicyjska, Iumillo, Crimean
P8810B5B3A2A2	Thatcher, Redman, Federation	Ostka Galicyjska, Iumillo, Crimean
P8913V2A5	Manitou, Park, Era, Neepawa	Ostka Galicyjska, Iumillo, Crimean
P8917B4D4, P8921Q4C5	HY 358	Ostka Galicyjska, Iumillo, Crimean
Pembina	Thatcher, Selkirk	Ostka Galicyjska, Iumillo, Crimean
Red Bobs	Marquis, Hard Federation	Ostka Galicyjska
Red-Fife	Ostka Galicyjska	Ostka Galicyjska
Red River 68, Shortana	Thatcher, Hope, Federation	Ostka Galicyjska, Iumillo, Crimean
Redman	Canus, Regent	Ostka Galicyjska
Regent	H-44	Ostka Galicyjska
Roblin	Neepawa, Manitou	Ostka Galicyjska, Iumillo, Crimean
SD 8036	Arthur 71, Thatcher, Hope	Ostka Galicyjska, Iumillo, Crimean, Indiana Swamp, Wisconsin 245
Selkirk	Redman, Garnet	Ostka Galicyjska Crimean
Thatcher	Marquis, Kanred, Iumillo	Ostka Galicyjska, Iumillo, Crimean
White Federation 54	Hope, Federation	Ostka Galicyjska
Wildcat	Glenlea, Manitou	Ostka Galicyjska, Iumillo, Crimean
Wisconsin 245 *	—	—

a. Thatcher — 13 ancestors including 7 unique.



b. Saratovskaya 29 — 11 ancestors including 9 unique.

c. Saratovskaya 35 — 9 ancestors including 8 unique.

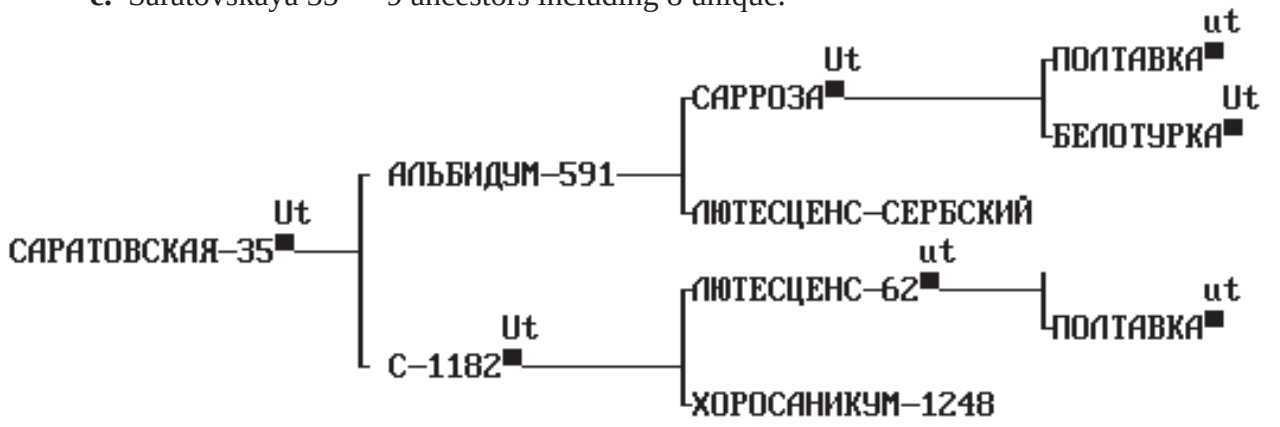


Fig. 1. The tracing of sources of resistance to loose smut for spring wheat cultivars by the GRIS: Thatcher (a), Saratovskaya 29 (b), and Saratovskaya 35 (c)

Table 5. Donors of genes for resistance to loose smut for North American spring wheat cultivars. Cultivars listed in bold type are most frequently used as parents. Cultivars marked with an asterisk (*) indicate source of resistance is unknown.

Cultivar name	Resistant parent/ancestor	Hypothetical sources of resistance
Alborubrum-1580	Kooperatorka, Saratov.28	Crimean, Ostka Galicyjska
Altaiskii Prostor	Uralskaya 52	Ostka Galicyjska
Amurskaya 75, Dalnevostochnaya, Lutescens 47	Thatcher	Ostka Galicyjska, Iumillo, Crimean
Bashkirskaya 11	Bashkirskaya 10, Saratovskaya 29	Ostka Galicyjska, Iumillo, Crimean, Selivanovskii Rusak, Beloturka
Bashkirskaya 24	Line 88 (*T. durum*)	
Bashkirskaya 4 and **10**	Pionerka	Ostka Galicyjska, Iumillo, Crimean
Bashkirskaya 8, Volzhanka	Bashkirskaya 10	Ostka Galicyjska, Iumillo, Crimean
Bashkirskaya 9	Moskovka	Ostka Galicyjska
Bezenchukskaya 134 and 140, Komsomolka, Lutescens 4, Michurin, Rannyaya, **Zhigulevskaya**	Bezenchukskaya 98	Ostka Galicyjska, Iumillo, Crimean
Bezenchukskaya 98	DC-II-21-44	Ostka Galicyjska, Iumillo, Crimean
Bezim, Niva 2, Zauralskaya 90	Irtyshanka 10	Selivanovskii Rusak, Beloturka
Budimir, Kuibyshevskaya 1	Saratovskaya 29, PV-18	Ostka Galicyjska, Iumillo, Crimean, Selivanovskii Rusak, Beloturka
Bulyak	Saratovskaya 29, Bashkirskaya 4	Ostka Galicyjska, Iumillo, Crimean, Selivanovskii Rusak, Beloturka
Cheremshanka	Novosibirskaya-67, Krasnoyarskaya, Dimitrovka 5-18-IZR *	Lutescens 1487, Ostka Galicyjska, Iumillo, Crimean, Beloturka, Selivanovskii Rusak
Dias 2	Novosibirskaya 67, Ring	Lutescens 1487, Ostka Galicyjska, Saumur de Mars
Erythrospermum 341	Selivanovskii Rusak	Selivanovskii Rusak
Erythrospermum 78-1	Hordeiforme 5783	Beloturka
Erythrospermum 841	LV-Ashhabad (TKM)	LV-Ashhabad (TKM)
Irtyshanka 10	Saratovskaya 36	Selivanovskii Rusak, Beloturka
Isheevskaya	Zhigulevskaya	Ostka Galicyjska, Iumillo, Crimean
Ivolginskaya, Novosibirskaya 20, Sibirskaya 65	Novosibirskaya 67	Lutescens 1487
Khabarovchanka	Indus 66 (Thatcher, Hope)	Ostka Galicyjska, Iumillo, Crimean
Krasnokutka 4	Erythrospermum 841	LV-Ashhabad (TKM)
Krasnoyarskaya	Saratovskaya 29, Saunders	Ostka Galicyjska, Iumillo, Crimean, Selivanovskii Rusak, Beloturka
Leningradskaya 95	Saratovskaya 29, Garnet	Selivanovskii Rusak, Beloturka, Ostka Galicyjska
Lutescens 1487 *	—	—
Lutescens 55-11	Erythrospermum 341	Selivanovskii Rusak
Lutescens 605 and 3646	Erythrospermum 341, Marquis	Ostka Galicyjska, Selivanovskii Rusak
Moskovka, **Saratovskaya 28**, **33**, and **758**, **Uralskaya 52**, Ferrugineum H-13	Kitchener	Ostka Galicyjska
Novosibirskaya 22	Krasnoyarskaya	Ostka Galicyjska, Iumillo, Crimean, Selivanovskii Rusak, Beloturka
Novosibirskaya 29, Omskaya 21	Novosibirskaya 22	Ostka Galicyjska, Iumillo, Crimean, Selivanovskii Rusak, Beloturka
Novosibirskaya 67	Lutescens 1487	Lutescens 1487
Omskaya 22, Pamyati Azieva, SIR-8, Sibakovskaya 3, **Spektr**	Saratovskaya 29	Selivanovskii Rusak, Beloturka

Table 5 (continued). Donors of genes for resistance to loose smut for North American spring wheat cultivars. Cultivars listed in bold type are most frequently used as parents. Cultivars marked with an asterisk (*) indicate source of resistance is unknown.

Cultivar name	Resistant parent/ancestor	Hypothetical sources of resistance
Omskaya 24	Krasnodar.39 (winter)	Kharkovskaya, Crimean
Orenburgskaya 13	Pembina	Ostka Galicyjska, Iumillo, Crimean
Pionerka	Marquis, Kanred, Iumillo	Ostka Galicyjska, Iumillo, Crimean
PPG-56, Prilenskaya 19	Kooperatorka	Crimean
S-1182 Horosanicum 1248	Horosanicum 1248	
Saratov.29, **Saratov.36**, **Saratov.39**	Lutescens 55-11	Selivanovskii Rusak, Beloturka
Saratovskaya 35	Sarroza, Horosanicum 1248	Beloturka, Horosanicum 1248
Saratovskaya 45 and 48, Zolotistaya	Selkirk	Ostka Galicyjska, Crimean
Saratovskaya 49	Saratovskaya 39	Selivanovskii Rusak, Beloturka
Saratovskaya 51	Alborubrum 1580	Crimean, Ostka Galicyjska
Saratovskaya 52	Saratovskaya 36, Nadadores 63	Selivanovskii Rusak, Beloturka, Ostka Galicyjska, Iumillo, Crimean
Saratovskaya 54	MN 2705 *	—
Sarroza	Beloturka	Beloturka
Selivanovskii Rusak *	—	—
Steklovidnaya 1, Zavolzhskaya	Sarroza	Beloturka
Tarasovskaya	PPG-56, Saratovskaya 39	Selivanovskii Rusak, Beloturka, Crimean
Tarasovskaya 2 and 5	Inia 66	Ostka Galicyjska, Iumillo, Crimean
Tarskaya 5, Tyumenskaya 96	Marquis and/or Red River 68	Ostka Galicyjska, Iumillo, Crimean
Tulaikovskaya Yubileinaya	Saratovskaya 35	Beloturka, Horosanicum 1248
Venera	Saunders	Ostka Galicyjska, Iumillo, Crimean
Voronezhskaya10, Kurskaya 263, Lutescens 218, 219, 697, and S-1797	Saratovskaya 29, Selkirk	Ostka Galicyjska, Crimean, Selivanovskii Rusak, Beloturka
Zoryan	Spektr	Selivanovskii Rusak, Beloturka

Saratovskaya 36 and Saratovskaya 39 in their pedigrees. Other sources of resistance were Lutescens 1487 (*T. aestivum* var. *ferrugineum* (LV-Yakutia)/*T. durum* var. *hordeiforme* (LV-Samara)) from the Samara province through the cultivar Novosibirskaya 67, an accession from Iran Horosanicum 1248 (Fig. 1c), cultivar Erythrospermum 841 selected from Turkmenistani landrace Ashhabad. A considerable part of the Russian spring wheat varieties has received resistance from the Canadian and U.S. cultivars Marquis and its derivatives (Kitchener and Red Bobs), Selkirk, Thatcher and its derivatives (Saunders, Pembina, Bezenchukskaya 98, and Pionerka), and also semidwarf cultivars from CIMMYT (PV-18, Inia 66, Nadadores 63, and Red River 68), which are present in the pedigrees of Thatcher and/or Hope. For varieties developed with the participation of winter wheats, probable sources of resistance genes for smut could be Kharkovskaya (a local variety from which Hostianum 237 was selected) through the cultivar Krasnodarskaya 39, and Crimean through Kooperatorka. Thus, resistance to loose smut in 36 % of the Russian accessions was obtained only through Russian and/or the ex-U.S.S.R. local sources; 35 % from North American material; and 22 % from both local and foreign sources.

Similar inventories of resistance sources in wheat varieties from other regions will assist the enlarging the gene pool of resistance genes used in breeding programs.

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ITEMS FROM THE REPUBLIC OF SOUTH AFRICA

SMALL GRAIN INSTITUTE
Private Bag X 29, Bethlehem 9700, South Africa.

Plant breeding – winter and intermediate breeding program.

J.C. Aucamp and D.J. Exley.

The winter and intermediate wheat breeding program has the exclusive aim of supplying new cultivars to the dry land, winter wheat producer of the Free State Province. The development and release of high-yielding, well-adapted and stable, winter and facultative wheat cultivars for the Eastern, Central, and Western Free State can be accomplished by breeding for cultivars with long coleoptiles that also have tolerance to drought and heat stress. To help the farmer make a profit from wheat production, these cultivars must have a high falling number, very good preharvest sprouting resistance, disease resistance (especially for yellow rust, stem rust, and leaf rust) and resistance to RWA. Bread wheat quality characteristics of the newly released cultivars have to comply with the quality criteria set by the processing industry. Cultivars with all these features will help the farmer to reach maximum yield and keep input cost as low as possible.

Plant breeding – spring wheat breeding program.

F. Middleton and P. Delport.

Although the breeding effort is aimed at the identification of generally adapted cultivars, specific adaptations also are selected for due to the heterogeneity in climatological and ecological conditions of regions within the Western Cape. For this reason, promising cultivars are evaluated at 11 sites that have been preselected to sample typical commercial conditions. In addition, the facilities at two state-owned experimental farms also are used to evaluate advanced nonsegregating lines and screen segregating material. Although our main objective is ultimately the improvement of rust (stem, leaf, and yellow) resistance and baking characteristics, the 2001 material also was characterized by resistance to Septoria and aluminium tolerance. Diversity, particularly in respect to baking quality, was further extended by the addition of several CIMMYT genotypes. The impact of these introductions will be evident when the material from crosses between these and the more adapted local varieties are evaluated.

Biedou, a spring wheat cultivar specifically adapted to the climate in the Western Cape production area, was released during 2001. The cultivar is resistant to the prevalent races of stem, leaf, and yellow rusts and provides moderate to good resistance against Septoria. Biedou exhibits a moderate to high yield potential and excellent yield stability across years and environments.

Plant breeding – irrigation-breeding program.

W.H.P. Boshoff.

Breeding objectives for the irrigation areas are concentrated to two major regions, the warmer (Mpumalanga, North West, and Northern Provinces) and cooler (Northern Cape) areas in the summer-rainfall region. Another, though smaller, region in KwaZulu–Natal also is covered.

Plant breeding – international nurseries.

A.D. Barnard and M.V. van Wyk.

The incorporation of new and advanced germ plasm and breeding material are important to prevent genetic narrowing. Annually, wheat, barley, triticale, and oats are imported form CIMMYT (Mexico), ICARDA (Syria), and Uruguay. These lines undergo intensive, daily evaluations at locations in Bethlehem, in the Free State, and Tygerhoek, in the Western Cape, for agronomic adaptability, disease resistance, yield potential, and quality characteristics. During the 2000–01 season, a total of 23 nurseries and 15 trials were planted and evaluated. Outstanding lines were selected and designated directly to the different breeding programs, whereas good lines were incorporated in a specialized crossing block for the improvement of undesirable characteristics with the focus on future releases. These materials aid breeders in developing improved cultivars for both the commercial and small-scale farmers.

Application of molecular and tissue-culture techniques to problems in disease resistance of wheat with an emphasis on stripe rust.

R. Prins, V.P. Ramburan and W.H.P. Boshoff; L.A. Boyd (Department of Disease and Stress Biology, John Innes Centre, UK); Z.A. Pretorius (Plant Pathology Department, University of Free State, RSA); and J.H. Louw (Genetics Department, University of Stellenbosch, RSA).

Adult plant resistance (APR) to stripe rust in the South African wheat cultivar Kariega was assessed in a DH-mapping population made from the F_1 of a cross between Kariega and the susceptible cultivar Avocet S. A partial linkage map covering 17 chromosomes was developed. Twenty-three of the 220 markers (protein, AFLP, and SSR) remained unlinked. None of the unlinked markers showed significant linkage with stripe rust resistance using single-marker regression. The partial linkage map was used in QTL interval mapping analysis (MAPMAKER/QTL) and confirmed the results obtained with a dissection (mixture) model analysis indicating that at least two APR stripe rust genes are present. The chromosome locations of these genes were determined and flanking AFLP and SSR markers were identified that can now be used to further improve the resolution of mapping. A third chromosome has been identified as possibly carrying a QTL by use of a restricted-multiple, QTL mapping procedure (MapQTL^{Æ}), but this needs to be verified.

Previous field trial analysis of the genetic material derived from Cappelle Desprez (CD) and Palmiet confirmed the effectiveness of *Yr16* (APR) against the South African pathotypes (6E16 and 6E22). We know that CD also carries the T5BS·7BS translocation, which is a complicating factor in studying *Yr16*. Chromosome 2D SSR markers, previously thought to be associated with *Yr16*, were tested on various resistant and susceptible lines. The molecular data suggest that the indicated *Yr16* position on chromosome 2D needs further verification. Various resistant plants were used in backcrosses to Avocet S and Palmiet and the resulting F_1s are at present used in the production of DHs to simplify future genetic studies.

Preharvest sprouting and falling number.

A. Barnard.

The South African wheat-producing areas, especially the Eastern Free State, are highly subjected to the risk of preharvest sprouting due to summer rainfall that occurs just prior to or during harvest. Because preharvest sprouting is related closely to falling number (FN), a substantial amount of research is done on both topics. Thousands of wheat spikes obtained from various commercial and newly released cultivars are evaluated for preharvest-sprouting tolerance with the help of a rain simulator. This information is handed down to the commercial farmer to enable him to make the right decision regarding his cultivar choice for the coming season.

The previous season saw the release of the Falling Number Report, which investigated various factors affecting FN as well as the need for such an analytic test in the South African-grading system. Although a lot of questions regarding FN were answered, many still remain unanswered. Research on the effect of temperature changes during certain stages of grain filling and the effect of kernel size on FN are just some of the areas to be investigated.

The ensuing season also marks the second year of cultivar evaluation from all localities planted on a national basis in the wheat-producing areas in South Africa (40 in total).

Small Grain Institute continues to combine efforts with the Cereal Research Non-Profit Co. in Szeged, Hungary. Research areas include the screening of both South African and Hungarian cultivars for elevated, preharvest-sprouting tolerance with which we hope to broaden the genetic breeding material from both countries.

Wheat production in the summer-rainfall region.

Because of the importance of cultivar choice in the summer-rainfall region, an extensive cultivar-evaluation program is followed for each of these areas. Different cultivars are planted in each region and these cultivars are evaluated and characterized in terms of yield reaction and stability in the different areas. Other characteristics also evaluated in this program include important quality specifications such as hectoliter mass, protein content, and falling number. These characteristics are used in recommending cultivars best suited for each area in the region.

Dryland production. Almost half of the South African wheat production is under dryland conditions in the summer-rainfall region. Because of the large variation in climatic conditions and soil types existing in this region, wheat production is very challenging. Not only are good cultivation and management practices essential for successful wheat production, but also the correct cultivar choice. The dryland production area is divided mainly into four homogenous areas where different cultivars, mainly winter and intermediate types, are planted. All the cultivar evaluation trials planted at 18 sites throughout the Western, Central, and Eastern Free State were successful and were reported on. Twenty entries were included in the trials, of which five were from Small Grain Institute, ten from Monsanto, and five from PANNAR.

Production under irrigation. Wheat produced under irrigation consists of about 20 % of the total wheat production of South Africa. This area is divided into six different irrigation regions. Because these regions have a very stable production area, they are of great importance. The types of cultivars grown include mainly spring types that are planted in the late autumn and early winter. Thirty-five out of 38 cultivar-evaluation trials planted at 20 sites throughout the irrigation areas of the summer-rainfall region were successful and have been reported on in a detailed annual report. Eight entries were included of which five originate from Small Grain Institute and three from Monsanto.

Wheat production in the winter-rainfall region.

There are mainly two wheat producing areas in the winter-rainfall region:

The Swartland area, which stretches from Durbanville in the south to the Sandveld area around Elandsbaai in the north and from Saldana Bay in the west to the mountain ranges in the east and

The Rûens or South Coast area, which stretches from Botrivier in the west to the Albertina district in the east and from Aghullas in the south to the Langeberg mountain range north of Greyton through to Riversdal.

Spring wheat varieties are grown in these two regions. These varieties do not require the same amount of cold to break dormancy as do the winter and wheat varieties grown in the rest of South Africa. Cultivar choice in the winter-rainfall region is of extreme importance because of the varied climatic differences between cultivation areas. The cultivars available differ in their reaction to the changing yield-potential conditions that exist in the winter-rainfall region. Other important factors that also have to be taken into consideration are grain quality, hectoliter mass, and disease susceptibility.

In the winter-rainfall region, the Cultivar Evaluation Program is run jointly by The Small Grain Institute and The Directorate Agriculture of the Western Cape. The program consists of 12 sites in the Swartland and 12 sites in the Rûens, with 14 cultivars included in the trials. Cultivars from ARC-Small Grain Institute, Monsanto, and PANNAR are tested annually for yield potential, quality, disease resistance, and adaptability.

Wheat Quality Laboratory.

A. Barnard, C.W. Miles, K.B. Majola, M.L.T. Moloi, M.M. Radebe, N.E.M. Mtjale, C.N. Matla, M.M. Mofokeng, M.L. Dhlamini, and N.M. Mtshali.

One of the main objectives of the Quality Laboratory is to maintain a cost-effective, highly scientific, and objective quality assessment of Small Grain Institute breeding lines; incorporate contract work for milling and baking industries and private companies; and provide an objective service to wheat producers. To ensure accurate data to researchers and external parties, the laboratory takes part in quarterly and monthly ringtests. A total of 40,341 analyses were made during 2001.

Seed Testing Laboratory.

H. Hatting.

Seed plays a vital role in the potential crop yield of each small grain producer. Small-grain seed must comply with legal requirements with regard to the purity and germination percentage before it can be marketed. The Small Grain Institute has an accredited Seed Testing Laboratory in which international methodology (i.e., ISTA (International Seed Testing Association) methods) is used to determine the quality characteristics of seed. The laboratory provides a unique service. Having the infrastructure and experience, seed analyses are conducted objectively on a commercial and need-driven basis for the seed industry.

Soil Analyses Laboratory.

L. Visser.

The Soil Analyses Laboratory provides an important service to researchers, farmers, advisors, and representatives of different fertilizer companies. In addition to reliable and accurate analysis results, clients who visit the laboratory also have the benefit of exposure to research information generated at the Institute. At present, the laboratory is actively involved in a research project to evaluate the fertility status of soils from resource limited farms. There is a huge need for more information, specifically on the soils of Qwa-Qwa and the Eastern Cape.

The external income of the laboratory increased by nearly 30 % during the past year. A total of 75,532 tests were performed on 430 plant and 9,947 soil samples. Fifty-five percent of these samples were internal research samples. The laboratory aims to improve these figures in the following year.

Nitrogen dynamics in a wheat-on-wheat system under conventional cultivation and rainfed conditions.

W. Otto.

Rainfed trials were planted in three of the major wheat-production areas under conventional-cultivation systems over two consecutive cropping years. A control (zero nitrogen fertilizer) and the recommended rate (per region) was banded at planting using the widely adapted cultivar Gariep. Crop development was monitored by biomass measurements, and nitrogen-uptake curves were calculated. Coinciding with these measurements, soil-mineral nitrogen (0–1,200 mm) also was measured. Multivariate analysis of measured yields, protein percent in the grain, and nitrogen-uptake values at harvest were used to determine the contribution of soil-mineral nitrogen at planting, soil-water content at planting, rainfall during the growing season, and applied fertilizer nitrogen to the changes in these values over the sites and years.

From the calculated analysis, soil mineral nitrogen, fertilizer applied, and soil-water content at planting contributed to 87 % of the variation in measured yields. Soil-water content, rainfall during the growing season, soil-mineral nitrogen at planting, and fertilizer applied explained 96 % of the changes in the measured grain-protein percentage.

Measured yield was the major contributor that explained changes in nitrogen uptake at harvest, and together with soil mineral nitrogen content and fertilizer applied, explained 96 % of the variation.

All the measured crop growth parameters were lower in the second cropping season, which is linked to soil mineral nitrogen availability at planting, in turn influenced by residue decomposition and soil water availability. Residue and cultivation management during the shortened fallow period between the cropping seasons is dependent on rainfall during this time. From the data collected from this project explanatory models were developed indicating the effects of certain measurable parameters on agronomically important factors. With further verification and refinement these models can be useful in fertilizer planning and recommendation systems.

Entomology — Karnal bunt: the road ahead.

V.L. Tolmay and K. Naudé.

The outbreak of Karnal bunt in the Douglas area in December, 2000, caused a stir in the wheat industry. Until recently Karnal bunt has been regarded a dreaded wheat disease worldwide and also in the U.S. The U.S. currently is considering deregulation of the disease. Such a step may affect the South African wheat industry.

Under guidance of the Karnal bunt Task Team, national surveys of all registered seed units and commercial grain were conducted. All seed units tested free of KB. KB infection of commercial grain occurred once again in the Douglas area. The Directorate has placed the Plant Health & Quality (National Department of Agriculture) under order. Regulations such as these are essential in containing the disease to the affected area. In the future, these surveys will help determine the extent of the disease in South Africa.

At the ARC–Small Grain Institute, measures have been compiled to prevent the spread of the disease through institute actions. A laboratory was established to test ARC–SGI seed-production units, seed increases, and trial material for the presence of KB spores. A washing facility currently is being built to wash seed needed for trials and seed production in the coming production season. These procedures will ensure that all seed planted at research stations and coöperator's farms are free of KB spores and other deleterious organisms.

Personnel.

Mr, Francois Koekemoer resigned his position as irrigation wheat breeder for ARC–SGI, effective February, 2001, to join Monsanto, Bethlehem as a wheat breeder. Dr Willem Boshoff has been appointed as irrigation wheat breeder in his place. Thom Steyn, who was responsible for no-till research, resigned to accept a post at Monsanto. John Tolmay will continue with the no-till research project. Dr. Hugo van Niekerk retired at the end of April after 30 years service to the wheat and barley industry. He headed the wheat breeding section from 1983 until his retirement and was instrumental in the release of at least 25 cultivars. Palmiet, a spring wheat cultivar became the most widely grown cultivar in South Africa during the mid 1990s, comprising 43 % of the wheat crop. Dr. Hugo Smit has replaced Dr. van Niekerk as Programme Manager of Plant Breeding. Olaf Müller resigned his position as winter and intermediate wheat breeder to join Monsanto as a maize breeder. Ms. Una Aucamp handles the program. Felix Middleton has accepted a position at the University of Stellenbosch. Dr. Hugo Smit has been assigned as interim project leader until a replacement for Mr. Middleton can be found.

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Breeding.

Variety listing and plant breeder's rights were obtained for two new spring triticale cultivars intended for cultivation in the Winter Rainfall Region of the Cape. **Bacchus** was selected from CIMMYTs 28th ITYN-48 (Supi 3//Hare 7265/ Yogui 1), and **Tobie** is a selection from the local cross 'Kiewiet/4/W.TCL83/Hohi//Rhino 4/3/Ardi 1'. Two of our cultivars, Tobie and USGEN 19, also have been released for cultivation in Ethiopia and will be the first triticales to be grown commercially in that country. A recurrent selection procedure for wheat that is based on genetic male sterility and hydroponic culture of spikes was continued.

Transfer of leaf rust resistance to wheat from Triticum species.

Twenty-five promising backcross populations, each derived from a different species donor, were tested with a total of nine leaf rust, four stem rust, and two stripe rust pathotypes endemic to South Africa. Five lines with resistance (from *T. turgidum* subsp. *dicoccoides, Ae. sharonensis, Ae. speltoides*, and *Ae. peregrina*) introgressed into wheat chromosomes and six disomic addition lines with added chromosomes from the wild species (*Ae. kotschyi, Ae. peregrina, Ae. umbellulata, Ae. biuncialis*, and *Ae. neglecta)* had wide-spectrum resistance. In several instances, stem and/or stripe rust-resistance genes were cotransferred with the targeted genes for leaf rust resistance.

Restructuring the Lr19 translocation.

A previous attempt to reduce the amount of foreign chromatin associated with leaf rust resistance by replacing homoeologous *Thinopyrum* chromatin with wheat chromatin yielded the shortened form *Lr19*-149 (chromosome 7BL). This translocation has lost the deleterious yellow endosperm pigment (*Y*) gene and subsequently was used in a further attempt to shorten the segment. The second attempt yielded the four *Lr19*-149 recombinants, 252, 299, 462, and 478. Physical mapping and monosomic analyses revealed that the recombinants still are associated with chromosome arm 7BL. In addition, recombinants 252, 299, and 462 resulted from proximal exchanges, whereas 478 resulted from a distal crossover. Recombinant 299 was a proximal form that had lost the most *Thinopyrum* chromatin. Recombinant chromosomes 299 and 478 then were combined in a heterozygote that was test crossed with a leaf rust-susceptible tester. The testcross progeny was screened for plants with a recombinant chromosome that combines the two shortened ends. Several such recombinants were found and are being confirmed with molecular markers.

Chromosome mapping.

Chromosome arm 7DL was targeted for mapping as part of an ongoing attempt to improve the utility of important genes on this chromosome, e.g., *Dn2*, *Dn5*, *Lr19*, and *Pch1*. Three mapping populations were used for this purpose.

Twenty-nine deletion mutant lines (produced by gamma irradiation) were used to extend a physical map of the *Lr19* translocation. One hundred and forty-four *Sse*8387I/*Mse*I and 32 *Eco*RI/*Mse*I primer combinations were used to obtain 95 useful AFLP markers. The physical map confirmed that terminal deletions were the most common, however, it appears that several intercalary deletions and a number of primer or restriction-site mutations also were induced. The markers allowed for the discrimination of the deletions into 19 clusters, with seven AFLP markers mapping close to *Lr19*. Using the extended physical map, the size of the shortened recombinant forms could be readily deduced, and the markers identified will be very useful for further reduction of the translocation.

A doubled-haploid mapping population consisting of 94 lines was established from the F_1 progeny from the cross Chinese Spring/PI294994. This population was evaluated for seedling resistance to RWA (*Dn5*), endopeptidase (*Ep-D1*), and four microsatellite loci (*Xgwm37*, *Xgwm111*, *Xgwm428*, and *Xgwm437*). Several RFLP probes and two PCR-RFLP markers were tested on the parental lines, but were not polymorphic. *Dn5* was linked to *Xgwm111* and *Xgwm437* at distances of 25.4 and 28.6 cM, respectively, but segregated independently from *Xgwm428*, *Xgwm37*, and *Ep-D1*.

AFLP markers associated with eyespot resistance gene. *Pch1*, and the endopeptidase locus, *Ep-D1*, were identified. One of the markers was cloned and sequenced. The sequence contained a microsatellite repeat motif and flanking primers were designed and tested on the material. The microsatellite marker, $XustSS30M90_{AG240}$ could distinguish between the parental genotypes used, and a map distance of 2 cM was calculated between it and the endopeptidase locus in an extended mapping population. We also were able to physically map the marker between the *Wsp-D1* and *Sr25* loci. The latter may prove to be more versatile for marker-assisted selection of eyespot resistance than the presently used *Ep-D1* marker.

Transfer of salt tolerance from Thinopyrum distichum to triticale.

There are two aspects to this project.

Identification of the critical chromosomes. *'Thinopyrum distichum*/4x rye' hybrids with genomes $J_1^dJ_2^dRR$ were pollinated with diploid rye and yielded F_1 offspring primarily with 21 chromosomes (two complete rye genomes and seven *Thinopyrum* chromosomes). We concluded that the homoeologous chromosomes of the J_1^d and J_2^d genomes regularly formed bivalents during megasporogenesis in the partially allohaploid F_1. As a result, egg cells received a random, yet balanced, set of seven *Thinopyrum* chromosomes. The F_1 plants were tested for salt tolerance and showed wide variation, implying that salt tolerance genes on some of the homoeologues may normally be suppressed. Fifteen highly salt-tolerant plants were C-banded and the *Thinopyrum* chromosomes in each were identified. We then assigned the *Thinopyrum* chromosomes to seven homoeologous pairs. We then began testing a set of diagnostic RFLP probes (John Innes Centre) on the same material to relate the *Thinopyrum* chromosomes to their wheat homoeologues. Up to now, it was possible to identify the chromosomes of homoeologous sets 3, 5, and 7. Dominance of certain homoeologues among the 15 selected plants was used to indicate that these chromosomes are primarily being expressed under salt-stress conditions. Up to six chromosomes may determine salt tolerance in this species.

Development of triticale lines with disomic additions of the *Thinopyrum* chromosomes associated with salt tolerance. A total of 35 putative disomic addition lines were developed, each presumably has a set of 42 triticale chromosomes plus a random pair of *Thinopyrum* homologues. As markers are found for the five critical chromosomes implicated above, they are used to test the disomic additions for the presence of the particular chromosome. Thus far, two addition lines were found to have the critical group-3 chromosome. Once the complete set of six critical additions is available, we can begin the process of testing the added chromosomes for complementation and plan the introgression of some of the chromosome sections to triticale.

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Differential induction of defense enzymes and the chromosomal location in wheat/Aegilops introgression lines of two Heterodera avenae resistance genes of Ae. ventricosa.

Two independent introductions of genetic resistance to the CCN from *Ae. ventricosa* to hexaploid wheat were compared. The *Cre2* (from *Ae. ventricosa* AP-1) and *Cre5* (from *Ae. ventricosa* #10) genes confer a high resistance level to the CCN–Spanish pathotype Ha71 in controlled conditions and under natural infestation. However, previous studies have shown the differential behavior of the *Cre*2 and *Cre*5 genes against other CCN pathotypes (Delibes et al. 1993; Jahier et al. 2001; Ogbonnaya et al. 2001). No susceptible plants were found in the F_2 progeny from a cross between the two accessions of *Ae. ventricosa* with the *Cre2* and *Cre5* genes, suggesting that their respective resistance factors were allelic. However, the *Cre2* and *Cre5* genes have been transferred to different chromosomal locations in the wheat introgression lines, H-93-8 and 6D/6N^v (substitution line) because some very susceptible F_2 plants were found in the segregation of the resistance trait in the progeny from the cross (6D/6N^v / H-93-8). A high proportion of F_2 plants appeared with null infestation, whereas other plants showed a low number of females, suggesting that the former could have both resistance genes (*Cre2* and *Cre5*) and the latter probably only one. Pyramiding resistance genes has been used successfully in many worldwide breeding programs incorporating different resistance genes into a single cultivar to delay the adaptation of the pathogen, which needs to overcome each resistance gene simultaneously to be able to grow on the host.

The induction of several defence responses during early incompatible interaction of resistant lines with the *Cre2* and *Cre5* genes also has been studied. Isoelectrofocusing isozyme analysis revealed changes of peroxidase (PER), esterase (EST), and superoxide dismutase (SOD) activities in infected roots of resistant lines in comparison to their

susceptible parents. Following nematode infection, changes in isozyme patterns of putative defence enzymes (PER, EST, and SOD) occurred in susceptible and resistant wheat hosts. The resistant lines (with *Cre2* and *Cre5* genes) differentially expressed these isozymes in timing and abundance. The highest differences between infected and uninfected roots were found for the peroxidase system, implicated in lignification, as previously described by other authors (Melillo et al. 1992; Zacheo et al. 1993; Andres et al. 2001). The results clearly confirm previous observations, that the *H. avenae* pathotype Ha71 was unable to overcome the resistance mechanisms conferred by the *Cre2* in the H-93-8 line (Delibes et al. 1993; Andres et al. 2001). No previous study has been made with the *Cre5* gene.

Molecular markers can support classical breeding in crop plants by shortening the selection time in the breeding programs. A linkage analysis of the resistance to CCN and a DNA marker, present in H-93-8 and *Ae. ventricosa* AP-1 (both with *Cre2* gene) and absent in *Cre5*-carrying genotypes, was made in individual F_2 plants from the cross between H-93-8 and their susceptible parent (H-10-15). The distribution of susceptibility scores for the two classes of plants (with and without markers) indicated that the linkage between the two traits could not be very tight. Evidence of linkage was found in all the clearly susceptible plants (with a female number/plant higher than 15) always without the marker. However, some plants classified as resistant did not have the DNA marker, which would be consistent with recombination between the introgressed chromosome of H-93-8, with both DNA segments, and a wheat chromosome. This result agrees with our previous work showing recombination between chromosomes of the N^v and D genomes in some H-93 lines. The partial resistance previously described in the parental line H-10-15 also could explain this fact (Delibes et al. 1993). Pathogens are known to more easily overcome resistance provided by a single gene. Durability of resistance has been increased in several crops by incorporating genetic diversity of the major resistance genes. Differences observed between the *Cre2* and *Cre5* genes with respect to the chromosomal location, induction of detoxifying enzymes, and behavior to different pathotypes, suggest that there are different *H. avenae* resistance sources for their introduction into commercial wheat cultivars. Selecting lines with *Cre2* and *Cre5* genes for construction of durable resistant cultivars also may be possible. These findings are significant because novel sources of resistance provide breeders with alternative genes in the event of new pathotypes emerging.

Coöperation with other institutions.

We are coöperating with Drs T. Bleve-Zacheo and M. T. Melillo (CNR-Bari, Italy) in the histochemical localization of enzymes related to *H. avenae* resistance in wheat.

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Resistance to Hessian fly conferred by the gene H27. Relationships with other sources of resistance and its effect on some agronomic traits.

Hessian fly is one of the most destructive pest of wheat. A Hessian fly resistance gene from *Ae. ventricosa* and its transfer to hexaploid wheat via interspecific hybridization had been described (Delibes et al. 1997). Transfer line H-93-33, which has 42 chromosomes and has been derived from the cross (*T. turgidum*/*Ae. ventricosa*//*T. aestivum*) was highly

resistant to the Spanish Hessian fly population tested. Resistance in *Ae. ventricosa* 10, *Ae. ventricosa* AP1, and H-93-33 (DS 4D/4N^v) was located on chromosome 4N^v and is inherited as a single dominant factor (*H*27), linked to a isozyme marker (*Acph*- N^{v}1), in the introgression line.

Lines derived from the backcross of H-93-33 line, as donor parent, and *T. aestivum* cultivars Astral, Adalid, and Cargifaro, as alternative recurrent parents, showed a high level of resistance to *M. destructor*. These lines, which were selected for resistance using *Acph-N*^{v}1 marker, were morphologically similar to bread wheat. Isogenic lines, with and without the *H*27 gene, have been compared by different characters affecting to seed production and bread quality. As average value, plants with and without the marker showed no difference for number of spikelets/spike and kernel weight/spike, but plants with the marker showed lower spike compactness and a lower number of kernels/spikelet and higher 1,000-kernel weight. However, some lines with the marker show no difference that those lacking the marker. No significant differences were observed in protein contents and SDS-sedimentation value. The same HMW-glutenin pattern as the recurrent progenitor was found in the resistant lines analyzed, which is an acceptable composition for bread-making performance.

Preliminary results in agronomic trials show a superior yield of some lines in relation with checks, both in normal conditions and with insect attack. Table 1 gives the results of some lines obtained during last season at three different locations.

Table 1. Grain yield (kg/ha) of selected lines at three locations in 2000–01.

ID	Pedigree /cultivar [1]	Gimenells [2]	Maguilla [3]	Azuaga [4]
Ma 67-7	H-93-33/AS//AD 3ƒ/3/3*AD	7,883	4,621	3,387
Ma-103-6	H-93-33/AS//AD 5ƒ/3/AD	6,635	4,498	2,535
Ma-93-3	AD/3/H-93-33/2*AD 5ƒ//AD	6,405	4,880	2,809
Ma-6-2	AD/4/H-93-33/2*AD 2ƒ//AD 2ƒ/3/CF	6,273	3,758	1,453
Ma-67-5	H-93-33/AS//AD 3ƒ/3/3*AD	6,263	5,464	2,373
Ma-117	H-93-33/ALM//3*AD 2ƒ/3/AD ƒ/4/AD	5,880	4,181	4,246
Ma-104-3	H-93-33/AS//AD 5ƒ/3/AD	5,514	5,530	2,256
Adalid	Adalid	5,495	3,937	3,964
Ma-129	H-93-33/AS//AD 3ƒ/3/AD ƒ/4/AD	5,437	4,117	2,707
Astral	Astral	4,781	1,750	2,933

[1] AS= Astral, AD = Adalid, ALM = Almatense, and CF = Cargifaro.
[2] Irrigation, attack of Hessian fly negligible.
[3] Dry land, attack of Hessian fly negligible.

The harvest index of experimental lines was superior to that of the checks (data not shown). Quality parameters (sedimentation with SDS and protein content) of experimental lines rank between Astral (low bread-making quality) and Adalid (good bread-making quality).

A high resistance level to the Hessian fly biotype prevailing in Azuaga (Badajoz, Spain) was found in cultivars with different resistance genes; including Abe (*H5*), Kay (*H11*), Ella (*H9*), Howell (*H9*), 841453H (*H12*), Brule (*H18*), 86925RAI-16 (*H13*), KS89WGRC6 (*H24*) and KS86HF (as yet unnamed); located on chromosomes 1A (*H5* and *H11*), 5A (*H9* and *H12*), 6DL (*H13* and *H24*), and 2BS (KS86HF).

The segregation of resistance in the F_1 and F_2 populations from the crosses 'Kay/H-93-33', 'Ella/H-93-33', 'Howell/H-93-33', '841453H/H-93-33', and 'Brule/H-93-33' has been studied. About 200 plants F_2 were recorded from each cross.

All plants of the F_1 generation showed a similar resistance level than their resistant parents. Most of F_2 plants were resistant, and a few plans were susceptible. These results support the hypothesis of two different loci, with two alleles in each cross, being the resistance genes dominant. Thus, the resistance to *M. destructor* in H-93-33 line would be determined by one different locus with respect to the genes *H9, H11, H12, and H18*, and the unnamed gene from KS86HF.

Cultivar diversification, cultivar mixtures, multilines, and pyramiding of resistance genes have been used successfully in many worldwide breeding programs. The last strategy incorporates different resistance genes into a single cultivar to delay the adaptation of the pathogen. Plants with two resistance genes to *M. destructor* could be obtained in the F_2 generation from the crosses previously mentioned. A high proportion of F_2 plants with appeared to

have no attack, whereas the other showed low number of pupae, which suggests the existence of resistant plants carrying two genes (*H27* and that of the other resistant parents) and others with only.

Coöperation with other institutions.

We are coöperating with Acorex (a coöperative of Extremadure farmers).

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ITEMS FROM THE UKRAINE

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Optimizing the integrated protection of spring wheat.

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These studies were conducted at the Plant Production Institute named after V.Ya. Yurjev under a 9-year crop rotation in southern Ukraine during 1997–2000. The wheat cultivars Kharkivska 18 (bread wheat) and Kharkivska 23 (durum wheat) were studied. The soil was a typical chernozem, with 5.9–6.1 % humus content in the plowing layer. Grain corn

was the forecrop. Fertilizers and pesticides were not applied to the control. The optimal nutrient rate was 60 kg of NPK/hectare. The optimized integrated protection of wheat against pests included a seed treatment with Rocksil or Vincit, a herbicide spray at the tillering, and a fungicide treatment at the start of heading. If necessary, in separate years the insecticides were used against pests of the generative organs of the crop at the milk stage of grain maturity.

Fuel consumption and pesticide use per unit of grain production were determined according to an original method developed by the authors. The estimates for the cultivar Kharkivska 18 are given as an example. Fuel consumption/hectare was 66.20 kg in the block without chemicals and fertilizer and 73.46 kg in the block with the optimized protection and mineral nutrition. The grain yield in these blocks was 24.8 c/ha and 37.3 c/ha, respectively. Under these conditions, the fuel consumption for the first block was 2.67 kg (66.2:24.8) for production of 1 centner of seeds/hectare and 1.97 kg (73.46:37.3) for the second block. The first block showed a decrease of 0.7 kg or 26.2 %.

Because the rates of application for various pesticides differ greatly, pesticide use per unit of grain production (one centner) is calculated in conventional units. The rate/hectare (i.e., for convenience in calculations, they are increased by 100 times) is divided by grain yield. Under the consumption of two rates of pesticides per hectare for the production of one centner of seed, the pesticide use in the blocks is 8.06 c.u. (200:24.8) without fertilizer and 5.36 c.u. (200:37.3) with the optimal system of nutrition. Thus, by optimizing the integrated protection system and mineral nutrition for Kharkivska 18 the expenditure of pesticides per unit of production is decreased by 33.5 %.

The results show that cultivars Kharkivska 18 and Kharkivska 23 were different in their resistance to pathogens of some fungal diseases. In the nonchemically treated block, *Helminthosporium–Fusarium* root rots at the waxy stage of wheat grain maturity averaged 14.1 % and 21.5 % for Kharkivska 18 and Kharkivska 23, respectively. In the same treatment, Kharkivska 18 and Kharkivska 23 averaged 2.6 % and 0.7 % for powdery mildew at the end of milk and the start of waxy stage, 3.6 % and 0.9 % for brown leaf rust at the same stage, and leaf damage by Septoria was nearly identical at 24.5 and 27.3 %, respectively.

Optimized application of fertilizer increased the development of *Helminthosporium–Fusarium* root rot from 16.3 to 20.1 %, Septoria from 23.5 to 28.9 %, powdery mildew from 0,.6 to 2.7 %, and brown leaf rust from 26.2 to 34.5 % on average. The total development of leaf diseases increased from 26.2 to 34.5 %. Although protecting wheats against a complex of fungal diseases, the biological effectiveness of Impact after 30 days of spraying on Kharkivska 18 and Kharkivska 23 was 43.8 and 49.4 % in the block without fertilizer and 35.4 and 49.7 % in the fertilized plots, respectively.

Table 1. Grain yield, fertilizer savings, overall savings, and pesticide expenditure per unit of production using an optimal, integrated protection plan against harmful pests and mineral nutrition during 1997–2000 for Kharkivska 18 bread wheat and Kharkivska 23 durum wheat. Treatments included integrated protection (IP) and nutrition by fertilizer (N).

System	Grain yield c/ha	Increase in grain yield (c/ha) due to			Fertilizer savings kg grain/ kg NPK	Decrease in cost/unit of production due to	
		IP	M	IP + N		Fuel	Pesticides
KHARKIVSKA 18							
Control	24.8	—	—	—	—	—	—
Protection	26.2	1.4	—	—	—	—	—
Nutrition	31.9	—	7.1	—	3.9	8.2	—
Protection and nutrition	37.3	—	—	12.5	6.9	26.2	33
KHARKIVSKA 23							
Control	21.5	—	—	—	—	—	—
Protection	22.9	1.4	—	—	—	—	—
Nutrition	27.0	0.0	5.5	—	3.1	7.4	—
Protection and nutrition	32.0	—	—	10.5	5.8	20.5	32.8

Optimizing the mineral-nutrition system increased the number of weeds/m^2 from 495 to 714 and their weight from 94 to 174 g, in comparison to the control. The biological effectiveness of herbicides increased considerably during fertilizer use due to a better wheat development, which biologically suppressed weeds. In the block without fertilizer, spraying with Dialen decreased the number of dicotyledonous weeds by 66 % and their weight by 35 % and by 86 and 87 %, respectively, in the fertilized plots.

The grain yield of spring wheat increases under optimized integrated protection and mineral nutrition. Savings in fertilizer and decreased fuel costs and pesticides per unit of production correspond to resource and energy savings and ecological and social safety (Table 1, p. 170). The average gain from the optimization of integrated protection and mineral nutrition is $54.74 USD/hectare.

Fertilization and field tolerance of wheat to cereal flies.

Yu.G. Krasilovets and N.V. Kouzmenko.

This study was conducted at the Experimental Farm of the Yurjev Plant Production Institute, situated in the Forest–Steppe of southern Ukraine. The soil is a typical chernozem. According to the data from the Laboratory of Agrochemistry at our institute, the soil indices are as follows: humus 5.9–6.1 %, pH (KCl) 6.4–6.7, total absorbed bases 40–45 mg Equiv, hydrolytic acidity 3–4 mg EQV/100 g, average content of easily available forms of elemental nutrients, easily hydrolyzable nitrogen (according to Cornfield) 100–120 mg, and labile phosphor and exchange potassium in an acetic acid extract (according to Chirikov) 70–90 and 60–80 mg/kg, respectively. We grew common cultivars of winter and spring wheats. The agronomic techniques employed are widely used in the investigated area. In stationary crop rotations, fertilizer for winter wheat was applied in the autumn in the form of ammonium nitrate, superphosphate, and potassium salt. In the spring wheat field experiments, they were applied in the spring before sowing in the form of ammonium nitrate, superphosphate, and potassium–magnesium. Counts for plant damage by the larvae of cereal flies were according to conventional methods. These studies show that winter wheat was damaged by such cereal flies as *Opomyza florum* F., *Oscinella frit* L., *O. pusilla* Mg., and *Phorbia securis* Tiens. Spring wheat was attacked by *O. pusilla* Mg., *M. destructor*, and a few others. In the winter wheat sowings, the total tillering ability when a black fallow preceded the crop in the unfertilized blocks was 1.3–1.4 times greater in comparison with either a vetch–oats or silage maize as forecrop (Table 2, p. 172). The application of phosphor–potassium fertilizers solely in silage maize sowings did not increase the index appreciably, but the vetch–oats forecrop increased the index by 1.4–1.5 times. The standard mineral fertilizer enhanced the total tillering ability in winter wheats after silage maize by 1.3–1.5, after vetch–oats by 1.4, and after black fallow by 1.1 times. In the spring wheat sowings after a stubble forecrop, the tillering ability was increased by 1.3 times. The sowing rate of winter wheat after silage maize was 5.0×10^6 viable seeds/hectare, after vetch–oats it was 4.5×10^6, and after black fallow it was 4.0×10^6. With spring wheat after a stubble forecrop, sowing rate was 5.5×10^6. The application of a standard mineral fertilizer related to higher tillering ability increased the number of tillers for these forecrops by 1.1–1.5 times.

In winter wheat fields after silage maize and vetch–oats, cereal fly damage was not decreased. This index in the blocks without fertilizers was 14.6–15.9 % and at application of phosphor–potassium fertilizer was 12.8–15.5 % and 16.1–18.6 %. The tillers, which had been damaged by fly larvae, were dead. Therefore, because of the higher tillering ability, the number of undamaged tillers in the blocks with standard mineral fertilizer was considerably larger than in the unfertilized blocks. In winter wheat sowings after silage maize the number of undamaged tillers was 40–57 % greater, after vetch–oats it was 44–45 % greater, and on black fallow it was greater by 4 %. Spring wheat sowings after a stubble forecrop had 28 % greater undamaged tillers. A considerable increase in the number of undamaged tillers in the fertilized blocks improved tolerance of wheat to the cereal fly. The number of productive tillers in the blocks with a standard mineral fertilizing as compared to the unfertilized block was 1.4–1.6 times greater in when winter wheat followed silage maize, 1.1–1.2 times greater after vetch–oats, 1.1 times greater following black fallow, and 1.2 times greater in spring wheat after stubble forecrop.

Full application of a mineral fertilizer improved the grain yield of winter wheat after silage maize by 49–104 %, after vetch–oats by 22–23 %, on black fallow by 21 %, and in spring wheat after a stubble forecrop by 29 %. Pesticides were not applied to these plantings of winter and spring wheats. Thus, the maximum grain yield did not exceed the indices for fertilized winter wheat after silage maize of 33.1 c/ha, after vetch–oats of 31.6 c/ha, and after black fallow 52.8 c/ha, or for fertilized spring wheat after a stubble forecrop of 26.5 c/ha. Our multiyear studies show that optimizing

mineral nutrition and chemical protection against a complex of harmful organisms increases average grain yield of winter wheat after silage maize to 56.8 c/ha, on full and black fallow to 70.9–74.7 c/ha, and in spring wheat after a stubble forecrop and maize for grain to 45.4–46.2 c/ha on the average.

Table 2. Field damage of wheats by cereal flies with respect to forecrop and mineral-nutrient status.

Fertilizer applied (kg/ha)						No. tillers/m²		Spike-bearing stalks		
Crop rotation		Under wheat		Total tillering	Damaged by flies (%)	total	not damaged by flies	per m²	% block with out fertilizer	Grain yield (c/ha)
N	PK	N	PK							
Stationary. winter wheat–silage maize as a forecrop (average for 1981–1985)										
0	0	0	0	2.4	14.6	840	717	385	100	16.2
0	88	0	100	2.4	12.8	840	732	385	100	15.5
42	88	50	100	3.2	10.5	1,120	1,002	525	136	24.2
0	88	0	360	2.7	15.5	945	799	455	118	18.1
42	88	180	360	3.7	13.0	1,295	1,127	595	155	33.1
Stationary. winter wheat–vetch oat as a forecrop (average for 1981–1985)										
0	0	0	0	3.0	15.9	1,080	908	540	100	25.6
0	88	0	80	4.5	18.6	1,620	1,319	540	100	27.2
42	88	40	80	4.3	15.8	1,548	1,303	576	107	31.6
0	88	0	280	4.3	16.1	1,,548	1,299	540	100	28.6
42	88	140	280	4.2	13.1	1,512	1,314	648	120	31.2
Stationary. winter wheat–black fallow (average for 1991–1995)										
0	0	0	0	3.4	21.2	1,169	925	571	100	47.3
40	60	90	120	3.6	23.4	1,261	966	630	110	52.8
Field experiment spring wheat (average for 1997–2000)										
—	—	0	0	1.3	1.3	665	643	495	100	20.6
—	—	60	120	1.7	2.1	868	824	582	118	26.5

Wheat lines with introgressed genes for resistance to diseases and pests created by the Wheat Genetic Resources Center in the USA.

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At present, the gene pool in cultivated bread and durum wheats varieties for resistance to diseases and pests does not guarantee their resistance. Further breeding progress may come from introgressing resistance genes from related species and genera in the tertiary (GP-3) and quaternary (GP-4) pools of genetic resources, using the classification of V.G. Konarev (1993). Research on gene introgression are made in many institutions around the world; among the most successful are those of the Wheat Genetic Resources Center, Kansas State University, U.S. (WGRC).

This paper presents information about the lines created by the WGRC that are of use in breeding programs. Sources of the information have been published in The et al. 1992; McIntosh et al. 1995; Rabinovich et al. 1996; Cox et al. 1997; Wilson et al. 1997; Rabinovych 1998; and Raupp (pers commun).

Ae. tauschii is the source of genetic resistance to the greatest number of biotic factors including leaf rust; powdery mildew; Septoria leaf blotch and *Septoria nodorum*; Helmintosporium (yellow) leaf blotch; the virus diseases WSBMV and WSSMV and also the vector of WSM; and the Hessian fly. Genes for resistance to powdery mildew, leaf rust, and Septoria leaf blotch were introgressed from *T. timopheevii* subsp. *armeniacum*; to leaf rust from *T. monococcum*

subsps. *aegilopoides* and *monococcum*; to the vector of WSMV from wheatgrass *Th. intermedium*; and to Hessian fly, leaf rust, and powdery mildew from cultivated emmer (*T. turgidum* subsp. *dicoccum*) and *S. cereale*. Because these lines were evaluated for resistance to U.S. isolates of these pests, it is expedient to test them in different regions of the Russian Federation and the Ukraine. The overwhelming majority of the lines are HRWWs, two lines, KS92WGRC24 and KS94WGRC29, are HRWW, and two lines, KS91WGRC14 and KS98WGRC41, are spring durum wheats. Information for these lines can be obtained from the WGRC web site at *http://www.ksu.edu/wgrc/Germplasm/grmplsm.html.*

Some winter wheat varieties used in pedigrees of the WGRC lines also have disease resistance. U.S. cultivars Century, Karl, and TAM 200 have genes for resistance to leaf and stem rusts (*Lr24* and *Sr24*) inherited from *Th. ponticum*, which also are effective in the Ukraine and Russia. A number lines also have the Oklahoma wheat variety Amigo, which has the wheat-wheatgrass genes *Lr24* and *Sr24* and wheat–rye translocation T1AL·1RS. Amigo also has a second gene for resistance to stem rust and new gene for powdery mildew resistance (*Pm17*) from Insave F.A. rye (through the triticale Gaucho). Resistance to two greenbug biotypes (gene *Gb2*) also has been identified in the Amigo. Two descendants of Amigo are often found in the pedigrees of lines from the WGRC, TAM 107 (five times) and TAM 200 (six times).

The value of the lines described here is that they are cultivated wheats that do not have traits of the wild species and, therefore, are considered as valuable breeding material.

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A history of the breeding, pedigrees, and high-molecular-weight glutenin composition of Myronivka wheats bred between 1929 and 2001 and their progenies throughout the world.

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The wheat cultivars created in Myronivka played an important role in increasing grain production in the countries of the former U.S.S.R. and a number of European countries, one-sixth of the world's cropland. These cultivars are widely used in wheat breeding in many countries throughout the world. These wheats are characterized by their high adaptability to the severe climactic conditions of the temperate zone and their capacity for high yields. In particular, the cultivar Myronivs'ka 808, in addition to winter hardiness, has a high regenerative ability and may produce new tillers after overwintering and other unfavorable factors. This property may have been inherited by a number of it derivatives and was the possible cause of their success. This paper analyses the pedigrees of wheat cultivars from different countries from literature published between 1928 and 2002. The pedigree analysis of several hundred cultivars of winter and spring wheat allowed us to reveal descendants of Myronivka winter and spring wheats in two woodland, 20 forest-steppe, and nine steppe regions of the Ukraine; eight regions of the Russian Federation from central to eastern Siberia; 16 institutions in eight countries of the former USSR from Lithuania to Tajikistan; seven countries of Europe; the United States; and Chile. The institutes within the different regions of the Ukraine, Russian Federation, Belarus', Lithuania, Armenia, and Kazakhstan are arranged in chronological order from the year that the first cultivar or derivative of Myronivka wheat was released or created.

The Ukraine. *V.N. Remeslo Institute of Wheat in Myronivka, Kyiv Region.* The V.N. Remeslo Institute of Wheat (prior to 1968 the Myronivka Breeding Station) celebrated its 90th year in 2001. Wheat cultivars of this institute and its descendants have been widely grown for the last 75 years and are widely grown at the present time. The first cultivar of Myronivka Breeding Station was Ukrainka with a quality score (QS) = 9 (Table 1, p. 195). The breeder V.E. Zheltkevich collected a number accessions with the name Banatka from different places. The first choices were made from the original Banatka of Austro-Hungary in 1915. Thirty seeds, under the number 246, were sown in the autumn of 1915 and were the beginning of this Ukrainka cultivar. The next selections were made in 1916–18 by L.I. Kovalevskyj and further breeding work was by I.M. Eremeev and released as winter wheat Ukrainka 0246 in 1928. Ukrainka was cultivated for more than 45 years in a wide area; grown on more than 7 x 10^6 ha in late 1930s.

More than 60 cultivars were created from Ukrainka during 1930–70s; more than 30 in the Ukraine alone. The first progeny of Ukrainka in the Ukraine, Lutescens 9, was registered in Verkhhjacka in the Cherkasy Region in 1938 and the last known one, Perlyna Lisostepu, was registered in 2001 by the Bila Tserkva Experimental Plant Breeding Station. The first derivatives of Ukrainka also were created in Myronivka. Lutescens 25F24, Lutescens 25f27, Erythrospermum 84-3, Yuvileyna and Ukrainka polypshena originated in Myronivka between 1924–55, but none were released. The second descendant of Ukrainka among the Myronivka wheats was the cultivar Kyivs'ka 893, created in 1964 from Ukrainka spring, which was developed from the winter wheat Ukrainka in 1953 in the Alma-Ata Region of South Kazakhstan. Myronivs'ka 31 (QS = 9), in cutivation since 1997, is derivative of Ukrainka indirectly through Bilotserkivs'ka 29.

The variety Bezostaya 1, a derivative of Ukrainka from a cross with Lutescens 17 and registered by the Verchnjachka Station, was grown on more 10 x 106 ha between 1960–80. Several hundred winter, intermediate, and spring wheats, all descendants of Bezostaya 1, are grown from Canada to Australia; everywhere wheat is cultivated. Many varieties in countries of the former U.S.S.R. and 10 world cultivars are derivatives of Bezostaya 1, either directly or through the Russian wheats Kavkaz $^{(T1BL\cdot1RS)}$ and Avrora $^{(T1BL\cdot1RS)}$; Siouxland $^{(T1BL\cdot1RS)}$ of the U.S; or Veery $^{(T1BL\cdot1RS)}$, Lira $^{(T1BL\cdot1RS)}$, and Loxi $^{(T1BL\cdot1RS)}$ in Mexico and its derivatives. All of them have the same lineage of Ukrainka through Lutescens 17.

Myronivs'ka 264 (QS = 9) was the next variety registered. This variety was the choice for late-autumn sowing of spring *T. durum* wheat Narodnaya. Released in 1960, it was cultivated widely for nearly10 years. Descendants of Myronivs'ka 264 include Myronivs'ka 10 (released in 1975) and it progenies Myronivs'kanyz'korosla (1979), Myronivs'ka 60 (1985), and Myronivs'ka 28 (QS = 9), a derivative of Myronivs'ka 808 through the the Russian wheat Krasnodarskaya 57, also registered in 1994 in the forest-steppe region of the Ukraine.

The third Myronivka wheat cultivar, Myronivs'ka 808 (QS = 9), was selected from the spring wheat Artemivka (QS = 7) in Donetsk Region and was released in the Ukraine and Russian Federation in 1963. It was grown in the Ukraine until the middle 1990s and continues to be grown in nine regions of the Russian Federation in 2002; from the northwest to western Siberia. Descendants of Myronivs'ka 808 include Illichivka (QS = 9), Myronivs'ka 808 polipshena, Myronivs'ka ostysta (QS = 9), Myrleben (QS = 7), and Myronivs'ka 28. The last cultivar, bred through the Russan wheat Krasnodarskaya 57 (QS = 9.5) were registered between 1974 and 1994. Myronivs'ka 63 (QS = 9) and Troyan (QS = 8.5), released in 1993 and 1999, respectively, are both progenies of Myronivs'ka 808. The cultivar Kryzhynka (QS = 9), registered in 2002 by the two Institutions (see Table 1, p. 195), is a derivative of Myronivka wheats Myronivs'ka 808, Myronivs'ka 28, and Myronivs'ka Yuvileyna, through Myronivs'ka 27.

Dedcendants of the Myronivs'ka Yuvileyna are Myronivs'ka 27 and its progeny Myrych (QS = 7), registered in 1992 and Myronivs'ka 64 (QS = 9), released in 1994. Myronivs'ka 27 also is a forefather of the six new varieties Myronivs'ka 30 (QS = 9) registered in 1995; Myronivs'ka 32 (QS = 9), registered in 1993; and Venera (QS = 8), Myronivs'ka 35 (QS = 9), Myronivs'ka 901 (QS = 8), and Oktava (QS = 6), registered in 2000–01.

Descendants of Illichivka include Myronivs'ka 25 (QS = 9), Myronivs'ka 61 (QS = 9), and Volgogradskaya 84 (QS = 9), registered in 1980, 1989, and 1989, respectively; and Myronivs'ka 808 poluintensyvna (QS = 9) and Myronivs'ka 33 (QS = 9) registered in 1993 and 1998, respectively. The wheats Myronivs'ka 11 (QS = 9), Myronivs'ka 62, and Myronivs'ka 32, released in 1973, 1989, and 1993, respectively, also are offspring of Illichivka.

Varieties registered between 1999–2000, Myronivs'ka 65 (QS = 9), Lira (QS = 9), Myronivs'ka 67 (QS = 9), and Vesta (QS = 8), are progeny of Myronivs'ka 27 (QS = 9) and Myronivs'ka 61. In pedigrees of Myronoivs'ka 27 and

Myronivs'ka 61 also are the German lines 6538 and 6508-74. Although these are T1BL·1RS wheat-rye translocation stocks, the HMW-glutenin composition of these new Myronivka wheats is not reduced.

In 2002, the V.N. Remeslo Institute of Wheat are registered several varieties in the Ukraine including Myronivs'ka 27 (T1BL·1RS), Myronivs'ka 28 (T1BL·1RS), Myronivs'ka 31 (T1BL·1RS), and Kryzhynka (QS = 9), registered between 1992–2002 for the forest-steppe region; Myronivs'ka 61 (T1BL·1RS), Myronivs'ka ostysta, and Myronivs'ka 30, registered between 1989–95 and Myronivs'ka 65 and Myronivs'ka Rannjostygla, registered in 2000 and 2002, respectively, for the forest-steppe and woodland regions; and Myronivs'ka 33, Myrych, Myrhad, Myronivs'ka 66, and Myronivs'ka 67 registered between 1998–2002 for cultivation only in woodland region.

Thirteen Myronivka cultivars have been registered in the Ukraine. Myronivs'ka 27, Myronivs'ka 28, and Myronivs'ka 31 were registered in 1992, 1994, and 1997, respectively for the forest-steppe region; Myronivs'ka 61, Myronivs'ka ostysta, and Myronivs'ka 30, registered in 1989, 1992, and 1995, respectively, and Myronivs'ka 65 and Kryzhzhynka, registered in 2000 and 2002, respectively, for the forest-steppe and woodland regions; and Myronivs'ka 33 and Myrych, registered in 1998 and 1999, Myrhad and Myronivs'ka 66, registered in 2000, and Myronivs'ka 67 registered in 2002 for the woodland region.

In the Russian Federation, three Myronivka wheats are registered including Myronivs'ka 808 in eight regions, northwest, central, Volgo-Vjatka, Central Chernozem, Middle Volga, Lower Volga, Ural, and western Siberia; Myronivs'ka Yuvileyna in the northwest and Lower Volga regions; and Myro-nivs'ka 61 in the Central Chernozem region.

Progenies of Myronivka wheats in different Regions of the Ukraine. 1. Woodland Region.

Nosivka Breeding–Experimental Station, Chernigiv Region. At the Nosivka Station, Nosivs'ka 2, a derivative of Ukrainka, was released in 1950. Zolotava Nosivs'ka and Nosivchanka 2, both progeny of Myronivs'ka Yuvileyna through Kyjanka, were released in 1990 and 1994, respectively.

Institute of Agriculture, Kyiv Region. The cultivar Polis'ka 87 (QS = 5) is the first derivative of Myronivs'ka 808 bred at this institution after the resumption of breeding work. This wheat was registered in 1990 and cultivated for 10 years in the woodland region. One derivative, Polis'ka 90 (QS = 9), was released in 1994 and also is a derivative of the Russian cultivar Bezostaya 1.

The variety Polis'ka Bezosta, bred in 1981, is a progeny of Myronivs'ka 264, through Rostovchanka (QS = 9) from the Russian Federation. The cultivars Polis'ka 29 and Polis'ka 95 were created here in 1996. The first is a progeny of Myronivs'ka 808, through Polis'ka 87 and of Myronivs'ka Yuvileyna through Kyjanka. Polis'ka 95 is a direct descendant of Myronivs'ka Yuvileyna and a progeny of Myronivka wheats through three Russian varieties from Zernograd, Zernogradka 3 (a derivative of Myronivs'ka 808 through Severodonskaya, Myronivs'ka 264, and Myronivs'ka 808, through Donskaya bezostaya; QS = 9), Donskaya intensivnaya (a progeny of Myronivs'ka 808 through Donskaya polukarlikovaya; QS = 9), and Zernogradka 6 (through sibs of Donskya bezostaya (a descendant of Myronivs'ka 264 and Myronivs'ka 808); QS = 9 and Donskaya polukarlikovaya (a progeny of Myronivs'ka 808 by Severodonskaya) QS = 9).

Forest–steppe Region.

V.Ya. Yur'ev Institute for Plant Production, Kharkiv. At the V.Ya. Yur'ev Institute for Plant Production (formerly the Kharkiv Breeding Station) 54 varieties were bred from 1924–2001. Twenty-two of these were registered. Among the registered varieties are 12 derivatives of Ukrainka, including Lutescens 266, Lutescens 238 (QS = 9), and Kharkivs'ka 4 (from Lutescens 17), released in the 1950s. The cultivar Novo-Yur'evka was created in the 1930s; Ukrainka Kharkivs'ka (QS = 9) and Salyut (Kharkivs'kyj) in the 1940s; Erythrospermum 107 in the 1950s; Albidum 145 (from Lutescens 266); two-time derivatives of Ukrainka, Erythrospermum 88 (through Erythrospermum 107 and Lutescens 17) and Kharkivs'ka 10 (from Pimenka and Lutescens 17), and Krupnokolosa (through Lutescens 238) in the 1960s; and Kharkivs'ka 38, a two-time derivative of Ukrainka from Erythrospermum 88 in the 1970s.

The first derivative of Myronivs'ka 808 in Kharkiv was Kharkivs'ka 63 released in 1969 followed by Napivkarlyk 3, a two-time descendant directly and by crossing with Kharkivs'ka 63 in 1985. The variety Kharkivs'ka 20, registered in 1988 as a fertilty restorer for hybrid wheat on the basis of CMS, has Myronivs'ka 808 in its pedigree three times. Kharkivs'ka 33 and Kharkivs'ka 50 (QS = 9), derivatives of wheat Kharkivs'ka 20, created in 1985 and 1992, respectively, also have Myronivs'ka 808 in their pedigrees three times. Lutescens 23, bred in 1978, has Myronivs'ka 808 in its pedigree four times, once directly and three time through Kharkivs'ka 20. The cultivar Kharkivs'ka 90 (QS = 9) is two-time derivative of Myronivka wheats Myronivs'ka 808 through Okhtyrchanka (QS = 9) and Myronivs'ka Yuvileyna

though the Krasnodarian wheat Polukarlikovaya 49. The variety Kharkivs'ka 92 is three-time derivative of the Myronivka wheats Myronivs'ka 264, through the Russian varieties Tarasovskaya 29 and Rostovchanka, Myronivs'ka 808, and Myronivs'ka Yuvileyna, through Kharkivs'ka 90. Myronvivs'ka 264 was registered in 1991 and Kharkivs'ka 92 was registreted in 1993.

The newest varieties, Kharkivs'ka 96 (a progeny of Myronivs'ka 808 through Kharkivs'ka 63; QS = 9), Kharkivs'ka 105 (a derivative of Myronivs'ka 264, Myronivs'ka 808, and Myronivs'ka Yuvileyna through Kharkivs'ka 92; QS = 9), and Myronivs'ka morozostijka (frost-resistant, pedigree unknown) were released between 1999–2001. Kharus (Kharkivs'ka 333) is a five-time derivative of Myronivs'ka 808, twice through Donskaya polukarlikovaya (QS = 9), twice through Erythrospermum 1490 (bred in Kharkiv through the Russian cultivar Severodonskaya), and once by a cross with the Ukrainian cultivar Okhtyrchanka (QS = 9). The wheat Kharus (QS = 10) was registered in 2002 for the forest-steppe and steppe regions of the Ukraine.

Direct progeny of Myronivs'ka 808 include the Kharkivs'ka 159 (QS = 9) and Kharkivs'ka 68 (QS = 9), released in 1969 and 1973, respectively. Descendants of Myronivs'ka 808 through Kharkivs'ka 63 include Kharkivs'ka 77 and Napivkarlyk 1 developed in 1972 and 1974, respectively. Lutescens 23, created in 1978, is direct descendant of Myronivs'ka 808, Kharkivs'ka 75 and Kharkivs'ka 82, the both progey of Myronivs'ka 808 through Kharkivs'ka 63 and registered in 1981. One derivative of Kharkivs'ka 75, Slov'janka (Kharkivs'ka 94; QS = 9.5), was created in 1993.

Derivatives of Myronivs'ka 808 through the Russian wheats Donskaya Polukarlikovaya and Severodonskaya are Slobozhanka (Kharkivs'ka 93, QS = 9, 1992), Kolosysta (QS = 9, 1994), and Kharkivs'ka 99 (QS = 9.5, 1997). The wheat Mogutnya (QS = 9) is a descendant of Myronivs'ka 264 and Myronivs'ka 808 through Donskaya Bezostaya and was registered in 1995. Kharkivs'ka 107, released in 1998, is six-time descendant of five Myronivka wheats, Myronivs'ka 27 and Myronivs'ka 28 directly, progenies of Myronivs'ka 264 and Myronivs'ka Yuvileyna through Spatanka (QS = 9) and Krynitsa (QS = 9), and two Russian wheats, Polukarlikovaya 49 (QS = 9), a progeny of Myronivs'ka Yuvileyna, and Rostovchanka, a derivative of Myronivs'ka 264.

Kharkivs'ka 96, registered in 1999, and Kharkivs'ka 105, registered in 2001, are for the forest-steppe region of the Ukraine. Kharkivs'ka 92, released in 1993, is for the middle Volga and lower Volga regions of the Russian Federation.

Verkhnjachka Experimental Plant Breeding Station, Cherkasy Region. Between 1924–81, this station developed nearly 20 cultivars, all progenies of Ukrainka. Among them, Erythrospermum 10 and Lutescens 9 were registered in 1935 and 1938, respecitvely, and Milturum 13, created in 1936. The varieties Erythrospermum 15 (synonym Stakhanivka) and Lutescens 17 (synonym Efremivka) were both registered in 1940. These cultivars were widely grown on nearly 0.5×10^6 ha for 23 years (1940–62). Fifteen years after its release, Erythrospermum 15 was used as a parent for the Ukrainian wheat Bilotserkivs'ka 198 (QS = 9), which was grown on 3.2×10^6 ha in 1964, and after 19 years, Lutescens 17 became a forefather of nearly a hundred winter, intermediate, and spring wheats that were descendants of Bezostaya 1 bred in many countries, from Canada to Australia.

Verkhnyachs'ka 16 and Radjans'ka 60 (Sovetskaya in the Russian Federation), both direct derivatives of Myronivs'ka 808, were created in 1977 and 1978, respectively. The cultivar Verkhnyachs'ka 20, registered in 1981, is a direct progeny of Myronivs'ka 808 and a derivative of Ukrainka through Bilotserkivs'ka 198 and the Verkhnyachka wheat Erythrospermum 15.

Veselopodil's'ka (formerly Veselopodoljans'ka) Experimental Plant Breeding Station, Poltava Region. Among the 30 cultivars created between 1924–2002 in Veselyj Podil, 11 were derevatives of Ukrainka, Myronivsska 808, and Illichivka. Three were direct descendants of Ukrainka, Erythrospermum 85-8626 (created in 1939), Veselopodol'jans'ka 1 and Veselopodol'jans'ka 5 (both bred in 1949). Veselopodol'jans'ka 711, released in 1959, is a progeny of Ukrainka through Veselopodol'jans'ka 1. Ukrainka is a forefather of Veselopodol'jans'ka 17 (created in 1970) and Veselopodol'jans'ka 6 (1978) through Veselopodol'jans'ka 711 and Veselopodol'jans'ka 1. The three varieties, Veselopodol'jans'ka 14 (registered in 1973), Podol'jans'ka (a synonym Soyuz, 1976), and Veselopodil's'ka 78 (released in 1983), are direct derivatives of Myronivs'ka 808. Veselopodil's'ka 80 (registered in 1979) is a direct descendant of Illichivka and Veselopodil's'ka 83 (QS = 9) is a two-time progeny of Myronivs'ka 808 through Podol'jans'ka and Okhtyrchanka. The variety Veselopodil's'ka 867, a derivative of Myronivs'ka 808 through Veselyj Podil line 3807-71, was released in 1993. The newer cultivar Glibovchanka is a derivative of Ukrainka through Al'batros odes'kyj, Mayak,

and Dniprovs'ka 521 and is a two-time progeny of Myronivs'ka 808 through Veselopodil's'ka 83. The variety Glibovchanka was registered in 2002 for the forest-steppe region of the Ukraine.

Vinnytsya State Agricultural Experimental Station. Fourteen winter wheats originated from this station between 1926–1962, including Erythrospermum 235 (created in 1939), a direct derivative of Ukrainka, and Erythrospermum 520 (in 1962), a progeny of Ukrainka through Bilotserkivs'ka 198 and Erythrospermum 15.

Bila Tserkva Experimental Plant Breeding Station, Kyiv Region. At the Bila Tserkva Station, more than 20 direct derivatives of Ukrainka were created from 1919–1997, among which are seven two-time, five three-time, and three four-time derivatives. Ukrainka is directly in the pedigree of Lisostepka 75, registreted in 1945, and Lisostepka 76, Kyivljanka 156, Erythrospermum 158, Velutinum 160, Erythrospermum 162, Erythrospermum 163, Erythrospermum 164, and Kyivljanka 2916, bred between 1936 and 1940. Ukrainka also is present in the genealogies of other cultivars through the pedigrees of the other Bila Tserkva varieties. Bilotserkivs'ka 47, Bilotserkivs'ka napivkarlykova and Perlyna Lisostepu, registered in 1981, 1999, and 2001, respectively, and Bilotserkivs'ka 184 and Bilotserkivs'ka 51, created in the 1970s, are all three-time derivatives of Ukrainka. Bilotserkivs'ka 177 and Bilotserkivs'ka 18, released in 1979 and 1982, respectively, are four-time descendants of Ukrainka.

Wide spread among the Bila Tserkov wheats is Bilotserkivs'ka 198 (Erythrospermum 15 and a derivative of Ukrainka/Kavwalle (USA)), registered in 1955 and grown on 3.3×10^6 ha in 1964. Bilotserkivs'ka 198 and its descendants are included in the pedigrees of all varieties created at Bila Tserkov, from Bilotserkivs'ka 23 registered in 1962 to Perlyna Lisostepu registered in 2001.

In the pedigrees of Bila Tserkva wheats bred since 1990 are present Myronivs'ka 808 (over Russian wheats Donskaya polukarlikovaya (QS = 9) and Severodonskaya (QS = 9)) in Bilotserkivs'ka intensyvna (QS = 9), registered in 1991, and Bilotserkivs'ka napivkarlykova, registreted in 1999. The cultivar Vira, created in 1997, is a two-time descendant of the Myronivka wheats, four times from Ukrainka and once from Myronivs'ka 808 through Dons'ka napivkarlykova (QS = 9) and Severodonskaya (QS = 9). The variety Kyjanka (QS = 9), registered by the Insttute of Molecular Biology and Genetics and by two other institutions, is a descendant of Myronivs'ka Yuvileyna and also a forefather for the Bila Tserkva cultivars Veselka and Olesya. Veselka was released in 1997 for the forest-steppe and Olesya was released in 2001 for the forest-steppe and woodland regions of the Ukraine. The newest wheat of the Bila Tserkva Station is Perlyna Lisostepu, a three-time derivatve of Ukrainka and once from Myronivs'ka 27, was registered in 2001 for the forest-steppe and woodland regions of the Ukraine.

Institute of Sugar Beet, Kyiv. Pimenka, the only wheat created at this institue and released in 1950, is adescendant of the Myronivka wheat Ukrainka through Lutescens 17.

Former Ukrainian Institute of Socialist Plant Production, Kyiv. The two sister wheats, Kyivs'ka 11 and Kyivs'ka 12, created in 1959 and 1960, respectively, are twice derivatives of Ukrainka, directly and through Lutescens 17.

Ivanivka Experimental Plant Breeding Station in Sumy Region. At this Station between 1919–1997, 25 cultivars were created. Only three derivatives of Ukrainka, Lutescens 317 (thorough Lutescens 59 from Bila Tserkva, released in the mid 1960s) and the two progenies of Lutescens 317, Ivanivs'ka 12 and its descendant Ivanivs'ka 60 (released in 1981 and 1986, respectively), were registered. In mid 1970s, Ivanivs'ka 8 and Ivanivs'ka 46, both direct derivatives of Myronivs'ka 808, were created at the Ivanivka Station. The variety Okhtyrchanka (QS = 9), a direct progeny of Myronivs'ka 808, was registered in 1978 and widely grown for nearly 20 years in some regions of the Ukraine and of the Russian Federation. In the early 1990s, through Okhtyrchanka, two descendants of Myronivs'ka 808 were developed including the cultivars Ivanivs'ka ostysta (QS = 9.5), registered in 1997, and Ivanivs'ka 19, created in 1996. The variety Sonyachna (QS = 10), a derivative of Ukrainka (through Lutescens 317 and Lutescens 59) and of Myronivs'ka 808 through Okhtyrchanka, was registered in 1996. Ivanivs'ka ostysta has been cultivated in forest-steppe region of the Ukraine since 1997.

L'viv State Agrarian University. The variety Pidgorna 24, a progeny of Ukrainka through Lutescens 17, was registered in 1961.

Ternopil State Agricultural Experimental Station. From this station Ternopil's'ka 1 was released in 1963, a descendant of Ukrainka through Erythrospermum 15.

National Agrarian University (formerly the Ukrainian Agricultural Akademia) in Kyiv. The variety Hostianum 219 was registered in 1963. Hostianum 219 is a three-time progeny of Ukrainka, once directly and once through Erythrospermum 15 and Lutescens 17. The cultivar Teremkivs'ka 10, registered in 1983, is descendant of Myronivs'ka 808.

V.V. Dokuchaev Kharkiv National Universitet. Two sister wheat varieties, Pioners'ka and Rogans'ka originated in 1976. Both are two-time progenies of Myronivs'ka 808.

Rivne State Agricultural Experimental Station. The wheats Rivnen's'ka 49, a direct descendant of Myronivs'ka 808, and Rivnen's'ka 88, a progeny of Myronivs'ka Yuvileyna through Kyjanka (QS = 9), were created in 1979 and 1989, respectively.

Institute of Molecular Biology and Genetics in common with Cherkasy State Agricultural Experimental Station and National Agrarian University. The cultivar Kyjanka, a derivative of Myronivs'ka Yuvileyna, was released in 1981.

Poltava State Agrarian Academy. Both Kolomak 3 (QS = 9) and Kolomak 5 (QS = 9) were registered in 1997. The first cultivar is a direct progeny of Myronivs'ka 808 and the second is a progeny through Dniprovs'ka 846. The variety Poltavs'ka bezosta is a derivative of Myronivs'ka 808 through Zagadka 44 (QS = 9) from Krasnodar and Poltavs'ka 37 (through Dniprovs'ka 782). The wheat Poltavs'ka 42 is a progeny of Poltavs'ka 37. These varieties were created in 1982 (Poltavs'ka bezosta), 1983 (Poltavs'ka 37), and 1989 (Poltavs'ka 42). Kolomak 2 (QS = 9), a direct derivative of Myronivs'ka 808, originated in 1996 and Ukrainka Poltavs'ka, registered in 2000, is a descendant of Myronivs'ka 808 by forefathers of Poltavs'ka 42, Poltavs'ka 37, Dniprovs'ka 782, and Zagadka 44. Kolomak 5 and Ukrainka Poltavs'ka, for the forest-steppe region, and Kolomak 3, for the woodland, forest-steppe, and steppe regions, continue to be cultivated in 2002.

Ternopil and Rivne State Agricultural Experimental Station in common with the Institute of Molecular Biology and Genetics. The cultivar Lutescens 118, a progeny of Myronivs'ka 808 through Lutescens 240, was registered in 1983.

National Agrarian University in common with Chernigiv Agricultural Experimental Station. The variety Vasilek, a derivative of Ukrainka by Bilotserkivs'ka 29, Bilotserkivs'ka 198, and Erythrospermum 15 from the Verkhnjachs'ka Station, was released in 1984.

Ternopil State Agricultural Experimental Station in common with Institute of Plant Physiology and Genetics and Cherkasy State Agricultural Experimental Station. The cultivar Lutescens 7 was registered in 1991 and Natalka in 1988. The both varieties are progenies of Myronivs'ka Yuvileyna through Kyjanka.

Maslivka Agricultural Tekhnical, Kyiv Region (near Myronivka). The variety Maslivs'ka 90, released in 1990, is a derivative of Myronivs'ka 808 through Okhtyrchanka (QS = 9) from the Sumy Region.

The Steppe Region.

Institute of Plant Breeding and Genetics, Odessa. The first direct derivative of Ukrainka was the Odes'ka 1 (QS = 9) created in 1936. The first registered progeny of Ukrainka was Odes'ka 26 (1965; QS = 9) through Lutescens 17 and the second was Albatros Odeskyj (QS = 10) released in 1990. Albatros Odeskyj is a descendant of Ukrainka by parental lines Mayak and Dniprovs'ka 521. Direct derivatives of Albatros Odes'kyj are Ukrainka Odes'ka (QS = 10), Symvil Odes'kyj (QS = 9.5), and Fantazija Odes'ka (QS = 10) and its progeny Krasunya Odes'ka (QS = 10) and Viktoriya Odes'ka (QS = 9.5) registered between 1995 and 1998. Direct progeny of Albatros Odes'kyj also include Lelya (QS = 10), Nikoniya (QS = 10), Selyanka (QS = 10), Zustrich, Ljubava Odes'ka (QS = 9.5), Znakhidka Odes'ka (QS = 10), and Syrena Odes'ka (QS = 10), registered in 2000–02. Lelya also is a derivative of Myronivs'ka 808 from two Russian wheats from the Rostov Region through Donskaya Polukarlikovaya (QS = 9) and Severodonskaya (QS = 9).

The varieties Zoryanka Odes'ka (QS = 9.5) released in the mid 1990s and Kujal'nyk (QS = 9), Povaga (QS = 9), and Poshana (QS = 10) released in 2000s, also are progenies of the Ukrainka by Albatros odes'kyj and forefathers Mayak and Dniprovs'ka 521. The wheat Poshana also is a derivative of Myronivs'ka 808 by Donskaya Polukarlikovaya and Severodonskaya. The cultivar Odes'ka 161, registered in 1995, is a descendant of the Myronivka wheat Ukrainka through the Russian variety Saratovskaya 8 and the Ukrainian cultivars Bilotserkivs'ka 198 and Erythrospermum 15.

The cultivar Odes'ka bezosta, released in 1960, is a progeny of Ukrainka through Lutescens 17. Descendants of the Ukrainka also include Yuzhanka through Bilotserkivs'ka 198 and Erythrospermum 15 (released in the 1960s), Storm by Yuzhanka (released in 1974), Mayak (released in 1977), and Arkadiya (release in 1978). Mayak and Arkadiya were bred through Dniprovs'ka 521 and Salyut odes'kyj through Odes'ka 26 and Lutescens 17.

Burevisnyk Odes'kyj (QS = 10), registered in 1985, Odes'ka Ostysta (QS = 9), registered in 1988, Bryz (QS = 10), registered in the late 1980s, Lada Odes'ka (QS = 9.5), registered in 2000, and a derivative of Bryz Luzanivka Odes'ka, released in 2001, are all derivatives of Ukrainka through Erythrospermum 127 and Vygodjans'ka 2. The wheat Odes'ka 161, released in 1991, is a progeny of Ukrainka through the two Russian wheats Saratovskaya 8 and Saratovskaya 4 and the Ukrainian wheat Bilotserkivs'ka 198.

Derivatives of Myronivs'ka 264 through Rostovchanka, include Odes'ka 76, Odes'ka 120 (QS = 9.5), and Darunok (QS = 9), registered in 1979, 1986, and 1991, respectively. Direct progeny of Myronivs'ka 808 include Odes'ka 162 and Odes'ka 267, and Odes'ka 265, a derivative of the Myronivs'ka 808 from Odes'ka 130, were registered in 1995, 1997, and 1996, respectively. Among the descendants of Myronivs'ka 808 are Odes'ka 83 (directly; QS = 9.5); Odes'ka 130 (QS = 9.5) and Odes'ka 160 (QS = 9.5), both across line N 400; Zolotava (QS = 9), through Donskaya Polukarlikovaya and Severodonskaya; and Mriya odes'ka, over Zaporizhs'ka 60 (QS = 9). These five were released in 1984 (Odes'ka 83), 1987 (Odes'ka 130), 1991 (Odes'ka 160), 1992 (Zolotava), and 1994 (Mriya odes'ka). The cultivar Kotovchanka, created in 1979, is a derivative of Myronivs'ka Yuvileyna.

Donets'k Institute of Agroindustrial Production (formerly the Artemivka Agricultural Experimental Station). Twenty varieties from this institute were created between 1932–94, six of which were registered in 1976–97. Derivatives of Ukrainka include Lutescens 347, released in 1948; Donets'ka 74 (through Lutescens 238 and Lutescens 17), registered in 1976; and Donets'ka 74 derivatives Donets'ka 58 (through Dniprovs'ka 521 and released in 1982; QS = 9) and Donchanka 3 (which was registered in 1995; QS = 9). Donets'ka 18, released in 1979, is a progeny of Myronivs'ka Yuvileyna and Donets'ka 38, which is direct derivative of Myronivs'ka 808 and Illichivka. The cultivar Donets'ka 79, a direct progeny of Myronivs'ka 808, was registered in 1975, and descendant, Donchanka (Gnom 1), was released in 1990. Donets'ka 39 (1993) is a derivative of Ukrainka through Donets'ka 74, Lutescens 238 from Kharkiv, and Lutescens 17 from the Verkhn jachka Station of the Cherkasy Region. In the pedigree of the Donets'ka 39 also are Myronivs'ka 808 via the cultivar Okhtyrchanka from the Sumy Region.

Krym Agricultural Experimental Station. The cultivar Tavrichs'ka, a direct derivative of Ukrainka, was registered in 1961 for the steppe region of the Ukraine. The wheat Kryms'ka 8, a progeny of the Ukrainka by two Kharkiv wheats Krupnokolosa and Lutescens 238 and Lutescens 17 from Verkhnjachka Station of Cherkasy Region, was registered in 1994. Kryms'ka 5, a descedant of Myronivs'ka 808 across Kharkivs'ka 63, was released in 1987. Four cultivars were registered in 1994. Kryms'ka 12 is a direct derivative of Myronivs'ka 808; Kryms'ka 11 is twice a derivative of Myronivs'ka 808 via Kryms'ka 5 and Kharkivs'ka 63 and two Russian wheats Donskaya Polukarlikovaya and Severodonskaya; Darena is a progeny of the Krasnodarian cultivar Spartanka (QS = 9); and Spartanka, in turn, is a descendant of Myronivs'ka 264 by Rostovchanka (QS = 9) and Myronivs'ka Yuvileyna through Polukarlikovaya 49 (QS = 9) and Krynitsa.

Institute of Grain Economy in Dnipropetrovs'k. The first winter wheat cultivar Dniprovs'ka 303, a progeny of Myronivka variety Ukrainka through Novoukrainka 83, was bred in 1964. Direct progenies of Ukrainka include the cultivars Dniprovs'ka 521 and Orbita, registered in 1971 and 1974, respectively, and a progeny of Orbita, Dniprovs'ka 117, released in 1995. Descendants of Ukrainka through Dniprovs'ka 521 are varieties Astra and Veseljanka, both registered in 1976, and Dniprovs'ka 133, released in 1983. The wheat Dniprovs'ka 37, released in 1983, is derivative of Ukrainka through Dniprovs'ka 303, the Russian variety Novoukrainka 83, and Myronovs'ka 808. Three varieties, Dniprovs'ka 782, released in 1973; Dniprovs'ka 846, registered in 1980; and derivative of Dniprovs'ka 782, Dniprovs'ka 39, developed in 1984, are descendants of Ukrainka and Myronivs'ka 808. Gorizont and Dniprovs'ka 52, originated in 1974 and 1979, respectively. Both are derivatives of Myronivs'ka Yuvileyna. The cultivars Dniprovs'ka 33, registered in 1986, and Dniprovs'ka 167, registered in 1995, are derivatives of the Myronivs'ka 808.

Odessa Agricultural Akademia. The cultivar Vygodjans'ka 2, a derivative of Ukrainka, was bred in the 1960s and Erythrospermum 127, a progeny of Ukrainka through Vygodjans'ka 2, was registered in 1974 for the steppe region of the Ukraine.

Zaporizhzhya State Agricultural Experimental Station. Derivatives of Myronivs'ka 808 from this institution are Zaporizhska 60, released in 1984, and Khortychanka, created in 1972.

Dnipropetrovs'k Agricultural Institute. Two derivatives of Myronivka wheats were released from this institute. The first was Era, which was registered in 1975 and has Myronivs'ka 264 in the pedigree, and the second was Peremoga, a progeny of Myronivs'ka 808 through Zagadka 44 and released in 1985.

Institute of Agriculture of Southern Region, Kherson. The cultivar Mriya Khersonu, a derivative of Myronivs'ka Yuvileyna through Khersons'ka 170, was registered in 1989. Another wheat Ostysta 5, a progeny of Ukrainka through Dniprovs'ka 521, was released in 1984. Tavrijs'ka, a descendant of the Myronivs'ka 808 through Donskaya polukarlikovaya and Severodonskaya, was released in 1989, and Berislavka, through Kharkiv wheats Napivkarlyk 3 and Kharkivs'ka 63, was released in 1994. The varieties Khersons'ka 170 and Khersons'ka 94 are direct descendants of Myroniivs'ka and were released in 1977 and 1982, respectively. Nakhodka 7, a progeny of Ukrainka by Ostysta 5 and of Myronivs'ka 264 and Myronivs'ka Yuvileyna through Spartanka, Krynitsa, and Polukarlikovaya 49, was created in 1988.

Other countries of the Former U.S.S.R. The Russian Federation. Central region.
Science-Research Institute for Rural Farming of Central Regions Non-Black-Earth Zone, Nemchinovka of the Moskow Region. The first direct derivatives of Ukrainka, Sovetskaya 1 and Nemchinovskaya 15, a progeny of Ukrainka through Erythrospermun 15, were released in 1956. The variety Kuntsevskaya 45, the first registered progeny of Ukrainka through Lutescens 17, was released in 1960. The winter wheat Ukrainka Podmoskownaya was created by means of transfomation of Ukrainka Jarovaya (spring) from southern Kazakhstan into a winter type. Ukrainka Jarovaya, in turn, was obtained by transformation of winter wheat Ukrainka into a spring type for conditions of southern Kazakhstan. Descendants of Ukrainka through L'govskaya 873, a wheat from the Central Region of Black-Earth Belt, are Nemchinovskaya 495 and Nemchinovskaya 41, released in 1964 and 1968, respectively. The variety Nemchinovskaya 121, released in 1971, is twice a progeny of Ukrainka through both parentals lines Nemchinovskaya 15 and L'govskay 873.

Direct progeny of Myronivs'ka 808 include Zarya (QS = 9), registered in 1978 and widely grown in 2002 in four regions of the Russian Federation. Direct derivatives of Myronivs'ka 808, Raduga, PPG 5 (wheat–wheatgrass hybrid), and Odintsovskaya 75 were created in 1976–77, Moskowskya 60 in the late 1970s, and PPG 113 and Nemchinovskaya 846 in the early 1980s. The cultivar Yantarnaya 50 (QS = 9) was selected from Zarya and has been registered since 1985 in more than 15 years in two regions of Russian Federation. The varieties Nemchinovskaya 52 (QS = 9) and Nemchinovskaya 86 (QS = 9), both direct descendants of Myronivs'ka 808, were registered in 1990 and 1991, respectively. The wheat Moskowskaya nizkostebel'naya (a semidwarf; QS = 9) is an offspring of Myronivs'ka 808 and the derivative Zarya, was released in 1990. Two-time derivatives of Myronivs'ka 808, Inna (QS = 9), through Nemchinovskaya 86 and Zarya (QS = 9), and Moskowskaya 642, through Zarya and the Ukrainian wheat Okhtyrchanka, were both registered in 1991. Moskowskaya 70 (QS = 9), is a three-time descendant of Myronivs'ka 808, twice directly and once through Zarya, and Pamjati Fedina (in memory of Fedin) (QS = 9) is a three-time derivative of Myronivs'ka 808, once directly and twice through Zarya and Yantarnaya 50. Moskowskaya (QS = 9) was registered in 1991 and Pamjati Fedina in 1993. A wheat with the title 'By Name of Rapoport' was bred in Nemchinovka in common with the Institute of Physical Chemistry, is a progeny of Myronivs'ka 808 and was registerd in 1995. The last registered Nemchinovka cultivar, Moskovskaya 39, a descendant of Myronivs'ka 808, was released in 1999.

The varieties Nemchinovskaya 25 (1992) and Nemchinovskaya 95 (1995; QS = 9), are both two-time derivatives of Myronivs'ka 808, directly and through Yantarnaya 50. The newest wheat Galina, was registered in the early 2000 is a five-time progeny of Myronivs'ka 808; three-times by Pamjati Fedina and twice by Inna.

Cultivars from this institution registered in 2002 in the northwest, central, Volgo-Vjatka, central region of Black-Earth Belt, and middle Volga Regions. The varieties Zarya (since 1978) and Inna (since 1991) have been registered in the northwest, central, Volgo-Vjatka, and central region of Black-Earth Belt regions. Moskowskaya nizkostebel'naya (a semidwarf) has been registered in the northwest, central, and central region of Black-Earth Belt regions since 1990, and Moskowskaya 70 in the central region of Black-Earth Belt since 1991. Registered in the northwest and central regions, Nemchinovskaya 52 has been registered in seven since 1990. Moskowskaya 39 was registered in the central, Volgo-Vjatka, and central region of Black-Earth Belt regions since 1999. Pamjati Fedina" has been registered in the central region since 1993, Yantarnaya 50 in the Volgo-Vjatka region since 1985, 'By name of Rapoport' in the central region since 1995, and Moskowskaya 642 in region the Vologo-Vjatka region since 1991.

Kaluga Science-Research Project–Tecnological Institute of Agro-Industrial Complex. The variety Kaluzhskaya 9, a descendant of Ukrainka through the Ukrainian cultivar Lutescens 17, was registered in 1962.

The Main Botanical Garden of Academy of Science of Russian Federation, Moskow. The cultivar Snegirevskaya 397, a derivative of Ukrainka through Lutescens 17 was created in 1965. Two direct descendants of Myronivs'ka 808, the varieties Istrinka (PPG 71) and Snegirevka (PPG 44), were released in 1978, and the wheat Snegirevskaya 8, a progeny of Myronivs'ka 808 by Snegirevka, was registered in 1984.

Tver' (formerly Kalinin) State Experimental Station for Rural Farming in common with Scientific-Research Institute for Rural Farming of Central Regions Non-Black-Earth Zone, Nemchinovka. The wheat Kalininskaya 11 is a derivative of Ukrainka by Lutescens 17 and was released in 1967.

Vladimir Science-Research Institute for Rural Farming, Suzdal' of Vladimir Region. The first direct derivative of Myronivs'ka 808 from this institution was Niva registered in 1981. The cultivar Suzdal'skaya 2, a progeny of Niva, was registered 2000. Slavjanka, a descendant of Illichivka, was bred in 1983. The newest variety Tau, also is a direct derivative of Myronivs'ka 808.

Vladimir Science-Research Institute for Rural Farming in common with Scientific-Research Institute for Rurar Farming of Central Regions of Non-Black-Earth Zone, Nemchinovka. The wheat Sloboda (synonym Grivna) is a direct descendant of Myronivs'ka 808 and was released in 1990.

K.A. Timirjazev Moskow Agricultural Academy. The cultivar Zvezda (QS = 10) was registered in 1992 and is a direct derivative of Myronivs'ka 808.

Central Region of Black-Earth Belt.

A.L. Mazlumov All-Russian Science-Research Institute of Sugar-Beet and Sugar, Ramon' of Voronezh Region. The variety Ramonskaya 883, a derivative of Ukrainka, was released in 1949.

L'gov Experimental Plant Breeding Station, Kursk Region. The variety L'govskaya 873, a direct derivative of Ukrainka, and L'govskaya 77, a direct progeny of Myronivs'ka 808, were registered in 1952 and 1981, respectively. The cultivar M-40 (released in 1947) is a descendant of Ukrainka through L'govskaya 873. The wheat L'govskaya 47 (released in 1973) is a derivative of Ukrainka by L'govskaya 873 and a direct progeny of Myronivs'ka 808. The varieties L'govskaya 16 and L'govskaya 64, released in 1978 and in 1979, respectively, are immediately progenies of Myronivs'ka 808. Zarjanka (L'govskaya), a derivative of Myronivs'ka Yuvileyna and registered in 1981, and L'govskaya 110, created in 1991, are descendants of Myronivs'ka 808 and Ukrainka through L'govskaya 47 and its forefather L'govskaya 873.

Orel Science-Research Institute for Rural Farming (formerly the Shatilovskaya Experimental Station). The cultivar Orlovskaya 7, registered in 1962, is a progeny of the Myronivka wheat Ukrainka by the variety Lisostepka 75 from the Ukrainian town of Bila Tserkva.

Belgorod State Agricultural Academy. Derivatives of Ukrainka from include the first cultivar of this institution, Belgorodskaya, a progeny of Myronivs'ka 808 and Myronivs'ka Yuvileyna and released in 1963 and the variety Belgorodskaya opushennaya (pubescent in English) created in 1984. The wheat Belgorodskasya 5, a direct derivative of Myronivs'ka 808, was registered in 1977 and Belgorodskaya 12, a three-time descendant of Myronivs'ka 808 through Belgorodskaya 5, Myronivs'ka 808, and Myronivs'ka Yuvileyna through Belgorodskaya opushennaya, was released in 1997. BELNIISKH 2 and BELNIISKH 1 were created in the early 2000s and also are progenies of Myronivka wheats. BELNIISKH 2 is a derivative of Ukrainka through Erythrospermum 127 and Vygodja-ns'ka 2 from the Odessa Region. BELNIISKH 1 is a descendant of Myronivs'ka 264 by Odes'ka 120, the Russian cultivar Rostovchanka (9), and Myronivs'ka 808 through Odes'ka 130.

Tambov Science-Research Institute for Rural Farming. The cultivar Pervenka, created in 1964, is a descendant of Ukrainka through Erythrospermum 15. Progenies of Pervenka include Yantar' and Chakinskaya 306, both direct derivatives of Myronivs'ka 808. These cultivars were registered in 1973 (Yantar') and 1976 (Chakinskaya 306).

I.V. Michurin Institute for Fruit and Vegetable Production, Michurinsk of Tambov Region. The variety Michurinskaya 1, a two-time derivative of Ukrainka directly and by Bilotserkivs'ka 198 and Erythrospermun 15, was released in 1966. The variety Tambovitsa is a direct progeny of Myronivs'ka 808 and was registered in 1984.

K.D. Glinka Voronezh State Agrarian Universitet. The variety Voronezhskaya 42 (released in 1975) is derivative of Ukrainka through Bilotserkivs'ka 198 and Erythrospermum 15. Both Voronezhskaya 34 (registered in 1975) and Poisk (registered in 1980) are progenies of Myronivs'ka 808. The two cultivars Volshebnitsa (released in 1980) and Voronezhskaya 17 (released in 1985) are descendants of Myronivs'ka 808 and Myronivs'ka Yuvileyna. The variety Voronezhskaya 4 was released in 1989 and is a derivative of Myronivs'ka Yuvileyna. A direct progeny of Myronivs'ka 808, Voronezhskaya 95 was released in 1997.

Kursk Experimental Point of N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry in common with All-Russion Research Institute of Soils Protection from Erosion. The first variety Seym was released in 1976, and the cultivars Zinaidovskaya (Seym 2) and Lotos (Seym 3) were released in 1978. All three are derivatives of Ukrainka by Lutescens 17 and direct progenies of Myronivs'ka Yuvileyna. The cultivar Rossija, a direct derivative of Myronivs'ka Yuvileyna, originated in 1980.

V.V. Dokuchaev Scientific-Research Institute for Rural Farming of Central Regions of Black-Earth Belt, Talovaja of Voronezh Region. Both Bazalt (QS = 9) and Chernozemka 212 (QS = 9) were registered in 1993. Bazalt is a two-time descendant of Ukrainka through Albidum 114 (QS = 10) and Albidum 11 (which were registered by the Research Institute of Plant Breeding and Seed Production of Volga Region in Kinel') and Novoukrainka 83. Bazalt also is a derivative of Myronivs'ka 808 through Donets'ka 79. Chernozemka 212 is progeny of Myronivs'ka 808 through Belgorodskaya 5. Directly derivatives of Myronivs'ka 808 include Chernozemka and Talovskaya created in 1976 and 1977, respectively, and Chernozemka 153 was release in 1983. Dokuchaevskaya Yuvileynaya, registered in 1991, is twice a progeny of Ukrainka, by Kinel' cultivars Al'bidum 114 and Al'bidum 11 directly and by Novoukrainka 83 and also twice a progeny of Myronivs'ka 808 through Kharkivs'ka 63 and its derivative Polukarlik 1. Two cultivars have been registered since 1993; Bazalt in the Central Region of Black-Earth Belt, Middle and Low Volga Regions and Chernozemka 212 in the Ural Region.

All-Russian Research Institute of Pulse and Groat Crops, Orel region. The variety Arbatka, a direct derivative of Myronivs'ka 808, was released in 1995.

North Caucasian Region.

North-Caucasian Science-Research Institute of Highland and Foothill Farming. Direct derivatives of Ukrainka include Gorskaya 19 (registered in 1942) and Erythrospermum 66 (created in 1949).

P.P. Luk'janenko Krasnodar Science-Research Institute for Rural Farming. The Myronivka cultivar Ukrainka parcipated directly in the pedigrees of Krasnodarian wheats Novoukrainka 83 (QS = 9) released in 1945 and its derivative Novoukrainka 84 released in 1953. Ukrainka, through the Ukrainian variety Lutescens 17, is used in pedigree of celebrity cultivar Bezostaya 4 (QS = 9) and progeny Bezostaya 1 (QS = 9), registered in 1954 and 1959, respectively. The variety Krasnodarskaya 70 (QS = 7) is progeny of Ukrainka by Novoukrainka 83 and Dakha (QS = 7) through the Rostov wheat Zernogradka 2 (QS = 9). Krasnodarskaya 70 and Dakha were registered in 1990 and in 1993, respectively. Deya wheat is a descendant of Ukrainka through Novoukrainka 83 and Azau is a derivative of Ukrainka through Al'batros Odes'kyj, Mayak, and Dniprovs'ka 521. The cultivars Krasnodarskaya 70, Dakha, Deya, and Azau are all progenies not only of Ukrainka, but also of other Myronivka wheats.

Between 1980 and 2000, more tha 20 derivatives of Myronivs' ka 808 were created at this institute; nine of these were registered between 1982 and 1999. Krasnodars'ka 57 (QS = 9.5), a direct derivative of Myronivs'ka 808, was the first to be registered in 1982. This variety is a parent of Sfera (QS = 8) and Pobeda (QS = 9.5), registered in 1993 and in 1998, respectively, and two Krasnodarian lines Krasnodarskaya 57-273 and Krasnodarskaya 57-324 created in the 1980s. Krasnodarskaya 57-273 was used in the pedigree of the Yugtina (QS = 8.5), released in 1994, and Krasnodarskaya 57-324 is in the genealogies of Zimorodoc (QS = 8) registered in 1997 and Otrada (QS = 9.5) created in 1994.

Direct derivatives of Myronivs'ka 808 are Kolos 80 (QS = 10) and Olympia (QS = 9), both registered in 1984; Rufa registered in 1994; and Rannyaya 47 (QS = 10) and Selyanka (Krasnodarskaya; QS = 10) registered in 1975 and 1999, respectively. The line Erythrospermum 12549, a direct progeny of Myronivka 808, is a source of fertility-restorer genes for cytoplasmic-male sterility. This line is found in the pedigrees of Krasnodarian cultivars Kupava (QS = 7), registered in 1998, and Rada (QS = 9) and Gorjanka (QS = 5), registered in 1991 and 1998, respectively. Olympia 2 (QS = 10), is a direct descendant of Myronivs'ka 808 and indirectly through the wheat Balkan (QS = 9) from the former

Yugoslavia, and was registered in 1990. Ejka (QS = 7), a derivative of Myronivs'ka 808 by Donskaya Polukarlikovaya was released in 1994 and Demetra, a progeny of the Myronivs'ka 808 through Severodonskaya was registered in 1997. The wheat Delta, registered in 1999, is three-time derivative of Myronivs'ka 808; once through Severodonskaya, twice through Olympia 2, and once directly through Balkan.

Progeny of Myronivs'ka 808 include Nak, through the Krasnodarian wheat Una (QS = 10) and Novosadska Rana 2 from former Yugoslavia, and Aliza, twice through Olympia 2 and directly through Balkan. These two varieties was registered in 1997 (Nak) and 1998 (Novosadska Rana 2). The very precocious wheat Uskorjanka is twice a derivative of Myronivs'ka 808 by Yugtina through Krasnodarskaya 57 directly and through Donskaya Polukarlicovaya by Severodonskaya (QS = 9). The cultivar Uskorjanka inherited the precocious habit from the Bulgarian variety Rusalka through the Russian wheats Donskaya Polukarlikovaya and Yugtina and also from the South Koreaan cultivar Geurumil. Krasnodarskaya 99 also is a derivative of Myronivs'ka 808 through Severodonskaya. The wheats Uskorjanka and Krasnodarskaya 99 were bred in 1999 and 2000, respectively.

The wheat Murat is a progeny of Myronivs'ka 264 and Myronivs'ka 808 by two Russian wheats Rostovchanka (QS = 9) and Severodonskaya and was registered in 1997, and the variety Rada, also a descendant of these parents, was created in 1991.

The variety Myronivs'k a Yuvileyna is part of the pedigrees of Krasnodarian cultivar Krynitsa, created in the 1980s, and its progenies Spartanka and derivaive Skifjanka and the variety Ofeliya (QS = 9.5). These lines were registered in 1988 (Spartanka), 1992 (Skifjanka), and 1996 (Ofeliya). Nika Kubani, created in 1992, is an offspring of Krynitsa. Myronivs'ka 264 was used in the genealogy of Krynitsa and numerous descendants.

The wheat Spartanka (QS = 9), a derivative of Myronivs'ka 264 through Rostovchanka, Myronivs'ka Yuvileyna, Polukarlikovaya 49, and Krynitsa, was registered in 1988 in some regions of the Russian Federation and the Ukraine. Direct derivatives of the Spartanka include Skyfianka (1992; QS = 7), Ekho (1997; QS = 10), and Kroshka (1997; QS = 10), and Lad, Naslednitsa (QS = 9), and Starshina, which were developed in 1995, 1998, and 2000, respectively. Progenies of Skifjanka include the wheats Pobeda 50 (QS = 9.5), registered in 1998, and the intermediate wheat Jara (QS = 9.5), created in 1997. Twice descendants of Skifjanka, Fisht and Verna were registered in 1999.

The wheat Novokubanka, created in 1994, is twice a progeny of Myronivs'ka 808; once by Okhtyrchanka and once by Polukarlikovaya 49 and the parental line Myronivs'ka Yuvileyna. The cultivar Kupava (QS = 7), registered in 1998, is a four-time derivative of Myronivka wheats Myronivs'ka 264 by the Rostovchanka, twice through Myronivs'ka 808 by Severodonskaya and Erythrospermum 12549 and Myronivs'ka Yuvileyna through Polukarlikovaya 49.

The variety Terchanka (QS = 6) was created in 1998 and is a four-time progeny of Myronivs'ka 264 over Rostovchanka, Myronivs'ka 264 and Myronivs'ka 808 through Donskaya Bezostaya, and Myronivs'ka Yuvileyna through Polukarlikovaya 49. Myronivs'ka 264, through Rostovchanka, twice by Myronivs'ka 808 by Okhtyrchanka and Russian variety Severodonskaya, and also Ukrainka and Myronivs'ka 808 through Dniprovs'ka 846, was used in pedigree of the five-time derivative of Goryanka and was registered in 1998.

The more widely grown, Krasnador cultivars among the derivatives of Myronivka wheats from are the varieties Bezostaya 4 and Bezostaya 1. Bezostaya 1, registered in 1959, nearly 45 years later is registered for the steppe region of the Ukraine and in north Caucasian and in Lower Volga Regions of the Russian Federation. Spartanka and Skyfjanka, registered in 1988 and 1992, respectively, were grown in the southern Russian Federation and in the forest-steppe and steppe regions of the Ukraine, Transcaucasia, and middle Asia countries on nearly 2×10^6 ha in 2000. In 2002, these cultivars are registered in North-Caucasian Region of the Russion Federation. Skifjanka also is registered in the steppe region of the Ukraine. Yuna has been widely grown in the southern Russian Federation, the forest-steppe and steppe of the Ukraine, and in middle Asia since 1992. The cultivars Zhirovka, Kroshka, and Pobeda 50 have been wide spread in the Krasnodar Territory since 1998. In 2002 in the North-Caucasian Region, the cultivars Dakha, Demetra, Ejka, Krasnodarskaya 90, Leda, Rufa, and Yugtina were registered between 1993–95; Del'ta, Zimorodoc, Kupava, Murat, Ofeliya, Umanka, and Ekho between 1996–99; and Russa and Lira between 2000–01. The Krasnodarian variety Yuna has been registered in the North-Caucasian and Lower-Volga Regions for more than 10 years, since 1992.

Stavropol Science-Research Institute of Rural Farming. Direct descendants of the Myronivka wheat Ukrainka include Stavropol cultivars Hybrid 491 and Hybrid 343, which were released since 1950 and 1957, respectively. Starnad 1 is twice a progeny of Ukrainka by Stavropol'skaya 4, Hybrid 491, and Hybrid 343, and once by Myronivs'ka 808 through

Yuna and Novosadska Rana 2. Starnad 1 has been registered since 2000 in North-Caucasian Region of the Russian Federation. Erythrospermum 161 and Erythrospermum 162, both direct derivatives of Ukrainka, were created in 1941. Stavropol'skaya 4, twice a descendant of Ukrainka through Hybrid 491 and Hybrid 343, was released more than 20 years later in 1962, and Edisseyskaya 9, a direct derivative of the Myronivs'ka Yuvileyna, was registered 25 years later in 1987. The cultivar Deminskaya, a progeny of Myronivs'ka 264 by Tarasovskaya 29 (QS = 9), was created in 1991.

All-Russian Institute of Breeding and Seed Production of Sorghum and Other Grain Crops (formerly the Zernograd Breeding Station), Zernograd of Rostov Region. The first derivatives of Myronivka wheats include Rostovchanka (QS = 9), a progeny of Myronivs'ka 264; Zernogradka 2 (QS = 9), a descendant of Ukranika by Novoukrainka 83, registered in 1973 and 1980, respectively. The next Zernograd varieties were Urozhajnaya (QS = 9), registered in 1982 and twice a progeny of Myronivs'ka 808; and Donskaya bezostaya (QS = 9), a derivative of Myronivs'ka 264 and Myronivs'ka 808 and registered in 1983.

The varieties Donskaya Poluintensivnaya (half intensive; QS = 9) is twice a progeny of Myronivs'ka 808, and Donskaya Intensivnaya (QS = 9) is a derivative of Myronivs'ka 808 by Donskaya Polukarlikovaya and Severodonskaya. Both cultivars were created in 1984. Zernogradka 3 (QS = 9) and its descendant Don 95 (QS = 9) are derivatives of Myronivs'ka 264 by Donskaya Bezostaya and twice derivatives of Myronivs'ka 808 by Donskaya Bezostaya and Severodonskaya. Zernogradka 3 was created in 1984 and Don 95 was registered in 1998.

Don 85 (QS = 9) is a direct derivative of Myronivs'ka 264 and Myronivs'ka 808, and Kolos Dona (QS = 9) is a direct progeny of Myronivs'ka 264 and Myronivs'ka 808 and twice a descendant of Myronivs'ka 808 through Urozhajnaya (QS = 9). These lines were registered in 1990 (Don 85) and 1993 (Kolos Dona). Three cultivars, Don 93 (QS = 9), a derivative of Ukrainka through Novoukrainka 83 and of Myronivs'ka 808 by Severodonskaya; Zernogradka 9 (QS = 9), a progeny of Myronivs'ka 264 through Rostovchanka and twice a descendant of Myronivs'ka 264 and Myronivs'ka 808 by Donskaya Bezostaya; and Podarok Donu (QS = 9), a derivative of Myronivs'ka 808 directly and twice by Severodonskaya and once directly and through Donskaya Polukarlikovaya, were registered between 1997–99. The wheat Stanichnaya, created in 1999, is twice a progeny of Myronivs'ka 808 directly and once by Donskaya Polukarlikovaya. Don Simb, bred in 1993 in collaboration with Ul'yanovsk Research Institute of Agriculture is twice a direct derivative of Myronivs'ka 808 (The town of Ul'yanovsk in the past was named Simbirsk).

Among the three cultivars registered since 2000, Donskoy Mayak (QS = 9) is a derivative of Myronivs'ka 264 and Myronivs'ka 808 through Donskaya Bezostaya; Dar Zernograda (QS = 9) is a four-time progeny of Myronivs'ka 808, twice directly and twice through Kolos Dona; and Kolos Dona (QS = 9) is a direct descendant of Myronivs'ka 264 and Myronivs'ka 808 and twice a progeny of Myronivs'ka 808 through Urozhaynaya. The wheat Zernogradka 10 (QS = 9), registered in 2001, is a direct derivative of Myronivs'ka 808, twice a progeny of Myronivs'ka 264, and of Myronivs'ka 808 by Donskaya Bezostaya and sib lines. Ermak, registered in 2001, is a one-time derivative of Myronivs'ka 264 and a four-time derivative of Myronivs'ka 808 through two Zernograd varieties, twice by Donskaya poluintensivnaya, once by Donshchina, and once through the Krasnodarian wheat Olympia.

The semidwarf wheat Donskaya Polukarlikovaya is a derivative of Myronivs'ka 808 through Severodonskaya and was registered in 1983 in the Ukraine and in the Russian Federation. The semidwarf cultivars Donchshina (QS = 9), Zernogradka 6 (QS = 9), Zernogradka 8 (QS = 9), and Donskaya Yubileynaya (QS = 9) were registered between 1992–94. All four wheats are twice derivatives of Myronivs'ka 264 by Rostovchanka and Donskaya Bezostaya and twice progeny of the Myronivs'ka 808 by Donskaya Polukarlikovaya and Donskaya Bezostaya (sibs of Donskaya Bezostaya Line 560-76 only were used in the pedigree of Zernogradka 6). Rostovchanka 2 (QS = 9), registered in 1994, is a one-time derivative of Donskaya Bezostaya and twice of Donskaya Polukarlikovaya. The varieties Zarnitsa (QS = 9) (Zernogradskaya) and Stanichnaya were both released in 1999. Zarnitsa is a three-time progeny of Myronivs'ka 808; once by Severodonskaya and twice by Donskaya Polukarlikovaya and Severodonskaya.

The semidwarf cultivars Donskoy Sjurpriz (QS = 9) and Zernogradka 11 (QS = 9) were registered in 2000. In pedigree of Donskoy Sjurpriz are Line 560-76 (a sib of Donskaya Bezostaya), Zernogradka 3, Zernogradka 8, Myronivs'ka 264 (used three times), and Myronivs'ka 808 (used eight times). The variety Zernogradka 11 has 11 uses of Myronivka wheats; five times with Myronivs'ka 264 and six times with Myronivs'ka 808 through the parents of Line 208-72, Donskaya Polukarlikovaya, Donshchina, and Zernogradka 6. We concluded that Myronis'ka 264 and Myronivka 808 are used more often in pedigrees of wheat culivars developed in Zernograd than in those of the other institutions, whereas Myronivs'ka Yuvileyna was not included in the pedigrees of Zernograd wheats.

Zernograd cultivars were widely grown in three regions of the Russion Federation in 2002. In the Central Region of Black-Earth Belt, the North-Caucasian, and Lower Volga Regions are registered Donskaya Bezostaya since 1983, Don 85 since 1990, and Don 93 since 1997. Donshchina, Zernogradka 8, Don 95, Dar Zernograda, Donskoy Mayak, Ermak, and Zernogradka 10 were registered between 1992–2001 for the North-Caucasian and Lower Volga Regions. Donskaya Yubileynaya, registered since 1994, and Zernogradka 9 and Podarok Donu, registered since 1998 and 1999, respectively are only for the North-Caucasian Region. The varietiy Donskaya Polukarlikovaya has been registered for the forest-steppe and woodland regions of the Ukraine since 1985 and Zernogradka 8 and Rostovchanka 2 for the steppe region since 1994.

Prikumsk Branch of Stavropol' Science-Research Institute for Rural Farming. The wheats Prikumskaya 36 (QS = 9), a direct progeny of Myronivs'ka 808, and Prikumskaya 110, a derivative of Myronivs'ka 264 through Rostovchanka, were registered in 1976 and 2001, respectively. Prikumskaya 40 is a direct descendant of the Myronivs'ka 808 and Prikumskaya 79 is a direct progeny of Myronivs'ka Yuvileyna. Both were created in the mid 1970s. Prikumskaya 98 and Prikumskaya 986, derivatives of Myronivs'ka 808 through Prikumskaya 36 were released in 1989.

Severo-Donetskaya (North Donetsk by English) State Agricultural Experimental Station, Tarasovka of Rostov Region. Among 18 cultivars bred at this station in 1957–2001, 16 are progenies of Myronivka wheats. Nine Severodonetsk wheats were or are widely registered in the Russia Federation and the Ukraine and two varieties are being studied in the State Variety Trials.

Severodonskaya is a widely grown derivative of Myronivs'ka 808 and has been registered since 1977 for more than 20 years in many regions of the Russion Federation. The variety Tarasovskaya 29, a progeny of Myronivs'ka Yuvileyna directly and of Myronivs'ka 264 through Rostovchanka, was registered in 1981 and for more than 20 years in the Central Region of Black-Earth Belt, North-Caucasian, and Low-Volga Region of the Russion Federation and for nearly 20 years in the Ukraine, since 1982.

The cultivar Severodonskaya 5 (QS = 9) is a descendant of Myronivs'ka 264 through Rostovchanka and Ukrainka through Bilotserkivs'ka 47, Bilotserkivs'ka 21 polipshena, Bilotserkivs'ka 21, Bilotserkivs'ka 198, and Erythrospermum 15. Severodonskaya 12 (QS = 9) is a derevative of Myronivs'ka Yuvileyna through Tarasovskaya 29 and of Myronivs'ka 264 through Tarasovskaya 29 and Rostovchanka. Tarasovskaya 97 (QS = 9) is a progeny of Myronivs'ka 264 and Myronivs'ka Yuvileyna by the parents of Spartanka. In the pedigree of Tarasovskayaostistaya (QS = 9) are found Myronivs'ka 264, through Tarasovskaya 29; Rostovchanka; Ukrainka through Al'batros Odes'kyj; Mayak; and Dniprovs'ka 521. The genealogical tree of Rosinka Tarasovskaya includes Myronivs'ka 808 through Donskaya polukarlikovaya and Severodonskaya and Myronivs'ka 264 and Myronivs'ka Yuvileyna through Donskaya Bezostaya. The variety Prestizh (QS = 9) is a descendant of Myronivs'ka 808; once by Severodonskaya, twice by Urozhaynaya, and by Ukrainka through Al'batros Odes'kyj, Mayak, and Dniprovs'ka 521.

Severodonskaya 5 and Severodonskaya 12 were registered in 1991 and 1996, respectively, and Tarasovskaya ostistaya and Rosinka Tarasovskaya were registered in 2001 for the North-Caucasian Region. Since 2001, Tarasovskaya 97 has been registered in the Central Region of Black-Earth Belt and Prestizh in the Central-Chernozem and Low-Volga Regions.

Both Severodonskaya 2 (QS = 9) and Tarasovskaya 61 (QS = 9) were created in 1983 and are descendants of Myronivs'ka 808 through Severodonskaya. Tarasovskaya intensivnaya (QS = 9), a derivative of Myronivs'ka 264 by Rostovchanka and Myronivs'ka 808 and Severodonskaya immunnaya, originated in 1983. Tarasovskaya 84 (bred in 1987) is derivative of Ukrainka through Zernogradka 2 and Novoukrainka 83. Tarasovskaya 89 (bred in 1991) is a progeny through Tarasovskaya 29 of Myronivs'ka Yuvileyna directly and of Myronivs'ka 264 through Rostovchanka. Severodonskaya 14, created in 1995, is a direct descendant of Myronivs'ka 264 and Myronivs'ka 808.

The cultivars Rodnik and Severodonskaya Yubileynaya were created in 2001. Rodnik is a three-time descendant of Ukrainka; twice through Bilotserkivs'ka 198 and Erythrospermum 15 and once through Bilotserkivs'ka 21 polipshena (improved), also a derivative of Bilotsekivs'ka 198. Rodnik also is a progeny of Donskaya Yubilejnaya. Also present in the pedigree are Myronivs'ka 808 through Donskaya Polukarlikovaya; Severodonskaya; Myronivs'ka 264; and Myronivs'ka 808 by Donskaya Bezostaya. The pedigree of Severodonskaya Yubileynaya includes four Myronivka wheats; Ukrainka through Albatros Odes'kyj, Mayak, and Dniprovs'ka 521; Myronivs'ka 264 by Tarasovskaya 29 and Rostovchanka; Myronivs'ka 808 from Krasnodarskaya 57; and Myronivs'ka Yuvileyna also through Tarasovskaya 29.

P.P. Luk'janenko Krasnodar Science-Research Institute for Rural Farming in common with the Karabach Science-Experimental Baze of Institute of Genetic and Breeding in Azerbaijan. The cultivar Birlyk (Dostlug), a derivative of Myronivs'ka Yuvileyna through Polukarlikovaya 49, was registered in 1989.

P.P. Luk'janenko Krasnodar Science-Research Institute for Rural Farming in common with the Prikumsk Branch of Stavropol' Science-Research Institute for Rural Farming. The variety Prikumskaya 140, created in 2000, is a derivative of Spartanka with Krinitsa, a progeny of Myronivs'ka 264 through Rostovchanka and Myronivs'ka Yuvileyna through Polukarlikovaya 49, in the pedigree.

Middle Volga Region.

P.N. Konstantinov Research Institute of Plant Breeding and Seed Production of Volga-Region, Kinel' of Samara Region. The cultivar Al'bidum 11, twice a derivative of Ukrainka directly and through Novoukrainka 83, was released in 1969; Al'bidum 114, a descendant of Al'bidum 11 released in 1973, and Kinel'skaya 4 (QS = 9), twice a derivaive of Ukrainka through Al'bidum 114 and a direct descendant of Myronivs'ka 808 was registered in 1985.

Botany Institute of Kazan' State University. The wheat Stolbishchenskaya was created in 1969 and is a derivative of Ukrainka through Novoukrainka 83.

Ulyanovsk Science-Research Institute for Rural Farming ("Selektsiya" Ltd). The first progeny of Myronovka wheats at this institution was Ul'janovskaya 76, a direct derivative of Myronivs'ka 808, was created in 1977. In 1997 after 20 years, the variety Volzhskaya 6, a direct descendant of Myronivs'ka 808 through Kinel'skaya 4 and twice a derivative of Ukrainka directy and by Novoukrainka 83, was registered. Volzskaya 100, registered in 1999, and also Volzhskaya N and Volzhskaya Z, registered in 2000, are all descendants of Kharkivs'ka 92. Volzhskaya Z is a progeny of three Myronivka wheats with QS = 9; Myronivs'ka 264, Myronivs'ka 808, and Myronivs'ka Yuvileyna through Kharkivs'ka 90. The wheat Volzhskaya K, created in 2000, is twice a derivative of Ukrainka by Al'bidum 114 and Albidum 11 and also a direct decendant of Myronivs'ka 808 by Kinel'skaya 4.

N.M. Tulaykov Samara (former Kujbyshev) Science-Research Institute for Rural Farming. The cultivar Malakhit, a derivative of Myronivka Ukrainka through Ukrainian varieties Albatros Odes'kyj, Mayak, and Dniprovs'ka 521, was registered in 2000 for the Middle-Volga Region. Stremnina is a direct derivative of Myronivs'ka 808 and was released in 1986; Bezenchukskaya ostistaya, a descendant of Myronivs'ka Yuvileyna by Ershovskaya 8, was released in 1989; and Samaryanka, a progeny of Myronivs'ka 264 and Myronivs'ka 808 through Donskaya Bezostaya, was released in 1997.

Tatarstan Science-Research Institute for Research Farming in common with State Unitary Enterprise Science-Production Association "Niva Tatarstana" of breeder E.F. Ionov. Meshinskaya, a direct derivative of Myronivs'ka Yuvileyna, was registered in 1989. The cultivars Meshinskaya 2, Meshinskaya 3, and Kazanskaya 560, all progenies of Myronivs'ka Yuvileyna through Meshinskaya, were registered in 1992, 1995, and 1999, respectively. Dustlyk wheat, a derivative of Ukrainka through Albidum 114 was released in 1995.

N.M. Tulaykov Samara (formerly Kujbyshev) Science-Research Institute for Rural Farming in common with P.P. Luk'janenko Krasnodar Science-Research Institute for Rular Farming. The cultivar Kujbyshevka, a derivative of Myronivs'ka 264 by Rostovchanka and Myronivs'ka 808 by Rannjaja 47 was registered in 1989 in Kazakhstan.

Lower Volga Region.

Science-Research Institute for Rural Farming of South-East Region, Saratov. The sole registered derivatve of Myronivka wheats from this institution is Saratovskaya 90 (synonym Saratovskaya 12; QS = 9) registered in 1995. Twice a direct derivative of Myronivs'ka 10 and once of Ukrainka, Saratovskaya 90 also has Saratovskaya Yubilejnaya and the Ukrainian wheat Lutescens 17 in its pedigree.

Saratovskaya Yubilejnaya was created in 1963 and is a progeny of Ukrainka through Lutescens 17. Saratovskaya 8 (registered in 1976) is a descendant of Ukrainka through the Ukrainian wheats Bilotserkivs'ka 198 and Erythrospermum 15. The cultivar Saratovskaya 11, bred 10 years later in 1986, is a direct derivative of Myronivs'ka Yuvileyna and twice a progeny of Ukrainka through Al'bidum 114 and Al'bidum 11. The Saratov wheat Lutescens 15 is twice a progeny of Ukrainka by Saratovskaya Yuvileyna and the Ukrainian wheat Lutescens 17, and once by Dniprovs'ka 521. Lutescens 15 also is a direct derivative of Myronivs'ka 808. The wheat Saratovskaya ostistaya, registered in 1995, was selected from Lutescens 15 (twice a derivative of Ukrainka). Viktoria 95, registered in 1998, is a two-time progeny

of Ukrainka by Lurescens 15 and twice of Myronivs'ka 808 by Odintsovskaya 75 from Moskow Region. The variety Guberniya, released in 1999, is three-times a direct progeny of the Myronivka wheat Illichivka.

Ershov Experimental Station for Irrigated Agriculture of the Saratov Region. The cultivar Ershovskaya 10, a derivative of two Volga-Region wheats Albidum 114 and Ershovskaya 8, was registered in 1995. Ershovskaya 10 is twice a descendant of Ukrainka directly and through Novoukrainka 83 by Al'bidum 114 and Al'bidum 11 and a progeny of Myronivs'ka Yuvileyna by Ershovskaya 8 (bred in 1980). The wheat Ershovskaya 11, registered in 1996, is a descendant of Myronivs'ka 808 by Zarya and twice a progeny of Myronivs'ka 264 and Myronivs'ka 808 by Donskaya Bezostaya from the Rostov Region.

N.I. Vavilov Saratov State Agricultural Academy. The cultivar Lutescens 72 (QS = 9) is a direct derivative of Myronivs'ka Yuvileyna was registered in 1988 for the Lower-Volga Region.

Ershov Experimental Station for Irrigated Agriculture in common with Science-Research Institute for Rural Farming of South - East Region. Levoberezhnaya, created in 2000, is a derivative of Myronivs'ka 264 and Myronivs'ka 808 through Donskaya Bezostaya.

Kalmykiya Science-Research Institute for Rural Farming in common with P.P. Lukjanenko Krasnodar Science-Research Institute for Rural Farming. The wheat Yakushljanka, a derivative of two Krasnodarian wheats Spartanka and it forefather Krinitsa, originated in 2000. In the pedigree of Krinitsa, two Myronivka wheats were used, Myronivs'ka 264 through Rostovchanka and Myronivs'ka Yuvileyna through the Krasnodarian variety Polukarlikovaya 49.

Ural Region.

Kurgan Science-Research Institute of Grain Economy. The cultivars Kurganskaya ozimaya 1 (winter) is a direct derivative of Myronivs'ka Yuvileyna and Erythrospermum 52 is a direct progeny of a spontaneous hybrid of Myronivs'ka 808 were registered in 1985 and 1987, respectively.

Bashkotorstan Research Institute for Rural Farming and Field Crop Breeding. A direct derivative of the winter wheat Myronivs'ka 808, Lutescens 9 was registered in 1993.

Western Siberian Region.

Instiute of Cytology and Genetic in common with Siberian Institute of Physiology and Biochemia, Novosibirsk. The cultivars Kulundinka, Bagrationovskaya, Zalarinka, and Novosibirskaya 32 are progenies of Myronivs'ka Yuvileyna; Irkutskaya ozimaya (winter type) of llichivka; and Pamjati Belyaeva (Memory of Belyaev) of Illichivka and Myronivs'ka Yuvileyna. All six varieties of this institution were released in the second half of the 1990s.

Siberian Scientific-Research Institure of Rural Farming, Omsk. The wheat Omskaya 4 (QS = 9) was bred in 1996 and is a descendant of the cultivar Myronivs'ka 25.

Altay Science-Research Institute of Agriculture and Breeding of Agricultural Crops in common with the Siberian Science-Research Institute of Rural Farming. A derivative of Illichivka, the variety Zhatva Altaya was created in 1996.

Instiute of Cytology and Genetic in common with Altay Science-Research Institute of Rural Farming and Breeding of Agricultural Crops. The cultivar Altayskaya ozimaya, a progeny of Myronovs'ka 808 and Illichivka, was registered in the early 2000s.

Moldovia.

Moldova Science-Research Institute of Breeding, Seed Production and Agrotechnik of Field Crops. Between 1959–1987, five cultivars were registered from this institute, all progenies of Ukrainian wheats. Bel'tskaya 39 is derivative of Ukrainka directly and was registered in 1959. Gloria, twice a progeny of Ukrainka, directly and through Novoukrainka 84 and Novoukrainka 83, was registered in 1970. Glyia, registered in 1979, is a descenant of Myronivs'ka Yuvileyna. Belchanka 4, released in 1983 (synonym of MK 82-04), is from Illichivka. Bel'chanka 6 is a direct derivative of Myronivs'ka 808 and was registered in 1987.

Chishenau Agricultural Academy. Direct derivatives of Myronovka wheats include Kriulen' 12, from Myronivs'ka 264 and released in 1970 and Kishinevskaya ostistaya (synonym Kishinevskaya 101) and Kishinevskaya 102, both from Myronivs'ka 808, released in 1972.

Faleshty Agricultural Experimental Station. Faleshtskaya 3, a progeny of Myronivs'ka 808, was released in 1980.

Lithuania.

Lithuania Science-Experimental Institute of Agriculture (formerly the Dotnuva State Breeding Station). The cultivar Muras, a derivative of Ukrainka), through Lisostepka 75, was registered in 1958, and Shirvinta 1, a progeny of Myronivs'ka 808 and Myronivs'ka Yuvileyna (9), was registered in 1989.

Stende Agricultural Experimental Station of Lithua Science-Experimental Institute of Agriculture. Direct derivatives of Myroniva'ka 808 and Illichivka include Stende released in 1982.

Belarus.

Belarus' Sciente-Research Institute of Agriculture and Forage. Among the direct progenies of Myronivs'ka 808 are Berezina and Nadzeya that were registered in 1985 and 1987, respectively, and Suzorje, a descendant of Myronivs'ka 808 through Berezina, registered in 1992. The cultivars Sojuz 50 and Zarnitsa, both direct derivatives of Myronivs'ka 808 and Myronivs'ka Yuvileyna, were created in 1973 and 1978, respectively. Bylina and Karavay, which were released in 1998, are progenies of Myronivs'ka 808; Bylina through Nadzeya and Karavay through Berezina.

Grodno Agricuctural Institute. The cultivar Prinemanskaya 11 is a direct derivative of Myronivs'ka 808 and was released in 1987.

Georgia.

Mtskheta Plant Breeding Station. Kartuli 18, a direct derivative of Myronivs'ka Yuvileyna, was registered in 1981.

Armenia.

Armenia Institute of Agriculture. The cultivars Graecum 24, Sevan 40, and Akunki, all three direct descendants of Ukrainka, were registered in 1946, 1962, and 1972, respectively.

Armenia Institute of Plant Protection. Derivatives of Ukrainka are cultivars Martuk and Altuk released in 1952 and 1956, respectively.

Leninakan State Plant Breeding Station. Direct descendants of the Ukrainka include Almagarit, registered in 1960, and two progeny lines Zepjur and Armaveni (synonym Aragaz 1). Both cultivars were released in 1971. The wheat Akhurjansckaya 1 is a progeny of Ukrainka by Novoukrainka 83. Leninakanskaya 5, released in 1978, is direct derivative of Ukrainka and Myronivs'ka 808.

Kazakhstan.

V.R. Wiliams Kazakhstanian Science-Research Institute of Agriculture. A direct derivative of Ukrainka, Hybrid 57 was registered in 1963. Zhalyn' and Almaly, the both progenies of Ukrainka by Dniprovs'ka 521, were released in 1984 and 1986, respectively. Zhetysu, twice a descendant of Ukrainka by Kharkivs'ka 38, was released in 1988.

Kazakhstanian Agricultural Academia. The variety Lutescens 12, a derivative Ukrainka by Lutescens 17 was registered in 1964. The descendants of Ukrainka through Lutescens 17 include Dzhungarskaya and Erythrospermum 10, both registered in 1959, Predgornaya 26 registered in 1979, Milturum 23 registered in 1985, and Albidum 8 registered in 1998. Only the variety Semirechenskaya, released in 1963, is a two-time derivative of Ukrainka through Lutescens 17 and Erythrospermum 15.

Institute of Botany of Academia Science of Kazakhstan. The cultivar AN 10 (*T. durum*) is derivative of Ukrainka through Bilotserkivs'ka 198 and was registered in 1974.

Former Karabalyk department of V.N.Remeslo Institute of Wheat. Komsomol'skaya 56 (synonym Kustanajskaya) was registered in Kazakhstan in 1989. This wheat is four-times a progeny of three Myronivka wheats including Myronivs'ka 264, Myronivs'ka 808, and twice by Myronivs'ka 10.

Kirghyzstan.

Kirghyz Science-Research Institute of Agriculture. Erythrospermum 72, bred in 1948, is direct derivative of Ukrainka.

Tajikistan.

Tajik Science Research Institute of Agriculture. The cultivars Navruz (in English, New Day), registered in 1982, and Gul'dfast, released in 1982, are derivatives of the winter wheat Myronivs'ka Yuvileyna.

European Countries.

France.

The French cultivar Renan (QS = 10; 2*.7+8.5+10) released in 1989, is one of the most western derivatives of Myronivs'k a 808 in west European winter wheats. The excellent quality of all HMW-glutenin subunits in Myronivs'ka 808 are with those of Maris Huntsman (QS = 4; N.6+8.2+12) with bad quality of all three glutenin subunits, and the French wheat Moisson (QS = 6; N.7+8.2+12) with two of three subunits with bad quality) are in the pedigree of Renan. High-quality glutenin subunits in Renan are from Myronivs'ka 808 only. The cultivars Open, Louvre, Amelio, and Eureka also are progenies of Myronivs'ka 808. These cultivars were released in France between 1987 and 1991.

Germany.

German derivatives of Myronivs'ka 808 include Miras, Faktor, Mikon, and Ramiro (all four with QS = 9) were bred jointly by GmbH Hadmersleben and V.N. Remeslo Institute of Wheat in Myronivka. These cultivars were released in Germany between 1984–89. In pedigrees of Miras and Ramiro also is Bezostaya 1. The varieties Myrleben (QS = 7) and Myrhad (QS = 5) were selected by this same joint program. Hybrid combinations were received in Germany and selections were completed in Myronivka. Myrleben and Myrhad were registered in the Ukraine in 1993 and 2000, respectively, but Myrhard (pedigree HDM 5355-80/Apscol), probably was not bred from Myronivka wheats. The new German variety Lars is a derivative of Myronivs'ka 808 through Ramiro.

Poland.

The varieties Emika, Gama, Ilawska, Kobra, Nike, and Rada are all direct derivatives of Myronivs'ka 808. The wheat Aleta is a progeny of Myronivs'ka 808 by Emika and Korweta by Gama. The cultivar Lanca is a descendant of Myronivs'ka 808 through the Balarus' wheat Nadzeya, and the varieties Toba and Wilga are offspring of Lanca. The variety Juma is a direct derivative of Myronivs'ka Yuvileyna, and the wheat Elena is a progeny of Myronivs'ka 808 through line SMH 1320 and Myronivs'ka Yuvileyna through line STH 12602.

Former Yugoslavia.

Among cultivars bred in the former Yugoslavia between 1975–2000, Novosadska Rana 1 (registered in 1975), Novosadska Rana 2 (registered in 1975), Novosadska Rana 3 (registered in 1977), and Novosadska Rana 4 (registered in 1978) are direct derivatives of Myronivs'ka 808. The variety Sidanka, registererd in 1976, is a progeny of Myronivs'ka Yuvileyna through Lutescens 7 and Kyjanka. Balkan $^{T1BS\cdot1RL}$ (QS = 9), registered in 1980, is a direct derivative of Myronivs'ka 808. The cultivars Nova Posavka and Pancevka are derivatives of Mytonivs'ka 808 through Novosadska Rana 2 and Lastais a direct progeny of Myronivs'ka Yuvileyna. All three of these wheats were registered in 1987. The varieties Novosadska Rana 5 (registered in 1991) and the progeny Dicna (registered in 1992) are both descendants of Myronivs'ka 808 by Novosadska Rana 1. Two wheats are descendents by Novosadska Rana 2, Evropa 90 (released in 1990) and Russija (registered in 1993). The cultivars Pobeda (registered in 1990), Lira (registered in 1994), and Pesma (registered in 1995) are derivatives of Myronivs'ka 808 through Balkan. Stamena (registered in 1998) is a progeny of Myronivs'ka Yuvileyna by Lasta. The newest variety from former Yugoslavia registered in 2000 is Sonata, a derivative of Myronivs'ka 808 through Kharkivs'ka 77 and its parent Kharkivs'ka 63.

Hungary.

In 1974–2000 in Hungary, 24 varieties that are descendants of Ukrainian wheat Myronivs'ka 808 were bred. Among these are cultivars MV 4 (QS = 9), MV 5 (QS = 9), MV 9 (QS = 9), and MV 12 (QS = 9) and derivatives MV Emese and MV 15 $^{T1BS\cdot1RL}$ and MV 20 $^{T1BS\cdot1RL}$ are direct progenies of Myronivs'ka 808. The wheats MV 23 $^{T1BS\cdot1RL}$ and MV Koma are descendants of Myronivs'ka 808 through MV 5, MV 16 $^{T1BS\cdot1RL}$ (QS = 8.5) through MV 4, and MV Optima through MV 5 and MV 9. The wheat Myronivs'ka 808 was used in the pedigrees of the cultivars MV Emma, MV Palma, MV Sigma, MV Vilma, and MV Matador, and also twice in MV Irma through MV 15. The varieties MV Martina and MV Summa are progenies of the Ukrainian cultivar Myronivs'ka 808 by MV 17 $^{T1BS\cdot1RL}$ through the Czech wheat Slavia. The variety MV 18 is a derivative of Myronivs'ka 808 through Rannjaja 47, and MV Dalma through Balkan.

The two Myronivka wheats Myronivs'ka 808 through MV 17 and Illichivka through the Slovakian cultivar Viginta (QS = 7_ are parents of MV Madrigal. Three Mironivka wheats are in the pedigrees of many new (registered since 2001) Hungarian cultivars including MV Mariska, through Russian cultivars from Krasnodar; Delta, a derivative of

Myronivs'ka 808 through the Russian wheat Severodonskaya; and Spartanka, throgh Krinitsa, a progeny of Myronivs'ka Yuvileyna by Polukarlikovaya 49 and Myronivs'ka 264 through the Rusian cultivar Rostovchanka. The Hungarian variety MV Magdalena is a descendant of Myronivs'ka Yuvileyna, MV 21 a direct progeny, and MV Madrigal a derivative of Illichivka through the Slovakian variety Viginta (QS = 7). The cultivars MV Magdalena, MV Emma, MV Palma, and MV Vilma are the varieties registered for the largest production area.

Czech Republic.
Thirty-seven winter wheats were bred in the Czech Republic between 1976–2001. These wheat are derivatives of four Myronivka cultivars Myronivs'k a 808, registered in the former Czechoslovakia in 1968; Myronivs'ka Yuvileyna, registered in 1971; Illichivka, registered in 1974; and Myronivs'ka nyz'korosla, registered in 1979). Among winter wheat varieties registered in 1976–85, Slavia (QS = 6), Hela, Mirela, Vala (QS = 4), and Hana (QS = 7) are direct descendants of Myronivs'ka 808. Cultivars bred from 1985–95 include Selekta (QS = 6), through Slavia; Sparta (QS = 6), Sofia $^{T1BS\cdot1RL}$ (QS = 6), and Senta $^{T1BS\cdot1RL}$ (QS = 7) through Stupice 933-74; Vega (QS = 8) through Hana; Asta (QS = 6.5) through the Ukrainian wheat Okhtyrchanka; and Alka (QS = 6) through Hana, are progenies of Myronivs'ka 808. Cultivars registered in 1996–2000 include Nella, through Selekta, and the four varieties Alana, Brea, Vlasta, and Sulamit (through Hana) also are descendants of Myronivs'ka 808.

Juna (QS = 6),Odra, Regina (QS = 7), Mara (registered between 1979–84), and Saskia (QS = 4) (registered in 1996) are direct progenies of cultivar Myronivs'ka Yuvileyna, and Alka (1994), by Hana; Bruta (1995), through Mara; Siria (1994; QS = 7) and Samara (1995; QS =5.5), both through Regina; and Ina (1997) are twice derivatives of Myronivs'ka Yuvileyna through Regina and Hana.

The cultivar Mona (selection name UH-Mi 61a) with a QS = 9 was registered in the Czech Republic in 1994. Mona was selected from Myronivka hybrid combination 'Illichivka/Germany line 6508-74', and this variety is a sib of the Myronivs'ka 61, which was registered in 1989 by the Institute of Wheat in Myronivka in the Ukraine and in the Russian Federation. In the late 1990s, a winter wheat with the German name Hannover and with a pedigree the same as Ukrainian variety Myronivs'ka 61 and Mona was registered for cultivation in Canada. We do not understand this problem.

The Czech varieties Runeta (registered in 1996) and Niagara (released in 1999) are derivatives of Illichivka through Viginta. The cultivars Samanta (QS = 8) and Saskia (QS = 4), which were registered in 1993 and 1996, respectively, and the variety Banquet, registered in 2001, are twice derivatives of Myronivs'ka 808 by Hana and Illichivka by Viginta. The cultivar Sarka (registered in 1996) is twice a derivative of Myronivs'ka nyz'korosla, a progeny of Myronivs'ka 10. The new Czech variety Svitana (registered in 2001) is twice a derivative of Myronivs'ka 808, through Hana and Okhtyrchanka and a one-time progeny Illichivka through Viginta.

Slovakia.
Derivatives of Myronivs'ka 808 include the cultivars Amika, Branka $^{T1BS\cdot1RL}$ (QS = 9), and Ilona (QS = 9) (the last two through Amica) wre registered in the 1980s; Vlada (QS = 9) and Torisa (QS = 6) (through Vala) were registered in the early 1990s. The only progeny of Myronivs'ka Yuvileyna is Bruta $^{T1BS\cdot1RL}$ (QS = 6) through Mara. The cultivar Viginta, registered in 1984, is a progeny of Illichivka. Five progenies of Viginta, Barbara (QS = 8), Blava (QS = 7), Rexia (QS = 9), Astella (QS = 9), and Solida (QS = 9), registered between 1992–95, and Salara, released in 1998, also are descendants of Illichivka through Viginta. Boka (QS = 7), registered in 1995, is twice a derivative of Myronivka wheat Myronivs'ka 808 throgh Slavia, and Selekta (QS = 6) from Illichivka through Viginta.

North and South American Countries.
Canada.
The cultivar Lennox, a derivative of Myronivs'ka 808, was registered in the province of Ontario in 1975, and its progeny Bordan, was registered on Prince Edward Island in 1984. The varieties AC Carrier and AC Winsloc are progeny of Myronivs'ka 808 through Lennox. AC Carrier was registered for Ontario and AC Winsloc for Prince Edward Island in the 1990s.

Chile.
The varieties Panadero Baer and AS Baer are both direct progenies of Myronivs'ka 808 registered in 1977 and 1983, respectively.

Spring Wheats. Progenies of Myronivka wheats in different countries of the world.
The Ukraine forest-steppe region.

V.M. Remeslo Institute of Wheat (the Myronivka Breeding Station prior to 1968). Spring wheats that are progenies of the winter wheat Myronivs'ka 808 include Myronivs'ka Jara (QS = 9) and Myronivchanka (QS = 9) registered in 1978 and 1999, respectively. The wheats Myronivs'ka 5 (QS = 7), twice a derivative of Myronivs'ka Jara, and Myronivs'ka Krupnozerna (QS = 10), a descendant of Myronivs'ka 808, were released in the mid 1980s. Elegiya Myronivs'ka, a progeny of Myronivs'ka 40, was released in 2000. Myronivs'ka Jara has been registered for the forest-steppe and woodland regions of the Ukraine in 1978 for nearly 25 years and for the eastern Siberian and far eastern regions of the Russian Federation for nearly 20 years. Myronivchanka has been registered in the forest-steppe region since 1999.

Ivanivka Experimental Plant Breeding Station, Okhtyrka of Symy Region. The spring wheat Jaroslavna, a derivative of Myronivs'ka Yuvileyna, was registered in 1978.

V.Ya. Yur'ev Institute for Plant Production. Two spring wheats Kharkivs'ka 12 (QS = 9), a direct descendant of Myronivs'ka 808, and Kharkivs'ka 22 (QS = 9), a progeny of Myronivs'ka 808 through the spring wheat Lugans'ka 4, were registered in 1991 and 1995, respectively.

Institute of Forages. The spring wheat Katjusha (QS = 7) is a deivative of Myronivs'ka Jara and was registered in 1996 for the forest-steppe region.

Steppe Region.
Lugans'k Institute of Agro-Industrial Production. The spring wheats Lugans'ka 4 (QS = 9) and Lugans'ka 3 are both direct progenies of Myronivs'ka 808. Lugans'ka 4 has been registered for the steppe region in 1978 for 23 years. Lugans'ka 3 was created in 1975.

Other countries of the former U.S.S.R. The Russian Federation. Northwest region.
North-West Science-Research Institute for Rural Farming. The spring wheats Druzhba, Lenmira, and Leningradskaya 90 are all descendants of Myronivs'ka 808 released in 1974, 1980, and 1985, respectively.

Central Region.
Science-Research Institute for Rural Farming of Central Regions of Non-Black-Earth Zone. The spring wheat Enita (QS = 10) is a derivative of the Ukrainian variety Myronivs'ka Jara and has been registered since 1990 for more 12 years for the northwest, central, and Volgo-Vjatka regions of the Russian Federation. Noris, a progeny of Myronivs'ka Jara through Enita, was released in 1996.

Volgo-Vjatka Region.
Nizhnegorodsky Research Project-Technological Institute (formerly the Gor'kovsky Agricultural Experimental Station). The spring wheat Gor'kovskaya 17 was created in 1948. Gor'kovskaya 20 was registreted in 1963 and for nearly 20 years in Lower Volga region. The both varieties are progenies of Ukrainka; Gor'kovskaya 17 through Lutescens 17 and Gor'kovskaya 20 through Erythrospermum 3591-46.

Vjatka State Agricultural Akademy. The spring wheats Krepysh and Solnysko are direct derivatives of Myronivs'ka 808 released in the 1970s and 1998, respectively.

North-East Science-Research Institute for Rural Farming. Veshenka spring wheat was released in 1988 and is a derivative of Myronivs'ka 808.

Central Region of Black-Earth Belt.
Kursk Institute of Agroindustrial Production in common with V.V. Dokuchaev Science-Research Institute for Rural Farming of Central Region of Black-Earth Belt. The spring wheat Kurskaya 263, released in 1989, is a derivative of Myronivs'ka 808 through the Ukrainian cultivar Lugans'ka 4.

V.V. Dokuchaev Science-Research Institute for Rural Farming of Central Region of Black-Earth Belt. The *T. durum* spring wheats Step' 3 and Step' 37, both are progenies of three winter wheats Myronivs'ka 264 by Rostovchanka and Tarasovskaya 29. The variety Step' 3 has been registered since 1998 for the Central Black-Earth Balt, Middle-Volga, Ural, and East-Siberian regions. Step' 37 was bred in 2000.

North-Caucasian Region.

P.P. Luk'janenko Krasnodar Science-Research Institute for Rural Farming. The spring wheat Bujan, created in the 1990s, is a derivative of Ukrainka through the Kazakhstanian spring wheats Pyrothrix 28 (QS = 9) and parents Shortandinka (QS = 7) and Akmolinka 1 (QS = 7).

Middle Volga Region.

P.N. Konstantinov Science-Research Institute for Plant Breeding and Seed Production of Volga Region, Kinel' of Samara Region. All four cultivars of spring wheats from this institute are direct derivatives of the winter wheat Myronivs'ka 808. Kinel'skaya 59 (QS = 7) was registered in 1995 for the middle Volga region and Povolzhskaya, Kinel'skaya 97, and Erythrospermum 3013 were created in 1978, 1985, and 2001, respectively.

N.M. Tulaykov Samara Science-Research Institute for Rural Farming. The spring wheat Tulaykovskaya belozernaya, a progeny of Ukrainka through the Kazakhstanian spring wheats Tselinnaya 21 and parental lines Lastochka and Akmolinka 1, was registered in 1995.

State Unitary Enterprise Science-Production Association "Niva Tatarstana" of breeder E.F. Ionov. The spring wheats Kerba and Debjut are direct derivatives of Myronivs'ka 808. Kerba was registered in 1998 for the middle-Volga region and Debjut was created in 2000.

Lower Volga Region.

Yershov Experimental Station of Irrigated Agriculture of the Science-Research Institute for Rural Farming of South-East Region. The spring wheat Erythrospermum 5 is a direct derivative of Myronivs'ka 808 and was released in 1985.

Science-Research Institute for Rural Farming of South-East Region, Saratov. The spring wheat Saratovskaya 68, bred in 2000, is a progeny of Ukrainka through Tselinnaya 20. Tselinnaya 20 is a descendant of the Ukrainka by the two Kazakhstanian spring wheats Lastochka and Akmolinka 1.

Ural Region.

Baskortostan Science-Research Institute for Rular Farming, Ufa. The spring wheat Kazangulovskaya was registered in 1974 and is a direct derivative of Myronivs'ka 808.

Chelyabinsk Science-Research Agricultural Institute in common with Omsk State Agricultural Academy. Niva 2 spring wheat (QS = 7.5) is a derivative of Myronivs'ka 808 registered in 1997 for the Middle-Volga, Ural, and West-Siberian Regions.

Chelyabinsk Science-Research Agricultural Institute in common with Kustanay Agricultural Research Institute (formerly the Karabalyk Agricultural Experimental Station). The spring wheat Darina is a direct derivative of Myronivs'ka 808 was created in 2000.

Western Siberian Region.

Siberian Science-Research Institute of Rural Farming, Omsk. Two spring wheats Omskaya 11 and derivative Omskaya 18 (QS = 7), were registered in the early 1980s and in 1991, respectively. These wheats are progenies of Ukrainka through Pyrothrix 28 and parental lines Shortandinka and Akmolinka 1. The cultivar Rosinka 2, released in 1996, also is a descendant of Ukrainka through Kazakhstanian wheats Tselinnaya 21, Lastochka, and Akmolinka 1. The cultivar Omskaya kormovaya (Omsk Fodder) 1, is a derivative of Ukrainka through Omskaya 18, progenies of Omskaya 11, and Pyrothrix 28, Shortandinka, and Akmolinka 1, was released in 1998.

Two direct descendants of Myronivs'ka 808 (9) are Omskaya 6 and Sibirjacka 8 released in 1973 and 1977, respectively. The wheat Omskaya 24 is a derivative of Myroniva'ka 808 through Sibirjachka 8 and was registered in 1996 for the western Siberian region. Two cultivars Omskaya 17 and Omskaya 19, progenies of Myronivs'ka 808 were registered for the western Siberian region in 1986 and 1989, respectively.

Siberian Science-Research Institute of Plant Production and Plant Breeding, Novosibirsk. The spring wheat Priobskaya, a progeny of Ukrainka through Novoukrainka 83, was registered in 1981 for the Far-East region. The spring wheat Novosibirskaya 20, a derivative of Myronivs'ka 808 by Omskaya 17 was released in 1999.

Siberian Science Research Institute of Plant Production and Breeding in common with North-Kulunda Experimental Station of Study and Developing of Saline Lands in Kazakhstan. The spring wheats Baganskaya 93 and Sibirskaya 99, both derivatives of Ukrainka through Kazakhstanian spring wheat Pyrothrix 28 and parental lines Shortandinka and Akmolinka 1, were created in 1996 and 2000, respectively.

Science-Research Institute of Rural Farming for North Trans-Ural (Tyumen') in common with V.R. Williams Kazakhstan Research Institute for Rural Farming. The spring wheat Ilinskaya is a direct progeny of Myronivs'ka 808 and was registered in 1997 for western Siberian.

Omsk Agrarian University. Spring wheat Sonata was created in 1999 and is a derivative of Ukrainka through three Kazakhstanian spring wheats Tselinnaya 20, Lastochka, and Akmolinka 1.

Altay Science-Research Institute of Rural Farming and Breeding. The spring wheat Altayskaya 60, a progeny of Ukrainka through Lutescens 17, was registered in 2001 for western Siberia.

Eastern Siberian Region.

Bur'yatsk Agricultural Research Institute. The spring wheat Bur'yatskaya 79 (QS = 7) is a progeny of Myronivs'ka 808 and has been registered from 1982–2000 for eastern Siberia. The spring wheat Lutescens 521 (QS = 9), a two-time descendant of Myronivs'ka Jara directly and from Myronivs'ka 808 through Bur'yatskaya 79, has been registered from 1991–99 for eastern Siberia. Selenga spring wheat is a derivative of Myronivs'ka 808 by Bur'yatskaya 79, and Lutescens 937 is a descendant of Selenga. These wheats also were registered in 1989 (Selenga) and 1996 (Lutescens 937) for eastern Siberia. The spring wheat Arjuna was bred in 1999 and is a direct derivative of Myronivs'ka Yuvileyna and a progeny of Myronivs'ka 808 through Bur'jatskaya 79 and Selenga.

Research Institute for Agicultural Problems of Khakassia. The spring wheat Bezim (QS = 6.5) is a two-time derivative of spring wheat Myronivs'ka Jara and winter wheat Myronivs'ka 808 through spring wheat Lutescens 521. Bexim was registered in 2000 for western Siberia.

Irkutsk State Agricultural Akademia. The spring wheat Studencheskaya, released in 2000, is a derivative of Ukrainka through Tselinnaya 20 and parental lines Lastochka and Akmolinka 1.

Kazakstan.

A.I. Baraev Kazakhstan Agricultural Research Institute of Crop Economy. The first progeny of Myronivka winter wheat Ukrainka, the spring wheat Akmolinka 1 (QS = 7), was registered in 1945. Registered derivatives of Ukrainka through Akmolinka 1 are spring wheats Shortandinka (registered in 1951; QS = 7), Tselinogradka (registered in 1967; QS = 7.5) through Milturum 45 (QS = 9), Pyrothrix 28 (registered in 1973; QS = 9) a selection from Shortandinka, Shortandinka 25 (registered in 1975; QS = 9) through parental lines Lutescens 38 and Akmolinka 1, Tselinnaya 20 (registered in 1978; QS = 9), and Tselinnaya 21 (registered in 1980; QS = 9). Tselinnaya 20 and Tselinnaya 21 are from Lastochka and Akmolinka 1. Tselinnaya 26 (released in 1986; QS = 9) and Tselinnaya 60 (released in 1986; QS = 9) are through Lutescens 38. The spring wheat Tselinnaya Yubileynaya is a direct derivative of Myronivs'ka 808 and twice a progeny of Ukrainka through Tselinnaya 21. Tselinnaya Yubileynaya was registered in 1988. Snegurka (QS = 6), Milturum 45, Lutescens 38 (QS = 7), and Poluostaya spring wheats were bred between 1954–59. Lastochka was released in 1962. All of these cultivars are progenies of Ukrainka through the Kazakhstanian spring wheat Akmolinka 1.

V.R. Williams Kazakhstan Research Institute for Agriculture. Ukrainka Jarovaya (Ukrainka spring) is a direct derivative of Ukrainka and was registered in 1953 for southern Kazakhstan.

Kustanay Science-Research Institute for Rural Farming (formerly the Karabalyk Agricultural Experimental Station). The spring wheats Diana and Lutescens 80 are direct derivatives of Myronivs'ka 808 and were registered in 1977 and 1980, respectively. The variety Karabalykskaya 90 is a progeny of Ukrainka through Kazakhstanian spring wheat Tselinnaya 21 and was registered in 1994.

Karaganda State Agricultural Experimental Station. The spring wheat Karagandinskaya 60, a deivative of Ukrainka through the Kazakhstanian spring wheats Tselinnaya 20, Lastochka, and Akmolinka 1, was released in 1983.

Zyrjanovskaya (formerly East-Kazakhstanian) State Breeding Station. The spring wheats Ulbinka 25, a descendant of Myronivs'ka 264, was registered in 1989, and Ulbinka 28, a derivative of Myronivs'ka Yuvileyna, was released in 1986.

V.R. Williams Kazakhstan Research Institute for Agriculture in common with Science Research Institute for Rural Farming of North Trans-Ural Region, Tymen'. SKENT 1 spring wheat is a derivative of Myronivs'k a Jara and has been registered since 1998 in Kazakhstan and the Ural and western Siberia regions of the Russian Federation.

Armenia.
Former Institute for Genetics and Breeding. The spring wheat Hybrid 389 is a derivative of Ukrainka and was registered in 1946

Eurpoean countries. Great Britain.
The spring wheats Chabis and Shizar, registered in 1995, are progenies of Myronivs'ka 808 through Jerico spring wheat from the Netherlands.

France.
The spring wheat Briscard is a derivative of Myronivs'ka 808 and was registered in 1984.

The Netherlands.
The spring wheats Jerico, Minaret, and Aleksandria are all derivatives of Myronivs'ka 808 registered in the early 1980s.

Austria.
Ervin spring wheat was registered in 1990 and is a derivative of Myronivs'ka 808 through Minaret from the Netherlands.

Czech Republic.
Progeny of Myronivs'ka 808 through the Stupice line 802-74 include two spring wheats Saxana and Linda registered in the early 1990s. The spring wheat Leguan, registered in 1998, is a derivative of Myronivs'ka 808 through Stupice line 234-84.

Former Yugoslavia.
The spring wheats Dugoklasa and Lelija, the both direct derivatives of Myronivs'ka 808 were registered in 1982 and 1983, respectively. The facultative wheat Nevesinjka is a direct progeny of Myronivs'ka 808 through Dugoklasa and was registered in 1990. Venera sprin wheat, a descendant of Myronivs'ka 808 through the spring wheat Dugoklasa, was released in 1993.

Table 1. The cultivars of winter bread wheat of the V.M. Remeslo Institute of Wheat in Myronivka in coöperation with other institutes that were created and/or registered between 1929–2002. Abbreviations of countries names are: COL = Colombia, CZE = Czech Republic, FRA = France, GRM = Germany, GBR = Great Britain, ITA = Italy, MEX = Mexico, POL = Poland, ROM = Romania, RUS = Russian Federation, USA = the United States of America, and YUG = Yugoslvia. An asterisk (*) next to the varietal name indicates a line with the T1BL·1RS wheat–rye translocation.

Year of release	Cultivar/comment	High-Molecular-Weigh glutenin subunit *Glu-A1*	*Glu-A2*	*Glu-A3*	Quality score (QS)
V.M. Remeslo Institute of Wheat, Myronivka.					
1929	Ukrainka	1/2*	7+9	5+10	9
	A selection from the original Banatka of the former Austro-Hungary.				
1960	Myronivs'ka 264	1	7+9	5+10	9
	A selection from initial material that was received by means of direct change of the *T. durum* Ukrainian spring wheat Narodna into a *T. aestivum* winter wheat.				
1963	Myronivs'ka 808	1	7+9	5+10	9
	A direct change of the spring wheat Artemivka (2*.7+9.2+12, QS = 7) into a winter wheat with a QS = 9.				
1964	Kyivs'ka 893	1	7+9	5+10	9
	A direct change of the Kazakhstanian spring wheat Ukrainka spring (a selection from the winter wheat Ukrainka) into a winter wheat.				
1971	Myronivs'ka Yuvilejna	2*	7+9	5+10	9
	A selection from the family of Lutescens 106; the direct change of spring wheat Artemivka into winter wheat)/Bezostaya 4 (QS = 9; RUS) *				
1974	Illichivka	1	7+9	5+10	9
	Bezostaya 4/Myronivs'ka 808.				
1973	Myronivs'ka polipschena	1	7+9	5+10	9
	A selection from Myronivs'ka 808.				
1973	Myronivs'ka 10 *	2*	7+9	5+10	9
	Bezostaya 1/Erytrospermum 2107 (wheat-rye hybrid (WRH) 74-49*, GRM/Pyronivs'ka 264 (QS = 9).				
1973	Myronivs'ka 11	2*	7+9	5+10	9
	A selection from Illichivka.				
1980	Myronivs'ka 25	1/2*	7+9	5+10	9
	Rannja 12 (RUS)/Illichivka.				
1979	Myronivs'ka 26 *	—	—	—	—
	intocultivar cross of variety Kavkaz***, RUS (8)				
1979	Myronivs'ka nyz'korosla *	—	—	—	—
	An intracultivar cross by free pollination of Myronivs'ka 10.				
1980	Mriya 1 * (Druzba)	1/2*	7+9	5+10	9
	Winnetou * (GRM)/Gaines (USA; QS = 8)/Leone (ITA).				
1981	Mriya 2 (Druzhba)	—	—	—	—
	Lutescens 6413/Nadadores 63 (MEX spring wheat).				
1989	Myronivs'ka 61 *	1/2*	7+9	5+10	9
	Illichivka/Hadmersleben (HDM) 6508-77 * (GRM).				
1983	Myronivs'ka 19	1	7+9	5+10	9
	A direct change of spring wheat WS 1812 (USA) into a winter wheat.				
1985	Myronivs'ka 60	—	—	—	—
	Prybiy (QS = 9)/Lutescens 4432 (a selection from Myronivs'ka 10).				
1989	Myronivs'ka 40	1	7+9	5+10	9
	A direct change of spring wheat Siete Cerros (MEX; 2*.17+18.2+12; QS = 8) into a winter wheat.				
1989	Volgogradskaya 84	1	7+9	5+10	9
	A line from the free pollination of Illichivka/Illichivka.				

Table 1 (continued). The cultivars of winter bread wheat of the V.M. Remeslo Institute of Wheat in Myronivka in coöperation with other institutes that were created and/or registered between 1929–2002. Abbreviations of countries names are: COL = Colombia, CZE = Czech Republic, FRA = France, GRM = Germany, GBR = Great Britain, ITA = Italy, MEX = Mexico, POL = Poland, ROM = Romania, RUS = Russian Federation, USA = the United States of America, and YUG = Yugoslvia. An asterisk (*) next to the varietal name indicates a line with the T1BL·1RS wheat–rye translocation.

Year of release	Cultivar/comment	High-Molecular-Weigh glutenin subunit *Glu-A1*	*Glu-A2*	*Glu-A3*	Quality score (QS)
1992	Myronivs'ka ostysta	1	7+9	5+10	9
	Narino 59 (COL)/Jaral 66 (MEX)//Myronivs'ka 808.				
1992	Myronivs'ka 27 *	2*	7+9	5+10	9
	Lutescens 6915 (Prybiy (QS = 9)/Myronivs'ka Yuvileina)/Lutescens 6538 * (GRM).				
1989	Myronivs'ka 62	2*	7+9	5+10	9
	Illichivka/SK2542 (CZE).				
1993	Myronivs'ka napivintensyvna	2*	7	5+10	8
	Maris Templar (GBR)/Ill'ichivka.				
1994	Myronivs'ka 28 *	1	7+9	5+10	9
	Prybiy/Lutescens 4432 (a selection from Myronivs'ka 10)//Krasnodarskaya 57 (RUS; QS = 9.5; a progeny of Myronivs'ka 808).				
1991	Myronivs'ka 29	1	7+9	5+10	9
	A double selection from a population resulting from the direct change of the spring wheat BT 2288 from Tunisia into a winter wheat.				
1995	Myronivs'ka 30 *	2*	7+9	5+10	9
	Intracultivar selection from Myronivs'ka 27.				
1997	Myronivs'ka 31 *	1	7+9	5+10	9
	Lutescens 7792/4/Myronivs'ka 25/F 29-76 * (ROM)//Erythrospermum 820 (Prybiy)/ Kavkaz * (RUS; QS = 8)/3/Bilotserkivs'ka 29.				
1993	Myronivs'ka 32	1	7+9	5+10	9
	Vala (CZE)/Illichivka//Myronivs'ka 27.				
1993	Myronivs'ka 63	1	7+9	5+10	9
	Donskaya polukarlikovaya (RUS; QS =9)/Lutescens 9217 (HDM 38305-73 (GRM/ Ershovskaya 3 (RUS)).				
1994	Myronivs'ka 64	2*	7+9	5+10	9
	Myronivs'ka Yuvileyna/KM 66-10-1-79 (CZE).				
1998	Myronivs'ka 33 *	2*	7+9	5+10	9
	Maris Templar (GBR)/Illichivka//NS 984 (YUG)/Kavkaz//Roazon (FRA; QS = 4; N.7.2+12).				
1995	Myronivs'ka 34	N	7+9	5+10	9
	A direct change of spring wheat Kommunar (ROS-KRD Kalyansona (IND)/a mutant of Saratovskaya 29 (ROS) into a winter wheat.				
1999	Myrych *	N	7+9	5+10	9
	Siete Cerros 66 (MEX; spring; QS = 8)/Myronivs'ka Yuvileina. //Yantor, BLG /3/Myronivs'ka 27*** (9)				
2000	Myronivs'ka 65 *	2*	7+9	5+10	9
	Myronivs'ka 61/Myronivs'ka 27.				
2000	Myronivs'ka 66	2*	7+9	5+10	9
	Lutscens 922/Erythrospermum 10071 (see pedigree of Myronivs'ka 68).				
1996	Lira *	2*	7+9	5+10	9
	Lutescens 14663 (a selection from Myronivs'ka 27)/Myronivs'ka 61.				
1996	Expromt	2*	7+9	5+10	9
	XGH 2875 (USA)/Trakia (BLG) F_2 + mutagen NEU 0.05 %.				
2002	Myronivs'ka 67 *	1	7+9	5+10	9
	Myronivs'ka 27/Myronivs'ka 61.				

Table 1 (continued). The cultivars of winter bread wheat of the V.M. Remeslo Institute of Wheat in Myronivka in coöperation with other institutes that were created and/or registered between 1929–2002. Abbreviations of countries names are: COL = Colombia, CZE = Czech Republic, FRA = France, GRM = Germany, GBR = Great Britain, ITA = Italy, MEX = Mexico, POL = Poland, ROM = Romania, RUS = Russian Federation, USA = the United States of America, and YUG = Yugoslvia. An asterisk (*) next to the varietal name indicates a line with the T1BL·1RS wheat–rye translocation.

Year of release	Cultivar/comment	High-Molecular-Weigh glutenin subunit *Glu-A1*	*Glu-A2*	*Glu-A3*	Quality score (QS)
1999	Myronivs'ka 68 *	N	7+9	2+12	5
	Rusalka (BLG)/Myronivs'ka 808//HDM 20581-87/3/Erythrospermun 10071 (Erythrosperm 5226 (WRH K-VIR 43822 *)/Line 2274/Line 6075 *(GRM).				
1999	Troyan	1/N	7+8/7+9	5+10	8.5
	Erythrospermun 10071/ST 204-84 (CZE)//Myronivs'ka 808.				
2000	Venera *	2*/N	7+9	5+10	8
	Ivanivs'ka 60/Mrija 1 (QS = 9)/Myronivs'ka 27.				
2000	Vesta *	2*/N	7+9	5+10	8
	Myronivs'ka 27/HDM 42555-83/Myronivs'ka 61.				
2000	Myronivs'ka 35	2*	7+9	5+10	9
	NS 2699/Moskovskaya 60//Sadovo Super (BLG)/3/MV 103 (HUN)/4/Myronivs'ka 27.				
2000	Remeslivna	2*	7+8	5+10	9
	A selection from Kavkaz/CUT-75 (MEX) into a winter wheat.				
2001	Myronivs'ka 901 *	2*/N	7+9	5+10	8
	Myronivs'ka 27/BR 1249 (CZE).				
2001	Oktava	N	6+8	5+10	6
	Myronivs'ka 27/Nike (POL).				
V.M. Remeslo Institute of Wheat, Myronivka in coöperation with Kazkhstanian Experimental Point of Institute of Wheat.					
1991	Komsomol's'ka 56 (Kustanajskaya)	1	7+9	5+10	9
	Erytrospermum 3387 (Myronivs'ka 808)//Myronivs'ka 264/WRH 74-49/Myronivs'ka 10.				
1996	Komsomol's'ka 75	1	7+9	5+10	—
	A selection from Albidum 2231-1-75.				
V.M. Remeslo Institute of Wheat in coöperation with the Institute of Grain Crops GmbH Hadmersleben.					
1993	Myrleben *	N	7+9	5+10	7
	A selection from F_5 16208-83-23833-73 * (GRM)//Gaines/6*Myronivs'ka 808/3/Alcedo (GRM; QS = 7).				
2000	Myrhad	N	7+9	2+12	5
	HDM 5355-80/Apscol.				
V.M. Remeslo Institute of Wheat, Myronivka in coöperation with the Institute of Plant Physiology and Genetics.					
2002	Kryzhynka *	1	7+9	5+10	9
	Myronivs'ka 27/Myronivs'ka 28.				
2002	Myronivs'ka ran'ostygla	1	7+9	5+10	9
	A selection several times of a population from a direct change into the spring wheat BT 2288 from Tunisia into a winter wheat.				