ITEMS FROM ROMANIA

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Yield potential and performance stability of winter wheat cultivars under diverse ecological condition of Transylvania province, Romania.

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Transylvania is a Romanian province with varied agro-climatic conditions that include environmental factors such as temperature, rainfall, fertility status, and other soil characteristics that play an important role in the varietal performance of winter wheat. The adaptability of a cultivar over diverse environments is usually tested by the degree of its interaction with different environments under which it is grown. A cultivar is considered to be adaptive or stable if it has high mean yield but a low degree of fluctuation in yield ability when grown under diverse environments.

Previously (Ann Wheat Newslet 49:91-95), we suggested that one of the best techniques used to rank genotypes for yield stability is the statistical model of Eberhart and Russell (1966). In this study, the coefficient of variation (CV) for yield will be considerate as a measure of yield stability.

Data for grain yield of the recommended winter wheat cultivars for Transylvania were obtained from trials grown under nine diverse environmental conditions at three locations (Turda, Targu-Mures, and Brasov) for 3 years (2002, 2003, and 2004). For each location and year, the trial was conducted in a balanced squared lattice design with six replications and a repeated the basic scheme. Thus, the first three replications were fertilized at optimum rate of nitrogen and phosphorus, whereas the other three replications were unfertilized or had a low rate of nitrogen applied. The three experimental years were highly variable for the degree of favorable climate for wheat; 2002 was favorable, 2003 was fair to unfavorable, and 2004 was very favorable.

The mean grain yield, range, and coefficient of variation on the first three replications of the trials with optimum rates of nitrogen fertilizer of the recommended winter wheat cultivars for Transylvania province are given in Table 1. No large differences in mean grain yield of the analyzed cultivars were observed. The data for wheat grain yield showed that Ariesan had the highest average yield at 6,225 kg/ha, whereas Apullum had the lowest mean yield at 5,720 kg/ha. However, the range between minimum and maximum grain yield of each cultivar was very wide. Maximum grain yields were reached in 2004 at Targu-Mures, exceeding 10,000 kg/ha for all except Apullum, which only was 9,000 kg/ha. The minimum values for grain yield were obtained in 2003 at Turda. In this year, yield was determined by high temperatures in the spring and summer and severe drought stress during the growing season.

Table 1. Mean grain yield (kg/ha), range, and coefficient of variation (CV) of the recommended winter wheat cultivars for Transilvania province, in nine yield trials at three locations (Turda, Targu-Mures, and Brasov, Romania) and three years (2002, 2003, and 2004).

	Grain yield (kg/ha)			
		Range		
Cultivar	Mean	Minimum	Maximum	CV
Fundulea 4	6,115	1,544	10,319	45.86
Ariesan	6,225	2,197	10,336	44.03
Apullum	5,720	1,638	9,183	43.76
Turda 95	5,927	2,297	10,406	45.64
Turda 2000	6,117	1,431	10,167	44.44
Ardeal	6,118	1,749	10,906	45.46

Yield stability is defined as the degree of a cultivars interaction with different environmental conditions under which it is grown. The large fluctuation in yield ability of the tested cultivars is reflected by relatively high CV values. Apullum seem to be a relatively stable cultivar (CV = 43.76). In this case, the relative advantage in stability is associated

with a lower mean yield and more a reduced maximum grain yield. However, this conclusion is not supported by our data for some of the other cultivars. Ariesan, which has the highest mean yield (6,225 kg/ha), has a smaller CV (44.03) comparative to other cultivars.

These data show that the currently grown wheat cultivars in Transylvania reached high yield potential (> 10,000 kg/ha). On the other hand, the highly variable environmental conditions of Transylvania (given by high CV for yield) reflect powerful constraints that prevent the full expression of the genetic potential for yield of the cultivars.

ITEMS FROM THE RUSSIAN FEDERATION

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Transformation of lodicules into pistils in flowers of soft wheat.

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Kyzlasov (1996) created a line of spring soft wheat with polygynous flowers. From two up to five pistils and three stamens are formed in normally developed flowers of this wheat. Under favorable conditions of plant cultivation the percentage of polygynous flowers is increased, under extreme conditions it is reduced. The number of caryopses formed per flower depends upon the number of pistils and the impact of environmental factors. In conditions of optimum temperature and normal air humidity, the number of caryopses per flower is increased, whereas in high or low temperature and over-damping, it is reduced. In the flowers with two, three, four, and five pistils, the caryopses are formed, upon pollination, at first from usual pistils, and only later, from lodicule pistils. The pistils originating from lodicules show reduced vitality. The lodicule pistils demonstrate high modification variability in regard of percentage of seed formation and individual caryopses weight (10 to 90 mg).

Previously, we did not know which part of the flower or germ the additional pistils originated. Close analysis of the structure of polygynous flowers showed that the additional pistils are formed from the lodicules. The number of lodicules from which the additional pistils are formed may be as many as four in one flower. Hence, the total number of pistils in a polygynous flower sometimes may be as many as five. Flowers having four or five caryopses are very rare.

The shape of caryopses formed in polygynous flowers is usually asymmetric. Sometimes they are oblate or crescent-shaped. Sometimes the germs are dislocated to the back of caryopsis for the caryopses formed from lodicules. The ventral side of lodicule caryopsis is turned outwards of the flower. In ergot-infected plants, a sclerotium occurs in place of one of the caryopses of the polygynous flower, whereas normal caryopses are formed from the other pistils after they are pollinated by pollen from their own flower.

The results of this research indicate that lodicules of flowers of soft wheat are potential pistils. A lodicule is an underdeveloped pistil. In relation to each other, these organs of the flower are epigenetic relatives.

Reference.

Kyzlasov VG. 1996. The phenomenon of multipistillity of wheat flowers. **In:** Abstr 5th Internat Wheat Conf, Ankara, Turkey, p.430.

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The influence of gene combination Lr19 + Lr26 on bread-making quality in 2005.

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

Gene *Lr26* in the T1BL·1RS translocation is used intensively in a majority of the wheat breeding centers of the world. This translocation has valuable genes for resistance to leaf rust (*Lr26*), stem rust (*Sr31*), stripe rust (*Yr9*), and powdery mildew (*Pm8*) and also promotes an increase in grain productivity, resistance to drought, and formation of larger grain. At ARISER, a set NILs with the *Lr26*-translocation and perspective lines were produced from the best Saratov-bred spring bread wheat cultivars. The data for 2005 indicate that the interaction of this translocation positively influences grain yield under conditions of a strong leaf rust epidemic and heat and drought during grains filling (Table 1). The main limiting factor for the use of T1BL·1RS in wheat breeding is the influence on bread-making quality. A decrease in bread-making quality is coupled with the genes for disease resistance and *Sec1*. In the set of the NILs produced in the genetic background of cultivar L503, the *Lr26* translocation significantly increased grain protein content, but did not influence gluten values. The increase in grain protein content was accompanied by an increase in grain yield for lines containing the *Lr26* translocation (Table 1). This effect may have been induced by a severe leaf rust attack on L503 and the absence of infection in lines carrying *the Lr26* translocation. Values for dough extensibility (P) and flour strength (W) were significantly lower in the NILs with the *Lr26* translocation. However, these deleterious effects can be eliminated by crossing with bread wheat cultivars with excellent bread-making quality (Table 2). Thus, positive effects from *Lr19* + *Lr26* translocations for disease resistance and grain productivity with good or excellent bread-making quality are possible.

Table 1. Grain productivity, grain protein content, and gluten values of NILs and perspective lines of spring bread wheat. Gluten strenght values were evaluated for the gluten deformation index.

NIL	Grain yield (kg/ha)	Grain protein content (%)	Gluten	
			content (%)	strength
L503 (*Lr19*)	2,524 a	15.53	35.6	70
L503 (*lr19+Lr26*)	2,850 b	18.08	39.0	70
L503 (*Lr19+Lr26*)	2,991 b	17.05	36.7	70
L505/L503 (*Lr19+Lr26*)	2,979 b	19.45	37.2	71

Table 2. Bread-making qualities of L503 NILs and perspective lines of spring bread wheat. Dough extensibility = P and flour strength = W.

NIL	Physical trait (alveograph)			Bread-making quality		
	P	P/L	W	loaf volume (cm^3)	porosity	crumb color
L503 (*Lr19*)	118	1.7	301	820	5.0	yellow
L503 (*lr19+Lr26*)	88	1.5	183	940	5.0	white
L503 (*Lr19+Lr26*)	79	1.4	164	900	5.0	yellow
L505//L503 (*Lr19+Lr26*)	122	1.8	327	890	5.0	yellow

Evaluation of spring bread wheat cultivars and lines for resistance to leaf rust in 2005.

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

In 2005, a sever epidemic of leaf rust was observed. Beginning at sowing time for winter wheat (which occupies two-thirds of the cultivated area of bread wheat), the epidemic was widespread on spring wheat sowings. Evaluation data of

a set NILs with *Lr* genes showed that the severity of the leaf rust epidemic on the susceptible cultivars was 70–75 % and with a grain yield loss of 20–25 %. The results of the IT evaluation are in Table 3. The IT was evaluated three times; first during shoot formation, second at heading, and finally at grain wax-ripeness. Highly effective resistance was from gene combinations *Lr14+23, Lr9+19, Lr19+24, Lr19+25,* and *Lr19+26*. Interestingly, the *Lr19*-gene in the background of cultivars L503, Dobrynya, and L2032 significantly decreased the severity of disease.

Table 3. Evaluation of spring bread wheat cultivars and lines for resistance to leaf rust in 2005. Degree of infection (IT) was were evaluated three times.

		Evaluation stage (IT/% severity)		
Cultivar/line	*Lr* gene(s)	shoot	heading	wax ripeness
Saratovskaya 29	none	3/5	3/70	3/70
As29	*Lr14*	3/trace	3/30	3/60
Belyanka	*Lr14 + Lr23*	0	0	0
L503	*Lr19*	3/trace	3/5	3/15
L2032	*Lr19*	3/trace	3/5	3/15
Dobrynya	*Lr19*	3/trace	3/5	3/15
L9-05	*Lr9 + Lr19*	0	0	0
L12-05	*Lr19 + Lr24*	0	0	0
L11-05	*Lr19 + Lr25*	0	0	0
L18-05	*Lr19 + Lr26*	0	0	0

The expression of Ut-genes in the spring bread wheat cultivars and lines.

A.E. Druzhin, V.A. Krupnov, S.N. Sibikeev, T.D. Golubeva, and T.V. Kalintseva.

Table 4. The expression of *Ut* genes to rece 23 = T18 in the spring bread wheat cultivars and lines under greenhouse (air temperature 18°C, regular watering, and 10-h daylength) and field conditions (air temperature during the first growth period 22°C, a moisture deficiency in the soil, and 12-h daylength).

	% infection in the	
Cultivar/line	greenhouse	field
Saratovskaya 57 (S57)	0.0	0.0
L2040 = L503/S57//L503	16.7	14.3
Prohorovka	79.6	68.5
L3630 = L2040/ Prohorovka	24.5	8.8
L164 = L504/S57//L504	75.0	54.8
L222	84.0	67.5
L2772 = L164/L222	32.1	13.3
Saratovskaya 70	51.6	7.7
Belyanka	53.5	37.1
L1242 = Saratovskaya 70/Belyanka	27.3	0.0
CI12633	0.0	0.0
L528	98.6	90.0
L2780 = CI12633/L528	2.0	0.0

The expression of *Ut* genes depends on the genotype of the host, the environment, the pathogen pathotype, and inoculum quantity. *Ut*-genes transferred from the spring durum wheat cultivar Saratovskaya 57 have different levels of expression in the spring bread wheat lines L2040, L3630, L164, and L2772 under identical environment and inoculation conditions with the pathotype (race 23 = T18) at an inoculum of 1 g/l. The expression of *Ut* genes was evaluated under greenhouse and field conditions. In the greenhouse, the degree of loose smut infection (%) was greater than that in the field. More favorable conditions for pathogen development in a greenhouse (air temperature 18°C, regular watering, and 10-h day length) than in the field (air temperature during the first growth period 22°C, a moisture deficiency in the soil, and 12-h day length) resulted in a decrease in the level of effectiveness of the *Ut* genes. The reaction to race 23 = T18 in the greenhouse and field in cultivars and lines of bread wheat can be very different. For Saratovskaya 70, field infection was 7.7 % and greenhouse infection was 51.6 %. The same difference was noted in lines L1242 and L2772. However, *Ut* genes in cultivars Saratovskaya 57 and CI12633 and lines L2040 and L2780 were nearly identical both in the field and in the greenhouse. Greenhouse evaluation has revealed the potential efficacy of *Ut* genes under the most favorable conditions possible for pathogen development.

Accumulating and spending structured and spare material in soft spring wheats from time of creation.

E.I. Zhanabekova, A.V. Firsov, and V.A. Kumakov.

We studied the accumulation and use of spare material of the spring wheats Lutescens 62, Saratovskaya 29, and Saratovskaya 58. The more advanced Saratovskaya 58 exports dry material not only from the culms located below the uppermost internode but also from those uppermost internodes that do not exist in Lutescens 62 and Saratovskoy 29. The more modern and productive Saratovskaya 58 spends spare material to a greater degree, which finally is reflected in grain mass. Climate can influence the process of accumulating and using spare and structured material to greater or lesser degrees.

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Special forms of Puccinia graminis on Graminaceous plants.

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The stem rust pathogen is a parasite on 300 cereal species of (Naumov NA, 1939, Rust of cereals in USSR, Selchosgiz, Moscow-Leningrad. 358 p). In addition to wild species, the fungus can damage wheat, rye, barley, and oats leading to significant crop loss. Urediospores from the wild cereals can be a source of new inoculation of stem rust on agricultural crops. Monitoring stem rust in wild cereals is needed.

Long-term observations of *P. graminis* development on cereals during seasons of differing weather were made in the Moscow (Central), Leningrad (Nord West), Rostov (Nord Caucasus), Tomsk (West Siberian) areas of the Russian Federation. Stem rust was found on cocksfoot (*Dactylis glomerata* L.), bluegrass (*Poa pratensis* L.), sheep fescue (*Festuca ovina* L.), perennial ryegrass (*Lolium perenne* L.), wheat grass (*Elytrigia repens* (L.) Gould.), and timothy (*Phleum pratense* L.). Highly susceptible cultivars of wheat, rye, and oats were infected by urediospores of *P. graminis* from these plants.

The rye form, *P. graminis* f.sp. *secalis* (Pgs), was found on all cereal species tested. The wheat form *P. graminis* f.sp. *tritici* (Pgt) was identified on cocksfoot, wheat grass, and sheep fescue. The oat form *P. graminis* f.sp. *avenae* (Pga) was found on cocksfoot, timothy, and sheep fescue (Table 1). The several forms of *P. graminis* can develop on the same species of cereal simultaneously. On cocksfoot, Pga, Pgs, and Pgt were found. On wheat grass, Pgs and Pgt were noted. Forms Pgs and Pga were found on timothy. On bluegrass we found the rye form of stem rust, Pgs (Table 1).

Table 1. Special forms of *Puccinia graminis* found on different Graminaceous plants.

P. graminis f.sp. *secalis*	*P. graminis* f.sp. *tritici*	*P. graminis* f.sp. *avenae*
cocksfoot	cocksfoot	cocksfoot
wheat grass	wheat grass	wheat grass
sheep fescue	sheep fescue	timothy
perennial ryegrass		
timothy		
bluegrass		

Stem rust development on wild cereal species depended on the plant–host conditions of development. Wheat grass stem rust appeared simultaneously with infection on rye and wheat. In the Northern Caucasus, urediospores from

wheat grass predominantly infected wheat (Pgt). In the Central and Northwest regions and Western Siberia, urediospores from wheat grass mainly infected rye (Pgs). The appearance of stem rust on other wild species was observed during autumn as a rule. We can conclude that if *P. graminis* development is depressed in cultured cereals, the wild species can serve as an additional source of infection in favorable conditions.

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Races of Puccinia graminis f. sp. tritici in the Russian Federation in 2004.

S.N. Lekomtseva, V.T. Volkova, L.G. Zaitseva, and M.N. Chaika.

In 2004, weak development of wheat stem rust was observed in Northern Caucasus (the Rostov area). The pathogen was not found in Central Russia (Moscow area). Aecia were collected on barberry in the botanical garden of the Moscow State University, in the main botanical garden of the Russian Academy of Sciences, and in some areas of the Moscow region during May–June. Stem rust was found in the Moscow region on wheat grass (*Elytrigia repens*) and barley by the end of July. Races were defined using the Pgt system according to the reaction of 16 isogenic lines of wheat (Roelfs and Martens 1998). In Russia in 2004, the two races, TKNT (5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp) and TKST (5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp) were dominate (73.9 % and 14.5 %, respectively). Other races were found at much lower levels (Table 2).

Table 2. Races of *Puccinia graminis* f. sp. *tritici* in Russian Federationin in 2004.

Race	Susceptibility of wheat *Sr* genes	Number of monouredinial isolates	Percent
TKNT	5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp	51	73.9
TKST	5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp	10	14.5
TTNT	5, 21, 9e, 7b, 11, 6, 8a, 9g, 36, 30, 9a, 9d, 10, Tmp	3	4.4
PKST	5, 9e, 7b, 6, 8a, 9g, 36,9b, 30, 9a, 9d, 10, Tmp	3	4.4
TKPT	5, 21, 9e, 7b, 6, 8a, 9g, 36, 30, 13, 9a, 9d, 10, Tmp	1	1.4
TTST	5, 21, 9e, 7b, 11, 6, 8a, 9g, 36, 9b, 30, 9a, 9d, 10, Tmp	1	1.4
Total		69	100.0

The same races were registered on barberry in the Central region of the Russian Federation in 2003 (Lekomtseva et al. 2004). The dominate race TKNT was selected from aecia on barberry and uredinia on barley and wheat grass in the Moscow and Rostov areas. Race TKST was found on barberry in the Moscow area and wheat in Rostov area. Races TTNT and PKST were found on barberry in the Moscow area. Races TKPT and TTST were found on wheat in the Rostov area (Table 3). All races studied were characterized by high

Table 3. Races of *Puccinia graminis* f. sp. *tritici* in the Russian Federation on different host plants in 2004.

Race	Area of collection	Plant host	Number of collections	Isolates of race Pgt
TKNT	Central Russia (Moscow region)	barberry	3	9
	Central Russia (Moscow region)	barley	1	3
	Nord Caucasus (Rostov region)	barley	1	3
	Central Russia (Moscow region)	wheatgrass	1	3
	Central Russia (Rostov region)	wheatgrass	1	3
	Nord Caucasus (Rostov region)	wheat	7	21
TKST	Central Russia (Moscow region)	barberry	26	
	Nord Caucasus (Rostov region)	wheat	3	4
TTNT	Central Russia (Moscow region)	barberry	1	3
PKST	Central Russia (Moscow region)	barberry	1	3
TKPT	Nord Caucasus (Rostov region)	wheat	1	1
TTST	Nord Caucasus (Rostov region)	wheat	1	1
Total			23	69

virulence. The dominating race TKNT contained 13 genes of virulence.

The evaluation of wheat NILs for resistance has shown that the majority of races were virulent to stem rust in 2004, except for lines with *Sr9b*, *Sr11*, and *Sr13* (Table 4).

Fungal isolates virulent to *Sr9b* were found in aecia on barberry in Moscow area but not on wheat. Long-term monitoring of the wheat lines with *Sr9b*, *Sr11*, and *Sr13* will increase the efficiency of these genes to wheat stem rust in Russia (Lekomtseva et al. 2004).

Acknowledgment. The work is supported by the Russian Foundation of Basic Researches.

Reference.

Lekomtseva SN, Volkova VT, Zaitseva LG, and Chaika MN. 2004. Pathotypes of *Puccinia graminis* f.sp. *tritici* from different host-plants in 1996-2000. Micologia i fitopatologia 38(5):37-43 (In Russian).

Table 4. The number of monouredinial isolates virulence to wheat Sr lines.

Sr line	%
5	100.0
6	100.0
7b	100.0
8a	100.0
9a	100.0
9b	20.2
9d	100.0
9e	100.0
9g	98.6
10	100.0
11	4.3
13	0.0
21	95.6
30	100.0
36	100.0
Tmp	100.0

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Breeding and genetic analysis of height in spring wheats.

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In the Russian Far East, tall cultivars of spring wheat lodge during the summer monsoons and when the grain yield is more than 2 t/ha. Semidwarf cultivars from the U.S., Mexico, Canada, India, and other countries were used in hybridizations to create lodging-resistant cultivars. One experiment at the Far Eastern breeding center in Khabarovsk showed that a short stalk was inherited very well but, at the same time, negative traits such as weak drought resistance, susceptibility to *Fusarium* and *Helminthosporium*, and unstable yield also were inherited. Initial material should not have these negative traits.

Materials and methods. Four hybrids, F_1–F_2 ERO-4/Dalnevostochnaya (ERO-4/Dv), Opal/Okeanskaya 39 (Opal/Ok 39), Molodyozhnaya/Primorskaya 1738 (Md/P 1738), and Molodyozhnaya/Lutescens 47 (Md/L 47) were used for the analysis. Height difference between cultivars was from 12–25 cm, $p < 0.001$. Each cultivar had one or more valuable features. ERO-4 (Brazil) is resistant to diseases and drought. Dalnevostochnaya (Russia) is a strong wheat with high technological quality. Opal (Germany) is medium height and resistant to lodging and disease with big, productive spikes. Molodyozhnaya (Russia) has a short stalk and is resists lodging. Lutescens 47 (Russia) is productive and moderately resistant to lodging and disease. Okeanskaya 39 and Primorskaya 1738 (Russia) have big spikes and a high 1,000-kernel weight.

Seeds were sown in the field according to the following scheme: P_1 (female parent) – F_1 – F_2 – P_2 (male parent). The cultivar Monakinka was used as the standard. The height of paternal cultivars and the standard were determined from the average of 20–30 plants, in the F_1 from 15–20 plants, and in the F_2 from 69–95 plants. Statistical indicators of variation in rows were calculated according to Dospekhov (1973), predomination degree according to Greefing (1950), heterosis according Omarov (1975), trangression frequency degree following Voskresenskaya and Shpot (1967), heritability (H^2) according to Warner (1971), and the number of different genes according to Rokitsky (1978). The degree of conformity of the actual results with the theoretically expected results, after splitting, was measured according to Pirson's X^2.

Results and Discussion. The efficiency of a feature in selection depends on the inheritance, the degree of variability, and some other parameters. Three F_1 hybrids had inherited plant height from an short parent and another hybrid (ERO-4/

Dalnevostochnaya) from a tall parent (Table 1). Hybrid F_1 Molodyozhnaya/Primorskaya 1738 had hp = –1.27, indicating a superdominance of an shorter parent, however, the difference between a hybrid and the short cultivar Molodyozhnaya was not certain. The short parent was dominant, but not superdominant.

Table 1. Heritability character of plant height by hybrid $F_1 – F_2$. For heritability, a CD+ indicates complete dominance of high indicator, ID– indicates incomplete dominance of low indicator, and ED– indicates extradominance of low indicator.

	Mean ± s (cm)				hp		
Hybrid	P_1	F_1	F_2	P_2	F_1	F_2	Heritability type in F_1
ERO-4 E Dv	74.2±1.4	86.0±0.6	83.0±0.9	86.1±1.1	0.98	0.47	CD+
Opal / Ok 39	75.9±1.1	77.0±0.4	87.6±0.7	86.5±1.3	–0.79	1.21	ID–
Md / P 1738	67.9±1.1	65.4±0.6	84.0±0.8	86.3±0.9	–1.27	0.75	ED–
Md / L 47	67.9±1.1	71.9±1.2	77.6±0.8	90.9±0.8	–0.65	–0.16	ID–
Monakinka (standard)	90.0±1.2						

Plant height increased in the F_2 compared to the F_1 because of splitting (the exception was ERO-4/ Dalnevostochnaya). The Opal/ Okeanskaya 39 hybrid increased by 10.6 cm, Molodyozhnaya/Primorskaya 1738 by 18.6, and Molodyozhnaya/Lutescens 47 by 5.7 cm. Heterosis of these hybrids can be explained by certain deviation of their height from the tall parent (Table 2).

Table 2. Tall plant heterosis in hybrid $F_1 – F_2$ (* True under $p < 0.001$).

	Tall plant–parent deviation (cm)		Heterosis (%)		
			F_1		F_2
Hybrid	in F_1	in F_2	standard	true	true
ERO-4 / DV	–0.1	–3.1	0.1	–0.1	–3.6
Opal / Ok 39	–9.5*	1.1	–10.4	–11.0	1.3
Md / P 1738	–20.9*	–2.3	–23.9	–24.2	–2.7
Md / L 47	–19.0*	–13.3*	–16.3	–20.9	–14.6

Table 2 shows that if the height of three hybrids F_1 is certainly lower than the height of tall parents ($p < 0.001$) the difference between the two in the F_2 Opal/Okeanskaya 39 and Molodyozhnaya/Primorskaya 1738 is uncertain, but in the Molodyozhnaya/Lutescens 47 hybrid the difference is lower than that of a tall cultivar in the F_1. The coefficients of dominance calculated for F_2 prove this conclusion. Three hybrids have an hp < 1, which implies incomplete positive (ERO-4/Dalnevostochnaya and Molodyozhnaya/Primorskaya 1738) or negative (Molodyozhnaya/Lutescens 47) dominance. The Opal/Okeanskaya 39 hybrid has an hp < 1 that indicates heterosis, but it is inconclusive. Hence, the lack of heterosis proves the expediency needed for selection in the early generations. Moreover, the variability of characteristics in the hybrid F_2s was higher than in most of paternal cultivars and the F_1 hybrids (Table 3, p. 103). Most of the phenotypic variation in the hybrid F_2s, except Opal/Okeanskaya 39, is determined by genotypic variability. The genotypic factors are 6.3–8.5 % and the phenotypic factors 7.8–10.3 % of the variability depending on the hybrid.

The analysis of variation for hybrids and their paternal forms was transgressive and splitting in the F_2 was not observed. The height of hybrids was within the limit of variations of the paternal cultivars (Table 3, p. 103). One exception was hybrid ERO-4/Dalnevostochnaya, which had a height that varied from 56–95 cm, whereas in the short, paternal cultivar ERO-4, the height varied from 66–88 cm and in the tall cultivar Dalnevostochnaya from 78–94 cm. The smallest hybrid F_2 plants were 10–24 cm shorter than similar plants of standard cultivar Monakinka, a difference of 20–35 cm in comparison to the medium height of the standard. Depending on the hybrid, the number of this type of plant varied from 10.6–55.6 % (Table 4, p. 103). All the hybrids have good signs of transgression with respect to the standard (Table 4, p. 103). Despite the lack of transgression with respect to the short, paternal cultivars (exception is ERO-4/Dalnevostochnaya), the combinations are better for selection of short plants than for the standard cultivar.

Table 3. Variability of height in paternal cultivars and hybrids. For Variation coefficient, numerator = phenotypic coefficient and denominator = genotypic variation.

Hybrid	Paternal offspring	Variability limit (cm)	Maximun difference (cm)	Variation coefficient (%)
ERO-4 / DV	P_1	66–88	22	7.9
	P_2	78–94	16	5.8
	F_1	83–91	8	2.9
	F_2	56–95	39	10.2/8.4
Opal / Ok 39	P_1	65–82	17	6.5
	P_2	73–100	27	7.4
	F_1	73–80	7	2.7
	F_2	70–101	31	7.3/4.8
Md / P 1738	P_1	62–76	14	6.7
	P_2	79–94	15	4.9
	F_1	60–70	10	3.3
	F_2	65–95	30	7.8/6.3
Md / L 47	P_1	62–76	14	6.7
	P_2	82–96	14	4.4
	F_1	60–87	27	7.3
	F_2	65–93	28	10.3/8.4

Table 4. Transgression parameters of plant height in hybrids F_2.

Hybrid	Minimum height (cm)		Transgression (%) toward			
			standard		undersized parent	
	undersized parent	hybrid	degree	frequency	degree	frequency
ERO-4 / DV	66.7	60.3	24.6	31.0	9.5	4.6
Opal / Ok 39	67.0	71.7	10.4	10.6	0.0	0.0
Md / P 1738	61.3	67.3	15.9	20.3	0.0	0.0
Md / L 47	61.3	65.0	18.8	55.6	0.0	0.0

Table 5. Plant height splitting in hybrid F_2.

Hybrid	Number of plants	Splitting (tall plants/undersized plants)		X^2	Significance level (p)
		actual	theoretical		
Md / P 1738	64	55:9	52:12	0.92	0.50>p>0.25
		13.75:2.25	13:3		
Md / L 47	80	33:4	35:45	0.22	0.75>p>0.50
		76.6:9.4	7:9		

The splitting of the F_2 hybrids for plant height showed that hybrids ERO-4/Dalnevostochnaya and Opal/ Okeanskaya 39, in which the difference between cultivars was not large (10–12 cm), had a phenotypic distribution close to normal. The splitting character was defined in hybrids Molodyozhnaya/Primorskaya 1738 and Molodyozhnaya/Lutescens 47, the paternal cultivars of which differed most in height (a difference of 25 cm). The plants that fit into the certain interval of paternal forms (mean ± 2) referred to the group of short and tall plants. For the group of short plants, the interval was 58.8 ÷ 77 cm (Molodyozhnaya), 78.1 ÷ 94.5 cm (Primorskaya 1738) for the group of tall plants, and 83 ÷ 98.8 for Lutescens 47. The ratio was close to 13:3 for the combination Molodyozhnaya/ Primorskaya 1738 after splitting of the F_2 hybrids into tall and short plants, and 7:9 for the combination Molodyozhnaya/Lutescens 47, which is right for dihybrid splitting (Table 5). These data suggest that the two different genes control short stalk in the hybrid combinations but by hybrid dominant complementary genes in Molodyozhnaya/ Lutescens 47.

Determining the number of genes that control height in the paternal cultivars showed that the differences were 2.0 and 2.24 genes in hybrid combinations Molodyozhnaya/ Primorskaya 1738 and Molodyozhnaya/Lutescens 47, respectively (Table 6, p. 104). The data should be expressed as a round number because the gene is descrete, or two genes for the first and three genes for the second hybrid. The paternal cultivars of hybrids ERO-4/Dalnevostochnaya and Opal/Okeanskaya 39 are likely to have a one gene difference in height and a weak phenotypic activity, which makes it difficult analyze the hybrids.

The coefficient of heritability (H^2) is a sufficient indicator of breeding efficiency of a character. The higher the H^2, the more successful selection. The highest coefficients were in hybrid ERO-4/ Dalnevostochnaya, 0.70; Molodyozhnaya/Primorskaya 1738, 0.67; and Molodyozhnaya/ Lutescens 47, 0.66 (Table 6). The lack of heterosis and high transgression and coefficients of genotypic variation in combination with high heritability led us to consider these hybrids as prospective parents for breeding for short-stalk plants and for resistance to lodging.

Table 6. Plant height heritability in hybrid F_2.

Hybrid	Range in cultivars and hybrids (σ^2)				Heritability (H^2)	Number of genes
	P_1	P_2	F_1	F_2		
ERO-4 / DV	34.65	24.90	6.07	72.08	0.70	0.40
Opal / Ok 39	24.62	40.49	2.71	40.62	0.44	0.49
Md / P 1738	20.54	16.71	4.69	41.61	0.67	2.00
Md / L 47	20.54	15.74	27.47	63.34	0.66	2.24

A result of this breeding and genetic research is the selection of the following lines from the hybrids populations: 131 and 132 (ERO-4/Dalnevostochnaya); 408, 721, 755, and 774 (Opal/Okeanskaya 39); 499, 502, and 523 (Molodyozhnaya/Primorskaya 1738); and 402, 426, and 438 (Molodyozhnaya/Lutescens 47). All the lines are 1.5–2 times more productive than the standard Monakinka, resistant to lodging and disease, and have optimal plant height (75–80 cm (standard is 90–100 cm)) for the conditions of the far eastern Russia.

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Acidification of the root system of wheat to the toxic influence of Al^{3+} ions.

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Reaction to stress allows the estimation of tolerance and the level of metabolism. The specific mechanisms of Al toxicity still are poorly understood in higher plants. The correlation between reaction to stress and resistance allows us to estimate this character in wheat. This study investigated the reaction of wheats to Al treatment at low concentrations.

The wheat cultivar Voronegskaya 14 is known to be aluminum tolerant. Seeds were germi-

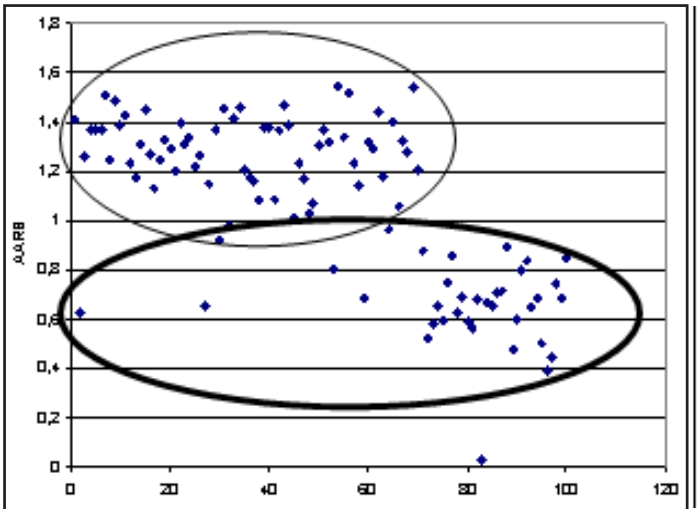

Fig. 1. Two biotypes found in the wheat population were 'A' (AARS > 1) and 'M' (AARS < 1).

nated in a solution of $CaSO_4$ x 10^{-5} M for 4 days. The wheat seedlings were disinfected for 30 min in 10 % H_2O_2 and placed in plastic caps (30 ml) on a plastic float. The plants were grown in four growth solutions: (1) $CaSO_4$ x 10^{-5} M, seedlings placed into this solution on day 3; (2) (control) KCl x 10^{-4} M + $CaSO_4$ x 10^{-5} M, seedlings exposed on day 1 then placed in the third solution; (3) KCl x 10^{-4}M + $CaSO_4$ x 10^{-5}M + 3m/l $AlCl_3$ (exposed for 1 day) then placed in solution 2 (designated as 2-2).

Table 1. Effect of aluminum on acidification activity of the root system (AARS) on wheat.

	AARS exposure (2)	AARS exposure (3)	Inhibition AARS (3) (% of control)	AARS exposure (2-2)	Rehabilitation AARS (2-2) (%)
Biotype M	1.16 ± 0.22	1.86 ± 0.033	–62.9 %	1.06 ± 0.15	91 %
Biotype A	0.43 ± 0.06	0.66 ± 0.03	–64.5 %	1.09 ± 0.09	58.6 %

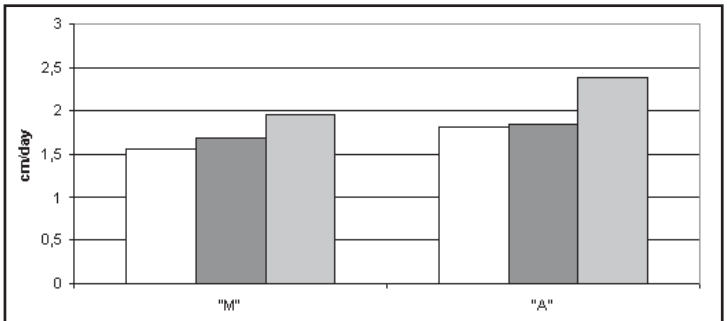

Fig 2. The increase in seedling length in biotype M (left) and biotype A (right) plants.

Results. In solution 2, the seedlings subdivided into two biotypes according AARS values (acidification activity of the root system), which were determined as a change in the pH value. We consider that in the first 24 h no Al-induced efflux organic acid occurs and as a result improved Al resistance. We found that exposure to solution 2 for 24 h led to division into two biotypes (Fig 1, p.104). Al exposure in solution 3 inhibited AARS and leads to a decrease in acidification (Table 1).

Table 2. Influence Al ions on root length (%).

	Root lenght	
	Biotype M	Biotype A
$CaSO_4$+KCl (2, control)	100 %	100 %
$Ca0SO_4$+KCl+$AlCl_3$ (3)	–45 %	–49 %
$CaSO_4$+KCl (2-2)	42 %	4 %

Both biotypes showed similar reactions AARS of the Al exposure. A decrease in AARS consisted of 62.9–64.5% compared with the control solution (2). However, following dipping in solution (2-2, reparation period) was found to have the most AARS recuperation of 'M' seedlings. The AARS of the M biotype increased to 91 percent from the control (2). For the A biotype, the recuperation effect increased 58.6 %.

The increase in seedling length is depicted in Fig. 2. With Al treatment, the growth rate in the apical parts of the seedlings of biotype A was 4.7 times less then that for biotype M plants (a decrease in seedling growth M 7.6 %, A 1.6 %).

We conclude that the seedling length of A biotype plants are more sensitive at Al treatment than those of the M biotype. Exposure (2-2) – (reparation period without Al^{3+}) leads to the highest growth activation in the A biotype. The growth of the A biotype increased by 29 %, whereas growth in the M biotype increased only 16 %.

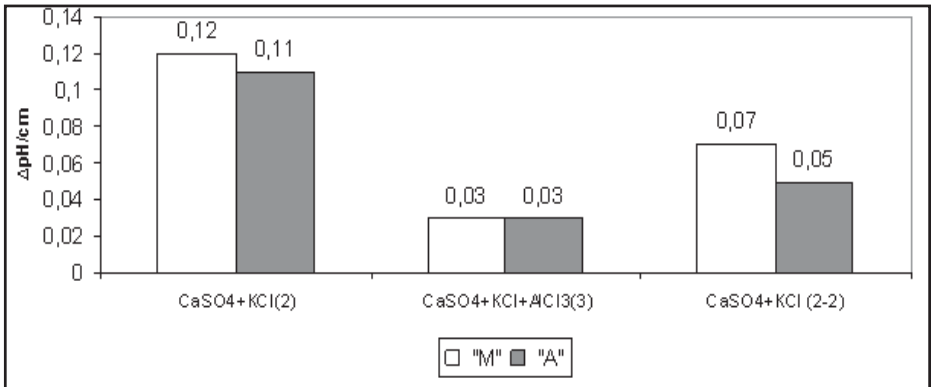

Fig. 3. Specific acidification activity of root system (SAARS) of biotypes of spring wheat (black, biotype M; white, biotype A).

These results indicate that metabolism damage was

not strong. The A-biotype plants were more sensitive to Al^{3+} ions, had more reduced AARS and shoot growth but were easily restored in reparation period, which may be indicative of high sensitivity to Al and the presence of a suppression system.

Al exposure led to a decrease in AARS and root length. Most likely, the change in AARS appears to be independent from root length, the value of which is more sensitive to Al toxicity- roots length or AARS.

To estimate the effect Al^{3+} toxicity, we must calculate the specific acidification activity of root system (SAARS). For this purpose, we divided the AARS in to length root system resulting in the SAARS. The distinction between the activities of root system length are similar in stress conditions (Fig. 3, p. 105), however, up to and after stress results in higher SAARS value for biotype M. A high change in the correlation in SAARS and changes in the length of the root system are observed.

The research concludes that the population of wheat consists of biotypes that respond differently to stress. The parity of these biotypes can define reaction of sensitivity of a grade to an ion of aluminum. The wheat cultivar Voronegskaya 14 has two biotypes. Plants of biotype A possess a greater AARS and are more sensitive to low concentrations of aluminum.

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Productivity of perspective spring bread wheat–alien lines resistant to fungal diseases.

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Perspective spring bread wheat–alien lines produced at the Agricultural Research Institute for the South-East Regions (ARISER) were studied. Donors of agronomic attributes for these lines were *T. turgidum* subsp. *dicoccoides* (line L2870), *A. intermedium* (lines Multy 6R, L487, and L484), and *Ae. speltoides* (line L784). Saratovskaya 55 and L 503 were used as standard cultivars. The lines Multy 6R, L487, L484, L784, and L2870 are resistant to leaf rust; L784 to stem rust; and L487, L484 and L784 to powdery mildew.

The wheat–alien lines were studied during 2004–05 for spike productivity (length of spike, quantity of spike lets/spike, weight, grains/spike, and grain weight/spike), 1,000-kernel weight, and coefficient of productive tillers. On average for these years, all parameters did not differ from standard cultivars. For grain yield, the spring bread wheat–alien lines were estimated for 3 years (2003–05). No differences were observed on average for these years between the wheat–alien lines and the standard cultivars. The introductions of this alien genetic variability has not decreased the agricultural value of these lines, which also provide resistance to fungal diseases that is valuable for bread wheat breeding.

Evaluation of near isogenic lines of bread wheat for resistance to loose smut.

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Buyenkov et al. (2004) have evaluate NILs containing genes for reduced height has been lead for resistance to loose smut. Lines with genes *RhtB1b*, *RhtB1b* in combination with *Lr19*, and *Rht14* have a high degree of resistance to loose smut pathotype L505 than their sib lines. Lines with *RhtB1c*, *s1*, and *Q* did not significantly differ from the sibs. To loose smut pathotype S60, the line with *RhtB1b* in combination with *Lr19* showed a higher resistance. Other NILs had different degrees of susceptibility.

Reaction to loose smut pathotype L505 was tested in NILs differing for resistance to leaf rust (*Lr*), glume color (*Rg*), grain color (*R*), and awns (*H, b1*, and *b2*) were not significantly different except for lines L 360 (*Rg*) and L 359 (*rg*), which were infected to a lesser degree. Pathotype S60 has a positive effect with *Lr* genes in two lines, L 3309 and L 359. NO significant differences were found in other NILs to this pathotype.

The resistance to preharvest sprouting of spring bread wheat in the Volga Region.

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White-grained cultivars of spring bread wheat grow only in areas of great drought, whereas mainly red-grained cultivars are grown in the more humid areas. During a preharvest period with unfavorable rainy weather, significant losses from sprouting of grain occur not only in white-grained cultivars but also in red-grained cultivars are observed. We have studied the reaction of several Saratov-bred spring bread wheat cultivars and lines for resistance to preharvest sprouting. Spikes were cut during physiological maturity and the seed germinated at 20°C. We evaluated sprouting after 7 days.

Of the 22 white-grained spring bread wheat cultivars and lines evaluated, the average germination rate over 3 years of testing (2003–05) was between 68 and 96 %. The 41 red-grained cultivars ranged from 9 to 91 %. Among commercial cultivars, Dobrynya and L503 have the highest resistance to preharvest sprouting. Dobrynya and L503 combine high resistance to preharvest sprouting and high resistance to leaf rust (*Lr19+Lr9*, *Lr19+Lr25*, and *Lr19+Lr26*).

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Evaluation of drought resistance in spring wheat cultivars and lines at the seedling stage.

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Breeders in eastern Siberia see the creation of drought-resistant cultivars of spring wheat as an important objective. Climatic conditions of this region are characterized by drought in late May to June. During this period, spring wheat seedlings are at phase 3 (four leaves to tillering), which is why the ability of spring wheat plants to withstand soil moisture deficit without detriment to the harvest is one of the key characteristics of the cultivars grown in eastern Siberia. Our work aims to determine the drought resistance of a number of cultivars and lines of spring wheat by a method patented in Russia.

Material and methods. The studies were conducted on etiolated seedlings of spring wheat. Bloated wheat seeds were placed in cuvettes on filter paper wetted with tap water and grown in a thermostat at 27°C for 48 h. We then selected seedlings with identical primary root lengths. These seedlings were used as initial material for further work.

Test seedlings were placed in cuvettes for further growth on filter paper wetted with an osmotic (polyethyleneglycol) and kept in a thermostat at 27°C for 24 h. The seedlings then were thoroughly washed with water and kept on wet filter paper for 24 h at 27°C. Root length of the seedlings was measured and the rate of root growth (mm/h) calculated.

Control plants were grown under the same conditions on water. Based on the root growth speed in optimal conditions and after water stress, we determined the degree of root growth speed restoration after stress or action according to the formula: V test / V control E 100 %, where V is the seedling growth rate.

Results. The degree of growth after the impact produced by the stress (osmotic) proved to be directly proportional to the degree of plant resistance. We could split all the tested cultivars and lines into three groups; 1, high drought resistance (restoration of growth exceeds 100 %; 2, average drought resistance (from 90 to 100 %); and 3, low drought resistance (below 90 %) (Table 1). Cultivars and lines from the first group and some cultivars from the second group are of interest to breeders from the standpoint of their use in breeding new drought-resistant cultivars of spring wheat.

Table 1. Evaluation of drought resistance in spring wheat lines by restoring growth speed of the primary root after termination of stressor impact. Values are expressed as M ± SE.

Cultivar or line	Control (48 h water)	Test (24 h on stressor 24 h water)	Restoration of growth rate (%)
High drought resistance			
Line 100	1.03 ± 0.10	1.21 ± 0.06	117.5
Buryatskaya	1.15 ± 0.07	1.24 ± 0.08	107.8
Tulunskaya 12	1.34 ± 0.08	1.44 ± 0.05	105.2
Line 94	1.16 ± 0.08	1.22 ± 0.08	105.2
Average drought resistance			
Irgina	1.37 ± 0.06	1.35 ± 0.07	98.5
Udarnitsa	1.17 ± 0.09	1.14 ± 0.07	97.4
Pirotrix 28	1.46 ± 0.11	1.41 ± 0.09	96.5
Saratovskaya 36	1.53 ± 0.10	1.46 ± 0.10	95.4
Tselinogradkaya	1.42 ± 0.06	1.33 ± 0.08	93.7
Tulunskaya 15	1.38 ± 0.10	1.26 ± 0.12	91.3
Tselinnaya 60	1.30 ± 0.10	1.19 ± 0.11	91.5
Low drought resistance			
Angara 86	1.34 ± 0.08	1.18 ± 0.09	88.1
Orkhan	1.34 ± 0.10	1.17 ± 0.11	87.3
Tselinnaya 20	1.45 ± 0.08	1.24 ± 0.08	85.5
Line 2	1.26 ± 0.08	1.06 ± 0.10	84.1
Skala	1.59 ± 0.04	1.29 ± 0.05	81.1
Balaganka	1.35 ± 0.05	1.04 ± 0.09	77.0

Reference.

Patent 1734596 (Russia, priority of 08.06.1992). 1996. Method of evaluation of plants resistance to drought of northern and southern type at early stages of ontogenesis. Discoveries and Inventions, No 18.

The impact of spring frosts on the growth of spring wheat seedlings of different cultivars.

A.K. Glyanko, N.V. Mironova, and G.G. Vasilieva.

Introduction. Plant growth under various stress factors has been the subject of many studies, but the impact of spring frosts, which cause significant damage to crop production, have not been fully covered in the scientific literature (Shevelukha 1977; Drozdov et al. 1977; Musienko et al. 1986). The impact of spring frosts on plant growth is evaluated largely on the accumulation of fresh and dry matter by a plant and the final productivity. Nevertheless, these parameters do not allow the determination of fairly precisely such disturbances of growth processes, which take place during immediate cold impact and during several days right afterwards, these data being important for forecasting productivity of the plants subjected to frost. With this in view, our work targeted the assessment of dynamics of linear growth of leaves of various spring wheat cultivars immediately during cold stress and after several days.

Materials and methods. The following spring wheat cultivars from the collection of the N.I. Vavilov research institute of plant industry (St. Petersburg, Russian Federation) were used for the study: Milturum 553, Karola, Kzyl-Bas, Albidum 43, and Skala. These cultivars differ in the length of their vegetative period. Seeds of the cultivars were sown in pots with a capacity of 4 kg of dry sandy soil. A nutrient mineral mixture with a nitrate source of nitrogen was introduced according to Thomas et al. (1979). Soil moisture in the pots during plant growth was maintained at 60 % of the soil complete moisture capacity. Frosts were simulated in the Siberian phytotron (Irkutsk, Russian Federation) based on natural models. Temperature was measured automatically according to an established program (Kurets 1974). Three modeled frost types differed in the value of minimum temperature: –2 to –3°C, –4 to –5°C, and –6 to –7°C. In each variant, we identified three conventional periods of gradual decrease and increase in temperature: I – a temperature decrease from 20 to 0°C; II – a temperature decrease from 0°C to the minimal value and then increased to 0°C; and III – a temperature increase from 0 to 15°C (Glyanko and Mironova 1974). The duration of period II amounted to 6 h, of which for 2 h the temperature was decreased from 0°C to a minimum value, for 1.5 h the plants were kept at the minimum temperature, and for 2.5 h the temperature was raised to 0°C. During the frosts, the plants were kept in darkness.

Before and after the frosts, plants were kept in the phytotron under stationary conditions of artificial illumination by DRL-700 lamps (illumination value 9,000 lux); a 24-h temperature of 19±1°C; and a 16-h illumination period. Linear growth of the upper leaf of the different spring wheat cultivars was measured by means of auxanographies (Shevelukha 1977). Seedlings were exposed to frost at the 4-leaf stage and growth was measured for 24 h. The data are presented in the form of average value of three independent experiments (M±SD).

Results and discussion. All the three experimental variants demonstrated significant growth reduction of different spring wheat plants exposed to below zero temperatures. Thus, at –2 to –3°C, leaf growth during 6 h in the different wheats varied from 0.96 (Kzyl-Bas) to 1.75 mm (Albidum 43), and growth rate from 0.16 to 0.29 mm/h, respectively. In the control plants, leaf growth varied from 4.5 to 9.0 mm and growth rate from 0.75 to 1.50 mm/h in Kzyl-Bas and Albidum43, respectively. Plants did not show any visual damage, proving the overcooling of seedlings during frosts.

Temperatures of –4 to –5°C inhibited leaf growth more intensely in Albidum 43 (0.84 mm), Milturum 553 (0.78 mm), Karola (0.72 mm), and Kzyl-Bas (0.66 mm), compared to the controls Albidum 43 (13.9 mm), Milturum 553 (9.0 mm), Karola (5.5 mm), and Kzyl-Bas (4.4 mm). The plants had visual damage. Albidum 43 and Milturum 533 plants had the lowest leaf damaged (in 55 and 10 % of plants, respectively), Skala plants were intermediate, and Karola and Kzyl-Bas plants showed no damage.

At –6 to –7°C minimum temperature, the seedlings showed practically no linear growth. Linear growth observed in two test variants at below zero temperature may apparently be accounted for by the increase of cells size due to ice formation in the tissues (Shevelukha 1977). There was observed visual damage of bottom leaves, which had terminated their growth, there were also cases of the whole plant perishing.

These data show that weak frosts (up to –4 to –5°C) in the period of immediate cold impact on the seedlings of different varieties of spring wheat did not fully stop growth processes, though inhibited them significantly. Frosts of –6 to –7°C almost completely inhibited linear growth of the leaf.

The aftereffect of frosts in nature creates a fairly favorable temperature regime. In our tests aftereffect of the frost was analyzed at the temperature increase from 0°C, with the plants being kept for 16 h in the cold chamber at the temperature, which in 4 h reached optimal value (15°C), and then they were transferred to the growth chamber with the environmental parameters identical to those preceding the frost.

It was found that immediately after the frost of –2 to –3°C the growth was intensely suppressed and its rate varied in different varieties from 0.13 (Kzyl-Bas) to 0.37 mm/h (Milturum 553), and in control from 0.73 to 1.50 mm/h, respectively. These are average data for 16 h period and they do not reflect dynamics of the growth processes. With this in view it should be noted that within the first 1–1.5 h after the temperature increase up to 0°C linear growth practically completely stopped, and further (with the temperature increase) restored, but its intensity during 6 h remained considerably lower than in control (Fig. 1).

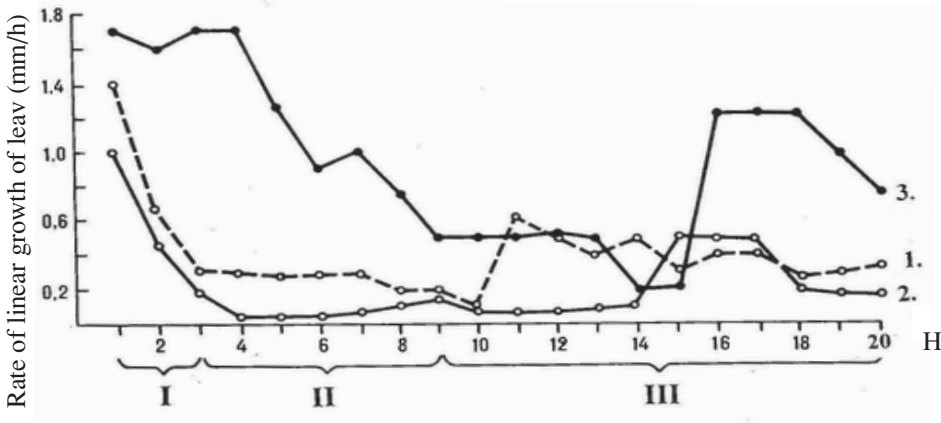

Fig. 1. Dynamics of the rate of linear growth of seedlings of the spring wheat cultivar Karola after the action of frosts. I = –2 to –3°C, II = –6 to –7°C, and III = control.

After the plants transfer to the lit growth chamber (24 hours after the frost start) their growth in the test variant was slightly behind the growth in control (by 13–15 %). However, already in the darkness after the first 16 h light period test and control variants showed no difference, and in some case a little

growth stimulation was observed. On the third day after the beginning of frost (in the light) dynamics of growth rate was analogous to that of control.

Thus, after effects of weak frosts did not produce significant negative impact on the growth processes. Growth inhibiting with the frost –4 to –5°C was observed only in the first 24 h, later growth inhibition was replaced for its stimulation and getting back to normal.

Frosts of –6 to –7°C caused intense damage, that is why we measured the growth of the plants, which had visually observed damage of leaves. Immediately after the frost termination (period III) the growth was considerably inhibited and its rate in different varieties amounted to 0.16–0.30 mm/h (Table 2). During the first 2–5 h after the temperature increase from 0°C the growth almost stopped (see Fig. 1, p. 109). This period observed even with the weak frosts may apparently called a 'cold shock' period, followed by the growth rate increase in the light, this rate still remaining below that of control plants. The most intense growth inhibition (up to 10 days) was observed in Albidum 43 (Table 2). Nevertheless, we note that the growth was measured in the plants with three perished leaves, and the growth stopped in the newly formed leaf, which was not there during the frost period.

Table 2. The speed of linear growth (mm/h) of leaves in different cultivars of spring wheat after a frost of – 6 to –7°C. Unidentified parameters indicated by blanks.

	Period after frost termination						
Test variant	First 16 hours in darkness (t > 0°C)	2nd day in the light	2nd day in darkness	3rd day in the light	3rd day in darkness	10th day in the light	10th day in darkness
Albidum 43							
Control	1.50 ± 0.16	2.61 ± 0.23	2.28 ± 0.25	2.27 ± 0.21	2.17 ± 0.15	2.53 ± 0.27	1.62 ± 0.17
Test	0.30 ± 0.03	1.50 ± 0.18	1.92 ± 0.20	1.65 ± 0.14	1.93 ± 0.12	1.52 ± 0.17	1.59 ± 0.16
Karola							
Control	0.91 ± 0.01	1.84 ± 0.15	1.95 ± 0.18	1.73 ± 0.16	1.80 ± 0.19	1.87 ± 0.18	1.47 ± 0.15
Test	0.16 ± 0.02	1.75 ± 0.19	1.36 ± 0.10	2.09 ± 0.19	2.08 ± 0.16	1.67 ± 0.15	1.34 ± 0.13
Skala							
Control	1.17 ± 0.13	2.03 ± 0.21	1.70 ± 0.17	2.04 ± 0.19	1.72 ± 0.20	3.23 ± 0.31	2.62 ± 0.23
Test	0.26 ± 0.03	1.93 ± 0.18	—	1.90 ± 0.21	1.30 ± 0.09	2.77 ± 0.20	2.71 ± 0.29
Kzyl-bas							
Control	1.23 ± 0.11	1.82 ± 0.19	1.31 ± 0.11	2.18 ± 0.20	—	—	—
Test	0.23 ± 0.03	1.34 ± 0.09	2.00 ± 0.21	2.03 ± 0.17	—	—	—

In the light, the duration of growth inhibition of the plants subjected to the impact of –6 to –7°C frost increased. Thus, in Albidum 43, small inhibition of leaf growth in the darkness observed on the second and third day was followed by stimulation on the fourth day. Later, growth increase of test and control plants showed no differences.

Temperatures of –6 to –7°C distinctly demonstrated three phases of the unfavorable factor aftereffects: growth inhibition (the duration depended on the degree of the plant damage); growth stimulation (with little or no damage); and return to normal. The first phase may be subdivided into three subphases of growth inhibition, immediately after the frost termination, in light, and in darkness.

Immediately after frost termination, we observed the most intense inhibition of plants growth, which was accompanied by a complete stop in the first hours after the temperature increase above 0°C. In the light, these processes had different durations depending on the degree of plant damage and were shorter in the dark than in the light.

Artificial frosts obviously fail to fully reproduce natural frosts, which is why regularities of linear growth of leaves observed in the course of artificial frosts will differ from those in natural conditions (Vinter 1981). These differ-

ences are primarily conditioned by different environmental conditions (insolation intensity, air temperature, and humidity), to which the plants were exposed before, during, and after frost. In natural conditions, plant damage during the frost may be more significant, because high humidity and intense cooling of plant organs foster ice formation in their tissues, particularly in the case of radiation-type frosts.

In our experiments, the plants underwent weak and medium frosts, apparently in an overcooled state. Nevertheless, with frosts of any intensity the growth was undoubtedly inhibited in the first 24 h after its termination. Analogous data were obtained by other authors (Musienko et al. 1986), who demonstrated the most intensive inhibition of wheat seedlings growth in the first 24 h after the influence of cold temperature, regardless of its tension and duration. Further growth inhibition degree depended on the extent of plant damage.

The negative impact of light intensification on unfavorable factors on different physiological processes has been described in the literature and is a photodynamic effect (Ivanova et al. 1987). This is presumably caused by intensification of photooxidizing processes in chloroplasts due to activation of superactive radicals, in particular oxygen ones, formation of which is intensified in the light (Merzlyak 1989). All this may produce negative impact on the leaves growth during aftereffect of unfavorable factor.

The negative impact of light on the leaves linear growth was particularly well shown in the plants with intense damage. These data coincide with those of Ivanova et al. (1987), who noted that severe damage by high temperature on the plants getting more intense light during the functional repair stage. Consequently, successful repairing of disturbed physiological functions requires darkness. Rapid change in the illumination regime (darkness/light) also caused growth response in plants subjected to frost. In our experiments, exposure to light in the phytotron inhibited their growth for 15–20 min. Duration of growth stop with the change of illumination regime (darkness/light) on the first and second days after the frost termination amounted to 45-80 min depending on the frost intensity. Analogous photoactive responses were described earlier (Shevelukha 1986).

We established that a period of no growth immediately following cold impact termination (cold shock) is longer if the frost is more intense. Apparently, the process of plants adaptation to the damaging factor should be accompanied along with metabolism reconstruction by low intensity of growth processes (Tyurina 1960; Udovenko 1979; Trunova et al. 1987). It should be noted that in our experiments in non-adapted plants artificial frosts killed mostly bottom leaves, which terminated their growth. Intense frosts in the bushing phase damaged the whole plant with bushing sprouts undamaged. Consequently, the growing organs of wheat plants demonstrated the highest resistance. At the same time it should be noted that quick-ripening varieties (Albidum 43, Skala, vegetative period of 82–105 days) characterized by high intensity of growth processes were more intensely damaged than varieties with long vegetation period (Karola, Kzyl-Bas, 120–130 days). However, growth processes in the course of reparation period of quick-maturing wheat cultivars were characterized by higher intensity than those of late-maturing cultivars.

Growth stimulation observed in the repair period apparently witnesses small disturbances emerging in spring wheat seedlings under the influence of frost. Substitution of physiological functions inhibition by their stimulation is and index of reparation processes intensity, which confirms reversibility of damage and gradual restoration of the functions. To forecast the productivity of the plants subjected to frost, further research should be targeted at the identification of correlation between the degree of growth processes damage and productivity.

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Assessment of spring wheat cultivar competitiveness in the agrophytocenoses of East Siberia.

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Introduction. The agrophytocenoses of East Siberia (Russia) in the last 10–15 years have been intensely choked with weeds. This factor negatively affects the productivity of spring wheat and other crops cultivated in this region. Economic plants may successfully counteract weeds if they are highly competitive. Competitiveness is one of the three vital strategies of plants in accordance with the classification proposed by Ramensky (1938) and Grime (1979, 2001), which include competitors (C), stress-tolerators (S), and ruderals (R). These types of strategies (C, S, and R), as a rule, do not occur in nature in the pure state. More often plants have mixed strategy types (Hodgson et al. 1999). Economic plants, in the course of selection for economically valuable features (largely productivity), have to a significant extent lost the competitiveness and stress tolerance strategies and may be characterized as ruderal plants. The most important characteristics of R plants is their ability to respond quickly to an improvement in growth conditions via enhancement of growth, development, and an increase in productivity (Glyanko and Vasilieva 2002).

The soft wheats cultivated in East Siberia normally possess a high potential productivity (50–70 metric center (mc)/ha). Nevertheless, the actual productivity potential of these species equals 12–25 mc/ha. One reason for the decrease of spring wheat productivity in the East Siberian agrophytocenoses is low competitiveness of spring wheat species with weeds.

We found no scientific data on determination of competitiveness of spring wheat species, which is why we made an attempt to assess the ability of four spring wheat species to resist weeds in the field, in effect to identify their degree of competitiveness.

Material and methods. The four cultivars of soft spring wheat used for this study were Angara, Studencheskaya, Tulun 15, and Tulunskaya 12. The test was conducted on an ameliorated, light-gray forest soil. The test site area was 1 m^2. The tests were repeated four times. Test variants were randomized. Test sowings were performed on pure black fallow. The presowing treatment system included early spring harrowing, two presowing cultivations, and packing. The test schemes were variant 1, site without wheat (only weeds); variant 2, site with wheat sown with weeds removed during the vegetative period (wheat without weeds); and variant 3, site sown with wheat without the removal of weeds (wheat + weeds). The number of grains sown/m^2 was 700 on 20 May, 2004. The plants were harvested manually at wax-ripeness (moisture 20–23 %) between 15–22 August, 2004.

The competitiveness of the spring wheat species and weeds was determined using the following formulas.

I. General competitiveness =

$$K_1 = \frac{A_1}{B_1}$$, where

K_1 = general competitiveness, A_1 = wheat productivity (straw and crop harvest) in variant 3 (wheat + weeds), and B_1 = wheat productivity (straw and crop harvest) in variant 2 (wheat without weeds).

II. Productive competitiveness =

$$K_2 = \frac{A_2}{B_2}$$, where

K_2 = productive competitiveness, A_2 = wheat grain productivity in variant 3 (wheat + weeds), and B_2 = wheat crop harvest in variant 2 (wheat without weeds).

III. Weed competitiveness =

$$K_3 = \frac{C}{D}, \text{ where}$$

K_3 = weed competitiveness, C = dry biomass of weeds in variant 3, and D = dry biomass of weeds in variant 1 (weeds without wheat).

Results. ***Quantitative and qualitative composition of weeds and their competitiveness.*** The estimate of weeds in variant 1 demonstrated that by 10 June on the site an average of 212 weeds were present, by 25 June 246 weeds, and by 7 July 405 weeds. The weeds were represented by 17 species with the following most predominant: *Chenopodium album* L., *Senecio vulgaris* L., *Stelaria media* L., *Sonchus arvensis* L., *Cirsium oleraceum* L., and also some species from *the Panicum* and *Leguminosae* families. *Crepis testorum* L., *Spergula vulgaris* L., *Polygonum convolvulus* L., *Polygonum divaricatum* L., *Artemisia vulgaris* L., and some other species occurred to a small degree.

The quantitative composition of weeds in the agrophytocenoses of different spring wheats showed that the dry mass of the weeds in agrophytocenoses with spring wheat at harvest were 15, 25, 51, and 116 g/m^2 in Tulunskaya 12, Tulun 15, Studencheskaya, and Angara, respectively. Thus, weed growth was intensely oppressed in agrophytocenoses with spring wheats Tulun 15 and Tulunskaya 12. This conclusion is confirmed after determining the weed competitiveness coefficient K_3. This parameter was the highest in agrophytocenosis with the spring wheat Angara (0.62), followed by Studencheskaya (0.27), Tulun 15 (0.13), and Tulunskaya 12 (0.08). The highest degree of weed competitiveness was observed in agrophytocenosis with Angara and the lowest with Tulunskaya 12.

Competitiveness of spring wheat cultivars. General and crop productivity were different in different cultivars (Table 3). Studencheskaya was characterized by the highest general and crop productivity, followed by Tulunskaya 12, Tulun 15, and Angara. Weed presence in the agrophytocenoses of spring wheat reduced general and crop productivity in all the cultivar to a different extent. The largest reduction in general productivity under the impact of weeds was observed in Tulunskaya 12 (by 22.5 mc/ha) and the lowest in Studencheskaya (by 5 mc/ha). Crop productivity under the impact of weeds was most reduced in Tulunskaya 12 (by 3.3 mc/ha) and Studencheskaya (by 3.2 mc/ha). In Angara and Tulun 15, the crop productivity was reduced by 2.4–2.5 mc/ha.

Table 3. Productivity of agrophytocenoses with different cultivars of spring wheat. Numerator = wheat biomass in the variant with weeds; denominator = wheat biomass in the variant without weeds.

	Productivity (g/m^2)	
Test variants	General dry biomass	Crop biomass
Angara	1,394 / 1,555	373 / 397
Studencheskaya	1,818 / 1,868	557 / 589
Tulun 15	1,555 / 1,632	373 / 398
Tulunskaya 12	1,589 / 1,814	400 / 433

Calculation of competitiveness coefficients K_1 and K_2) of the spring wheats indicated that Tulunskaya 12 and Angara had the lowest values at 0.87 and 0.92 and 0.89 and 0.93, respectively. Tulun 15 had the highest values at 0.97 (K_1) and 0.94 (K_2); Studencheskaya insignificantly different at 0.95 (K_1) and 0.93 (K_2). Thus, we observed high sensitivity of weeds to Tulunskaya 12 (which shows in a low K_3 coefficient of 0.08 and, on the other hand, a high sensitivity in this cultivar to weeds (K_1= 0.87 and K_2 = 0.92). Weeds respond less to Angara plants, which have a high K_3 coefficient of 0.62 and low K_1 and K_2 coefficients (0.89 and 0.93, respectively).

Consequently, the reduction of productivity in Angara apparently is conditioned by the negative impact of weeds, that is interspecific competition for vital sources. In Tulunskaya 12, considerable importance apparently is the intraspecific competition associated with the density of wheat plants per square area unit. In conclusion, we note that the spring wheat cultivars studied possess various degrees of competitiveness with weeds. This property presumably depends both on interspecific and intraspecific competition between plants for vital sources.

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The influence of cyclosporin A, Ca^{+2} ions, and fatty acids on the mitochondrial swelling of cold-stressed and cold-hardening winter wheat shoots.

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Opening the high-conductance permeability transition pore (PTP) induces the mitochondrial permeability transition, which is characterized by mitochondrial swelling, uncoupling, and inner membrane permeabilization to solutes up to 1,500 Da. The opening of the PTP is an important factor in both necrotic and apoptotic cell death (Zoratti and Szabo 1995; Bernardi et al. 1998; Hirsch et al. 1998; Crompton 1999). PTP is considered a complex composed of a voltage-dependent anion channel (VDAC), an ADP/ATP antiporter, cyclophilin D, and possibly other proteins (Crompton 1999). He and Lemasters (2002) proposed a new model of PTP formation and regulation in which PTP forms by aggregation of misfolded integral membrane proteins damaged by oxidant and other stresses. The existence of classic cyclosporin A (CsA)-sensitive PTP in plant mitochondria still is discussed. PTP in plants is both sensitive to CsA (Arpagaus et al. 2002; Tiwari et al. 2002) and insensitive (Fortes et al. 2001; Curtis and Wolpert 2002; Virolainen et al. 2002). Induction of pore opening in plant mitochondria is accompanied by mitochondrial swelling and release of cytochrome *c* (Arpagaus et al. 2002; Curtis and Wolpert 2002; Tiwari et al. 2002; Virolainen et al. 2002). These events are characteristic for induction of animal PTP. The present investigation studies the mitochondrial swelling in the presence of inductors (Ca^{+2} and palmitic acid) and inhibitor (cyclosporin A) of PTP in cold-resistant winter wheat after short-term cold stress and cold hardening.

Materials and methods. Three-day-old etiolated seedlings of cold-resistant winter wheat cultivar Zalarinka were germinated on moist paper at 26°C. Seedlings were subjected to short-term (–1°C, 1 h) cold stress or were cold-hardened for 7 days at 4°C. The mitochondria were isolated from seedlings shoots by differential centrifugation (Pobezhimova et al. 2001). Isolated mitochondria were resuspended in 40 mM MOPS-KOH buffer (pH 7.4), 300 mM sucrose, 10 mM KCl, 5 mM EDTA, and 1 mM $MgCl_2$. Mitochondrial swelling was followed spectrophotometrically by the decrease in absorbance of the mitochondrial suspension (0.25 mg/ml) under de-energized conditions at 26°C at 540 nm. We used two types of incubation media: 1) 300 mM sucrose and 20 mM MOPS (pH 7.4) and 2) 200 mM KCl and 20 mM MOPS (pH 7.4) (basic medium). Test reagents were used at concentrations of 1 mkM cyclosporin A, 1.75 mM Ca^{+2}, and 50 mkM palmitic acid. In the experiments using CsA and Ca^{+2}, the preincubation time was 5 min at 0°C. The concentration of mitochondrial protein was analyzed by according to Lowry et al. (1951). Results are represented as the mean of at least three determinations per experiment.

Results and discussion. Low and high temperatures and oxidative stress are known to be inductors of programmed cell death (PCD) in plants (Koukalova et al. 1997; Balk et al. 1999; Tiwari et al. 2002). In the present work, we studied the swelling of mitochondria, isolated from control (nonstressed and non-hardened), cold-stressed and cold-hardened winter wheat shoots.

We found that changes of optical density of mitochondrial suspension in the presence of sucrose did not occur (Fig. 2g, p. 115), whereas the isotonic KCl buffer caused a decrease of optical density and mitochondrial swelling (Fig. 2a, p. 115). This medium was used to study the influence of mitochondrial pore inductors and inhibitors on the swelling winter wheat mitochondria in our work.

In experiments with incubation of control winter wheat mitochondria with CsA, we detected a decrease in optical density of mitochondrial suspension (Fig. 2b, p. 115). Because Ca^{+2} accumulation in mitochondria is known to cause PTP opening (Gunter and Pfeiffer 1990), we studied the influence of Ca^{+2} on the swelling of winter wheat mitochondria that were preliminarily incubated with and without CsA. The presence of Ca^{+2} in the incubation medium stimulated the extent of swelling already in 20 sec of incubation, and this stimulation was 3-fold in 5 min (Fig. 2c, p. 115), compared with the swelling of mitochondria incubated without Ca^{+2}. The Ca^{+2}-induced swelling was inhibited after preliminary incubation of mitochondria with CsA. In this case the swelling was sensitive to CsA action on 70–75 % (in 5 and 10 min of incubation) (Fig. 2d, p. 115). We observed an increase in mitochondrial swelling extent in the presence

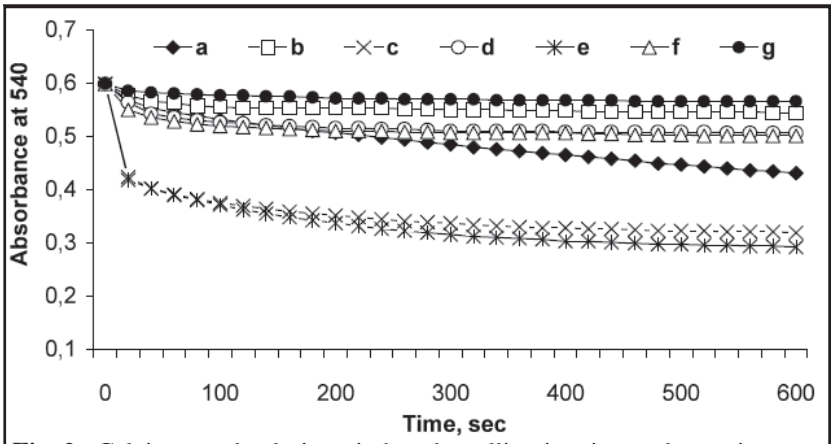

Fig. 2. Calcium- and palmitate-induced swelling in winter wheat mitochondria under de-energized conditions. Experiments were at 26°C in isotonic KCl-based swelling buffer, pH 7.4 (traces a–f) and a medium containing 300 mM sucrose and 20 mM MOPS (pH 7.4) (trace g). Traces: a and g – mitochondria without any addition; b – mitochondria after preincubation with CsA; c – mitochondria after preincubation with Ca^{+2} ions; d – mitochondria after preincubation with CsA followed by the addition of Ca^{+2} ions; e – mitochondria after addition of palmitic acid; f – mitochondria after preincubation with CsA followed by the addition of palmitic acid. Results are represented as the mean of at least three determinations per experiment.

other inductor of PTP – saturated fatty acid – palmitic acid, the action of which was similar to Ca^{+2} action. Palmitic acid caused a 4-fold increase in swelling within 5 min of incubation, which was sensitive to CsA addition (Fig. 2e and f).

Short-term exposure by low temperature on the winter wheat shoots caused the decrease of optical density in isolated mitochondria and theirs swelling. The swelling extent in 5 min of incubation of the mitochondria was 1.4 times higher than the swelling extent of mitochondria isolated from non-stressed shoots (Fig. 3a). The swelling of mitochondria from cold-stressed shoots was less sensitive to CsA (20 % and 40 % inhibition in 5 and 10 min of incubation with this inhibitor, respectively) (Fig. 3b). Incubating mitochondria with Ca^{+2} stimulated the extent of swelling, which was 2.75 times higher (in 5 min of incubation) than the swelling of mitochondria incubated without Ca^{+2} (Fig. 3c). We detected that CsA did not inhibit the Ca^{+2}-induced swelling but stimulated swelling (70 % increase in 5 min of incubation) (Fig. 3d). The swelling induction of mitochondria from cold-stressed shoots in the presence of palmitic acid was less expressed (2 times) in comparison to that of the acid in mitochondria isolated from nonstressed shoots. Palmitate-induced swelling of mitochondria from cold-stressed shoots was fully inhibited by CsA (Fig. 3e and f).

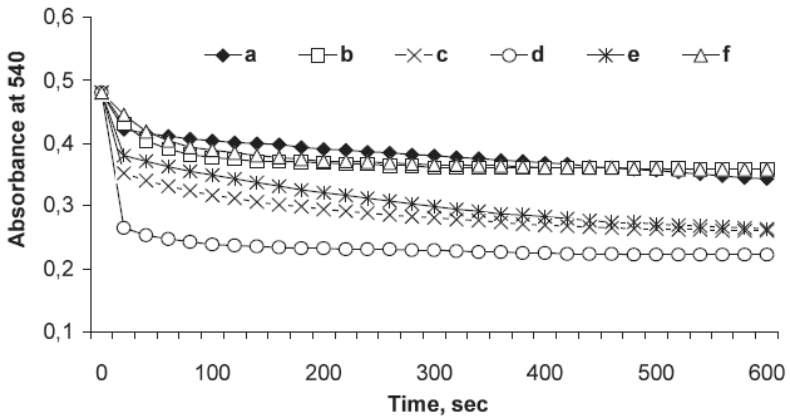

Fig. 3. Calcium- and palmitate-induced swelling in mitochondria isolated from cold-stressed seedlings of winter wheat (–1°C, 1 h) under de-energized conditions. Experiments were at 26°C in an isotonic KCl-based swelling buffer, pH 7.4. Results are represented as the mean of at least three determinations per experiment. Traces a–f as described in the legend to Fig. 2.

Cold hardening of winter wheat shoots caused the swelling of isolated mitochondria similar with swelling of isolated mitochondria from cold-stressed shoots. The swelling extent of mitochondria was 1.3 times as higher (in 5 min of incubation) than that of mitochondria isolated from nonstressed shoots (Fig. 4a, p. 116). The swelling of mitochondria of cold-hardened shoots was less sensitive to CsA (20 % inhibition in 5 and 10 min) (Fig. 4b, p. 116). Incubating mitochondria with Ca^{+2} stimulated 2-fold degree of swelling during the time of incubation in comparison with mitochondria incubated without Ca^{+2} (Fig. 4c, p. 116). Ca^{+2}-induced swelling was not sensitive to CsA (Fig. 4d, p. 116). The swelling induction in mitochondria isolated from cold-hardened shoots after the addition of palmitic acid was less expressed and 1.4-fold compared with mitochondria that were incubated without the addition of the acid. Palmitate-induced swelling of mitochondria from cold-hardened shoots was fully inhibited by CsA (Fig. 4e and f, p. 116).

Mitochondrial swelling is one event of PTP opening. We concluded that the swelling of winter wheat mitochondria are associated with opening of mitochondrial pore. The stimulation of swelling by Ca^{+2} and the inhibitory effect of CsA indicate Ca^{+2}-dependent, CsA-sensitive, mitochondrial pores function in winter wheat shoots. At the same time, cold stress and cold hardening decrease the sensitivity of mitochondria to cyclosporin A, which may function in CsA-insensitive pores in conditions of cold stress and hardening. Our data show that different mechanisms of opening pore regulation in normal and stress conditions exist.

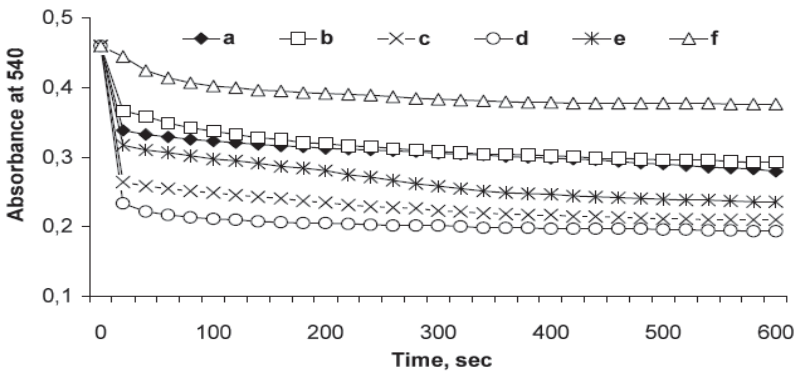

Fig. 4. Calcium- and palmitate-induced swelling in mitochondria isolated from cold-hardened seedlings of winter wheat (7 days at 4°C) under de-energized conditions. Experiments were at 26°C in an isotonic KCl-based swelling buffer, pH 7.4. Results are represented as the mean of at least three determinations per experiment. Traces a–f are as described in the legend to Fig. 2.

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The influence of oxidative stress on winter wheat mitochondria function and alternative oxidase contribution.

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Oxidative stress has significant influence on cell metabolism of plants. Under oxidative stress conditions the expression of such mitochondrial protein as cyanide-resistant alternative oxidase (AOX) occurs (Maxwell et al. 1999; Szal et al. 2003; Polidoros et al. 2005). AOX catalyzes quinol-oxygen oxidation/reduction that is not linked to proton pumping and consequently does not generate a proton electrochemical gradient. The low expression of AOX in roots of wheat seedlings can explain observed symptoms of oxidative stress (Biemelt et al. 1998). One of the functions of alternative oxidase is its antioxidant role (Popov et al. 1997; Purvis, 1997; Maxwell et al. 1999). AOX induction can represent the important mechanism prevented activation of programmed cell death (Amor et al. 2000; Robson and Vanlerberghe 2002; Vanlerberghe et al. 2002).

We have shown previously that cold shock and cold hardening caused the increase of AOX contribution to total respiration of winter wheat mitochondria (Grabelnych et al. 2004). Taking into account the important role of alternative oxidase in plants, we studied the reaction of winter wheat mitochondria under oxidative stress conditions and AOX activity changes. The aim of the present investigation was to study influence of oxidative stress on winter wheat mitochondria energetic activity and AOX contribution to total respiration of the mitochondria in these conditions.

Materials and methods. Three-day-old etiolated shoots of winter wheat (*Triticum aestivum* L, cv. Zalarinka) germinated on moist paper at 26°C, were used. Oxidative stress was induced by immersing root tips of intact three-day-old seedlings in 0.5 mM solution of H_2O_2 in the dark at 26°C for 3 h. Coleoptiles of treated seedlings were harvested for mitochondria isolation.

Mitochondria were extracted from winter wheat shoots by differential centrifugation as describes previously (Pobezhimova et al., 2001). Isolated mitochondria were resuspended in 40 mM MOPS-KOH buffer (pH 7.4), 300 mM sucrose, 10 mM KCl, 5 mM EDTA, and 1 mM $MgCl_2$. The intactness of mitochondria was determined by and measurement of cytochrome c oxidase activity and swelling measurement. The activity of mitochondria was recorded polarographically at 27°C using a platinum electrode of a closed type in a 1.4 ml volume cell. The reaction mixture contained 125 mM KCl, 18 mM KH_2PO_4, 1 mM $MgCl_2$, and 5 mM EDTA, pH 7.4. Oxidations substrates were 10 mM Malate in the presence of 10 mM glutamate and 8 mM succinate in the presence of 10 mM glutamate. During succinate oxidation, 3 mkM rotenone, which blocks electron transfer through complex I, was added to incubation medium. Test reagent concentrations were 1 mM benzohydroxamic acid (BHAM) (AOX inhibitor), 20 mkM antimycin A (complex III inhibitor), and 0.4 mM KCN (complex IV inhibitor). Polarograms were used to calculate the rates of phosphorylative respiration (state 3), nonphosphorylative respiration (state 4), the rate of respiration after BHAM addition, the rate of respiration after Ant-A addition, respiration control by Chance-Williams, and the ADP:O ratio (Estabrook 1967). The concentration of mitochondrial protein was analyzed by Lowry method (Lowry et al. 1951). All the experiments were made in 3–6 preparations. The data obtained were analyzed statistically, i.e., arithmetic means and standard errors were determined.

Results and discussion. Winter wheat mitochondria isolated from shoots exposed under oxidative stress differ significantly in their coupling degree of oxidation and phosphorylation processes and phosphorylative and non-phosphorylative rates from nonstressed shoots mitochondria. In malate-oxidizing (when transfer of electrons starts with complex I of respiratory chain) winter wheat mitochondria, oxidative stress caused a 56.2 % decrease of phosphorylative and a 23.1 % decrease of nonphosphorylative rates of respiration as comparison to nonstressed mitochondria (Fig. 5, p. 118). At the same time, we observed a 43.0 % decrease of respiratory control coefficient under stress conditions. When succinate was used as oxidation substrate (when transfer of electrons starts with complex II of respiratory chain), oxidative stress caused a 52.7 % decrease of phosphorylative, a 54.0 % decrease of nonphosphorylative rates of respiration, and a 20.0 % decrease of respiratory control coefficient in winter wheat mitochondria (Fig. 6, p. 118). The decrease of respiratory rates points out on the repression oxidative phosphorylation under oxidative stress.

Using inhibitor analysis, which allows the blocking of terminal oxidases or certain electron-transport chain complexes, we studied the contribution of different electron transport pathways into total plant mitochondria oxygen uptake. Changes of cytochrome and alternative pathways contribution to respiration of winter wheat mitochondria under

oxidative stress were investigated. The contribution of different electron transport pathways to respiration of winter wheat mitochondria from nonstressed shoots during malate oxidation is that the main part (62.5 %) of mitochondrial oxygen uptake depends on the cytochrome pathway function (Fig. 5). AOX contribution was about 12.5 % and residual respiration was about 25.0 % (Fig. 5). Oxidative stress caused an increase in the contribution of the AOX pathway in oxygen uptake that was about 52.6 % and a decrease in the contribution of the cytochrome pathway of about 31.2 % (Fig. 5).

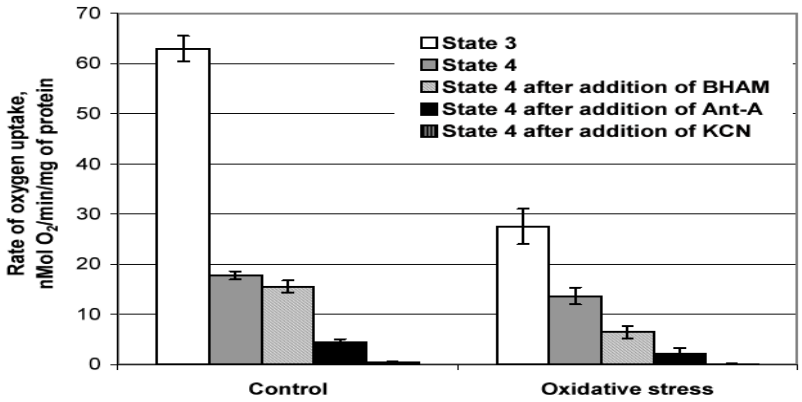

Fig. 5. The influence of the cytochrome pathway (antimycin A and KCN) and alternative pathway (BHAM) inhibitors on oxygen uptake by winter wheat mitochondria isolated from nonstressed shoots (control) and shoots exposed under oxidative stress. The oxidation substrate is 10 mM malate in the presence of 10 mM glutamate. *n*=3–6.

Succinate-oxidizing winter wheat mitochondria showed a similar picture. We found that the main part (85.6 %) of mitochondrial oxygen uptake in nonstressed mitochondria depends on the cytochrome pathway function (Fig. 6). Oxidative stress caused the increase of contribution of AOX pathway in oxygen uptake of about 41.2 %, and the decrease in the contribution of the cytochrome pathway of about 42.0 % (Fig. 6). Residual respiration was about 14.9 %.

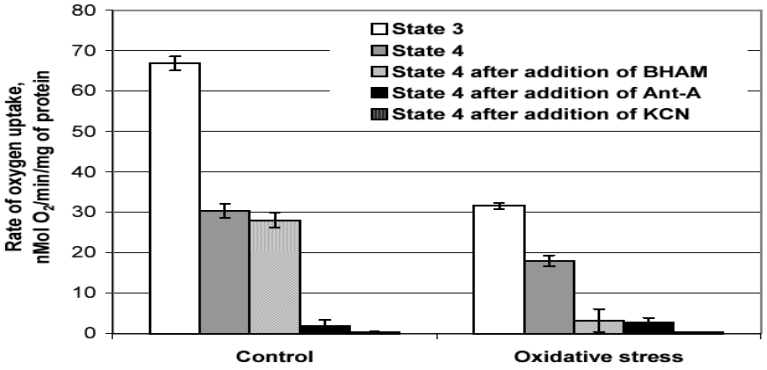

Fig. 6. The influence of the cytochrome pathway (antimycin A and KCN) and alternative pathway (BHAM) inhibitors on oxygen uptake by winter wheat mitochondria isolated from nonstressed shoots (control) and shoots exposed under oxidative stress. The oxidation substrate is 8 mM succinate in the presence of 5 mM glutamate. *n*=3–6.

Oxidative stress induced by H_2O_2 causes a decrease in the coupling degree of oxidative phosphorylation in winter wheat mitochondria and the increase of alternative oxidase activity. From this data on alternative oxidase activation in winter wheat mitochondria under oxidative stress conditions and previous data obtained about the significant increase of AOX contribution to total respiration of winter wheat mitochondria under cold shock and cold hardening (Grabelnych et al. 2004), we identify the protective role of this protein in stress conditions.

Acknowledgments. The work has been performed, in part, with the support of the Russian Science Support Foundation, Russian Foundation of Basic Research (project 05-04-97231) and Siberian Division of Russian Academy of Sciences Youth Grant (project 115).

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Defensins of Triticum kiharae and other wheat species.

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Fungal and bacterial diseases cause severe crop damage and present an ongoing challenge for farmers. Breeding crops resistant to multiple infections by conventional methods has serious limitations. Introduction of antimicrobial peptides via genetic transformation of plants offers a strategy for production of resistant crops. Several antimicrobial peptides expressed in plants demonstrated enhanced resistance to pathogens (Allan et al. 2004).

Defensins are small cationic peptides implicated in the first-line host defense against pathogens. Their spatial structure is similar in different species including animals and plants and involves Cys-stabilized α/β-motif. Despite striking similarity in tertiary structures, their amino-acid sequences are highly variable except for eight cysteine residues that are conserved (Thomma et al. 2002). Variation in primary structure may account for different biological functions reported for defensins. They were found to exert antifungal (Terras et al. 1995), antibacterial (Segura et al. 1998), and inhibitory activities against α-amylases (Bloch and Richardson 1991) and proteinases (Wijaya et al. 2000). Increasing evidence indicates that the activities of defensins within a given species may be different. Of two defensins isolated from *Medicago truncatula*, MsDef1 strongly inhibited the growth of *F. graminearum in vitro*, whereas MsDef2, which shares a 65 % amino-acid sequence homology with MsDef1, was inactive against *F. graminearum* (Spelbrink et al. 2004). Similar results were obtained earlier with *Raphanus sativus* defensins (De Samblanx et al. 1997). Unlike the mammalian defensins, antifungal plant defensins cause membrane permeability through specific interaction with high-affinity binding sites on fungal cells (Thevissen et al. 2000) but do not form ion-permeable pores in artificial lipid

bilayers. Defensins likely may act through different mechanisms. Defensins from *Zea mays* inhibited sodium currents in a rat tumor cell line but showed no antifungal activity (Kushmerick et al, 1998). A plant defensin, MsDef1, selectively blocked the mammalian L-type Ca^{+2} channel, however, two structurally similar defensins, MsDef2 and Rs-AFP2 from *Raphanus sativus*, did not block the L-type Ca^{+2} channel (Spelbrink et al. 2004).

Our previous studies showed that *T. kiharae*, a synthetic allopolyploid produced by crossing *T. timopheevii* subsp. *timopheevii* with *Ae. tauschii* and is highly resistant to most fungal pathogens, is a good source of antimicrobial peptides and a promising model for studying their properties and role in plant defense. Earlier we identified seven families of antimicrobial peptides in the seeds of this species. Here, we focus our attention on defensins and compared their structure and complexity with defensins from other *Triticum* species.

Material and methods. Seeds of several wheat species were used in this study: *T. kiharae*, *T. turgidum* subsp. *timopheevii*, *T. militinae*, and *T. aestivum* subsp. *aestivum* cultivars Khahasskaya and Rodina). Wheat flour was defatted with petroleum ether (1:10) and extracted with an acid solution (1 M HCl and 5 % HCOOH) for 1 h at room temperature and desalted on a Aquapore RP300 column. Freeze-dried acidic extract was subjected to chromatography on Heparin Sepharose. Proteins and peptides were eluted with a stepwise NaCl gradient. The 100-mM NaCl fraction was collected, desalted as described above and separated on a Superdex Peptide HR 10/30 column (Amersham, Pharmacia, Biotech, Uppsala, Sweden). Proteins and peptides were eluted with 0.05% TFA, containing 5 % acetonitrile at a flow rate of 250 l/min and monitored by absorbance at 214 nm. The peptide fraction was further separated by RP-HPLC on a Vydac C18 column (4.6 x 250 mm, particle size 5 m) with a linear acetonitrile gradient (10–50 %) for 1 h at a flow rate of 1 ml/min and 40°C. Peptides were detected at 214 nm. Mass spectra were acquired on a model Reflex III mass spectrometer (Bruker Daltonics, Bremen, Germany). N-terminal amino acid sequences were determined by automated Edman degradation on a model 492 Procise sequencer (Applied Biosystems) according to the manufacturer's protocol.

Results and discussion. From *T. kiharae* seeds, six defensins were isolated from the 100-mM fraction. Their N-terminal amino acid sequences were as follows:

D1: RTCQSQSHKFKGAC
D2: RTCESQSHKFKGPCF
D3: RDCKSDSHKF
D4: RDCTSQSHKFVG
D5: RECRSESKKF
D6: RDCRSQSKTFVG

Sequence comparison showed that the purified peptides were highly homologous and represented a family of closely related peptides differing in point amino acid substitutions. The molecular masses of defensins determined by mass spectrometry were 5,735, 5,691, 4,970, 4,980, 5,150, and 5,089 Da for D1 to D6, respectively. The total yield of these peptides estimated from the results of sequencing averaged approximately from 0.2 to 2.4 g/g of dry seed and comprised 0.07 % of the total protein. We determined the number of cysteine residues in defensins by estimating mass difference between alkylated and nonalkylated proteins because their position and number is a characteristic feature of this class of antimicrobial peptides. The results obtained for all peptides were similar indicating the presence of eight cysteine residues.

The RP-HPLC separation of defensins from other species produced very similar chromatographic profiles, suggesting that homologous peptides occur in all species studied. However mass determination and N-terminal sequencing were used to confirm this suggestion. The results obtained showed that D1–D6 defensins were present n all species studied. For example in the *T. aestivum* subsp. *aestivum* cultivar. Khakasskaya, the molecular masses of the defensin-like peptides were 5,736, 5,692, 4,971, 4,981, 5,151, and 5,090, which is the same as we obtained for *T. kiharae*, indicating the presence of identical peptides. Mass data were confirmed by N-terminal sequencing.

Homologous peptides were isolated from other wheat species, however, the amount of individual peptides varied in different species indicating that their expression level in seeds may be different. Variation in expression level may account for differences in the resistance level and/or specificity of reaction to the pathogen attack. Our results show that defensin complement in wheat species (*T. timopheevii* subsp. *timopheevii*, *T. militinae*, and *T. aestivum* subsp. *aestivum*) of different genomic composition (A^bG, for *T. timopheevii* subsp. *timopheevii* and *T. militinae*, A^bGD for *T. kiharae*, and A^uBD for *T. aestivum* subsp. *aestivum*) is similar, therefore, the genes encoding D1–D6 defensins were already present in tetraploid wheat and were preserved in the evolution during the formation of hexaploid species.

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Triticale breeding.

A new stem rust pathotype appeared that is virulent on the recently released cultivar Tobie, and a new leaf rust pathotype, first seen in 2004, also has increased in frequency and caused particularly high infections in Bacchus. To counter this, we initiated a search for, and a crossing program with, further effective resistance genes. Results of the 2005 trials have shown that Tobie was the commercial cultivar with the best grain yield and hectoliter mass.

Wheat recurrent mass selection.

A commercial-scale, recurrent selection program is being conducted. Female plants (*Ms3ms3*) destined for crosses are selected as F_1 seedlings, however, male parents are field tested and are not used in crosses until the $F_{7.}$ Approximately 10 500 F_1 from the 2004 crossing block were tested for seedling resistance to an inoculum mix of eight leaf rust and six stem rust pathotypes. About 2,800 (50 % female and 50 % male) resistant plants were planted for crosses and single seed descent (SSD) and about 60,000 potentially different F_1 seeds were produced. At the same time SSD inbreeding was initiated with seedling stem and leaf rust resistant F_1 male plants. Following a sedimentation test, 500+ F_4 SSD families (2003 crossing block) were derived and field planted for single plant selection. A total of 1692 F_6 lines (2002 crossing block) were evaluated for agrotype, field disease resistance, and mixograph. The entire population was also screened (molecular marker) for presence of *Sr24*/*Lr24*. An additional 146 junior selections, 45 senior, and 16 elite trial

entries were evaluated. To continue to enrich the base population with resistance genes, the development of two groups of material was continued. (i) Marker-assisted recurrent backcrosses targeting *Lr19*-149 and the *Sr31*/*Lr26*/*Yr9*/*Pm8* complex (without the sticky dough characteristic) were initiated. (ii) Various other genes in diverse genetic backgrounds were backcrossed into adapted backgrounds in order to evaluate them for introduction into the base population.

Genetic studies.

(a) Transfers of leaf rust and stripe rust resistance genes *Lr53*/*Yr35* (6BS; from *T. turgidum* subsp. *dicoccoides*), *Lr54*/*Yr37* (2DL; from *Ae. kotschyi*) and *Lr56*/*Yr38* (6A; from *Ae. sharonensis*) have been completed. The genes were distributed to local breeders and were entered into the South African, United States and Australian wheat germ plasm collections. (b) A gene with temporary designation *LrS15* (from *Ae. peregrina*) appears to be located on 1AL, however, its location needs to be confirmed with microsatellites. (c) A leaf rust resistance gene from *Ae. neglecta* (temporary designation *LrS20*) has apparently been transferred to chromosome 3A of wheat. Genetic studies, RFLP and microsatellite analyses are being done in order to further characterize the resistance. (d) Attempts to transfer leaf and stripe rust resistance genes from a *Ae. biuncialis* group-3 addition chromosome produced a putative translocation that is being characterized.

Chromosomes $2J_1^d$, $3J_1^d$, $4J_1^d$, $5J_1^d$ and $7J_1^d/7J_2^d$ of the indigenous grass, *Th. distichum*, appear to contribute to salt tolerance in this species. Disomic additions of chromosomes $3J_1^d$, $5J_1^d$ and $7J_2^d$ and monosomic additions of $2J_1^d$ and $4J_1^d$ have been obtained. Using the addition stocks, RAPD fragments specific for each (except $7J_1^d$) have been recovered and are being converted into SCAR markers. Testcross progenies from an attempt to induce translocations between $3J_1^d$ and corresponding triticale homoeologues are being screened for translocations making use of the newly developed markers.

Publications.

Marais GF, Pretorius ZA, Wellings CR, McCallum B, and Marais AS. 2005. Leaf rust and stripe rust resistance transferred to common wheat from *Triticum dicoccoides*. Euphytica 143:115-123.

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Characterization of resistance to cereal cyst nematode (Heterodera avenae) in Triticum aestivum/ Aegilops introgression lines.

The gene *Cre2* that confers resistance to the cereal cyst nematode *H. avenae* has been transferred from *Ae. ventricosa* to the *T. aestivum* subsp. *aestivum* introgression line H-93-8. We combined different strategies to characterize peroxidase expression in different tissues and times of lines, H-93-8 and H-10-15 (susceptible parent) in presence or absence of the nematode. Northern analysis using peroxidase-specific probes showed that root tissue taken from line H-93-8, at the nematode feeding site, seven days after infection, contained significantly more peroxidase transcripts than any other tissue sample. We cloned and sequenced RT-PCR products using primers based on conserved sequences among wheat peroxidases. Some of the resulting transcripts have homology with *pox2*, a gene preferentially expressed in roots in response to different stresses. Some of these transcripts could be specific of the nematode feeding site in the root. All these rapid changes in PER activity might be associated to defence mechanisms. A similar study is being carried out with line TR-3531, which carries the *Cre*7 gene transferred from *Ae. triuncialis*. The *Cre2* and *Cre*7 genes have been introgressed into commercial wheat cultivars with high yield and/or good quality. To assist the selection of resistance conferred by *Cre* genes we are currently searching markers based on LRR sequences, which are a common motif on resistance genes in plants. In parallel, we are investigating relationships between mobile elements and resistance genes in wheat.

Material and methods. The resistant line H-93-8, carrying the *Cre*2 gene, was obtained from the cross '*T. turgidum* cv. Rubroatrum, H-1-1/*Ae. ventricosa* AP-1//*T. aestivum* cv. Almatense H-10-15' (Delibes et al. 1993). The resistant line TR-3531, carrying the *Cre*7 gene, was derived from the same bridge and recipient *Triticum* species, but using *Ae. triuncialis* as donor species (Romero et al. 1998). Seedlings of H-93-8, cultivated in the laboratory under controlled conditions, were inoculated with the Spanish pathotype Ha71 of *H. avenae* (100 individuals J2/plant). Susceptible parent H-10-15 and uninfected H- 93-8 were used as controls. Root sections and leaves taken four, seven and fifteen days after infection were excised and used for analysis of mRNA. Peroxidase expression was analyzed by Northern using a peroxidase specific probe (Båga et al. 1995). Obtaining of cDNAs and cloning of RT-PCR peroxidase products were carried out as described by suppliers of reverse transcriptase (Amersham Pharmacia Biotech) and of pGEM-T Easy cloning vector (Promega), respectively. Sequencing was performed on Applied Biosystem ABIPRISM 3100 sequencer and the sequences analysis was done using BLAST and CLUSTALW. Markers for *Cre2* were searched using a PCR

approach that combine in a single reaction a primer annealing regions typically conserved in plant resistance genes (Yu et al. 1996), and a primer complementary to conserved motifs within mobile elements naturally present in monocots and characterized by a high copy number and preferential insertion to gene-rich regions (Moreno-Vázquez et al. 2005; Sabot et al. 2004). The search was based on a $F_{2:3}$ population generated from the cross H-93-8 x H-10-15.

Resistance genes *Cre2* and/or *Cre*7 were incorporated into the genetic background of commercial cultivars with suitable agronomic traits by backcrossing. Commercial wheat cultivars, Anza, Rinconada, Cartaya, Betres, Recital, Alcotán, and Osona, were used as recurrent parents, whereas H-93-8 and TR-3531 were the donor lines for *Cre*2 and *Cre*7, respectively. Isoelectrofocusing patterns from advanced lines were obtained as described in Andrés et al. 2001.

Results and conclusions. The introgression line H-93-8 showed increased mRNA peroxidase levels on roots at the nematode feeding site in response to *H. avenae* infection, reaching a maximum 7 days postinoculation. Consistent results were obtained analyzing peroxidase activity by spectrophotometry and IEF (Andres et al. 2001; Delibes et al. 2004). No significant rise in the peroxidase levels was observed in leaves in any case. 3'mRNA sequences for leaf and root peroxidases from both infected and uninfected H-93-8 plants were obtained by RT-PCR. Cluster analysis separated in two clear-cut groups leaf and root sequences. The group containing root sequences exhibited higher variability and some of them shown less homology to wheat peroxidases from the Genebank than the group containing leaf sequences. We are currently investigating if these root peroxidases could have been introgressed from *Aegilops ventricosa* in H -93-8 and if some of them could be nematode-induced. The results obtained with TR-3531 line are still preliminary.

A PCR marker for *Cre*2 has been found. For the generation of this marker a primer annealing the LTR region of a typical monocot retro-element and a primer annealing the NBS region of published NBS-LRR disease-resistance genes in monocots, were combined in the same PCR. We are currently evaluating the performance of this marker in different segregating populations and breeding lines.

Advanced bread wheat lines carrying *Cre2* and/or *Cre*7 resistance genes, evaluated under field conditions, showed tolerance as well as a lower number of cysts than their susceptible controls. Evaluation of grain yield over 2 years of field testing across four locations in Spain, showed a good performance for our advanced lines compared to commercial wheat varieties (Table 1). Peroxidase patterns of these advanced lines obtained by IEF, revealed an early response in infected roots, indicative of the presence of *Cre*2 (in ID-2150) and *Cre*7 (in ID-2181 and T-2003).

Table 1. Average cultivar grain yield of advanced bread wheat lines tolerant to *Heterodera avenae* over two years (cycles 2003–04 and 2004–05) of field testing across four locations (localities): Foradada and Gimenells (Lerida) and two in La Poveda (Madrid). Average score values for *H. avenae* from infested field in La Poveda, Spain.

Advanced line (resistance gene)	*H. avenae* (cysts/g root)	2003–04 yield (kg/ha)	2004–05 yield (kg/ha)
ID-2150 (*Cre*2)	28	6,155	3,241
ID-2181 (*Cre* 7)	14	6,408	3,506
T-2003 (*Cre* 7)	29	6,445	3,605
Recital (susceptible control)	53	4,679	2,638
Anza (susceptible control)	49	5,591	3,347

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ITEMS FROM SWEDEN

THE NORDIC GENE BANK
P.O. Box 41, SE230 53, Alnarp, Sweden.

The diversity in Nordic wheat material.

Agnese Kolodinska Brantestam, Louise Bondo, Oscar Diaz, and Bent Skovmand.

During more than 25 years of existence, the Nordic Gene Bank (NGB) has collected various plant material including more that 1500 *Triticum* sp. accessions, representing 18 species.

At the NGB, we have evaluated wheat accessions for morphology, agronomic performance, quality components and resistance to biotic and abiotic stresses. Projects characterizing Nordic spring and winter wheat can be found on the webpage of the Nordic gene bank (http://www.nordgen.org/ngb/) as follows:

Spring wheat — susceptibility to diseases (*Erysiphe graminis, Puccinia recondite*, *Puccinia striiformis*, *Septoria nodorum*)
— morphology (awenednes, ear density, ear emergence, growing time, lodging, plant growth habit, lower glume hair, plant height)
Winter wheat — cold resistance (winter survival)

Triticum sp. material stored at the NGB includes cultivated wheat from the Nordic countries starting from the early breeding period at the end of the 19th and the beginning of 20th centuries and landraces up to recent cultivars from 1990s (http://www.nordgen.org/ngb/).

Currently, we carry out a project aiming at reviewing published diversity information on Nordic wheat and other cereals in order to estimate the breeding impact on diversity of these crops. This project indicates that Nordic wheat has significantly changed during more than a century of breeding. Relative genetic gains for agronomic characteristics, e.g., yield and reduced plant height, were obtained in Nordic wheat germ plasm (Ortiz et al. 1998, 2003). There are also changes in race specific disease resistance genes of Nordic wheat. The variability in bread making quality characteristics has increased compared to material from the middle of the 20th century (Uhlen 1990; Johansson et al. 1993). However, much of the disease resistance and quality data are still missing on older material to make a comparison if genetic diversity has decreased or not. New genes for quality traits and disease resistance from foreign cereal material have been introduced in modern wheat. However, loss of certain alleles and qualities also were detected, emphasizing that conservation of Nordic landraces and old cultivars is important as they can form valuable sources of genetic diversity for future breeding.

According to molecular data no significant decrease of diversity is present in Nordic wheat (Christiansen et al. 2002). Though temporal fluctuations were found that indicates that monitoring diversity changes in the Nordic material is important in order to improve breeding strategies and to maintain successful cereal cultivation in the future.

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ITEMS FROM THE UKRAINE

INSTITUTE OF PLANT PRODUCTION N.A. V.YA. YURJEV
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New winter cultivars of the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of the Ukrainian Academy of agrarian Sciences.

Svitlana V. Rabinovych and Oleg Yu. Leonov.

Bahira. Developed by the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and the Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2005. Bred by V.V. Shelepov, V.M. Remeslo, V.I. Dubovyi, L.M. Holik, G.S. Basanets', L.P. Bershads'ka, S.M. Marynka, V.V. Kyrylenko, S.O. Khomenko (MIW), V.V. Morhun, and V.F. Logvynenko (IPPG).

This cultivar was created by multiple individual selection from a plant population obtained by transformation of the spring wheat Sunnan (Sweden) into a winter type. Economic and biological characteristics include high yield capacity in competitive trials at the MIW, 5.9 t/ha, which is 0.46 higher than that of the standard Myronivs'ka 61 and in 2005 at the Volyn'skiy Experimental Point, Bahira yielded 9.8 t/ha; a medium ripening time; high resistance to lodging (9 score); high winter hardiness (9); resistance to drought and shattering (9); resistance to powdery mildew (score of 7), leaf rust (5), Septoria (5), and root rot (6). The grain volume weight is 750–790 g/l, grain protein content 13.8 %, raw gluten 25–28 %, and bread volume 690–800 cm^3. Bahira is a lutescens variety with a medium plant height (85–100 cm), red grain, and 1,000-kernel weight of 40 g.

Vdyachna. Developed by the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2005. Bred by V.V. Shelepov, L.P. Bershads'ka, G.S. Basanets', S.M. Marynka, V.M. Remeslo, L.M. Holik, V.T. Koluchiy (MIW), V.V. Morhun, and V.F. Logvynenko (IPPG).

This cultivar was created by group selection from the line Erythrospermum 13908, which was obtained by means of transformation of growth habit of line BT-2288 (Tunisia) into a winter type. In competitive trials at the MIW (2002–04), Vdyancha yielded 7.5 t/ha, equal to that of Myronivs'ka 65. Vdyacnha is very early maturing; resistant to drought and shattering; resistant to powdery mildew (score 6), leaf rust (6), and Septoria (5). The grain volume weight is 840 g/l, grain protein content 14.4 %, gluten content 36.2 %, and bread volume 820 cm^3. Vdyachna is a strong wheat of the erythrospermum variety. Plant height is 85–100 cm, grain is oval and very large. The 1,000-kernel weight is 52 g.

Voloshkova. Developed by the Myronivs'kiy Institute of Wheat n.a. V.M.Remeslo of UAAS and Institute of Plant Physiology and Genetics of Ukrainian NAS. In State Cultivar Trial since 2004. Breeders included V.V. Shelepov, V.M. Remeslo, V.I. Dubovyi, L.M. Holik, L.P. Bershads'ka, V.V. Kyrylenko, S.M. Marynka, S.O. Khomenko (MIW), V.V. Morhun, and V.F. Logvynenko (IPPG).

This cultivar was created by multiply individual selection from a plant population obtained by transformation of the spring wheat cultivar Elambard (France) into a winter type. Voloshkova has a high yield capacity in competitive trials (2000–02) 6.4 t/ha, which is higher than that of the standard cultivar Myronivs'ka 61 by 0.6 t/ha. In 2005 at the Volyn'skiy Experimental Point, Voloshkova yielded 8.9 t/ha. This cultivar is medium maturing, with high resistance to lodging (9 score); high winter hardiness (9); and highly resistant to seed fall (9), drought (8-9), powdery mildew (7), leaf rust, and Septoria (5). Grain protein content is 13.4 %, raw gluten 25–27 %, flour strength 224 alveograph units, and bread volume 650–720 cm^3. Voloshkova is a lutescens variety with medium plant height (83–110 cm), red grain, and a 1,000-kernel weight of 42.8 g.

Harazivka. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M.Remeslo of UAAS. In State Cultivar Trial since 2003. Bred by V.I. Dubovyi, R.V. Yaremenko, and T.Ya. Hayvorons'ka.

Harazivka was created by selection frost-resistant plants of Lutescens 26769 (in the pedigree of the cultivar Illichivka) under conditions of frost exposure. With a high yield capacity between 7.3–7.9 t/ha, Harazivka is a medium maturing (vegetative period 290–302 days) and highly frost resistance under artificial frost exposure (9 score). Harazivka also is highly resistance to lodging (9 score), seed fall (9), drought (8–9), powdery mildew (7), leaf rust, and Septoria (6). Milling and bread making qualities of the cultivar are high. Gluten content is 25.7 % (1st group), flour strength is 224 alveograph units, and bread volume is 710 cm^3. Harazivka is of the valuable wheat quality class, a lutescens variety, has a 1,000-kernel weight of 42–46 g.

Dubynka. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS. In State Cultivar Trial since 2003. The breeding team was V.I. Dubovyi, R.V. Yaremenko, and T.Ya.Hayvorons'ka.

Dubynka was created by exposure to frost and selection of frost-resistant plants from the line Erythrospermum 26146 (pedigree: Napivkarlyk 3 (Kharkiv) / Myronivs'ka 27 (Myronivka)). This cultivar has a high yield capacity (7.0–8.0 t/ha), a guaranteed yield increase 0.6–1.8 t/ha. Dubynka is medium-late maturing (vegetative period 294–306 days) with high winter hardiness (score of 9); and highly resistant to lodging (8), seed fall (9), drought (8–9); and powdery mildew, leaf rust, and Septoria (scores of 6). Milling and bread making qualities of the cultivar are good, grain protein content is 14.0 %, gluten content 25.0–28.6 % (1st group), flour strength 211–278 alveograph units, and a bread volume 780–860 cm^3. Dubynka belongs to the valuable wheat quality class, is of the erythrospermum variety, and has a 1,000-kernel weight of 44–48 g.

Dashen'ka. Developed by the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and the Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2004. Bred by O.L. Dergachov, N.P. Zamlila, G.B. Vologdina, O.M. Cheremkha, A.A. Shevchenko (MIW), V.V. Morhun, and V.F. Logvynenko (IPPG).

The cultivar Dashen'ka was created by intraspecific hybridization with the pedigree 'Myronivs'ka 27 (Ukraine) / SMH 583 (Poland) // Myronivs'ka 62 (Ukraine)' followed by individual selection. Dasen'ka high yielding; producing 5.6 t/ha between 1998–02 (Myronivs'ka 61 check was 5.2 t/ha). The highest yield obtained was 9.1 t/ha in 1998. The cultivar is of the intensive type and medium maturity, heading simultaneously with Myronivs'ka 61. Dashen'ka is resistant to lodging and preharvest sprouting, is as winter hardy as Myronivs'ka 61, resistant to drought, powdery mildew and leaf rust (scored 5), and Septoria (score of 6). Grain quality strength of flour is 227 alveograph units, bread volume from 100 g of flour is 732 cm^3, and total bread value is 4.2. Myronivs'ka is of the valuable wheat quality class, belongs to the variety lutescens, and has a 1,000-kernel weight of 38–42 g.

Ekonomika. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and the Institute of Plant Protection of UAAS (IPP). In State Cultivar Trial since 2005. The breeding team included V.V. Kyrylenko V.V. Shelepov, V.I. Dubovyi, L.A. Kolomyyets, V.A. Vlasenko, L.V. Dubyna L.P. Bershads'ka, G.S. Basanets', G.M. Kovalyshyna, V.T. Kolyuchyi, G.P. Marusych (MIW), M.P. Lisovyi, Z.M. Dovhal', and M.P. Sokolovs'ka (IPP).

Ekonomika was created by individual selection from a group resistant to diseases with the use of complex infection backgrounds for the most important pathogens of winter wheat in the F_3 of hybrid combination 'P.r. 12/96 / Lutescens 24446'. Ekonomika has a high yield capacity. In competitive trials at MIW, Ekonomika yielded 8.1 t/ha, which is 0.5 higher than that of the Myronivs'ka 65 check. Ekonomika is a medium- early ripening and has high winter hardiness. Resistant to preharvest sprouting, Ekonomika also is resistant to disease, including powdery mildew (8), leaf rust (7–8ſ, Septoria leaf blotch (6), Cercosporella (6), and Fusarium head blight (6). Grain volume is 786 g/l, grain protein content is 13.5 %, raw gluten is 27 %, and bread volume is 840 cm^3. Ekonomika is a valuable wheat of the lutescens variety with a plant height of 100 cm and 1,000-kernel weight of 40–45 g.

Kalynova. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and the Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2005. Bred by the team of V.A. Vlasenko, V.V. Shelepov, S.M. Marynka, S.O. Khomenko, L.A. Kolomyyets, G.S. Basanets' (MIW), V.V. Morhun, V.F. Logvynenko, and I.P. Artemchuk (IPPG).

Kalynova was created by individual selection of spikes in the F_4M_4 and an elite plant in the F_5M_5 progeny of the hybrid-mutant combination 'Kyivs'ka 7 / Albatros odes'kyi + Diazoacetilbutan 0.1 %). Kalynova is high yielding, producing 8.2 t/ha in competitive trials at MIW, which is 0.6 higher than the Myronivs'ka 65 check. A medium maturity wheat, the cultivar has high winter hardiness (score of 9). Kalynova has resistance to powdery mildew (7), leaf rust (6), and Septoria (6). With a grain volume weight of 822 g/l, a grain protein content of 13.4 %, raw gluten of 29.6 %, and a

bread volume of 860 cm^3, Kalynova belongs in the valuable wheat quality class. Kalynova is of the lutescens variety and has a plant height of 107 cm and a 1,000-kernel weight of 42.6 g.

Kolos Myronivshchyny. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and the Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2005. Breeders include L.A. Kolomyyets, V.I. Dubovyi, V.V. Shelepov, V.V. Kyrylenko, V.A. Vlasenko, G.S. Basanets', L.P. Bershads'ka, V.T. Kolyuchyi, V.I. Ishchenko (MIW), V.V. Morhun, and V.F. Logvynenko, (IPPG).

This cultivar was selected from an elite plant in the F_3 of the hybrid-mutant combination 'Donyets'ka 39 / Erythrospermum 26561'. Kolos Myronivshchyny has a high yield capacity, yielding 7.5 t/ha in 2002–05 in competitive trials at the MIW, which is 0.5 higher than the check cultivar. Medium maturing, the cultivar has high winter hardiness scores (8–9) and is resistant to drought and shattering. The cultivar is susceptible to powdery mildew (10 %), leaf rust (15 %), and Septoria (10 %). Kolos Myronivshchyny has a grain volume weight of 800 g/l, a grain protein content of 13.8 %, raw gluten of 28–34 %, a bread volume of 770 cm^3, belongs to the lutescens variety, has a plant height of 105 cm, and a 1,000-kernel weight of 41 g.

Mytets'. Released by the Myronivs'kiy Institute of Wheat n.a. V.M.Remeslo of UAAS. In State Cultivar Trial since 2005. Breeders are M.P. Chebakov, G.D. Lebedeva, N.P. Zamlila, G.B. Vologdina, O.M. Cheremkha, L.O. Turchenyuk, and L.O. Zhyvotkov.

The cultivar is created by the way of intraspecies hybridization with following individual chose from hybrid combination Inna / Mercia // Fedorivka. The yield capacity of Mytets' in competitive trials at the MIW in 2004 was 0.9 t/ha. Winter hardiness is higher than average. Plant height is medium. The cultivar is of an intensive type. With medium maturity (vegetative period of 274 days), Mytets' is resistant to lodging and shattering. Disease resistance in this cultivar is 10 % to powdery mildew, 15 % to leaf rust, 8 % to Fusarium head blight, and 15 % to Septoria. Raw gluten content is 25.5 %, flour strength is 310 alveograph units, bread volume is 670 cm^3, and grain vitrosity is 95 %. Mytets' belongs to the valuable wheat quality class and is of the variety lutescens. Plant height is 92–108 cm. The 1,000-kernel weight is 42.0 g. Mytets' has very good response to mineral fertilization.

Mad'arka (Syn. Maritsa). Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2005. Bred by M.P. Chebakov, G.D. Lebedeva, N.P. Zamlila, G.B. Vologdina, O.M. Cheremkha, V.V. Sorokin, V.T. Kolyuchyi (MIW), V.V. Morhun, V.F. Logvynenko, and I.P. Artemchuk (IPPG).

This cultivar was created by mass selection from the winter wheat line F_5 (MV-213-98). Yield in competitive trial at the MIW was 8.7 t/ha (2004). Winter hardiness is above average. The cultivar is of the intensive type. A medium maturing cultivar, the vegetative period is 276 days. Mad'arka is highly resistant to lodging and shattering. Disease resistance on infection were 8 % to powdery mildew, 10 % to leaf rust, 7 % to Fusarium head blight, and 10 % to Septoria. Raw gluten content is 29.5%, flour strength is alveograph units, bread volume is 650 cm^3, and grain vitrosity is 95 %. Mad'arka is a valuable wheat for quality class and of the variety lutescens. Plant height is 120 cm, and the 1,000-kernel weight is 44 g. The cultivar has very good response to mineral fertilization.

Monolog. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW). In State Cultivar Trial since 2005. The breeding team was M.P. Chebakov, G.D. Lebedeva, N.P. Zamlila, G.B. Vologdina, O.M. Cheremkha, V.V. Sorokin, H.M. Kovalyshyna, and L.P. Mel'nikova.

Monolog was created by intraspecific hybridization with an individual chosen from the hybrid combination 'TAM 200 / Myronivs'ka 29'. Yield in a competitive trial at the MIW was 8.0 t/ha in 2004. Winter hardiness is above average. Monology is an intensive cultivar with medium maturity, a vegetative period of 272 days, resistant to lodging and shattering. When exposed to disease pressure, Monolog was infected 5 % by powdery mildew, 5 % by leaf rust, 7 % by Fusarium head blight, and 10 % by Septoria. Raw gluten content is 29.5%, flour strength is 340 alveograph units, bread volume is 760 cm^3, and grain vitrosity is 95 %. Monology is of the valuable quality class. The variety is erythrospermum. Plant height is 90–110 cm and 1,000-kernel weight is 40.8 g. Monology has very good response to mineral fertilization.

Monotyp. Developed at the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW) and Institute of Plant Physiology and Genetics of Ukrainian NAS (IPPG). In State Cultivar Trial since 2005. The breeding team included M.P. Chebakov, G.D. Lebedeva, N.P. Zamlila, G.B. Vologdina, H.M. Kovalyshyna (MIW), V.V. Morhun, V.F. Logvynenko, and I.P. Artemchuk (IPPG).

This cultivar was created by intraspecific hybridization with one individual chosen from the hybrid combination 'Lutescens 9950 / CIMMYT 15 // Erythrospermum 10071'. Yield in a competitive trial at the MIW was 8.7 t/ha in 2004. Winter hardiness is greater than average. The cultivar is of the intensive type. Monotyp is a medium maturing wheat with a vegetative period of 272 days. Monotyp is resistant to lodging and shattering. Under disease pressure, Monotyp has 10 % infection by powdery mildew, 1 % by leaf rust, 8 % by Fusarium head blight, and 12 % by Septoria. Raw gluten content is 29.0 %, flour strength is 240 alveograph units, bread volume is 720 cm^3, and grain vitrosity is 95 %. Monotyp is of the valuable quality class and the variety erythrospermum. Plant height is 75–85 cm and 1,000-kernel weight is 40.2 g. Monotyp has very good response to mineral fertilization.

Modus (Syn. Mykolayivka). Developed by the Myronivs'kiy Institute of Wheat n.a. V.M. Remeslo of UAAS (MIW). In State Cultivar Trial since 2005. Bred by M.P. Chebakov, G.D. Lebedeva, N.P. Zamlila, G.B. Vologdina, O.M. Cheremkha, H.M. Kovalyshyna, and L.O. Zhyvotkov.

Modus was created by intraspecific hybridization and an individual was chosen from the hybrid combination 'H.18264 / H.27556-78 // Adriano'. Yield in competitive trial at the MIW was 8.6 t/ha in 2004. Modus has above average winter hardiness and is an intensive type cultivar. Of medium maturity, the vegetative period is 274 days. Modus is highly resistant to lodging and shattering. Modus is infected 12 % with powdery mildew, 5 % with leaf rust, 10 % with Fusarium head blight, and 5 % with Septoria. Raw gluten content is 28.5%, flour strength is 220 alveograph units, bread volume is 640 cm^3, and grain vitrosity is 95%. Modus is of the valuable quality class and the lutescens variety. Plant height is between 85–100 cm and 1,000-kernel weight is 40.7 g.

Inheritance in the F_1 of disease resistance form wheats having wild and cultivated relatives in their pedigrees.

V.P. Petrenkova, S.V. Rabinovych, I.M. Chernyaeva, and L.M. Chernobay.

In order to study the inheritance of disease resistance, some lines and cultivars of winter wheat with resistance to head smut and leaf spot were crossed. The lines included Erythrospermum 24220, Tyler, CO 890323, CO 900134, CO 900166, *Ae. juvenalis*/6*CHRIS//9*Selkirk, *Ae. ventricosa/T. durum*//3*Selkirk, Brigadier, and Norman. Hybrid F_1 of 80 crosses were grown in 2005. Preliminary analysis of resistance to Septoria and leaf rust were made.

In one experiment, Septoria-resistant and moderately resistant lines (Norman, Brigadier, Myronivs'ka 68, and Kharkivs'ka 105) were crossed with susceptible lines (Napivkarlyk 3, Odes'ka napivkarlykova, Turbo, and Renown). Intermediate levels of resistance were found in the F_1 hybrids of 'Myronivs'ka 68 / Napivkarlyk 3', 'Kharkivs'ka 105 / Napivkarlyk 3', and 'Kharkivs'ka 105 / Odes'ka napivkarlykova'. F^1 hybrids from crosses 'Norman / Turbo', 'Brigadier / Turbo', and ;Brigadier / Renown' had dominant resistance genes. No cytoplasmic effect was observed.

The F_1 hybrids from crosses of resistant and moderately resistant to Septoria from different ecological areas were 'Myronivs'ka 67 / Brigadier', 'Norman / Myronivs'ka 68', 'Myronivs'ka 68 / VP 655', 'Knyazhna / Myronivs'ka 68'. No hybrid was better than the parental lines.

We observed resistance to leaf rust in some of the parental forms used in the crosses as sources of resistance to head smut and leaf spot, and this was transferred to the F_1 hybrids. The F_1 of line TX71A1039 in reciprocal crosses with three susceptible wheats scored a 7 (on a 1–9 scale with 9 the most resistant). High leaf rust resistance (score of 8) also was observed in reciprocal crosses with the cultivar Brigadier.

Leaf rust resistance was fully dominate in the F_1 hybrids of Erythrospermum 24220 (score of 7) as the maternal parent with two susceptible and two moderately susceptible forms. In one cross, the inheritance was intermediate. In reciprocal crosses with Erythrospermum 24220 as male parent, no dominance was observed or the hybrids were equal in

resistance to that of the susceptible maternal form. The leaf rust-resistant wheat Myronivs'ka 68 when crossed with the susceptible cultivar Napivkarlyk 3 did not produce any resistant progeny.

The parental forms together with the hybrid F_1 and F_2 of the above crosses were sown in autumn 2005 to study the inheritance of the resistance to Septoria, leaf rust, and head smut. A series of crosses with 68 combinations also were made with 15 new sources of resistance to Septoria, leaf rust, and head smut to study their donor ability and development of perspective initial material for breeding.

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The correlation between IAA and ABA in leaves of near-isogenic Vrn gene lines of winter wheat.

V.V. Zhmurko and O.A. Avksentyeva.

Vrn genes determine the type of development (spring or winter) in wheat. In spring genotypes, *Vrn* genes define the speed of transition from vegetative to generative stages (Pugsley 1971). In our intensive investigation, molecular-genetic mechanisms were used to determine the expression of this gene in cultivars and NILs of wheat under the influence of cold temperature (vernalization) (Beales et al. 2005, Danyluk et al. 2003).

Phytohormones are one of the main physiological systems of regulation of growth and development in plants (Gaspar et al. 2003). The process by which *Vrn* genes act may be through changes phytohormone activity. The transition in photoperiod-sensitive species to different length days is under the control of the phytohormones indoleacetic acid (IAA), abscisic acid (ABA), cytokinins (CK), and gibberellic acid (GA) (Pugsley 1971). The control of growth and development of plants is determined by the interaction between the different phytohormones (Zhmurko 2001).

The purpose of our study is the interaction between IAA and ABA in leaves of *Vrn* gene NILs of soft wheat during ontogenesis. The soft wheat cultivar Mironovskaya 808, a spring type with the genotype *Vrn1Vrn1*, *Vrn2Vrn2*, and *Vrn3Vrn3*, and a winter genotype with *Vrn1Vrn1*, *Vrn2Vrn2*, and *Vrn3Vrn3*, were used. Plants were grown in the field after a spring sowing. During the vegetative phase, *Vrn* genes probably express at different times in spring genotypes because they differ in speed of transition to the flowering phase.

Table 1. Phytohormone contents in leaves of spring and winter wheat NILs (mg/g dry mass). Plants were grown in the field in the spring of 2005.

			Stage of development			
NIL	Genotype	Type	18 June	25 June	02 July	09 July
IAA						
1	*Vrn1Vrn1*	spring	24.6 ± 1.2	27.0 ± 1.3	35.0 ± 1.3	27.1 ± 1.4
2	*Vrn2Vrn2*	spring	24.2 ± 1.3	30.1 ± 1.4	28.1 ± 1.3	24.0 ± 1.4
3	*Vrn3Vrn3*	spring	29.2 ± 1.3	25.0 ± 1.4	26.0 ± 1.4	27.0 ± 1.5
0	*Vrn112233*	winter	27.0 ± 1.2	27.0 ± 1.2	28.0 ± 1.2	30.0 ± 1.2
ABA						
1	*Vrn1Vrn1*	spring	91.6 ± 3.2	82.0 ± 2.3	71.0 ± 2.3	53.1 ± 1.4
2	*Vrn2Vrn2*	spring	88.2 ± 4.3	89.1 ± 3.4	49.1 ± 1.3	71.0 ± 2.4
3	*Vrn3Vrn3*	spring	90.2 ± 4.3	82.0 ± 2.4	65.0 ± 1.4	77.0 ± 2.5
0	*Vrn112233*	winter	86.0 ± 2.2	71.0 ± 1.2	61.0 ± 1.2	77.0 ± 2.2
IAA/ABA						
1	*Vrn1Vrn1*	spring	0.27	0.33	0.49	0.51
2	*Vrn2Vrn2*	spring	0.27	0.34	0.57	0.34
3	*Vrn3Vrn3*	spring	0.32	0.32	0.40	0.41
0	*Vrn112233*	winter	0.31	0.38	0.46	0.39

Our previous research showed that the first transition to flowering in the *Vrn3Vrn3* line is over 4–5 days, lines with *Vrn1Vrn1* and *Vrn2Vrn2* flower 25–30 days later (Zhmurko et al. 2004). When sown in the spring, winter-type lines do not transition to flowering.

Phytohormones in spring-type lines with *Vrn1Vrn1*

and *Vrn2Vrn2* during the vegetative phase show IAA increases and then has a small decrease at the finish of the vegetative period (Table 1, p. 131). In *Vrn2Vrn2* lines. this change begins and ends earlier. The IAA content in *Vrn3Vrn3* lines decreases insignificantly. In the winter line *Vrn1Vrn1 Vrn2Vrn2 Vrn3Vrn3*, almost no change was observed.

The ABA content in the spring line *Vrn1Vrn1* gradually decreased during the vegetative phase. In spring lines with *Vrn2Vrn2* and *Vrn3Vrn3* and the winter lines, the ABA concentration decreases until the finish of the vegetative period, then increases. The correlation between IAA and ABA increases in spring *Vrn1Vrn1* lines during the vegetative phase. In spring lines *Vrn2Vrn2* and *Vrn3Vrn3* and the winter *Vrn1Vrn1 Vrn2Vrn2 Vrn3Vrn3*, the correlation between IAA and ABA increases gradually but then decreases at the end of the vegetative period.

Our preliminary results allow us to propose that the speed of regulation in the vegetative phase in these NILs is due to the interaction between IAA and ABA. However, this question needs a more detail investigation of the role IAA, ABA, gibberellic acid, and cytokinins in regulating the development in NILs of spring and winter type.

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ITEMS FROM UNITED KINGDOM

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A key U.K. wheat reference mapping population.

John Snape, Leodie Alibert, Robert Koebner, and Simon Orford.

Under the auspices of the U.K. Wheat Genetic Improvement Network (WGIN) (see Ann Wheat Newslett 50:192), a doubled haploid population developed from the cross 'Avalon/Cadenza' has been chosen to be the reference U.K. wheat mapping population. The aim is to offer to U.K. wheat researchers and breeders a reference map to study QTL and major genes of interest.

The 'Avalon/Cadenza' map is being developed at John Innes Centre and, to date, 203 lines have been genotyped largely with microsatellites and DArT™ markers. The current map includes 90 SSR loci, 3 HMW-glutenin genes, 202 DArT™ markers, and a small number of other markers. The ultimate aim is to develop a saturated map using all publicly available SSRs, and other marker types. In addition to SSRs, Sequence tagged microsatellite (STM) markers, which we now have primer sequences for (Hayden et al. 2006), are being added. Current linkage groups vary in length

from 70–120 cM, with a marker every 10 to 20 cM. The exceptions are in chromosomes 1D, 2A, 2D, 3D, and 6D, where the linkage groups are smaller.

The map will be soon available on the WGIN website (www.wgin.org.uk), as well as some trait data such as ear emergence, height, and yield taken over the last 2 years in the field.

Genetic biodiversity for yellow rust resistance in wheat.

Lesley Boyd, Clare Lewis, Muge Sayar, James Melichar, Luke Jagger, Hale Tufan, and Nicola Powell.

A number of programs are continuing to characterize the genes/QTL responsible for yellow rust resistance in U.K. wheat cultivars, including the U.K. cultivars Claire, Guardian, and Brigadier.

The genetic diversity studies have also expanded into an assessment of Turkish wheats (durum and bread) as part of collaboration with Prof. M. Sayar, Bogazici University, Istanbul (EU - Marie Curie Fellow) and Dr. J. Braun, CIMMYT, Ankara, Turkey. NBS-profiling is being used to characterize the genetic diversity within the wheat genome associated with NBS (R-gene) sequences. The Turkish cultivars are being compared to a selection of 30 wheat cultivars from across Europe.

Novel sources of resistance to biotrophic fungal pathogens in wheat.

James Melichar and Lesley Boyd.

A number of mutants, generated by gamma-radiation in the U.K. cultivar Guardian, were originally selected in the field for enhanced resistance to yellow rust. This enhanced resistance was shown not to express in seedlings, but to be developmentally regulated, expressing at adult plant growth stages.

In addition to the enhancement of resistance to yellow rust a number of the mutants also exhibit enhanced resistance to leaf rust and/or powdery mildew. Doubled-haploid populations have been developed for Guardian and two of the mutants. These are being used to locate both the partial yellow rust APR in Guardian, the mutations responsible for the enhancement of yellow rust resistance, and resistance to leaf rust and powdery mildew. These populations now form part of a European Union-funded program – BioExploit.

Factors affecting yellow rust infection efficiency.

Ruth MacCormack and Lesley Boyd.

A Defra-funded program examined the early stages of yellow rust infection to determine what factors optimize infection efficiency of this fungal pathogen. The preinoculation light quantity received by wheat seedlings influenced the ability of the fungal pathogen to find and enter stomata. We are now screening for genetic variation between wheat genotypes for the ability of preinoculation light quantity to effect yellow rust infection efficiency.

Nonhost resistance in wheat and rice.

Hale Tufan and Lesley Boyd.

A new program within the group started in 2005 funded by the CIGAR – Generation Challenge Program. This program – CEREAL IMMUNITY, forms a collaboration with seven research groups around the world and is lead by Dr. Pietro Piffanelli, AGROPOLIS, Montpellier, France. The program aims to use the Affymetrix wheat micro array to study gene expression in wheat in host and nonhost pathogen interactions and links in with similar studies in rice being carried out by Prof. P. Ronald, UC Davis, USA and Prof. S. Kikuchi, NIAS, Japan.

An immortal population of mutagenized spring wheat.

Simon Orford, Pauline Stephenson, and Robert Koebner.

As part of our continuing contribution to the Wheat Genetic Improvement Network (see Ann Wheat Newslet 50:192), we have further advanced an immortal population of EMS mutagenized spring wheat cultivar Paragon by single-seed descent. The initial M_1 population numbered ~3,500 individuals, from which two M_2 seeds were sown per M_1 plant. The population is currently being sown in the field as ~7,000 single-ear rows representing the M_5 generation. A number of fixed phenotypic mutants have been isolated, for example reversion from spring to winter habit, dwarfness, ear morphology, awnedness, spelt etc. From summer 2006, this field multiplied seed will be made available to collaborators for gene discovery and functional gene analysis. Interested researchers can make contact via the WGIN website (www.wgin.org.uk).

Homoeologous silencing in hexaploid wheat.

Andrew Bottley and Robert Koebner.

Using an SSCP platform, we have been analyzing patterns of transcriptional silencing (frequency, genome identity, and organ specificity) within unigene homoeologous sets, by assaying gDNA and cDNA amplicons derived from 236 such genes mapping to one of homoeologous groups 1, 2, 3, and 7 of wheat. In about 27 % of unigenes expressed in leaf and about 26 % of those in root, one (rarely two) homoeologs were not represented in the cDNA template. Organ-specific regulation is commonplace, with many homoeologs transcribed in leaf but not root (and *vice versa*). We have detected little indication of bias towards selective silencing of a particular genome copy. Surprisingly, the expression of some of these non-transcribed homoeologs was restored in certain aneuploid lines and varieties. A simple repressor mechanism could explain about one-third of these cases, but for the remaining two-thirds, an epigenetic mechanism of silencing is suspected. We suggest that this form of genetic variation may be a significant player in the determination of phenotypic diversity in breeding populations.

Molecular outcomes of mutagenesis in wheat.

Nicola Hart and Robert Koebner.

As research into crop improvement continues to yield the DNA sequences of agronomically important genes, the opportunity to study the outcome of mutagenesis at the DNA level is becoming available. We are investigating the size, nature and frequency of induced genetic lesions following g irradiation and EMS mutagenesis of the bread wheat cultivar Paragon. The major focus is on the *Rht-1* semidwarfing genes, which meet certain necessary criteria (known DNA sequence, single copy, known chromosomal location, and recognizable effect on phenotype). We have developed sets of primers to amplify the full length (in ~500-bp segments) of *Rht-B1* and *Rht-D1* and are using an SSCP platform to search for sequence alterations in the various amplicons across an EMS population of 7,000 individuals. To date, seven independent mutants (from a screen of about 2,000 individuals) in the 5' amplicon of *Rht-B1* have been identified, four of which predict an amino-acid change. Global levels of mutation in the population are also being explored using a retrotransposon-based S-SAP assay.

Unravelling the 50-year-old Ph1 puzzle in wheat.

Simon Griffiths, Tracie Foote, and Graham Moore.

Insights into the control of chromosome pairing in polyploid wheat have been recently realized through a molecular and cell biological characterization of the *Ph1* locus. In most species, chromosome pairing is first initiated via telomere interactions, manifested by the clustering of telomeres at the start of meiosis. However, we have seen in wheat that the telomeres of homologs pair correctly whether or not *Ph1* is present. So what is *Ph1* affecting in the rest of the chromosome? It has long been known that premature and asynchronous chromatin condensation affects wheat F_1 hybrids; meanwhile in model organisms such as yeast, premature chromatin condensation results when *cdc2* is over-expressed. In

the absence of *Ph1*, the condensation of meiotic chromosomes is particularly asynchronous and premature. Differential condensation of homologs implies asynchrony in their chromatin conformation, thereby increasing the possibility of illegitimate pairing. Correct pairing at the telomere, followed by illegitimate association of sites along the arms would generate the multivalent structures observed in *Ph1*-deficient genotypes. Interestingly, there is a known correlation between condensation and recombination sites, which may explain why multivalents fail to resolve in the absence of *Ph1*. What happens at centromeres? In the presence of *Ph1* the centromeres pair prior to meiosis and go on to form seven distinct clusters, just as the telomeres are clustering at the start of meiosis. In contrast, in the absence of *Ph1,* although the centromeres still pair, the number of clusters is only rarely reduced to the seven, reflecting the fact that the centromeres themselves are less condensed.

Thus we have a cell biological explanation of how *Ph1* functions within wheat itself, so how do wide hybrids behave? The presence of multiple B chromosomes (which are highly heterochromatic) can compensate for the absence of *Ph1*, resulting in suppression of homoeolog pairing and recombination. Their presence also delays S phase, leaving the chromosomes more condensed at an equivalent meiotic stage. This supports the model that *Ph1* functions through the control of chromatin condensation. In wheat-rye hybrids we have shown that in the presence of *Ph1*, chromosomes are more condensed at the point of pairing initiation, than in its absence. As in wheat itself, in *Ph1* hybrids all the centromeres fuse to seven clusters at the start of meiosis, while in *ph1* hybrids, they rarely form as few as seven clusters.

We have now completed a molecular characterization of the *Ph1* locus. This has revealed that, following polyploidization, a subtelomeric heterochromatin block became inserted into a group of *cdc2*-like genes on 5B. As it is now clear that *Ph1* is involved in the regulation of chromatin condensation, it seems likely that this insertion event generated a functional and/or regulatory change at the 5B *cdc2*-like gene family. At the moment, the exact nature of how this rearranged locus functions remains to be determined. The wider implication of this discovery is that a newly synthesized allopolyploid needs to tightly control the meiotic checkpoint to ensure synchronized control of chromatin replication and condensation at meiosis. In particular, it is necessary that homologs condense in a coordinate way in order to ensure their correct pairing and the resolution of recombination events during the course of meiosis.

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An integrated approach to stabilizing Hagberg Falling Number in wheat: screens, genes, and understanding.

Peter Jack (RAGT Seeds Ltd), Mike Field (Advanta Seeds Ltd), Peter Werner (CPB Twyford Ltd), Chris Chapman (Nickerson (UK) Ltd), Tina Henriksson (SW Seed Ltd), David Feuerhelm (Elsoms Seed Ltd), Tina Barsby (Biogemma UK Ltd), Graham Jellis (HGCA), Alex Waugh (NABIM), Sue Salmon (CCFRA), James Brosnan (SWRI), Andy Phillips (Rothamsted Research), Michael Holdsworth (University of Nottingham), John Snape (John Innes Centre), and Peter Kettlewell (Harper Adams University College).

This large (£2.15 M BPS, $3.77 M USD) multidisciplinary project (HFN LINK Project LK0975) started in October 2005 and runs until March 2010, seeks to identify genes and environmental stimuli that control variation in Hagberg falling number (HFN), an industry standard measure of starch integrity. Two independent phenomena are involved, preharvest sprouting (PHS) and prematurity amylase (PMA), with differing underlying genetic components and environmental triggers. In both cases, controlled conditions for expression of the character will be developed and used to help identify candidate genes involved and to map these against genetic markers identified in a broad range of elite U.K. germ plasm. The objective is to generate and validate DNA markers, ideally within the controlling gene(s), to enable breeders to select against undesirable PHS and PMA alleles in conventional crossing programs.

The breeding partners will supply and genotype a range of mapping populations, test their HFN performance across multiple locations over multiple years, and help test candidate gene leads. The academic groups will be responsible for various upstream activities. Harper Adams will develop a screening system to reliably induce PMA, largely based on what is known concerning the environmental factors which induce it. The potential of the established association between large grain size and PMA will be assessed to explore manipulation of grain growth as an alternative to an

environmental screen. The screening system will be used to phenotype the mapping populations as a prelude to identifying molecular markers linked to genes or QTL for resistance. Rothamsted Research will complement this work by investigating the molecular basis for PMA production in developing grain, using a combination of amylase-GUS reporter lines, laser capture microdissection of individual grain tissues, microarray analysis and quantitative RT-PCR. TILLING will be attempted to identify novel alleles of genes involved in PHS and PMA from cultivar collections and mutagenized populations of wheat. The University of Nottingham will focus on PHS induction, by examining the relationship between dormancy in wheat embryos and PHS susceptibility. This will involve an examination of the developmental windows of dormancy induction, maintenance and loss during maturation, an analysis of genotype variation in depth of dormancy, relating depth of dormancy to PHS in a scalable way, comparing PHS induction under controlled environments with field performance, and the development of a lab-based smart screen for the analysis of PHS. The John Innes Centre will identify and analyze genetic variation for HFN with additional input from breeding companies' field trials, DNA marker analyses, and novel germplasm. An array of varieties and mapping populations representing HFN diversity among modern U.K. winter wheats will be physiologically assayed for resistance to PHS and PMA at two sites over three years, which will facilitate gene discovery via gene mapping. Collaborative development of both screening methods and identification of resistance/candidate genes will integrate the effort to supply the industry with intelligent phenotype and genotype selection tools, to promote the breeding of new wheat varieties with stable HFN and enhanced grain quality.

The project is being coördinated by RAGT Seeds Ltd and is strongly endorsed by the entire supply chain, especially the breeding community.

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