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Breeding of spring wheat in Saratov.

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In 2009–10, spring bread wheat cultivars from different wheat breeding centers of the Russian Federation, Germany, Belarus, and Kazakhstan were studied in the field trials at the Agricultural Research Institute for the South-East Region (ARISER, Saratov). The modern cultivars developed in the ARISER were used as a check. Grain yield of old Saratov cultivars (introduced into agricultural production in 1924–57) was 43.8% that of the modern cultivars. The closest yields to those the modern ARISER cultivars were those from Samara (Russia), the grain yield of which reached 66.9%. Yield capacity of cultivars from the relatively dry regions of Russia (Ufa, Orenburg, Kurgan, and Barnaul) and Kazakhstan was 53.9–55.1% that of the Saratov cultivars. Grain yield of Moscow Region's cultivars made up only 51.1%, whereas that of cultivars developed in the relatively moist regions of Germany and Belarus comprised 36.5% that of the Saratov cultivars (Table 3).

Table 3. Yield capacity of spring bread wheat cultivars produced by different wheat breeding centers in 2009–10.

Region where the cultivar was created	Grain yield capacity	
	t/ha	%
Saratov (modern cultivars)	1.78	100.0
Saratov (historically developed cultivars)	0.78	43.8
Samara	1.19	66.9
Ufa, Orenburg	0.98	55.1
Kurgan, Barnaul, Kazakhstan	0.96	53.9
Moscow	0.91	51.1
Germany, Belarus	0.65	36.5
LSD05	0.39	—

These data demonstrate that the bioclimatic potential of Saratov Region is most fully used by Saratov spring bread wheat cultivars. The cultivars created in other regions are less adaptive. The farther they are in their origin in time or space from the modern Saratov cultivars, the lower the yield capacity. To get optimal use from the bioclimatic potential of the region, the reach of regional breeding centers should be created and developed. The distance between them will depend on the agro-climatic differences between the regions. An increase of 10–15% of the modern local cultivars yiel capacity over those developed in neighboring regions may be used as an indicator of the working efficiency of any regional breeding center.

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Joint inheritance of resistance to leaf rust, spike productivity, and stem length in hybrid soft wheat plants.

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The soft wheat winter cultivar Moscovskaya 39 is characterized by a complex of valuable agronomic features. The cultivar is high-yielding and winter-hardy, and its grain quality is very good. However,Moscovskaya 39 is not resistant to leaf rust. Our aim was to provide resistance to leaf rust from a disomic substitution (2n = 42) wheat–*Aegilops* line (DSL) using a backcrossing technique. The disomic substitution line was selected from a hybrid population '*T. aestivum*/*Ae. speltoides*' (Kyzlasov et al. 2004) that is resistant to leaf rust.

The 'Moscovskaya 39/DSL' hybrid F_1, as well as the DSL itself, proved to be completely resistant to leaf rust. Resistance in the DSL is dominant. The 'Moscovskaya 39/DSL//Moscovskaya 39' F_1 hybrid segregated for resistance to leaf rust in a ratio of 104 resistant plants : 115 affected plants ≈ 1 : 1. The experiment demonstrated that the resistant plants, in comparison with susceptible plants, had less productive spikes and longer stems (Table 1). The resistant plants had small caryopses, thin stems, narrow laminas, and longer glumes and lemmas.

When joining the features of high spike productivity and short stem with resistance to leaf rust in the same genotype, the author faced some problems because of their linked pattern of inheritance.

Table 1. Spike productivity and stem length in plants susceptible and resistant to leaf rust from a cross 'Moscovskaya 39/DSL//Moscovskaya 39'.

Leaf rust reaction	Spike productivity	Stem length (cm)
Resistant	1.8	119
Susceptible	2.1	101
Significance limit (0.05)	0.2	14

Reference.

Kyzlasov VG, Yatchevskaya GL, and Lazareva HN. 2004. Selection of soft wheat lines disomically substituted by chromosomes of *Ae. speltoides*. Ann Wheat Newslet 50:104-105.

Rye apomixis nonheritable by homozygous offspring.

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This report continues Kyzlasov (2010), which presents the results of a study of rye offspring obtained with no paternal parental participation. A reasonable opportunity for the creation of obligatory apomicts using polyploidization and duplication of homologous chromosomes of heterozygous genotypes is reported.

The germination capacity of the apomictic progenies studied was lower than that of normal rye by 20–30%. Sprouting was observed 2–5 days later than in the control group. Stooling was late as well. Slower plant growth was noted. Most plants died in the winter. A mere 7% of the progenies had survived by harvest time. The plants differed dramatically in their productive capacity, number of shoots/plant (1–30), stem length (30–120 cm), and spike and lamina size. Generally, strong inbreeding depression was manifested in the development of quantitative features, which means that the initial maternal plants, which produced apomictic offspring without pollination, had been heterozygous.

Surprisingly, recombinant plants with normally developed anthers and pollen, appeared among the apomictic progenies. Plants of spring type were found. The initial apomictic maternal plants had sterile pollen and all were winter type. These facts defy explanation, because spring type and pollen fertility are dominant features, whereas winter type and pollen sterility are recessive. As a result of reproducing plants with recessive features, no progeny with dominant features can appear. In the population studies, plants resistant to oidium and unable to produce stems, were found.

Before flowering, stamens were removed from 58 spikes of apomictic origin. One-half of the plants had sterile pollen in the F_3, the other half had fertile pollen. Emasculated spikes were covered with paper cages. Without pollination, practically no seed set in the emasculated flowers. Of 3,550 emasculated flowers, only three produced caryopses in the absence of pollination. Sucha negligibly low frequency of a feature development is statistically insignificant. The studied progenies did not inherit the apomictic reproduction pattern of the maternal plants. A noninheritable apomixis type was earlier described in soft wheat (Kyzlasov 2008).

Normal rye plants are always heterozygous. The studied offspring's failure to inherit apomictic reproduction pattern of their maternal plants can be explained by a transfer of the apomixis genes to homozygous state. We assumed (Maheshwari 1954) that the embryo sac oocyte without pollination can give rise to a diploid embryo due to chromosome endoduplication. The resulting progenies will be, in this case, fully homozygous. There are no reports about homozygous apomicts in the literature. Haploid organisms are fully homozygous. They also are unable to reproduce themselves via apomixis. The apomixis pattern described by the author in winter rye can be an effect of interaction of apomixis genes located in homologous chromosomes of heterozygous plants. Therefore, it is not inherited by homozygous progenies produced due to apomictic reproduction. Apomixis of this type is manifested in the phenotype of heterozygotes only. In homozygous plants, it disappears like the heterosis effect. Kyzlasov (2010) observed in apomictic reproduction, that apomictic progenies have to inherit their maternal plants ability to reproduce themselves via apomixis. However, they were not found to.

In another experiment, the formation of apomictic progenies was repeated in a hybrid population of 'F_2 winter rye R-1 with sterile pollen / spring rye R-2'. Apparently, there are carriers of pollen sterility genes in the population of spring rye R-2. Therefore, pollen appeared to be sterile in approximately 6% of the F_1 hybrid plants obtained. Without pollination, no seed formation was observed in the flowers of these plants. The other plants had fertile pollen. The second generation hybrid population had a segregation ratio by pollen viability of 118 plants with fertile pollen : 41 plants with sterile pollen ≈ 3 : 1 (Table 2). Formation of apomictic caryopses was revealed in the plants with sterile pollen without pollination. Their rate was approximately 10% of the total number of flowers in the spike

Table 2. Segregation pattern of an AaBb rye hybrid in F_2 for pollen sterility (+ = plants with fertile pollen, – = plants with sterile pollen).

	AB	Ab	aB	ab
AB	+	+	+	+
Ab	+	+	+	+
aB	+	+	–	–
ab	+	+	–	–

One-half of the apomictic progenies in the F_3 demonstrated fertile pollen, and the other half had sterile pollen. In the absence of flower pollination, 68 apomictic progenies in the F_3 produced no seeds, in the same manner as in the experiments of prior years. A model of formation of rye apomictic progenies with sterile pollen (aaBb) can be imagined as a result of allelic interaction between 'B' and 'b' genes in heterozygous state (B – b).

This apomictic reproduction type, revealed in rye, is supposed to be inherent to heterozygous plants only. A possibility of apomict formation through the interaction of genes located on homologous chromosomes of heterozygous organisms, is reported for the first time. In such cases, obligate apomicts can appear as a result of chromosome set doubling in genotypes heterozygous by apomixis genes, or unequal crossingover in heterozygous plants in meiosis, or a duplication of homologous chromosomes of heterozygous plants. Possibly, that is why the apomicts found in nature are usually polyploids or aneuploids with unbalanced chromosome number. In sexual reproduction also, flowering plants are known produce seeds entirely as a result of interaction of genes located in homologous chromosomes. If without the flower pollination, no seeds will appear.

These results are consistent with the hypotheses of apomictic plant species formation by means of hybridization and polyploidy (Strasburger 1905; Ernst 1918; Winkler 1908; Powers 1945). The data obtained substantiate the principles of the theory, now universally recognized, that apomixis is determined by the action of genetic factors (Petrov 1988).

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