ATLANTIS PRESS

Advances in Biological Sciences Research, volume 7

1st International Symposium Innovations in Life Sciences (ISILS 2019)

Retrospective of Spring Wheat-couch Hybrids Breeding in the Department of Remote Hybridization MBG RAS

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***Abstract*—The article presents the results of breeding in the department of remote hybridization of the Main Botanical Garden n.a. N.V. Tsitsin (MBG RAS) from 1946 to 2019. The aim of this work is to create high-yielding varieties of spring wheat of an intensive type that most fully meet the peculiar conditions in a changing climate. During this time, next varieties were created and passed the State variety test: Hybrid 56, Vostok, Grekum 114, Botanicheskaya 2, Botanicheskaya 3, Botanicheskaya 4, Botanicheskaya 5 and Botanicheskaya 81.**

Keywords—spring wheat, breeding, variety, wheat and wheat hybrids, distant hybridization

I. INTRODUCTION

Increase of the grain varieties plasticity in a rapidly changing climate has always been one of the most important tasks facing plant breeders. A large role in this process belongs to the hybridization of cultivated cereals with wild ones. Interspecific and intergeneric hybridization of plants is a powerful source of morphogenesis and opens up wide prospects for selection [1,2].

II. EXPERIMENTAL

An adaptive breeding, which gained popularity by the end of the 20th century, has become a prior trend in the beginning of new century. This trend was caused by global warming threats, poor predictability of current meteorological conditions, a general tendency to biologize agriculture, associated with a deterioration of the ecological situation, and also due to the threat of new pathogens emergence and the wide spread of existing ones. As noted by some foreign and Russian scientists, there is a significant decrease in the genotypic diversity of cultivated plants and gradual depletion of the gene pool due to the use of a limited number of genes in selection [2, 4, 5]. Leading breeders agree that only distant hybridization can most effectively solve the problem of cultivated plants germplasm enrichment [6].

The creation of early-growing, high-yielding, short-stemmed varieties of strong spring wheat is of great economic importance for the regions in which it is the main grain crop [1]. Along with these indicators, it is necessary to develop varieties with strong resistance to various infectious backgrounds. Distant hybrids are of great interest for studying disease resistance as well, due to their qualitatively new genomic composition [2,7].

Academician N.V. Tsitsin made a great contribution to the development of theoretical and methodological aspects of cereals intergeneric hybridization. He was the first to conduct a study on the hybridization of wheat with wild cereal common couch (*Elytrigia repens L.*), studied the broad formative process and on this basis created a number of original forms and varieties of Triticum-Elytrigia hybrids, as well as new varieties of winter and spring hybrids. From 1949 to July 1980, studies on distant hybridization were conducted under the guidance of N.V. Tsitsin in the Department of Remote Hybridization, MBG RAS, and then on the experimental base of the Scientific Research Center «Snegiri» (SRC «Snegiri»). The tasks of the research included the selection of parental pairs for crossbreeding,

since the development and orientation of the morphogenesis process largely depends on what type of wheat and wheatgrass are used in hybridization. It was found that when wheat and couch are crossed, the best results are obtained when the maternal form is wheat with hybrid origin. The breeders of the MBG RAS also had the task to choose the type of wheatgrass that would be most successfully involved in crossbreeding.

I order to get spring Wheat-Couch hybrids (WCH) a breeding procedure was carried out in between 1946-2019 in full scheme. From 1946 to 1953 in Ostankino (Moscow), and since 1953, the main breeding work was carried out in the department of remote hybridization (Russia, Moscow region, Rozhdestveno). The main method is intraspecific and interspecific hybridization followed by individual selection. One of the main criteria for individual selection was resistance to a complex of diseases, resistance to lodging, shedding and sprouting on the root, resistance to abiotic factors and productivity. Samples in the nursery stock were sown manually and for varietal testing with seeders. The seed placement depth was 6 ... 8 cm with 5.5 ... 6 million germinating grains per 1 hectare (ha). Phenological observations and rejection of unpromising numbers were carried out during the growing season. Harvesting was carried out manually with threshing on a thresher and with a Sampo 500 combine harvester. The selection process involved promising common wheat varieties from domestic and foreign breeders (*Triticum aestivum* L.), and two types of wheatgrass (*Agropyron glaucum* Roem et Shult (= *Elytrigia intermedia* (Host) Nevski *subsp. Intermedia*), *Agropyron elongatum* Roem et Shult (= *Elytrigia elongate (*Host) Nevski)).

III. RESULTS AND DISCUSSION

By the personal initiative of Academician Nikolai Vasilievich Tsitsin and with the consent of the Presidium of the USSR Academy of Sciences, the Presidium of the Supreme Soviet of the USSR dated May 15, 1953 included the Snegiri farm (Moscow Region, Rozhdestveno) in the system of the USSR Academy of Sciences and the institutes of the biological department of the USSR Academy of Sciences. On May 18, 1953, the Snegiri Scientific and Experimental Farm was transferred to the Main Botanical Garden for testing and propagating new valuable wheatgrass hybrids bred by Academician N.V. Tsitsin for their quickest introduction into the country's agricultural production. In the autumn of 1953, all winter selection material that was created in the laboratory of vegetative hybridization from 1939 to 1949 and stored at the Zonal Scientific Research Institute of Grain Farming (now Federal State Budgetary Institution Federal Research Center Nemchinovka) was already sown on the fields of the SRC Snegiri. All the hybrid breeding material of younger and older generations was also involved in the breeding procedure, work with which lasted from 1949 to 1953 in the remote hybridization department of the MBG. During the development of hybridization plan N.I. Tsitsin and his colleagues used the source material of the same species, but distant in the aspects of kinship and geography, following the principle of I.V. Michurin, who argued that such hybrids adapt more easily and fully to the new conditions, and vice versa hybrids are stubbornly supporting almost all the traits of one of the parents or sibling when closely related varieties growing for a long time in the same area on the same soil are hybridized [1].

While working with spring WCH the main task was to obtain a high-yielding and non-lodging variety of spring wheat with good grain quality. Moreover, it was desirable that it could be successfully cultivated on floodplain lands and with irrigation, since the main work on the study of spring WCH at that time was carried out in the Kazakhstan, eastern regions of the Soviet Union, and the tests were held in the collective farms of the Alma-Ata and Kustanai regions of Kazakhstan and the Altai Territory. To achieve this goal, an American xerophilic early-ripening spring common wheat «Extra Prelude» was crossed with winter WCH hybrid No. 1. As a result, already in the 2nd and 3rd generation valuable hybrid forms were obtained in terms of productivity and lodging resistance. Morphologically, they were similar to WCH1, but had a spring type of development. However, the seed quality of these hybrids was unsatisfactory.

In 1954, it was decided to conduct series of crosses with spring wheat Moskovka. In 1958, breeders Artyomova A.S. and Yakovlev A.V. reported at the conference on distant hybridization of plants and animals in the MBG about new varieties of WCH hybrids created at the Almaty station. The most valuable varieties in their opinion were hybrids No. 56 and No. 7. As a result, Hybrid No. 56 was zoned in 1957 in the Almaty region. In the State Register, it was listed under the name Hybrid 56.

He possessed a whole complex of economically valuable attributes. In addition to high productivity, it was characterized as early ripening, drought tolerant, non-crumbling during prolonged harvest, non-lodging and with extremely high resistance to smut infection. WCH 56 combined these economically valuable properties with high technological qualities of grain (table 1).

According to the results of the State Test, Hybrid 56 in terms of productivity got one of the first places among other hybrids, which at the same time turned out to be one of the most early-ripening varieties too. The productivity of this cultivar at different State Test sites of Kulunda in 1958 ranged from 23.6 to 34.0 centners per hectare (c/ha). Cultivated area of Hybrid 56 increased in 6 years from one hectare in 1954 to 20 thousand hectares.

TABLE I. FLOUR AND BAKING QUALITIES OF SPRING WCH VARIETY HYBRID 56 (ACCORDING TO THE STATE COMMISSION IN 1957)

Cultivars	**Vitrescence, %**	**Crude gluten content, %**	**Flour strength**	**Baking mark (with sugar)**
Altai region				
Hybrid 56	64	43,2	135/0,34	3,2
Lutescens 758 (Standart)	52	37,6	90/0,32	3,2
Krasnoyarsk region				
Hybrid 56	67	34,8	253/0,62	3,5
Lutescens 758 (Standart)	45	29,2	190/0,61	3,7
Penza region				
Hybrid 56	73	42,5	308/1,05	3,7
Lutescens 758 (Standart)	31	30,6	219/0,80	3,8

During the period from 1959 to 1965, another 2 varieties of spring WCHs were transferred to the state variety test. These are WCH 172 in 1959 and the Vostok variety in 1962.

WCH 172 is a mid-season ripening variety. It was characterized by high productivity, drought tolerance, non-crumbling, non-lodging plant. Another valuable trait of this variety was its resistance to brown and yellow rust, even in the years of high infectious load. Baking qualities were satisfactory. Productivity in different years of testing ranged from 38 to 49 c/ha (without lodging).

The spring WCH «Vostok» was characterized by early maturity, productivity, drought resistance, and resistance to lodging and crumbling, resistance to smut and yellow rust. It had high technological qualities of grain. The cultivar was recognized as promising for most regions of the Kazakh USSR. Due to its economically valuable traits, and most importantly, easier threshing, it gradually replaced the WCH 59 and since 1963, its' cultivated area began to decrease markedly in favor of the new Vostok cultivar.

To obtain early-ripening spring wheat varieties for the regions of Siberia and Kazakhstan, crossing of the Vostok and Saratovskaya 29 cultivars started, as well as WCH 56 and WCH 22850. Subsequently, almost all valuable varieties were obtained by selection from the Vostok and Saratovskaya 29 cross offspring.

Very soon, breeders Artemova and Yakovlev identified a new WCH 114 (further Grekum 114). In the department's report for 1966, it was characterized as a productive, mid-season variety with high resistance to lodging, weakly affected by rust and with high flour-baking qualities on par with Saratovskaya 29. It was planned that in 1967 it will be transferred to a variety test for study it in areas of spring wheat cultivation under irrigation.

In 1968, at a plenary meeting of the State Commission, it was decided to pass Grekum 114 spring wheat in the state variety test. This year it was tested in 67 variety plots in 26 regions of the European and Asian parts of the Soviet Union. According to the test results, its productivity ranged from 14.6 c/ha in the East Kazakhstan region to 41.9 c/ha in the Almaty region. Grekum 114 showed a yield advantage over other 13 areal spring wheat cultivars. It was noted for its high resistance to lodging even in irrigated areas, as well as resistance to smut and powdery mildew. Afterwards, seed production of Vostok and Grekum 114 cultivars was expanded in the remote hybridization department in Snegiri.

From the department's report for 1970, it follows that Grekum 114 was already tested in 50 regions of the Soviet Union on 210 test plots. During the test since 1968, it proved to be a high-yielding cultivar, coarse-grained, non-lodging, non-shedding and resistant to smut infection in a number of regions of Siberia and Kazakhstan. He had the highest weight of 1000 grains in comparison with areal and state-tested spring wheat cultivars - up to 55 g.

After a successful test of the Grekum cultivar, in 1972 it was transferred to many areas. In February 1973, the State Commission decided to classify Grekum 114 as one of the most valuable wheat cultivars. Moreover, by means of scientific sessions and articles published in journals a widespread introduction of this cultivar in industry happened. In SRC Snegiri, primary seed production was held mainly for this variety; the Vostok variety remained only on 2 hectares totally.

In parallel with the widespread introduction of Grekum 114, further breeding of spring WCHs continued. It was mainly aimed to get cultivars with reduced height. For this, the Mexican cultivar Pitic 62 was crossed with Grekum 114 and the WCH 1752/49 (obtained after Vostok and Saratov 29 cultivars crossing). Crossbreeding of WCHs with the Pitik 62 variety made it possible to obtain short-stem hybrids with high productive bushiness. In addition, the promising variety Grekum 114 was crossed with the Indian short-stemmed cultivar Sherbati Sonora. This cultivar was obtained as a result of exposure to gamma rays and ultraviolet rays from the Sonora 64 cultivar. The Sherbati Sonora was valued for its high protein content of 16.5% and 3.4% lysine content.

As a result of this work, a new variety of spring WCH Botanicheskaya 2 appeared (it was obtained by crossing varieties Pitik 62 and Raduga). Since 1976, a competitive variety testing of the Botanicheskaya 2 began. It was characterized by high productivity, early maturity, drought tolerance, resistance to lodging and various infections with high-quality grain. In 1982, it was transferred in a number of regions of Siberia and Kazakhstan. In 1980, seed production in SRC Snegiri was carried out for three varieties Grekum 114, Vostok and Botanicheskaya 2.

In October 1982, a WCH 1489, called Botanicheskaya 3, was transferred for cultivar testing. It was obtained by crossing Red River 68 and Grekum 114. According to the results of competitive variety testing, over three years the hybrid showed a yield of 33.3 c/ha, which is 10.8 kg/ha higher than the standard (Saratov 29). He had a higher degree of resistance to various infections than the standard. In addition, the new hybrid had high grain quality. As an early-ripening, short-stemmed, high-yielding, non-obstructing cultivar with high-quality grain, Hybrid 1489 was at that time of high practical value for the regions of Siberia and Northern Kazakhstan.

During these years, Hybrid 1742 was also obtained by crossing the Red River 68 with a Grekum 114. Hybrid 1742 is a mid-early, non-obstructing, non-shedding cultivar. During the test period from 1982 to 1984, he did not suffer from yellow stem rust, dusty and hard smut. It also surpasses Saratov 29 in grain quality. In 1984, this hybrid was handed over to state trials under the name Botanicheskaya 4.

Over the next 5 years, varieties Botanicheskaya 5 and Botanicheskaya 6 were created, however, all spring WCHs called "Botanicheskaya", starting from number 3, were not transferred to other areas after the cultivar testing.

In the 1990s, breeding process in the department of remote hybridization of the MBG RAS, as well as in many other scientific institutions of the country, was significantly reduced, and in some areas completely stopped.

And only in 2016, as a result of hard work, WCH 81 called Botanicheskaya 81 was sent for state cultivar testing. According to the results of testing in 2018, it exceeded standard cultivars in the Kaluga and Moscow regions, as well as in the Altai region. In other regions, this variety was either at the standard level or slightly lower. However, the mass of 1000 grains in all varietal sections without exception was from 3 to 10 g higher than the standard.

IV. CONCLUSION

Scientists at the Department of Remote Hybridization of the MBG RAS managed to develop promising spring-type wheat cultivars as a result of crossbreeding with common couch followed by individual selection. These cultivars are resistant to a number of diseases, non-crumbling, non-lodging, with stable yield in regions with increasing climate aridity.

ACKNOWLEDGMENT

The work was carried out in accordance to Institutional research project №19-119012390082-6.

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