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Wheat Special Report No. 13

Wheat and Wheat Breeding in the Former USSR

A.I. Morgunov, Associate Scientist
CIMMYT Wheat Program

November 1992

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Preface

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The USSR is one of the main wheat-producing countries in the world. It has a long-established wheat breeding network involving institutes and stations nationwide. Soviet scientists have contributed to modern varieties and germplasm as well as to scientific knowledge about wheat genetics, physiology, and breeding. Up to now information for English-speaking audiences about wheat and wheat breeding in the USSR has been very limited. The objective of this review by A.I. Morgunov, associate scientist in the CIMMYT Wheat Program, is to present the current status of wheat breeding in the region. He concentrates on breeding objectives and methods and the organization of the breeding system itself.

Although we realize that the Union of Soviet Socialist Republics (USSR) no longer exists, the name is used for simplicity and because the events described refer to a period before the breakup of the Soviet Union.

Due to the lack of literature, this special report often refers to a book published in the USSR, *Wheats of the World* (Dorofeev et al. 1987), which gives a very comprehensive description of wheat breeding in the country.

Note on Citing this Wheat Special Report

By sharing research information in this Wheat Special Report on Wheat and Wheat Breeding in the Former USSR, we hope to contribute to the advancement of wheat breeding in this region and to the importance of shared knowledge. However, the information in this report is shared with the understanding that it is not published in the sense of a refereed journal.

Correct Citation: Morgunov, A.I. 1992. Wheat and Wheat Breeding in the Former USSR. Wheat Special Report No. 13. Mexico, D.F.: CIMMYT.

Introduction

Area and production

Wheat is the most important cereal crop in the USSR, currently covering an area of some 48.2 million hectares--nearly twice that of barley, the second most important cereal (Table 1). Traditionally, wheat or wheat/rye bread has been one of the major components of the every-day diet in Russia, the Ukraine, and other republics populated by Slavs.

The dramatic increase in area in the 1960s depicted in Table 2 was associated with opening up of new lands in northern Kazahkstan and Siberia. During the 1970s, area stabilized at around 60 million ha. The 1980s saw about a 10 million ha reduction in wheat area, which was part of a general tendency to decrease cereal cultivation during the decade (Table 1). The reduction in area certainly has not been driven by production surpluses because the country has to import between 30 and 50 million tons of grain every year. Most likely, the area reduction is due to the worsening economic situation, which has caused farmers to grow less labor-intensive crops such as forages. Since the

Table 1. Area and yield of different cereal crops in the USSR (1948-1990).

Crop	1948-52	1961-65	1970	1975	1980	1985	1990
			Area (million ha)				
Wheat	42.6	66.6	65.5	62.0	61.5	50.2	48.2
Rye	23.6	16.3	11.0	8.0	8.6	9.5	10.4
Barley	8.6	18.3	21.5	32.5	31.5	29.2	26.1
Maize	4.4	5.9	4.6	2.6	2.9	4.4	4.4
Oats	16.1	7.3	8.5	1.2	11.8	12.6	10.7
Millet	3.8	3.8	3.0	2.8	2.9	2.8	2.9
Rice	0.1	0.2	0.3	0.5	0.7	0.7	0.6
Cereals	*101.1*	*120.5*	*114.2*	*122.3*	*121.9*	*111.4*	*105.4*
			Yield (t/ha)				
Wheat	0.84	0.96	1.44	1.07	1.60	1.55	2.24
Rye	0.76	0.93	1.36	1.13	1.18	1.65	2.02
Barley	0.74	1.11	1.30	1.10	1.38	1.66	2.18
Maize	1.31	2.23	2.83	2.76	3.18	3.21	3.62
Oats	0.81	0.83	1.29	1.03	1.55	1.63	1.76
Millet	0.45	0.70	1.00	0.41	0.64	1.03	1.26
Rice	1.45	2.46	3.64	4.02	4.19	4.38	4.06
Cereals	*0.75*	*1.02*	*1.57*	*1.10*	*1.49*	*1.64*	*2.17*

Source: FAO Yearbook, Rome, v.25-44,1970-1990.

Table 2. Wheat area, production and yield in the USSR (1948-1990) (FAO Yearbook, Rome, Vol. 25-44, 1975-1990).

Year	Area, million ha	Production, million t	Yield, t/ha
1948-1952	42.6	35.76	0.84
1961-1965	66.6	64.21	0.96
1970	65.5	94.00	1.44
1971	64.0	98.76	1.54
1972	58.5	85.99	1.47
1973	63.1	109.68	1.74
1974	59.7	83.91	1.41
1975	62.0	66.14	1.07
1976	59.5	96.88	1.63
1977	62.1	92.16	1.48
1978	62.9	120.80	1.92
1979	57.7	90.21	1.56
1980	61.5	98.18	1.60
1981	59.3	88.00	1.49
1982	57.3	87.00	1.52
1983	50.8	78.50	1.54
1984	51.1	76.00	1.49
1985	50.2	78.08	1.55
1986	48.7	92.31	1.89
1987	45.7	85.00	1.86
1988	48.1	84.44	1.76
1989	47.7	92.31	1.94
1990	48.2	108.00	2.24

end of World War II, wheat yields have steadily increased from 0.84 t/ha in 1948-52 and 0.96 t/ha in 1961-1965 to 1.93 t/ha in 1986-1990 (Table 2).

Most of the wheat grown in the USSR is bread wheat. Durum wheat used to occupy around 10% of the wheat area, but has steadily declined to 7% in 1971 (5 million ha) and to 4.4% in 1981 (2.6 million ha) (Dorofeev et al. 1987). More recent data are not available, but it is unlikely that the area has dramatically changed much over the last 10 years. Farmers prefer growing bread wheat because it is less sensitive to fluctuations in environmental conditions and agronomic practices and as a result provide more yield.

Winter and spring wheat zones

Wheat-producing areas are situated mainly between 45 and 56^{o}N, which is equal to the northern U.S. and southern Canada. Although distinct areas of winter and spring wheat cultivation exist (Figure 1), farmers in some areas sometimes risk sowing winter varieties in the spring areas for the distinct yield advantage instead of playing it safer by sowing spring varieties. Average meteorological data for the different regions of the former USSR are provided in Appendix 1.

The southern part of Russia (Northern Cuacasus) as well as Ukraine cultivate mainly winter wheat. Spring wheat does exist in these areas, but it is used almost entirely to resow winter varieties that did not survive. Both types of wheat are cultivated in the central part of Russia and Volga Region. But in the eastern agricultural areas (Ural Mountains, Eastern and Western Siberia, Northern Kazakhstan) only spring wheat is cultivated. Table 3 gives the areas planted to winter and spring and wheats in these regions.

Table 3. Area under winter and spring wheat in different regions of the USSR (USSR Yearbook, M. 1989).

Region	Area (million ha) under: Winter wheat	Spring wheat
Russian Federation		
Central Region	0.97	0.15
Volgo-Vyat Region	0.14	0.33
Chernozem Region	1.60	0.02
Volga Region	1.85	1.98
North Caucasus	4.15	0.01
Ural	0.01	4.61
Western Siberia	0.01	5.58
Eastern Siberia	0.00	1.85
Far East	0.00	0.23
Russia total	***8.95***	***14.81***
Middle Asian States	1.00*	
Kazakhstan	1.07	13.20
Ukraine	6.80	0.09

* Estimated.

Major stresses

Abiotic--The major stresses that affect wheat yields are abiotic: drought (affecting 60% of cultivated wheat) and the cold winter (Dorofeev et al. 1987). Winter wheat is rarely affected by drought because it can efficiently use residual moisture in the soil after winter snow. On the other hand, winter wheat suffers from severe winters and in some areas does not survive one year in three. Although winter wheat yields higher than spring wheat, spring wheat has reduced risk of being killed by stresses over large areas.

Droughts and cold winter, coupled with the existing level of agriculture in the country, are responsible for fluctuating low yields from year to year (Table 2). Weather also influences total wheat production in particular years (e.g., 76 million tons in 1984 and 108 million tons in 1990). Wheat is usually not irrigated because other crops (vegetables and cotton) are given priorities, particularly in the southern republics.

Biotic--The main diseases that affect wheat are leaf rust (*Puccina recondita*), powdery mildew (*Erysiphe graminis*), loose smut (*Ustilago tritici*), common bunt (*Tiletia caries*), and root diseases. Yellow (*P. striiformis*) and stem (*P. recondita*) rusts and *Septoria* spp. may be observed occasionally as well.

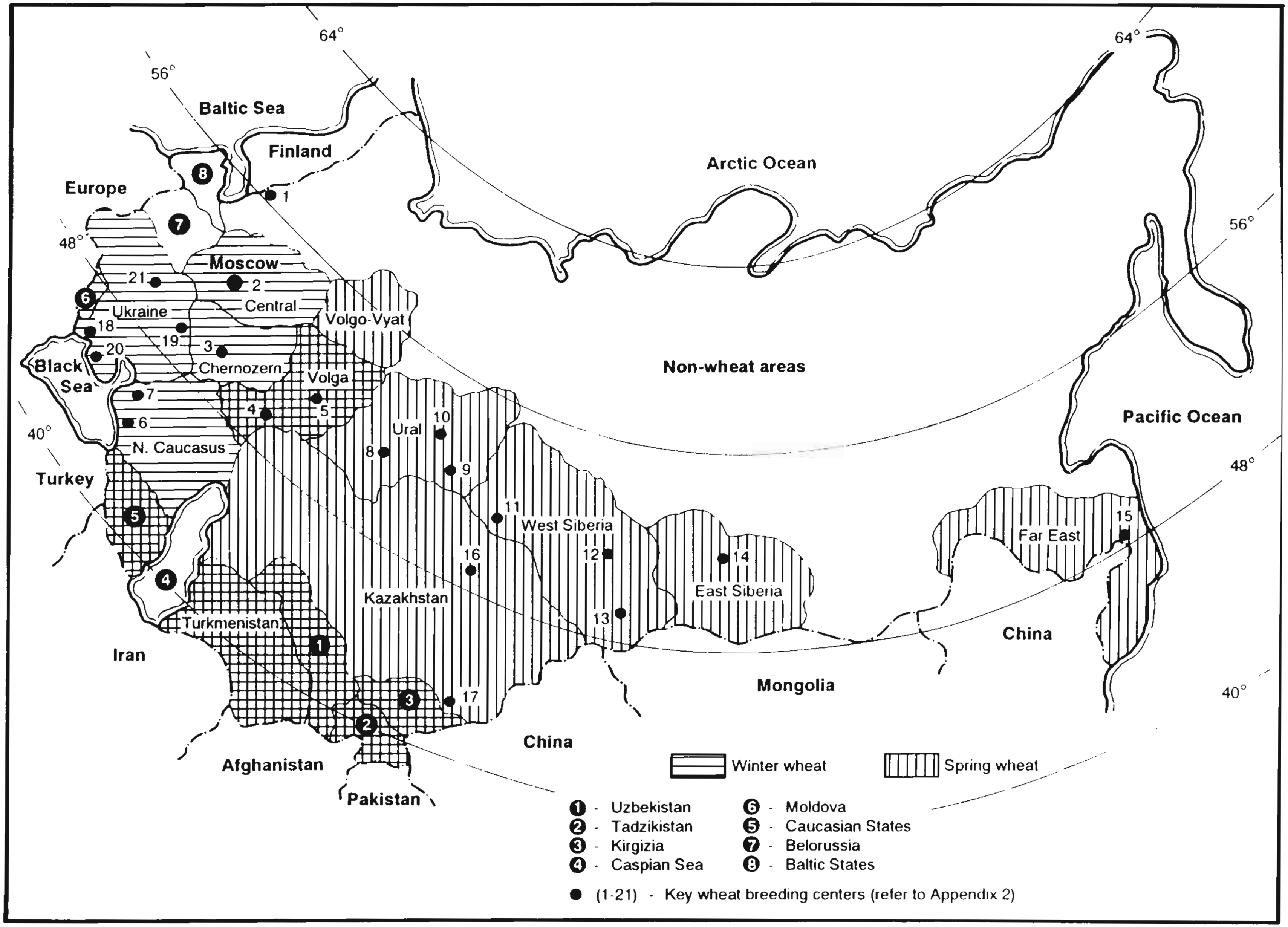

Figure 1. Spring and winter wheat areas and key wheat breeding centers in the former USSR.

History of Wheat Breeding in the USSR

Peasant-developed landraces

Centuries ago, peasants in Central Russia and Ukraine cultivated wheat along with other traditional crops such as winter rye, buckwheat, peas, and millet. All these crops contributed to the everyday sustenance of the people. The peasants bred wheat by selecting best spikes, threshing them, and sowing the seeds. Early records mention a spring wheat landrace called Ledianka, which was cultivated in the 18th century (Dorefeev et al. 1987). When the Russians conquered Siberia, they brought their wheat varieties with them. The wheats cultivated in Siberia were introduced to Turkmenistan, Kirgistan, and Kazakhstan when these Asian areas joined Russia in 1855.

As the result of wheat cultivation and long-term selection by the peasants, there were many landraces available by the end of the 19th century. They differed in properties depending on the area of cultivation, but generally they were very well adapted to stresses, particularly drought. Another important trait was their heterogeneity; in fact, they were actually populations. All these landraces served as the basis for modern wheat breeding in the 20th century. Interestingly, some of these landraces played a great role in wheat breeding in Canada. The variety 'Ladoga' brought from Russia to Canada in 1886 was instrumental in the development of a number of North American varieties like 'Preston', 'Reward', and 'Prelude'. Similarly, the landrace 'Orega' is the origin of the varieties 'Ruby', Garnet', and 'Pioneer'.

Early field stations and breeding programs

The end of the 19th century and especially the beginning of the 20th century (the period between the war with Japan in 1905 and World War I in 1914-1918) were marked by relatively high economic growth, both in industry and agriculture. Farmers across Russia realized that yield increases would be impossible without detailed knowledge of crop science.

With government support, experimental fields and stations were established in different areas. In the Ukraine, a station was set up in Kharkov in 1912 (now the Ukranian Institute of Crop Production and Plant Breeding). Two stations, Saratov and Samara, were established in the Volga Region in 1910 and 1912, respectively. In Moscow, an experimental station and agricultural school were established as early as 1898 (Dorofeev et al. 1987). The first priority for all these agricultural institutions was to develop the most appropriate agronomy practices to fit farmers' needs. They also started to compare existing wheat varieties and supplied peasants with the seeds of the best ones. These stations started the first wheat breeding programs.

Since all the landraces were highly heterogeneous, the selection of particular biotypes within the populations resulted in more advanced varieties with higher yield, but similar adaptability levels. This first stage of wheat breeding lasted into the 1930s. Even so, wheat varieties originating from these landraces were still cultivated on millions of hectares well into the 1950s.

By 1913 Russia had a relatively efficient agricultural system, mainly due to land reforms, advanced agronomy practices and adapted crop varieties. In addition to flax, lentil, and vegetable oil, it exported wheat with good breadmaking quality to many European countries.

Civil strife paralyzes progress in agriculture

The turbulent period between 1914 and 1924 (World War I, the Revolution, and Civil War) paralyzed the country's agriculture and the production of wheat and other crops was reduced to such an extent that many areas in Central Russia suffered from famine in 1922-1923; tens of thousands starved to death.

Wheat breeding also suffered from the upheaval, but where possible, experiment stations established before the revolution continued to develop new varieties. Some breeders started to use crosses in their programs once they realized that the selection from landraces could supply only limited additional variation. This work was especially successful in Saratov, Kharkov, and Samara and gave rise to new germplasm with a combination of useful traits.

The new Soviet government that took power in 1917 did pay attention to plant breeding. The stations and agricultural schools that existed before the revolution were supported and new ones were set up throughout the country. Breeders selected from landraces and also made crosses between varieties and between species. In the 1920s, scientists in different parts of Russia also conducted numerous studies on wheat genetics and physiology.

Influence of Vavilov

Wheat breeding in the USSR was highly influenced by Nikolai Ivanovich Vavilov, whose contribution to wheat research is recognized worldwide. By the end of the 1920s, the Plant Research Institute established in Leningrad was concentrating on germplasm collection and its utilization. Almost at the same time, the All-Union Academy of Agricultural Science was set up in Moscow. Vavilov was director of the Institute in Leningrad and president of the Academy. His expeditions to different parts of the world led to the establishment of a gene bank in Leningrad. He also contributed to knowledge on the variability of cultivated plants and described the centers of origin for many species. His book, *Scientific Basis of Wheat Breeding*, served as an important guide for wheat breeders. Although he was not a breeder and never developed a variety himself, his contributions to crop breeding in Russia have been invaluable.

Tragic consequences of Lysenko's theory

In the late 1930s, agricultural science in the USSR was influenced by the politics of the day. Stalin and his followers accepted the ideas of a new man--Trofim Lysenko. He denied the existence of genes and inheritance through them as a basis for crop breeding. Instead, he claimed that in a socialist society, plants can be "educated". For instance, winter wheat vernalized and sown in the spring can perform better and yield more. Another example was that within-variety crosses were supposed to disturb the nature of the plants and to help in their "education". The main idea was that if crops were cultivated in an appropriate environment, they would give high yields under any new conditions simply by changing their nature. This theory was in line with Stalin's ideology that socialists can rule and change everything including nature. This approach was not associated with such complicated things as genes and it did not require time for creating new varieties.

The consequences were tragic. Vavilov was arrested and died in a Saratov prison in 1940. All scientists were forced to conduct studies that "confirmed" the validity of Lysenko's theory. Many wheat breeders spent a lot of resources on experiments and methods that had nothing to do with scientific breeding. At that time, words like "genes" , "hybridization", "inheritance" were strictly prohibited. One cannot blame these breeders because it was not a choice between scientific approaches, rather it was a choice between life and death.

This period lasted until Stalin's death in 1953. Although some breeders did make crosses and tried to develop new varieties by scientific methods, in general, wheat science was far behind that of other countries. Another sad consequence was that a whole generation of breeders was not taught genetics, but knew only Lysenko's theory. They had to learn what genes are and how they work in mid-career. The fact that breeders were now free to do what they wanted did not contribute to breeding efficiency.

Opening of new wheat areas

The late 1950s were marked by an ambitious wheat project in northern Kazakhstan. The government, worried about food supplies, decided to put into production some 10-15 million hectares of uncultivated lands in dry areas of the republic. It took only 3-5 years to set up state and collective farms and to start wheat cultivation over huge areas. The priority for wheat breeding for this new area was given to the All-Union Institute of Cereals Production in Shortandy.

Current Status of Wheat Breeding in the USSR

By the end of the 1960s, a modern wheat breeding network in the USSR had been established. Today, it involves more than 40 state agricultural research institutes and stations nationwide. The country is subdivided into regions with similar soil and climatic conditions. There is a large plant breeding center located in each region which, in turn, has a network of satellite agricultural research stations. These plant breeding centers are usually parts of regional research institutes. The main objective of the institutes is to supply farmers in the region with new agronomy methods, recommendations for crop protection, and new varieties.

Most regional institutes still belong to the All-Union Academy of Agricultural Science headquartered in Moscow. The Academy has branches in different parts of the country with each branch responsible for a few closely related regions. For example, the Siberian branch is responsible for all regional institutes in Siberia. In addition to the regional institutes, all-union institutes, under direct administration of the Moscow headquarters, specialize in a particular discipline and do more basic research--the results of which they supply to the regional institutes. The leading institutes for wheat breeding are the All-Union Institute of Breeding and Genetics in Odessa and All-Union Institute of Cereals Production in Shortandy (Kazakhstan).

Wheat breeding used to be financed by the Academy either directly for all-union Institutes or through its branches for regional institutes. In 1991, only 40-50% of the expenses were covered by the Academy. The remaining funds had to be raised by breeders who sell pre-basic or basic seeds to farmers.

The State Commission for Testing Varieties releases new wheat varieties. Lines are accepted for testing only if they outyield checks in breeders' trials or have a significant advantage in quality or resistance to disease or lodging. The Commission has its own network of trial sites nationwide, which are usually situated on farmers' fields. New varieties are tested for yield and other traits for 3 years. The decision whether to release a new variety or not is made on a regional level during an annual meeting of farmers, agricultural administrators, breeders, and representatives of the Commission with approval in Moscow.

After a new variety is released, a certificate is issued to each member of the breeding team. It specifies the percentage contribution to creation of the variety by each team member. This is important for sharing possible monetary awards. It may be given twice: after three years of testing depending on how many regions it is released in and five years later, depending on the area it occupies. The second award should not exceed 20,000 rubles (US$2000-3000 at the 1989-1990 exchange rate) and is shared by the co-authors according to their contribution. The actual contribution (percentage for each breeder) is publicly agreed upon prior to the submission of a new variety to the State Commission. There are about 20 new spring and 20 winter wheat varieties submitted to the State Commission every year.

A wide assortment of varieties are cultivated nationwide. For instance, in 1988 there were 144 winter and 130 spring wheat varieties under cultivation. At the same time, a relatively small number of varieties are grown on huge areas. In 1988, six winter wheat varieties occupied 41.2% of the winter wheat area (leading variety--Mironovskaya 808 on 3.16 million ha) and 10 spring varieties were cultivated on 59.5% of the spring wheat area (leading variety--Saratovskaya 29 on 9.87 million ha). See Appendix 3 for a list of new spring bread wheat varieties submitted to the State Commission in 1991. Appendix 4 lists recently released wheat varieties (1985-91) in the former USSR currently available in the CIMMYT Bread Wheat Section.

Regional Agronomic Practices and Breeding

Regional subdivisions in the Russian Federation and Ukraine are based on economy and agricultural practices. These were accepted by government and relevant institutions and effective in 1991 and in most cases still are.

Russian Federation
Central Region--Winter wheat prevails in the Central Region (0.97 million ha) over spring wheat (0.15 million ha) although cold temperatures in winter can be quite severe (down to -35^{o}C). Winter wheat does not survive one year in five, but the yield advantage makes the risk worthwhile. Soil is not fertile (2-3% of humus), but the region has sufficient precipitation (450-550 mm). The government has exercised a special investment policy in the region aimed at increasing agricultural production in this highly-populated urban area. Availability of fertilizers and chemicals makes it possible to increase cereal yields. The grains are mainly used for animal feed.

The best preceding crop for winter wheat is bare fallow, which is kept free from weeds. Manure is applied during summer. One option is planting maize for silage or an oats/legume mixture harvested in July. The optimum planting date for winter wheat is during the first 10 days of September. Snow cover lasts from mid-November to mid-March. Once the field is free of snow, nitrogen (20-40 kg/ha) is applied. Chemicals against diseases (leaf rust, powdery mildew, Septoria) are applied once or twice during the growing cycle. Winter wheat is harvested in mid-July.

Spring wheat usually follows legumes or winter rye or potato. It is planted in late April/early May and harvested in August. The main soil preparation is made in autumn--application of fertilizer followed by plowing. In spring, there is a slight pre-planting cultivation when the soil is ready. Spring wheat is planted as early as possible to take advantage of moisture left in the soil after the snow melts. This is true not only for Central Region but for other spring wheat producing areas as well. Even if cold weather and snow come after planting, it seldom damages the crop.

The leading breeding institution in the Central Region is the Agricultural Research Institute of the Non-Black Soil Zone situated on the outskirts of Moscow (founded in 1931). It has a well equipped and highly professional staff mainly because of the proximity to Moscow.

The main problem winter wheat breeders face is combining winter hardiness with lodging resistance. Semidwarf wheats bred in Krasnodar or other southern institutions cannot survive the winter here. The dominating cultivars in the region are either the old, tall variety Mironovskaya 808 or its derivatives. A real breakthrough occurred 3-5 years ago when the institute released a new variety, Inna, which combines high yield, semidwarf stature, and acceptable winter hardiness (V. Kruppa, pers. comm.).

The spring wheat program at the institute has been very successful. The variety Moskovskaya 35 has spread all over the European part of Russia and occupies more than 1 million ha. The program widely uses winter x spring crosses to increase the yield potential of spring varieties.

Volgo-Vyat Region--This region, being a marginal area for both winter and spring wheat cultivation, does not have a wheat breeding program. Varieties from the Central Region and Ural are cultivated here on a relatively small area (0.47 million ha).

Chernozem Region--Mostly winter wheat is cultivated here accounting for 1.6 million ha compared to 0.02 million ha of spring wheat. The region has very good, fertile soil (5-7% humus), but cold winter and limited precipitation do not allow producing as much as in regions further south. Agronomy practices are similar to those of the Central Region.

The main breeding center--the Central Chernozem Zone Agricultural Research Institute founded in 1931--runs winter and spring wheat programs, but so far has not been very successful. For winter wheat, environmental conditions require high winter hardiness coupled with drought tolerance. The institute has released a number of winter wheat varieties with very good winter hardiness, but they cannot compete with Mironovskaya 808, which is the leading variety in the zone.

Spring wheat breeding has been more successful with some adequate varieties released and cultivated, although on a small scale. The recent success has come from the durum wheat breeding program, which released a semidwarf variety named Svetlana that is high yielding with good drought tolerance. It has been accepted for cultivation in the region and areas outside.

Volga Region--This is a traditional area of spring wheat cultivation (1.98 million ha of both bread and durum wheats) as well as winter varieties (1.85 million.ha). Unique environmental conditions (droughts and relatively fertile soil) reduce yields, but allow for extremely good grain quality. Yields for spring wheat exceeding 2 t/ha and for winter wheat exceeding 3 t/ha are considered very good. Sometimes frosts will kill winter wheat across huge areas; and drought can reduce spring wheat yields to below 1 t/ha.

Agronomy practices for winter wheat are aimed at creating conditions favorable for winter survival. It means a good preceding crop, i.e., fallow, early harvested forage crops, grasses that allow carefully prepared soil for planting, or a row of high crops like mustard planted every 10-15 m to keep snow from being blown by the wind. Planting and harvesting dates are similar to those of the Central Region.

As far as spring wheat is concerned, agronomic practices are aimed at keeping moisture in the soil. The soil crust is destroyed by tractor-pulled harrows to prevent moisture evaporation. This can also be repeated several times after planting and seedling emergence. Fertilizers are applied depending on their availability, but priority is given to phosphorus application at sowing. Planting density is 350-400 seeds/m^2.

Durum wheat is also cultivated in this region. The government policy was to encourage farmers to grow more durum wheat by increasing prices for good quality durum grain. This crop is believed to be more sensitive to stresses than bread wheat and needs the precise agronomy to provide good yield. For this reason, many farmers still prefer to grow bread wheat which yields more.

The Agricultural Research Institute of the Southeast, situated in Saratov and founded in 1910, used to be and still is a leading institution in spring wheat breeding in the country. Its early success was associated with A.P.Shekhurdin, who worked at the institute from 1911 to 1951. Before the actual breeding program started, the peasants cultivated very well adapted landraces of bread and durum wheat like Poltavka, Beloturka, Rusak, Khivinka. The selection of one line from the landrace Poltavka resulted in the variety Lutescens 62, which was released in the early 1920s and was under cultivation for more than 50 years . In 1956, it occupied an area of around 7 million ha (Iljina et al. 1986).

Dr. Shekhurdin started hybridizations in 1912. One cross between the bread wheat Poltavka and the durum landrace Beloturka followed by 10 years of individual plant selection resulted in the varieties Sarrubra and Sarrosa. They combined relatively high yield, drought resistance, and excellent breadmaking quality. These two varieties became progenitors for a chain of Saratov wheats (57 varieties) produced since then. The real masterpiece was the variety Saratovskaya 29, first released in 1950 and still cultivated on huge areas. When new lands in northern Kazakhstan were brought into cultivation, Saratovskaya 29 was the variety grown there. As a result, it occupied an area of around 21 million ha nationwide in the early 1970s (Iljina et al. 1988).

The strategy of spring wheat breeding in Saratov was determined by two factors: 1) new varieties had to have a high level of drought tolerance or would yield little and 2) the Volga Region is a traditional area for producing grain with excellent breadmaking quality, which used to be exported to Europe. The only way to increase yield considering these two factors was to cross local germplasm and to accumulate favorable genes step by step. Apparently, almost all the varieties from Saratov are based on local material. Only three foreign parents have been used in the origin of new varieties--Nadadores 63, Selkirk, and Kitchener. There is a strong belief in Saratov that a significant increase in yield potential would ruin the unique genetic structure of the varieties responsible for drought tolerance and breadmaking quality. Many wheat breeders in other parts of the country doubt this is true. In any event, the varieties produced in the last 10-15 years at Saratov do not compete very well with germplasm from other programs.The breeding efforts in Saratov did result in an unique xeromorphic type of wheat that is popular in many drought-affected regions. The varieties are normally relatively tall (100-120 cm) and have narrow leaves covered with hairs. The color of the leaves and stem is blue-green due to a layer of wax. Spikes are awnless and of medium size. Tillering capacity is limited to one to three productive spikes per plant.

The other plant breeding center in the region--Samara Agricultural Research Institute in Bezenchuk--demonstrates that a different breeding approach to these environments may be also efficient. The breeding work started here in 1912 and originally its objectives and methods were similar to those at Saratov. However, for the last 15-20 years, a new generation of breeders has widened considerably the germplasm used for crosses. Breeders now cross the best spring and winter type wheats from many countries (including CIMMYT) to local lines and sometimes make topcrosses. A number of varieties has been produced.

There are a few more agricultural stations that breed wheat in the region. Although they are not as advanced as the Saratov and Samara, their varieties are sometimes very successful and maintain a healthy competition in the region.

Winter wheats are also bred in the region in several institutions where winter hardiness is the main trait concentrated on. Although some winter wheat varieties have been released,they cannot compete with Mironovskaya 808, major winter wheat variety in the region.

North Caucasus--Farmers in North Caucases are the country's main producers of winter wheat--some 4.15 million ha. The area, characterized by high soil fertility and warm winters, is the highest-yielding wheat zone in Russia and supplies the southern part of the country with its wheat. Farmers' yields range from 3.0 to 6.0 t/ha.

This is a high-input area with sufficient amounts of fertilizers and chemicals being applied. Winter wheat is sown in September and harvested in June. It usually survives the mild winter and if not, it is replaced by March-sown spring wheat or barley. Frost resistance and winter hardiness are not of high priority as long as the germplasm has a certain level of tolerance.

Wheat breeding started in 1920 at the Kuban Research Station in Krasnodar (now Krasnodar Agricultural Research Institute). Initially, the mere selection from cultivated variety populations was implemented. In 1930, A. Lukjanenko became leader of the wheat breeding program. His main approach was to cross geographically diverse genotypes in order to combine high yield and wide adaptability. During his life, he created 50 varieties. The first success, Novoukrainka 83 released in the late 1930s,outyielded existing varieties by 30-40%. The real triumph of his work was variety Bezostaya 1 cultivated on area exceeding 11 million ha in 1972. It was followed by varieties Aurora and Kavkaz, which obtained the 1B/1R translocation from western European varieties. They certainly outyielded Bezostaya 1, but they were inferior in breadmaking quality. Their high level of leaf rust resistance bestowed by major genes was attractive to growers, but once the resistance was overcome by pathogen mutation, they lost their advantage (Dorofeev et al. 1987).

Prof. Lukjanenko died in the field from a heart attack rumored to be caused by the appearance of rust on his new varieties Aurora and Kavkaz. There is a monument on the spot commemorating his contributions to wheat breeding and agriculture. Prof Lukjanenko is highly regarded in the country as a breeder and agriculturist. An award in Lukjanenko's name is given every 3 years for outstanding accomplishments in wheat breeding/research.

Y. Puchkov succeeded Lukjanenko as head of the wheat breeding program. A strong team of breeders at Krasnodar have produced a set of varieties characterized by high yield potential, superior bread making quality, and resistance to important diseases like leaf rust, septoria, and powdery mildew. All the varieties are semidwarf having the mutant Rht gene from Krasnodari Dwarf 1. The breeding system is based on a large number of crosses (1000-1500 annually) and corresponding material screened every year. The Institute is well equipped and well financed mainly by rich state and collective farms that do well by growing high quality wheat.

Donskoi Agricultural Research Institute in Zernograd, Rostov reg., established in 1930 is another successful breeding center. During 1960-83 period, the institute released 13 winter wheat varieties that occupied around 20% of wheat area in the Russian Federation. Wheat varieties are aimed at two environments--those with very high yield potential cultivated after a good previous crop and those having wider adaptability placed after crops that are not favorable in the crop rotation. In general, varieties bred at Donskoi are similar to those from Krasnodar. They are also high-yielding with excellent breadmaking quality and semidwarf in stature (Dorofeev et al. 1987).

These two institutes compete and hence provide a good choice of varieties for farmers in the area. Moreover, other winter wheat breeding programs are benefitting from their success by using new germplasm in crosses.

Ural Region--This region has variable environmental conditions. Its northern mountainous part has more or less a sufficient amount of precipitation while the southern part is often affected by drought. Yield is higher in the northern part, but southern areas produce higher quality wheat. This is a steppe zone that is affected by wind-caused soil erosion. Agronomic practices are aimed at preventing soil erosion (moldboard plowing is seldom done; only chiseling is done to keep the upper soil layer undestroyed) and maintaining soil moisture. Spring wheat is sown twice on the same fields in succeeding years followed by 1 year of fallow.

Wheat breeding for the northern part is done at the Krasnoufimsk Breeding Station near Ekatirinburg. The breeders have produced a number of varieties of different maturities. Krasnoufimsk varieties, more oriented to yield potential than drought tolerance, have acceptable grain quality although not as good as Saratov wheats. Earliness is quite important here because, due to late planting and cold summers, wheat may be exposed to early killing frosts. The crosses involving Scandinavian varieties (Diamant, Svenno, and Pompe) have been successful and produced a number of varieties used by farmers (Dorofeev et.al. 1987). Generally speaking, Swedish varieties have good adaptation for some areas of the USSR, including the Central Region and Siberia because they combine earliness, yield potential and good breadmaking quality. They are not well adapted to drought conditions.

The main breeding center for the south is Kurgan Agricultural Research Institute, Kurgan reg., which started intensive wheat breeding in 1974. Three recently released varieties, resulting from one winter x spring cross (Bezostaya 1/Saratovskaya 29), combine relatively high yield potential (up to 5 t/ha), drought tolerance, and good breadmaking quality (Dorofeev et al. 1987).

Western Siberia--Spring wheat, the main crop (5.6 million ha), is sown in the first half of May. Environmental conditions are characterized by late spring-early summer drought, which lasts for approximately 1 month. A particular wheat type has been developed for the region, which at the 3-4 leaf stage, the plant stops growing and only tillers as it waits for the first summer rains. This particular kind of development significantly increases the level of adaptability to the type of drought that dominates in the region. However, the varieties are late and likely to be affected by rains and frosts in September.

Of the many wheat breeding programs in the region, the Siberian Agricultural Research Institute situated in Omsk is probably the leading one. The variety Milturum 553 (based on a cross with Kitchener) dominated in the region during the 1940-60 period, until it was replaced by Saratovskaya 29. A number of new good varieties have been developed in Omsk over the last 20 years, namely Omskaya 9, 12, 14, 17, and 19; Sibiryachka 4; and Irtyshanka 10. The crossing strategy was to transfer wide adaptability and other traits from the best winter varieties to spring germplasm. Many varieties originated from crosses between Bezostaya 1 and Mironovskaya 808 on one hand and Saratovskaya 29 on the other. The simple breeder's rule, "cross the best to the best", worked in this case. Varieties from Norway (Lade) and the USA (FKN 25, Red River, and Heines) are in the pedigrees of recent varieties (Aziev et al. 1989). The wheat breeding program at Omsk is considered very strong and competes with Saratov for leadership in the nation's spring wheat breeding.

The Siberian Institute of Crop Production and Breeding in Novosibirsk has also contributed to wheat production in the region. Its most popular variety, Novosibirskaya 67, is probably the only cultivated spring wheat in the country created through mutagenesis--it was made by gamma-ray application of an old variety. Recent efforts include crosses between locally adapted germplasm and winter varieties as well as the best foreign material.

Eastern Siberia--The region, which has a spring wheat area of 1.85 million ha), has a limited frost-free period that makes earliness a high priority along with drought tolerance. The Krasnoyarsk Agricultural Research Institute released a number of early varieties (Skala, Zarnitsa, Krasnoyarskaya, and Taezsnaya) with relatively high yield potential. They originate from the crosses made mainly within the local gene pool or early Canadian varieties with good breadmaking quality.

Kazakhstan

The northern and central parts of Khazakhstan cultivate spring wheat as a major crop (13.2 million ha). Since the late 1950s when millions of hectares of new lands were brought under cultivation, Kazakhstan became the second highest producer of wheat grain (after the Russian Federation), accounting for as much as 30% of the land in the USSR devoted to this crop. Although the yield here is usually not high (2 t/ha in the best years), the grain produced has extremely good breadmaking quality with the protein content at 17-18%.

The common crop rotation system is based one year of fallow followed by two succeeding years of wheat cultivation. Agronomic measures try to prevent soil from wind erosion and to maintain soil moisture. Inputs are not high in this area and can be limited to moderate applications of fertilizer, seed treatment, and most necessary crop protection measures.

There are naturally many spring breeding programs working for this part of Kazakhstan. The most famous and successful one is former All-Union (now Kazakhstan) Institute of Cereals Production at Shortandy. Its breeding activity started well before the cultivation of new lands. The variety Akmolinka 1 (originated from Marquis) was released in 1945 and cultivated for 20 years. Saratovskaya 29 was the main variety on newly cultivated lands only recently being replaced by new germplasm from Shortandy and Omsk. These new varieties--Tselinnaya 20, 21, 26, 90, and Tselinnaya Ubileinaya--were derived from crosses made between local germplasm and Saratovskaya 29. They have better resistance to lodging and higher yield potential although in a plant type similar to Saratovskaya 29; breadmaking quality is excellent.

Other institutions working for the spring-sown areas of Kazakhstan are Karabalyk Agricultural Research Station, Karaganda Agricultural Research Station, and Severo-Kazakhstanskaya Agricultural Research Station.

The southern part of Kazakhstan has environmental conditions that favor both winter and spring wheats. Breeding objectives are different from the north. The comprehensive breeding program for both types of wheat is concentrated at the Kazakhstan Research Institute of Crop Production near Alma-Ata. New winter wheat varieties (Krasnovodopadskaya 26, 210, Bogarnaya 56, Karlygash, and Opaks 1) are based on Bezostaya 1 or Kavkaz. They are high-yielding and well adapted to local environments. A number of spring varieties was also released that vary in their adaptability type, which depends on the environment they are aimed at (Dorofeev et al. 1987).

Middle-Asian States (Turkmenistan, Kirgizstan, Uzbekistan, and Tadzikistan)
The Middle-Asian States have a long history of wheat cultivation. In fact, wheat was brought here by Neolithic tribes from Iran in the 7th century B.C. Many local landraces were cultivated at the beginning of the 20th century. In 1913, wheat was cultivated on 1.8 million ha with 75% being irrigated. After the 1917 revolution and following economic development, the area under wheat has gradually declined. It became more economic to import wheat from other regions by train and to cultivate cotton instead. Recent data on wheat area are not available, but is estimated to be no more than 1 million ha.

Winter, facultative, and spring varieties are grown mainly in mountain valleys. Irrigation is desirable, but generally environmental conditions are favorable for wheat cultivation. The highest wheat yield ever recorded in the USSR was obtained here (variety Lutescens 46--11.85 t/ha) (Dorofeev et al. 1987). There is at least one plant breeding center in each wheat-growing state.

The Uzbekistan Research Institute of Grain released a set of facultative varieties during the past 10-15 years. They were selected from crosses between local facultative varieties and Bezostaya 1 (Dorofeev et al. 1987).

The Kirgizstan Research Institute of Crop Production is probably the most advanced in Middle Asia. It combines breeding work with basic research in genetics and physiology of wheat. All types of varieties (winter, facultative, and spring) are bred at the institute. They are characterized by high yield potential, semidwarf stature, and disease resistance (Dorofeev et al. 1987).

Turkmenistan Research Institute of Crop Production started to work with wheat in 1972 in cooperation with the Uzbekistan Institute of Grain. Interestingly, it released a facultative variety, Gyaurs 1, by direct selection from the well known CIMMYT variety, Siete Cerros 66 (Dorofeev et al. 1987).

The Tadzsikistan Research Institute of Crop Production has been breeding facultative wheats to create high-yielding genotypes adapted to high elevation and mountainous climates. Two varieties were released in the 1980s based on local germplasm (Dorofeev et al. 1987).

The Ukraine
The Ukraine is subdivided into three main ecological zones: 1) Polesje in the north, 2) Lesosteppe in the central, and 3) the Steppe in the south (Shivotkov et al. 1989). Winter wheat (6.80 million ha) dominates the state; spring wheat is sown only where winter varieties were killed in severe winters. Different breeding institutions have mandates for breeding wheat in one of the three zones.

The Polesje (15% of all wheat) is characterized by variable soils, a sufficient amount of precipitation, and relatively cold winters. Agronomic practices are normal for winter wheats aimed at creating the best conditions for overwintering (Zhivotkov et al. 1987). In this zone, the Ukranian Research Institute of Crop Production makes crosses between local germplasm or the variety Mironovskaya 808 and western European winter wheats that are most promising in terms of yield potential and disease resistance. On the other hand, they lack breadmaking quality important for the zone.

The Lesosteppe Region has milder winters and less precipitation than the north. Winter hardiness is still important here as is some level of drought tolerance (Zhivotkov et al. 1987). The most successful breeding program is represented by the Mironovski Institute of Wheat Breeding. All the respect and honor given to this institute are due to only one variety--Mironovskaya 808, which has an interesting history. Dr. Remeslo, a leading wheat breeder, conducted experiments in line with Lysenko's theory in the 1950s. The spring variety, Artemovka, was sown in the autumn in order to be "educated" to become a winter wheat. The entire plot died except for one plant, which later became the most popular wheat in the country--Mironovskaya 808. Many papers were written that explained how this happened according to Lysenko's theory, but most breeders believe that it was either a mixture or result of a previous cross pollination from nearby winter varieties. Mironovskaya 808 was released in 1963 and by 1968 occupied 7 million ha nationwide and in eight other countries. Relatively tall, it is believed to have durable leaf rust resistance and its bread-making quality is superior. A very important trait is its stable yield under variable conditions and agronomy (Dorofeev et al. 1987).

Since then, the transformation of winter wheats into spring wheats and vice versa has become a routine. Strangely enough it has worked. Mironovskaya 808 transformed back to spring habit gave rise to variety Mironovskaya Yarovaya. Though it has not been cultivated on large areas, it certainly is a good variety. Around 150 spring varieties including those from CIMMYT, India, the USA, and Canada have been transformed into winter types (Dorofeev et al.,1987). The winter wheat Mironovskaya 19 is a transformation of World Seeds 1812. Of course, many varieties were created by hybridization and a number of them are cultivated in Ukraine and Russia.

The Ukranian Institute of Breeding and Genetics in Kharkov has another Lesosteppe wheat breeding program that started in 1910. Its winter wheat varieties are characterized by good winter hardiness, disease resistance, and semidwarf stature. Many varieties have Mironovskaya 808 in their pedigrees. There is also a strong spring wheat breeding program in Kharkov where a breeder running both bread and durum wheats managed to create varieties of bread wheat suitable for the spaghetti industry and durum wheat suitable for breadmaking. Spring wheat varieties end up in Russia because there are few places for them in Ukraine (Dorofeev et al. 1987).

The Steppe Zone, a major producer of high quality wheat grain, has mild winters but affected by drought and sometimes heat during spring/summer. Winter wheat is sown (500-600 seeds/m^2) in mid-September and harvested in June (Zhivotkov et al., 1989). The former All-Union Institute of Breeding and Genetics in Odessa is a leading institution. There are two breeding trends: 1) varieties with high yield potential for high-input technologies and 2) varieties with wide adaptability for areas more affected by stresses. There are four separate breeding teams competing with each other. They supply a good choice of varieties for the area that are mainly semidwarf, high-yielding, and with good bread-making quality. Most successful parents are Odesskaya 51, Bezostaya 1, and Kavkaz. The breeders also use in crosses semidwarf spring wheats. Crosses involving Choti Lerma, Red River 68, and Lerma Rojo resulted in a number of new winter wheat varieties. The institute is very well equipped, conducts basic research, and used to be a coordinator of winter wheat breeding in the country. It also had strong ties to institutions in other socialist countries like Bulgaria, Yugoslavia, and Hungary (Dorofeev et al. 1987).

Irrigated winter wheat is cultivated in southern Ukraine and accounts for 35% of all cereals. The Institute of Irrigated Crop Production situated in Kherson produces semidwarf, lodging-resistant varieties with yield potentials between 8.0 and 9.5 t/ha. Recent varieties (Khersonskaya 153, 170 and Khersonskaya Jubileinaya) satisfy these requirements (Dorofeev et al. 1987).

Wheat breeding programs also exist in the Baltic States, Armenia, Azerbaigan, Georgia, and Moldova, but the area under wheat cultivation is small compared to the ones just discussed.

Breeding Objectives

Yield potential

Yield potential is one of the main objectives in wheat breeding in the USSR. The State Commission for Testing Varieties does not accept new varieties unless they outyield the existing check. In many cases, new high yielding varieties accepted for cultivation do not increase yield in farmers' fields. This was demonstrated by many impact studies in wheat and barley.

Usually, agricultural research institutes are more advanced in technology and for spring wheat they may provide yield of 4-6 t/ha. The trial sites of the State Commission are less advanced, but still better (3-4 t/ha) than farmers' fields (1.5-2.5 t/ha). The initial idea was that by the time new varieties reach farmers, they will advance their technology. It never happens. So, a new variety with yield potential higher than the check can demonstrate an advantage in Commission trial sites, but after release it does not show any yield increase when cultivated by farmers--it may even yield less in some unfavorable years. The yield gap between research institutions and farms is less for winter wheat. Anyhow, there are many examples when new recommended high-yielding varieties were rejected by farmers who prefer to grow old varieties with stable yield performance.

Many breeders realized this situation and 5-10 years ago their attention shifted to wider adaptability. The purpose is to increase the lowest yield under unfavorable conditions, which are the norm, instead of building up high yield potential with little chance to use it. Of course, the particular situation depends on the region. For instance, agriculture in the North Caucasus is well advanced and has favorable conditions. High-yielding varieties from Krasnodar are accepted by farmers and demonstrate their advantage in the field. But for the majority of spring wheat areas, the ability to provide reasonable yield under stress is more important than high yield potential.

In practice, almost every wheat breeding program has two goals: 1) to breed so-called intensive varieties for high-input technologies and 2) to develop semi-intensive varieties that fit ordinary agronomic practices. These goals are achieved by manipulating fertilizer rates, sowing dates, and crop rotations to simulate real situations in the region, and by studying the adaptability patterns of new varieties. Multilocational testing is also popular.

Plant height is an important trait as far as yield potential is concerned. Winter wheat varieties cultivated in North Caucusus or in the southern Ukraine are semidwarfs (70-90 cm). High yield requires good lodging resistance and an acceptable level of winter hardiness for these areas and could be achieved with semidwarf germplasm. More to the north in other winter wheat areas, moderately tall or tall varieties (90-120 cm) are mainly grown. As mentioned earlier, there is a positive correlation between plant height and winter hardiness. Many high-yielding semidwarfs cannot survive winters in the Central and Volga Regions.

Practically all spring wheat varieties are moderately tall or tall. Semidwarfs are believed to be more susceptible to stresses and drought particularly. Some years when it rains little the height of tall plants becomes 70-90 cm. In this case, semidwarfs are 40-60 cm, which makes machine harvesting difficult. The other reason why many farmers prefer tall varieties is that they collect the wheat straw after harvesting and in some years give it to cattle in winter or often use for bedding on the lay down floor.

Tolerance to abiotic stresses

Winter hardiness--Winter hardiness is crucial for winter wheat production throughout the country. In areas like Volga or Central Russia, the minimum temperature can reach -35°C. A thick snow layer (30-60 cm) is necessary to keep temperature at a point that the crop withstand (-10 to -15°C). Winter hardiness is a complex trait that can be subdivided into more basic components: 1) frost tolerance, 2) tolerance to waterlogging, 3) tolerance to ice cover, and 4) resistance to *Fusarium nivale*. The relative contribution of each trait towards winter hardiness depends on the environmental conditions of particular area. In many cases, frost tolerance is the most important. Germplasm with a high level of frost tolerance is available in many breeding programs; this includes Mironovskaya 808 and some relatively old varieties from the Volga Region.

There are many field and laboratory methods of screening for winter hardiness and its components. The most popular is to keep plants sown in boxes free from snow, but exposed to frost; survival rate is then estimated every 15-20 days. The genetic and physiological aspects of winter hardiness are well explored in the country, which help breeders to choose appropriate strategy.

Drought--Drought affects spring wheat in Volga, Ural, Siberia, and Kazakhstan. Around 80% of the droughts affect plants from the tillering stage to flowering (Dorofeev et al. 1987). Droughts during the grain filling period are rare. Areas producing spring wheat have a continental climate and, very often, if drought does come it covers millions of hectares causing a real agricultural disaster.

There are many approaches to drought tolerance breeding. Breeders may concentrate on morphology of the plant (like Saratov xeromorphic wheat), the pattern of wheat plant development (like in Siberian wheat), the strength and penetration of the root system, and many others. In fact, different approaches have proven to be relevant in producing germplasm with a high level of drought tolerance. It indicates that this trait is complicated and it is unlikely to expect easy progress, especially in combining drought resistance and high yield. Many methods of screening for drought tolerance are used by breeders. There is also an extensive study of wheat under drought going on in many regions.

Other abiotic stresses--There are other stresses of varying importance that affect wheat: heat in Volga, Ural, Siberia, and Kazakhstan; acid soils in Central Region, salinity in Western Siberia, and cold temperature at maturity in Eastern Siberia, micronutrient deficiency.

Disease resistance

The main diseases that affect wheat are leaf rust (*Puccinia recondita*), powdery mildew (*Erysiphe graminis*), loose smut (*Ustilago tritici*), common bunt (*Tilletia caries*), and root diseases. Yellow (*P. striiformis*) and stem (*P. recondita*) rusts and *Septoria* spp. may be observed occasionally as well.

Leaf rust is most widespread in North Cuacasus and Ukraine although it is often observed in all spring wheat-producing areas. It is transmitted by wind from early winter wheat from the south to the north of the country. Often, it comes to spring wheat too late to damage the crop. Anyway, resistance to leaf rust is one of the objectives in wheat breeding in all regions.

The genes effective so far against the pathogen are *Lr9*, *Lr19*, *Lr24*, and *Lr25* (Zhivotkov et al. 1988). *Lr23* has been recently overcome by the pathogen, which affects many varieties. There is no agreed strategy among wheat breeders as to which genes to use in different areas. Moreover, winter wheats are used by spring wheat breeders as sources of resistance and vice versa. It makes the wheat area uniform in terms of the genetic background that protects against leaf rust. There are a few examples of recent varieties that are immune to leaf rust. A spring wheat from Saratov called Samsar for instance has resistance transferred from *Aegilops*. Some varieties have various levels of resistance, probably due to minor adult stage resistance genes. There are also examples of durable resistance: the winter wheat Mironovskaya 808 and the spring wheat Moskovskaya 35 which have not been explored in terms of genetic structure.

Powdery mildew mainly affects wheat in the European part of the USSR where moderate temperatures and humidity favor the development of the pathogen. Genes *Pm2+Pm6* and *Pm4b* are efficient (Zhivotkov et al. 1989). There are no immune varieties. Only a limited number of genotypes have low levels of infection. Tselinnaya 20 and 21, Saratovskaya 48, Botanicheskaya 2 and 3, and Kutulukskaya are among them (Dorofeev et al. 1987).

Loose smut used to be a major disease in Russia during the first quarter of the century. Although it still damages spring wheat, seed treatment and new varieties keeps yield loses low (Dorofeev et al. 1987). Although a number of chemicals exist for seed treatment, breeders try to incorporate genetic resistance into new varieties. Resistance reported to be under polygenic control (Dorofeev et al. 1987) although McIntosh et al. (1988) listed four major genes. There is a choice of sources of resistance in adapted germplasm. Many breeders transfer the gene(s) to new varieties by backcrossing within 2 years using greenhouses.

Common bunt is also widespread. Resistance genes efficient against the pathogen are *Bt5*, *Bt6*, *Bt9*, and *Bt10* (Dorofeev et al. 1987). Extensive screening of germplasm shows that immune varieties do not exist at least within the gene pool from the USSR. Only a few varieties demonstrate resistance: Kharkovskaya 6, Mironovskaya 4, and Zarya. Variety Bezenchukskaya 98 possess durable resistance to the pathogen having been cultivated for more then 40 years without breakdown.

Root diseases are caused primarily by *Fusarium* and *Helminthosporium* spp. and also by *Cercosporella herpotricoides* and *Ophiobolus graminis*. The former two affect both winter and spring wheat, especially in cool rainy years in crop rotations where wheat follows wheat or other cereals. There are no completely resistant varieties (Dorofeev et al. 1987). It seems that resistance depends on many factors like plant morphology, the pattern of plant development, the root system, and to a great extent conditioned by the environment. So far, there is no clear strategy for breeding resistant varieties. Breeders mainly rely on screening of advanced lines on fields heavily infected with the pathogens.

Generally, breeding for disease resistance is implemented in cooperation with plant pathologists. At a given breeding center, the pathologist might be a member of a breeding team or more often belong to pathology lab, but in any event he works closely with breeders. The pathologist's responsibility is to create artificial infection in breeders' plots as well as to evaluate separate plots or to look at races of different diseases in the laboratory. There are a few large research institutes specializing in pathology that supply breeders with spores and make some more complicated evaluations of breeding material.

Breadmaking quality

The strategy of breeding for breadmaking quality is determined by the government policy to reduce the amount of wheat grain imported from the USA and Canada. The State Commission for Testing Varieties may not accept a variety if breadmaking parameters are below certain level. Very often, this appears strange because only 30-40% of grain is used by bread industry. Nearly half of the production is feed for animals. A small part is used in cookie industry and in alcohol production. Some areas that never actually produce grain for breadmaking are encouraged to cultivate varieties with superior quality instead of higher yielding wheat for livestock feed. In addition, soft wheat does not exist in the country although the cookie industry consumes millions of tons of hard grain. There are only a few released feed varieties. The consequence for the breeders is to create breadmaking quality wheat independently whether the region produces such grain or not.

There are three grades of quality in the country: 1) superior, 2) very good, and 3) satisfactory. Superior wheat should contain more than 14% protein, more than 32% gluten, and an alveograph value of more than 280. Once a new variety is released, it is given a grade. Farmers producing grain of superior quality which meets requirements can sell it at prices 2-3 times higher than for ordinary wheat. Breeders can also receive a higher monetary award if they release superior quality wheat.

To a great extent, this policy influences wheat breeding in the country. For example, the 1B/1R translocation, which demonstrates a worldwide advantage in yield and adaptability, is very rare in varieties from the USSR. Many good varieties were not released because of grain quality. Breeders take incredible efforts to keep yield and quality parameters high.

Breeding for quality is based on traditional methods. Almost all plant breeding centers have up-to-date equipment for quality evaluation. Electrophoresis of gliadins is widely used to screen for bread-making quality since Sozinov and Poperelya (1980) showed that some bands correlate with good quality. Strangely, high-molecular weight glutenins are not used in breeding for quality.

There is also a sprouting problem in many areas, especially in the Central and Volga Regions, Northern Ural, and sometimes Siberia and Kazakhstan. The majority of wheat is harvested in a two-stages process. First, wheat is cut at the wax maturity stage and left in the field in rows for 7-10 days; then it is threshed. This allows for weed seed-free grain and uniform drying. If it rains for a few days during this period, the crop can be damaged by sprouting.

Almost all winter wheat varieties have red grain color, but around 30% of spring varieties have white grain. There is variability for sprouting resistance within each class of grain color. Breeders use different methods for screening. They are mainly based on exposing spikes to high humidity and evaluation of falling number afterwards.

Wheat Breeding Systems in the USSR

The common wheat breeding system in the USSR is determined by the requirements of the State Commission for Testing Varieties. The Commission does not require complete homogeneity of new varieties such as is the case in many European countries--members of UPOV. For this reason, wheat breeders aimed at a level of homogeneity that allows new varieties to look more or less uniform in the field without taking into account such things as biochemical or other markers. In addition, there is a belief among a number of breeders that heterogeneity of a variety provides more stable yield and wide adaptability in varying environmental conditions due to compensating effect of different biotypes of a variety. There are examples in favor of this theory as there are those that show opposite results. For instance, the widely cultivated winter wheat Mironovskaya 808 is reported to be heterogeneous while the spring variety Saratovskaya 29 is homogeneous. They both are cultivated on huge areas and provide relatively stable yield.

The pedigree method of breeding is not used for wheat in the USSR. Figure 2 shows the typical seven-stage wheat breeding scheme, which represents only a general breeding system. In reality, it probably does not exist because there are as many variants as there are breeders in the country.

Stage			
A	1st year	P1 x P2	Crosses made
B	2nd year	F1	Seed multiplication, discard poor crosses
C	3-4th year	F2-F3	Individual plant or head selection
D	4-5th year	F3-F4	Small plot (single or double row) observation, bulk of selected lines
E	5-6th year	F4-F5	Unreplicated yield test (3-5 m^2 plot), bulk of selected lines
F	6-7th year	F5-F6	Replicated (2-3 reps) yield test (5-10 m^2 plot), bulk of selected lines, head selection from the best lines for seed purification
G	7-11th year	F6-F9	Full-scale yield trial (4 reps, 10-25 m^2 plot, 2-3 locations) selection of the best lines, submission to the State Commission

Figure 2. Common wheat breeding procedure in the USSR.

Stage A
The number of crosses differs from program to program and mainly depends on the breeder's approach. One of them is to pollinate 12-15 spikes per cross thus making fewer crosses in total and another is to pollinate 2-3 spikes per cross resulting in a larger number of crosses. The first approach is more popular and believed to create a sufficient level of variability within the F2 population. Breeders usually practice the so-called Krasnodar method developed by Lukjanenko when a cluster of 5-8 closely situated spikes are emasculated and covered by one bag along with 8-10 paternal spikes which stay in a bottle or can with water. Two-way crosses are the most popular although some backcrosses are made with special purposes. One wheat breeding program makes 200-400 crosses annually on the average, but large and strong programs like in Odessa or Krasnodar may be well above 1000.

Stage B
F1s are multiplied under favorable conditions in order to obtain more seeds. Some of them are discarded based mainly on disease performance or productivity traits. Recently, spring wheat breeders started to use greenhouses for the F1 and even F2 multiplication during winter season. It certainly speeds up breeding, but has some disadvantages like lower yield comparing to the field, limited possibility for evaluation, and very high cost especially in cold areas where difference in outside/inside temperature is around 50oC.

Stage C
The selection of individual plants takes place starting from the F2 or F3 and may be continued in later generations for the best crosses. The populations are either space- or solid-planted, depending on the area and selection objectives. For spring wheat, tillering ability is not very important in most of the areas so the populations are planted solid, but with reduced plant density (300-400 seeds/m^2) comparing to farmers' fields (500-550 seeds/m^2). In this case, head selection is done. For winter wheat, tillering is more important, so it may be space-planted and individual plants are selected. In both cases, the population size of 1000-3000 plants seems to be appropriate. While selecting in segregating populations, breeders pay attention to height, disease resistance, plant type, and maturity like elsewhere in the world.

Stage D
The number of lines screened in this nursery may amount to 5000-10000 in the average program. The layout depends on availability of machinery, but it is usually double or triple row and around 0.5 m2. Visual selection takes place here considering plant type, disease resistance, etc. Head selection from promising but heterogeneous lines may also be done.

Stages E-F
These steps are virtually unreplicated (or 2-3 reps) preliminary yield trials on plots of larger size from year to year, depending on the availability of seeds. Some breadmaking quality parameters may be taken as early as stage E or sometimes even D. Reaction to diseases may be estimated on separately sown plots with artificial inoculation. The seed purification procedure may start at stage F for most promising lines. The breeders have to supply 3 t of certified seed when they submit a new variety to the State Commission. So the simultaneous pure seed preparation takes place while yield trials are under way. This is done by breeders and this, to some extent, eliminates heterogeneity picked up in the F2-F3.

Stage G
The final yield trials usually have four replications and 3-years' data are necessary prior to submitting a new variety. All possible evaluations are made here including stress tolerance and more detailed analysis of grain quality. Many breeding programs have a network of sites for multilocational testing within their region. This may start at earlier stages as well in order to estimate adaptability levels. Usually, the lines performing better than the checks in different locations are selected.

Durum Wheat Breeding

Spring durum wheat is mainly cultivated in the Volga Region, Ural, Siberia and Kazakhstan. Some is grown in Chernozem Region, and Ukraine.

The first varieties released after the revolution in 1917 were selections from local landraces cultivated before in the Volga Region, Ukraine, and Kazakhstan. They were also used as parents in crosses. Resulting varieties--Melyanopus 26, Krasnokutka 6, Bezenchukskaya 139, Kharkovskaya 46, and others--occupied the majority of the durum area during the 1940-1970 period. They are characterized by excellent quality, drought tolerance, and relatively high and stable yield. Most remarkable variety is Kharkovskaya 46 (originated from a cross between *T. durum*, *T. dicoccoides*, and *T. turgidum*) with extremely wide adaptability; it has been under cultivation for more than 30 years in different ecological regions.

A new generation of varieties appeared in the early 1980s, namely Almaz, Altaika, Atlant, Svetlana, Kharkovskaya 3, and 5 and others. Some have reduced height. They are high yielding and responsive to high inputs and more resistant to common diseases. Kharkovskaya 46 is in the pedigree of many of them. Crosses with *T. dicoccoides* showed good potential and resulted in a number of varieties.

Main institutions conducting durum wheat breeding are the Research Institute in Saratov, Krasnyi Kut Breeding Station (close to Saratov), Samara Agricultural Research Institute (Volga Region), Orenburg Agricultural Research Institute (Ural), Altai Agricultural Research Institute (Ural), Siberian Agricultural Research Institute (Omsk), and Ukranian Institute of Breeding and Genetics (Kharkov).

There are several winter durum wheat programs located in the South of the European part of the USSR. The most successful is the one in Odessa where the initial objective was to develop winter durums with yield potential and winter hardiness close to those of bread wheat. The initial crosses involved winter hardy bread wheats and spring durums. Selected winter durum lines were crossed with bread wheat once again to strengthen the winter hardiness. These crosses resulted in varieties Michurinka and Novomichurinka. The following breeding was based on crosses between winter durums and winter bread wheats or between durums. Among the varieties developed, Korall Odesski released in 1985 (Dorofeev et al. 1987) is the most famous. It outyields Bezostaya 1 and has equal winter hardiness. Krasnodar Agricultural Research Institute also has a small winter durum program. Three-way crosses (winter bread x spring durum) x winter durum showed advantage and resulted in promising breeding lines (Dorofeev et al. 1987).

Cultivation of winter durum wheats is limited by its low degree of winter hardiness. Its potential is by no means compared to bread wheat. For instance, there has been a small group working with winter durums in Saratov for 20 years. Although the objective was to improve survival during severe winters, significant progress has not been reported yet.

Performance of CIMMYT Germplasm in the USSR

CIMMYT germplasm initially brought to the USSR in late 1970s attracted breeders' attention. Everybody was talking about the "Green Revolution" and of course the varieties which came from Mexico were put through comprehensive studies in physiology, genetics, pathology, and other sciences in all wheat-producing areas. Breeders naturally started to make crosses. Some varieties were put on trials directed by the State Commission of Testing Varieties. Two or three of them (including Siete Cerros) were released for irrigated conditions in the South.

From a scientific viewpoint, the introduction of CIMMYT germplasm into the country caused an incredible explosion of experiments that looked at dwarfing genes and different aspects of their actions. The general conclusion was that semidwarfs are good, but they need high inputs and irrigation to manifest their yield potential. They are not for the spring wheat areas because they are too short and suffer from drought.

Why has CIMMYT germplasm not been very successful in Russia? It seems that the two advantages that made CIMMYT semidwarfs so popular worldwide--day-length insensitivity and a short stem--are the limiting factors in the USSR. Practically all spring wheats cultivated in traditional areas are day-length sensitive. Being planted in early May, they start heading in late June/early July--in 55-65 days after planting. CIMMYT varieties sown at the same time would be 15-20 days earlier because of their day-length insensitivity. They have only 40-55 days to form vegetative structure. For instance, in the Yaqui Valley, Mexico, this period lasts 75-85 days. As a result, short plants (50-65 cm) are formed with limited tillering. The plants could be constrained even more if drought occurs during this period.

However, CIMMYT germplasm or its derivatives from India and the USA have been involved in at least eight new varieties of both winter and spring types released between 1976 and 1986: Obrii (Red River 68), Zirka (Choti Lerma), Druzina (PV-18), Salut (PV-18), Rodina (World Seeds 1877), Priamurskaya 93 (World Seeds 1812), Aisi (Sonora 63), and Omskaya 17 (Red River 68) (Dorofeev et al. 1987). This is not much taking into account that 40-50 new varieties are submitted every year. However the important thing is that CIMMYT-derived germplasm possesses useful traits that can be transferred to varieties cultivated in Russia and other states.

Many CIMMYT lines or their derivatives were investigated in the network of the N.I. Vavilov Institute of Crop Production in Leningrad. It has many small research stations nationwide. When new foreign germplasm of any crop comes to the country, it first goes to the Vavilov Institute where detailed observations are made on its stations and then the best varieties are recommended to breeders. Many breeders think that this is not efficient because they wait from 3 to 5 years instead of making quick evaluations themselves. So, based on these observations, CIMMYT germplasm was found to be very useful for improvement of particular traits. Six varieties (Bajio 67, Cocorit, PV-18, Nadadores, Inia 66, and Tanori 71) were recommended as sources of earliness, 18 varieties (including Jaral 66, Inia 66, Nadadores 63 and others) for lodging resistance breeding, and varieties Red River 68 and Inia 66 were recommended for breadmaking quality. Nothing was recommended for drought tolerance (Dorofeev et al. 1987).

Table 4. Number of CIMMYT lines/varieties with resistance to diseases in Western Siberia (1971-1984).

Pathogen	Number of resistant* genotypes		
	Total	From CIMMYT	% CIMMYT/total
Leaf Rust	783	239	30.5
Stem Rust	925	305	33.0
Stripe Rust	207	52	25.1
Three Rusts Combined	24	13	54.2
Powdery Mildew	220	17	7.7
Loose Smut	189	13	6.9
Common Bunt	335	15	4.5

* Reaction 0, R, or MR.

CIMMYT germplasm turned out to be especially good in regard to disease resistance. The Siberian Agricultural Research Institute in cooperation with N.I.Vavilov Institute made a comprehensive study that screened for disease resistance in 1971-1984 (Shirokov et al. 1988). The survey included more than 4000 spring wheat genotypes from all continents. CIMMYT germplasm was reported to have a high level of resistance to rusts (Table 4).

On average, one third of all varieties resistant to rusts originated from CIMMYT. Considering combined resistance to the three species, CIMMYT accounts for 54.2% of such genotypes. Figures for bunt, smut, and powdery mildew resistance are not as impressive, but still give breeders access to resistant lines with semidwarf stature. There is not much difference in the population of rusts in Siberia and the European part of the country. So, the same lines could be used in breeding programs situated in Volga Region or Ural.

Unfortunately the flow of CIMMYT germplasm into USSR has not been regular and is unpredictable. More recently, it used to be forwarded to Krasnodar and Odessa--places very marginal for spring wheat cultivation. At the same time, leading spring wheat breeding centers in Saratov, Omsk, Shortandy receive it via the N.I. Vavilov Institute with a 3- to 5-year delay. For this reason, it is difficult to describe the performance of more recent CIMMYT lines. They either have not yet reached breeders or are still under investigation.

Performance in Mexico of Varieties from the USSR

Varieties from the USSR are rarely seen in CIMMYT plots although the winter wheat Kavkaz did contribute to the development of the successful Veery family of lines. The most comprehensive study of spring wheat varieties from the USSR in Mexico was conducted in Escuela de Agronomia y Zootecnia near Irapuato, Guanjuato, in 1982-1983 (Koshkin et al. 1989). The N.I. Vavilov Institute established an outreach location there (2 persons) to collect cultivated species or their progenitors and to multiply some crops. A small research activity was carried out as well. So, during two seasons (winter 1982-1983, summer 1983), 80 spring bread wheat varieties were planted and compared with five CIMMYT lines (Nadadores, Pitic 62, Inia 66, Siete Cerros, and Tanori 71). Varieties from the USSR represented all regions where spring wheat is cultivated. The data were recorded for number of days to heading, height, reaction to stripe and leaf rusts, and yield components (Tables 5 and 6).

Due to the day-length sensitivity, the varieties from the USSR were significantly later then CIMMYT germplasm. For instance, in the winter season, the heading date was 10-30 days later compared to locally adapted varieties. The average plant height varied from 103 to 145 cm in the winter cycle with maximum of 162 cm. Soviet varieties were inferior in number of grains per spike and other yield components. If we compare different parameters in wheats from the USSR and CIMMYT, the varieties from North Caucasus (Krasnodar) seem to be closer to genotypes developed in Mexico. At the same time, performance of representatives from the main spring wheat areas (Volga, Siberia, Kazakhstan) indicate a completely different adaptability pattern. It is worth mentioning that 13 varieties were resistant to leaf rust and 18 to yellow rust.

Another observation of Soviet varieties in Mexico was carried out at CIMMYT in the Yaqui 91-92 and Toluca 92 cycles. Around 70 very recent spring wheat varieties were planted in mid-January at the Obregon experimental station.

Table 5. Agronomic performance of spring wheat varieties from different regions of ex-USSR in Mexico (Irapuato, summer 1983) (calculated from Koshkin et al. 1989).

Region	No.of varieties	Days to heading	Height cm	Grains per spike	1000 k. weight
Central + Chernozem	10	57	101	37	37
Volga	22	63	115	34	33
Ural	16	56	110	38	35
W. Siberia	21	73	116	34	26
E. Siberia + Far East	14	61	114	30	28
N. Caucasus	8	49	81	39	39
Ukraine	7	53	102	37	36
Kazakhstan	12	67	114	39	30
Mexico	**5**	**51**	**79**	**54**	**33**

Table 6. Agronomic performance of spring wheat varieties from different regions of the USSR in Mexico (Irapuato, winter 1982-1983) (calculated from Koshkin et al. 1989).

Region	Days to heading	Delay* in heading d.	Height cm	Grains per spike	1000 k. weight
Central + Chernozem	109	52	133	50	38
Volga	116	53	145	51	35
Ural	112	56	138	55	36
W. Siberia	122	49	145	55	33
E. Siberia + Far East	114	53	144	47	33
N. Caucasus	101	52	103	61	39
Ukraine	105	52	127	46	36
Kazakhstan	120	53	144	49	36
Mexico	**91**	**40**	**99**	**60**	**31**

* Calculated as a difference between heading date in winter and summer cycles.

Ten percent headed within 10-15 days after the check (Oasis) and the rest within 30-45 days. Due to exposure to high temperatures in May, almost all of them were completely sterile while Oasis escaped the heat and produced close to normal yield. The difference in heading date was significantly less in the summer cycle at Toluca because of the longer day length. However, the tall plants (more than 110 cm) lodged and the majority of varieties were highly susceptible to yellow rust.

Judging by the performance of CIMMYT germplasm in the USSR and vice versa, one conclusion can be drawn: CIMMYT lines and varieties from the former Soviet Union represent far-separated gene pools in terms of development pattern, plant type, grain quality, genetic protection from diseases, stress tolerance, and others which makes their adaptability also very different.

Future Perspectives

The future of wheat production and breeding in the former USSR will be determined by current political and economical changes in the country. The strategic policy of the Russian government in agriculture is to privatize land. This means that existing collective and state farms will be split up into smaller private farms with the families or individuals having 20-100 ha each. If this goal is implemented within 2-3 years, the country may face a dramatic reduction in wheat area. New farmers would lack appropriate machinery and other facilities to cultivate and process cereals. There is no infrastructure so far which would help them to establish these new small farms. Taking into account the worsening financial and economical situation in the country, it is unlikely that new farmers will increase agricultural production in the short term.

Breeding institutions are affected by the lack of funds. If they had 40-50% of their expenses covered by the government in 1991, this year the funding was possibly reduced to 20-30%. Many breeding programs used to sell basic and pre-basic seeds of new varieties to farms which were specialized in seed production. The price was 5-10 times more than for ordinary grain. It helped to keep breeding programs going. These days, many farmers will most likely stop buying such new varieties because they lack money and they cannot make any profit. It is possible that the current situation will encourage farmers to use their own seeds of old varieties for planting. In this case, an important source of funding for breeders will be significantly reduced.

The possible consequences for the breeders are: 1) to close down breeding programs of minor importance and to reduce those left, 2) to look for alternative sources of funding like new successful private enterprises or foreign companies, 3) to privatize breeding institutions, and 4) to change the activity and start producing goods (for instance seeds of vegetables) that can be sold on the market. These are the possible perspectives for breeders at least for the next 2-5 years.

Acknowledgments

The author thanks R.A. Fischer, S. Rajaram, and Gene Hettel for reviewing the manuscript and making helpful suggestions.

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Appendix 1. Average meteorological data in different regions of the former USSR (calculated from CD-ROM World Weather Disk).

Location	Latitude (N)	Precipitation, mm		Temperature, °C			No. of days with t>0 °C
		May-Aug.	Year	May-Aug.	Dec.-Feb.	Year	
Russian Federation							
Central							
Moscow	5545	265	615	16.7	-8.3	5.0	208
Volgo-Vyat							
Kirov	5839	235	599	15.0	-13.3	1.1	173
Chernozem							
Voronezh	5142	225	580	17.8	-8.3	5.6	214
Volga							
Saratov	5134	177	465	19.4	-8.9	6.1	206
Samara	5315	174	493	18.3	-11.1	4.4	188
North Caucasus							
Krasnodar	4502	207	650	20.0	-1.1	11.1	274
Rostov	4715	179	503	20.6	-4.4	8.9	253
Ural							
Ekaterinburg	5648	274	490	15.0	-13.3	1.7	159
Kurgan	5528	179	353	16.7	-16.1	1.7	167
Western Siberia							
Omsk	5456	160	284	15.6	-17.2	0.0	164
Novosibirsk	5502	219	500	16.1	-15.0	1.1	167
Eastern Siberia							
Krasnoyarsk	5600	212	366	15.6	-16.7	0.6	158
Far East							
Khabarovsk	4831	451	721	17.8	-18.6	2.2	179

Appendix 1. Continued.

Location	Latitude (N)	Precipitation, mm		Temperature, °C			No. of days with t>0 °C
		May-Aug.	Year	May-Aug.	Dec.-Feb.	Year	
Kazakhstan							
Alma-Ata	4314	227	612	19.4	-3.9	9.4	228
Karaganda	4948	168	338	16.7	-15.6	2.2	168
Pavlodar	5217	125	249	17.8	-16.7	2.2	168
Ukraine							
Kiev	5054	254	579	17.8	-5.0	7.2	229
Kharkov	4956	198	543	18.9	-5.0	7.8	234
Odessa	4629	173	472	20.0	-1.1	10.6	269
Uzbekistan							
Tashkent	4116	32	290	24.4	1.7	13.9	284
Turkmenistan							
Ashkhabad	3758	72	193	27.8	5.6	16.7	309

Appendix 2. Key wheat breeding centers in the former USSR as of January 1, 1992.

No.* Institution	Address	Contacts
Central Region		
1. Vavilov Institute (VIR)	42 Gertsena St., St.Peterburg 190000 Russia	Prof. A. Merezsko bread & durum
2. NPO "Podmoskovje"	Nemchinovka-1 Moskow reg. 143013 Russia	Prof. E. Nettevich bread wheat
Chernozem Region		
3. NIISKH im. Doku-chaeva	Talovski Dist. Voro-nezh reg. 397463 Russia	Ms. E. Malokostova bread & durum
Volga Region		
4. NIISKH of the Southeast	27 Tulaikova St., Saratov, 410020 Russia	Mr. A. Galkin bread wheat Dr. N. Vasilchuk durum wheat
5. Samarski NIISKH	p.Bezenchuk, Samara reg., 446080 Russia	Dr. A. Vjushkov bread & durum
North Caucasus		
6. Krasnodar NIISKH	Krasnodar-12, 350012 Russia	Dr. Y. Puchkov bread, winter Dr. A. Burdun bread & durum
7. Donskoi NIISCK	19 Lenina St., Zerno-grad, Rostov reg., 347720 Russia	- bread, winter
Ural Region		
8. Bashkirski NIISKH	19 R.Zorge St., Ufa. 450059 Russia	Dr. V. Nikonov bread & durum
9. Kurganski NIISKH	p/o Ketovo, Kurgan reg., 641325 Russia	- bread wheat
10. Uralski NIISKH	21 Glavnaya St., Ekatirinburg, 620061 Russia	- bread wheat

Appendix 2. Continued.

No.* Institution	Address	Contacts
Western Siberia		
11. Siberian NIISKH	2 Koroleva St., Omsk, 644012 Russia	Dr. V. Zykin bread wheat Dr. M. Evdokimov durum wheat
12. Siberian NIIRS	p. Krasnoobsk, Novo-sibirsk, 633128 Russia	Dr. V. Maksimenko bread wheat
13. Altai NIISKH	Nauchnyi Gorodok, Barnaul-51, 656051 Russia	Dr. N. Korobeinkov bread wheat Dr. B. Yanchenko durum wheat
Eastern Siberia		
14. Krasnoyarski NIISKH	66 Svobodnyi Pr., Krasnoyarsk, 660062 Russia	Dr. G. Pushkina bread wheat
Far East		
15. Far-East NIISKH	107 Marx St., Khaba-rovsk 680031 Russia	Dr. I. Shindin bread wheat
Kazakhstan		
16. Kazakhski NIIZH	p/o Shortandy, Tseli-nograd reg., 474070 Kazakhstan	Dr. V. Movchan bread wheat
17. Kazakhski NIISKH	p/o Almalybak,Alma-Ata reg., 483133 Kazakhstan	- bread wheat
Ukraine		
18. Ukranian Inst. of Breed. & Genetics	3 Ovidiopolkaya Dor., Odessa 270036 Ukraine	- bread winter
19. Ukranian NIIRSIG	142 Moskovski Pr., Kharkov 310006 Ukraine	Dr. V. Golik bread & durum
20. Ukranian NIIOZ	p. Nadnepryanski, Kherson, 325908 Ukraine	- bread winter
21. Mironovski NIISSP	p/o Tsentralnoe, Kiev reg., 256816 Ukraine	Dr. Zsivotkov bread winter

* Numbers correspond to locations on the map in Figure 1.

Appendix 3. New spring bread wheat varieties submitted to the State Commission in 1991.

Variety	Origin	Institution
Albidum 29	Saratovskaya 46/ Albidum 2809	Krasnyi Kut Breeding Station
Bashkirskaya 24	Saratovskaya 46/ Lutescens 88	Bashkirski NIISKH
Zozyan	Mutant of variety Spektr	Krasnodar NIISKH
Krasa	Mutant of variety Volya	Krasnoyarski NIISKH
Domsinskaya 90	Hybrid 491/Almaz	Kazakhstan NIIZKH
Tselinnaya 90	Bezostaya 1/x//Saratovskaya 46/3/Justin /4/Albidum 24	Kazakhstan NIIZKH
Shortandinskaya 125	Albidum 488/ Tselinnaya 21	Kazakhstan NIIZKH
Ishimskaya 90	Pirotrix 28/Saratovskaya 48//Saratovskaya 29	Kazakhstan NIIZKH
Amurskay 90	Glenma/Altair 12	Blagoveshenski SKHI
Omskaya 20	-	Siberian NIISKH
Pamyat 47	N298669//L-10/Michurinka/3/Bezostaya 1/4/ CIMMYT int.	Krasnovodopadskaya Breeding Station
Rovenskaya 60	WS 1877/Rovenskaya 9	Rovenskaya Breeding Station
Samsar	-	Samsarski NIISKH
Srednevolzskaya	Nadadores/Saratovskaya 29//Lee/Un Rka	Kinelskaya Breeding Station
Kharkovskay 14	Steklovidnay 1/Kharkovskay 6	Ukranian NIIRSIG
Iya	Krasnoyarskaya/L 454	Tukinskaya Breeding Station

Appendix 3. Continued

Variety	Origin	Institution
Krasnoyarskaya 90	Skala/Snabbe//Red F.	Krasnoyarsk NIISKH
Karababkykskaya 90	L5714/Tselinnaya 21	Kustanai NIISKH
Primorskaya 25	Hebros/Lenningradka	Primorski NIISKH
Erithrospermum 59	Chaika/Irtyshanka 10	Omski SKHI
Zauralskaya 90	Tezpishar 512/ Irtyshanka 10	Kurganski NIISKH
Lutescens 90	Znitsa/Start	Kazakhstan NIISKH
Kazakhstanskaya uluchshennaya	Saratovskaya 29/ Bezostaya 1	Kazakhstan NIISKH
Voronerzskaya 10	Slavyanka/ Kamyshinskay 3// Kharkovskay 93	NIISKH im. Dokuchaeva

Appendix 4. Recent (1985-1991) wheat varieties from the former USSR available in the CIMMYT Bread Wheat Section.

Central Region
Academia, Botanicheskaya 3, Enita, Ivolga, Ljuba, Moskovskaya 35, Priokskaya

Chernozem Region
Voronezskaya 10, Krasa, Krestjanka, Kurskaya 263

Volga Region
Albidum 10, Bezenchukskaya 380*, Eritrospermum 786, Eritrospermum 35, Eritrospermum 1041, Isheevskaya, Kinelskaya 59, L-503, L-1974, PPG 596. Samsar, Simbirka, Srednevolzskaya, Vavilovskaya, Volgodar*, Zemchuzina Zavolzja

Ural Region
Bashkirskaya 20, Bashkirskaya 21, Bashkirskaya 22, Ilmenskaya, Irgina, Krasnoufimskaya, Mereke, Uralochka

North Caucasus
Budmir, Daha*, Druzina, Kommunar, Massiv*, Skifjanka*, Spartanka*, Spektr, Sfera*, Una*, Zeleznyar

Siberia
Angara 86, D-565, Eritrospermum 59, Irkutyanka 90, Ishimskaya 90, Krasnoyarskaya 90, Lutescens 101, Novosibirskaya 89, Omskaya zernof., Omskaya 14, Oya, Rodnik, Tulunskaya 12

Ukraine
Mironovskaya 5, Mironovskaya 40*, Mironovskaya krupnozernaya, Odesskaya krasnokolosaya*, Kharkovskaya 13, Kharkovskaya 15, Kharkovskaya 17

Kazakhstan
Dominskaya, 90, Karabakykskaya 90, Kazakhstanskaya 12, Kazakhstanskaya rannyaya, Komsomolskaya 29, Komsomolskaya 90, Shortandinskaya, Pamyat 47, Tselinnaya 90, Tselinnaya24, Uljbinka 30

Far East
Lutescens 521, Khabarovchanka

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* Winter wheat.

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