Food and Agriculture Organization of the United Nations

WHEAT LANDRACES IN FARMERS' FIELDS IN UZBEKISTAN: NATIONAL SURVEY, COLLECTION, AND CONSERVATION, 2010-2015

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ANNEXES

ABBREVIATIONS AND ACRONYMS

BCE	Before Common Era
CE	Common Era
Cat#	Catalogue number
CIMMYT	International Maize and Wheat Improvement Center
FAO	Food and Agriculture Organization of the United Nations
FAO-SEC	Sub-regional office of FAO for Central Asia
ha	hectare
ICARDA	International Center for Agricultural Research in the Dry Areas
IWWIP	International Winter Wheat Improvement Program
masl	meters above sea level
t, t/ha	metric tons, metric tons per hectare

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BACKGROUND

Central Asia is one of the oldest areas of human civilization. Uzbekistan is home to several sites of ancient irrigated agriculture. Archeological data indicate that by the end of the 2nd millennium BCE in the delta region of the Amu Darya river, the agricultural civilization of ancient Khorezm already had a highly developed irrigated agriculture with a complex system of irrigation canals and wheat was widely cultivated (Tolstov 1948, Andrianov 1969). In the north and east of the Fergana Valley, where the fertility of the soil and an abundance of mountain rivers allowed the irrigation of large areas, numerous stone pit granaries, that could hold up to 2 t of wheat or barley were found, along with grain grinders and bronze sickles (Bernshtam 1951). Also at the end of the 2nd millennium BCE, wheat was widely cultivated in what is now the Surkhandarya region of Uzbekistan.

The cultivation of wheat for over thousands of years in the severe conditions of Central Asia has produced wheat landraces adapted to the local soil and climatic conditions. Typically, they are characterized by early maturity, requiring heat in the last phases of development. Depending on the elevation at which they are cultivated and the temperatures and moisture conditions in their growing seasons, there are landraces distinguished by drought, heat, and salt tolerance, ability to withstand hard winters, and producing flour with good flavor, favored for bread making. A characteristic trait of the landraces of the plains, foothills, and mountainous areas is the coarseness of all parts of the plants, in particular, the spike: the grain is tightly enclosed by the lemma and palea so it is difficult to thresh and the awn breaks off easily. The climate of Central Asia is not conducive for the development of dangerous annual pests and diseases; as a result the local landraces of wheat are exclusively susceptible to them when conditions do favor pests and pathogens. The straw of the landraces is not strong and is brittle, and under intensive farming, plantings suffer heavy lodging. Central Asian wheat landraces in areas with poor rainfall have higher pest and disease tolerance than do landraces from areas with higher precipitation, and the spike form of these landraces is similar to that of spelt (*Triticum aestivum* ssp. *spelta*). In the highlands of Central Asia, where wheat can only be cultivated under irrigation, landraces are found with a distinct type of erect leaves with delicate auricles and no ligules (Udachin and Shakhmedov 1984).

A detailed description of wheat environments in Uzbekistan and wheat production and breeding history is presented in the World Wheat Book, Volume III (Khalikulov et al., in press). In the past, the main areas of wheat production in Uzbekistan were in the

rainfed foothill and mountain areas where it is warm enough and annual rainfall exceeds 250 mm, the minimum required for sustainable cultivation of wheat. These areas are located mainly in the western, southwestern, and northwestern foothills of the Tian Shan and Pamir-Alay mountain ranges. In the Surkhandarya region, the production area is bounded by mountains on the east and to the north of the Denov district, then the ranges reach south again constricting the production area as it extends west into the Kashkadarya region. The production area reaches north again along the east of the Samarkand region, and then northeast to the Tashkent region (Udachin and Shakhmedov 1984).

OBJECTIVES

The main focus of this project was the identification of wheat landraces cultivated in Uzbekistan. For this purpose a number of expeditions to remote regions were organized to survey local wheat populations and collect samples. For each sample, we described the local area of its cultivation, determined the purpose of its cultivation, and described its yield and bread-making qualities. The project was implemented under the overall supervision of the Sub-regional Food and Agriculture Organization for Central Asia (FAO-SEC) in close cooperation with the International Winter Wheat Improvement Program (IWWIP) represented by the International Maize and Wheat Improvement Center (CIMMYT) Turkey office.

SURVEY AND EXPEDITIONS

Preparative studies

The Galla-Aral Institute of Cereals located in the Jizzakh region is one of the oldest research institutes in Uzbekistan where plant breeding started 100 years ago. We interviewed the plant breeder from this institute, Mr. **Negmat Umirov**, other scientists as well as several farmers, heads of agricultural enterprises, and older men from remote parts of Uzbekistan. The main goal of the interviews was to investigate the genetics, breeding, baking, and testing qualities of wheat landraces and their planting areas. During this survey, it was determined that the government did not invest in seed production of wheat landraces in the rainfed areas and, thus, the area of landraces was smaller that it could have been. The expansion of the area under intensive cultivation with high-yielding wheat cultivars resulted in the reduction of the area sown to wheat landraces. These landraces were only kept by local farmers in the remote parts of the country where commercial cultivars were not promoted. Many local people contributed to our work, such as Mr. **Eshboy Khasanov**, a teacher, and Mr. **Tura Nazarov**, a local farmer, (Fig. 1) both from the Boysun district of the Surkhandarya region, and Dr. **Zohid Ziyadullaev**, a former director of the Karshi Institute of Grain Breeding and Seed Production.

Figure 1. Wheat landrace Boboky in the village Pulkhokim of Boysun district with Mr. **Tura Nazarov** (village school teacher, left) and Mr. **Eshboy Khasanov** (farmer, right) (N: 38.16484; E: 067.38905, 1,050 masl)

Uzbek wheat landraces and old cultivars, identified from a literature review, and possible areas where they can be cultivated

Uzbekistan can be divided into four zones in which wheat production takes place:

1. The Fergana Valley is located in the most northeastern part of the country and is surrounded by mountains. About 500,000 ha are arable and 200,000 ha of this is sown to wheat, primarily Russian winter bread wheat cultivars. In this region in 2007, bread wheat cultivar Mars, selected from an old wheat landrace Kzylkiltik (red awn), and cultivar Chillaki, selected from the Krasnodar breeding material, were released. In 1915, Navrotskiy identified 15 botanical varieties of bread wheat in the Fergana Valley, the most frequent were *meridionale*, *greacum*, and *erythrospermum* (Navrotskiy 1915). In the past, the Fergana Experiment Station released durum wheat cultivars Leucurum 2F and Provinciale 88-F, both selected from local landraces. Rainfed wheat fields are located in hilly areas of Fergana and on the Chatkal ridges to the north (growing landraces Kayrak bugday, Ak-Radi bugday, and Talim bugday, Fig. 2), while in the irrigated lowlands, winter wheat landraces Tramai Safedak, Tramai Surhak, Ak bugday (white wheat), and Kzyl bugday (red wheat) were grown. Cultivars like Greacum 433, Alborubrum 22308, and Oshishkaya were selected from local wheat landraces.
2. In the two southeastern regions, Kashkadarya and Surkhandarya, wheat is cultivated on 200,000 ha in rainfed areas and 200,000 ha in irrigated fields. This zone differs from other subtropical areas of the world with its continental climate and frequent southeasterly wind from Afghanistan. In the mountain-zone conditions, irrigated winter wheat landraces are grown, such as Khivit-Surhak and Khivit-Safedak (Fig. 2), which are characterized by longer vegetative periods requiring more than a year from sowing to maturity. In the middle of the basins of Kashkadarya and Surkhandarya regions, the amount of rainfall reaches 300 to 450 mm a year which has enabled cultivation of rainfed wheat for hundreds of years. Famous drought-resistant cultivars like Greacum 283, Greacum 289, and Erythrospermum 242 were developed in these basins.
3. The lower Amu Darya river zone includes the Khorezm region and the Republic of Karakalpakistan. The climate here differs from other regions of Uzbekistan because it is located in a transition area between the hot deserts to the south and the cold semi-deserts to the north. Here wheat can be grown only under irrigated conditions. The winter wheat cultivars that are grown here possess frost resistance. In this zone, the soil water layers are close to the surface, leading to high salinity, therefore, salinity tolerance has been a priority for wheat cultivars. Cultivars were selected from landraces such as Tokmakbash, Ak jaydari, Kzyl jaydari, and Yumalak bugday (Fig. 2) and released in this zone with tolerance to cold weather and salinity. The cultivar Khivinka had a high transpiration coefficient that allows tolerance to atmospheric drought. This cultivar was actively involved in the famous Saratov breeding program in Russia and is included in the pedigree of important spring wheat varieties developed in the 1950s. In 1916, S.K. Kondrashev surveyed

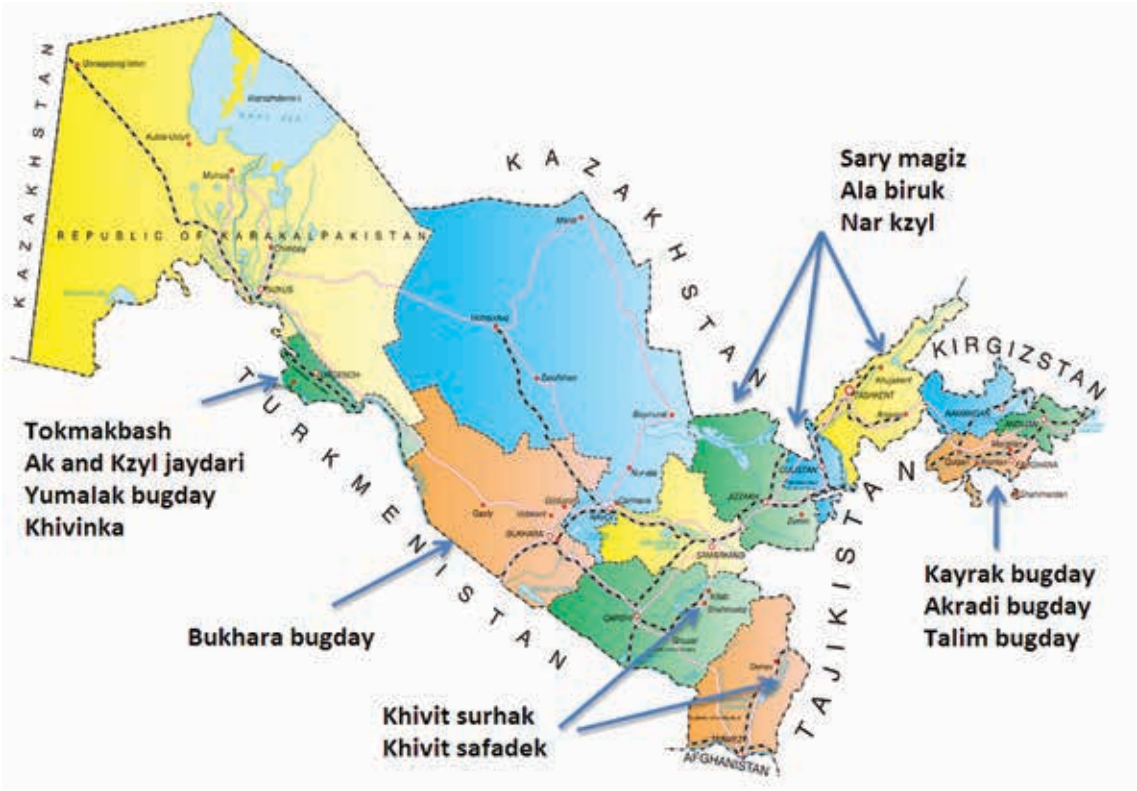

Figure 2. Wheat landraces of Uzbekistan identified during surveys from 1920 to 1950 (Udachin and Shakhmedov 1984)

wheat landraces of what is today the Khiva district of the Khorezm region and reported wide cultivation under irrigation of winter wheat Bukhara bugday and spring wheat Yazlyk bugday and a complete absence of rainfed wheat (Kondrashev 1916).

4. The northern zone of Uzbekistan covers a wide foothill strip of between the Sirdarya and Zarafshan rivers and includes territory of the Tashkent, Sirdarya, Jizzakh, and Samarkand regions. The climate of this zone is characterized by much higher precipitation than in the three other zones (around 280 to 700 mm per year). The main abiotic stress factor comes from spring frosts. A combination of low relative humidity and winds during the warm period of the year often creates conditions of heat waves. Local wheat landraces (Ak bugday, Kzyl bugday, Sary Magiz, Ala biruk, and Nar Kzyl, Fig. 2) are characterized by their high drought resistance, early maturity, productivity, and winter growth habit. From this zone many cultivars such as Pseudoturtsikum 2115, Erythrospermum 5755, Vatan, and Greacum 240 originated.

EXPEDITION AND LANDRACES COLLECTION IN 2010

In 2010 we conducted expeditions to survey and collect landraces in Jizzakh, Kashkadarya, and Surkhandarya regions. By questioning locals in the targeted areas, we determined potential sites where landraces might be grown. During the expeditions, around 200 spikes were collected from each field with landraces. If spikes from the growing plants were not available, we collected 2 to 3 kg of stored seed from the farmers. Altogether, we collected over 50 samples, but only 24 of them were kept, representing different landraces and areas (Annex 1). The remaining collections were discarded because they were duplicates of other accessions from neighboring fields or farmers. Many accessions, otherwise different, had been given the same names by the growers. In order to describe the diversity of the landraces and distinguish them, we conducted morphological descriptions of collected spikes and matched them to the botanical variety designations as used by Vavilov (1966) and recently interpreted by Zuev et al. (2013) (Table 1). The majority of the landraces were classified as either botanical variety *greacum* (white glume, awned, and white grain) or *erythrospermum* (white glume, awned, and red grain). Four white-glumed

Table 1. Spike and grain characteristics of the main botanical varieties of *Triticum aestivum* ssp. *aestivum* and *T. turgidum* ssp. *durum* (Zuev et al. 2013)

T. aestivum ssp. *aestivum*	*T. turgidum* ssp. *durum*	Awn presence	Glume		Grain color
			pubescence	color	
albidum	*candicans*	No	No	White	White
lutescens	*schechurdinii*	No	No	White	Red
alborubrum	*subastrale*	No	No	Red	White
milturum	*stebutii*	No	No	Red	Red
leucospermum	*muticovalenciae*	No	Yes	White	White
velutinum	*muticinazillennse*	No	Yes	White	Red
delfi	*muticitalicum*	No	Yes	Red	White
pyrotrix	—	No	Yes	Red	Red
greacum	*leucurum*	Yes	No	White	White
erythrospermum	*affine*	Yes	No	White	Red
erythroleucon	*hordeiforme*	Yes	No	Red	White
ferrugineum	*murciense*	Yes	No	Red	Red
meridionale	*valenciae*	Yes	Yes	White	White
hostianum	*durum*	Yes	Yes	White	Red
turcicum	*italicum*	Yes	Yes	Red	White
barbarossa	*aegyptiacum*	Yes	Yes	Red	Red

landrace collections had a mixture of spikes with red glumes not exceeding 16%. Compact or club-type spikes were present in two landrace collections.

During our first trip to Jizzakh region on 17-18 July 2010, we collected landraces in the Galla-Aral district, while in the Bakhmal district, wheat did not reach maturity due to its higher elevation. Many farmers grew cultivar Surkhak originating from a breeding program in neighboring Tajikistan and cultivars of local breeding programs for wheat production under rainfed conditions. The farmers were satisfied with the yield and wheat quality based on the responses to the survey. However, there was no uniformity and the crop was often a mixture. Weed contamination, especially wild barley, is widespread. Almost all the surveyed farmers who cultivated modern commercial cultivars wanted to improve their grain quality. They are ready to allocate the land and multiply new, improved, or old cultivars.

The second trip took place 20-22 July 2010 beginning in the Kashkadarya region. In Yakkabog district, in rainfed and semi-desert conditions, farmers cultivated two landraces: Kzyl bugday and Korakiltik (black awn). However, both landraces have mixtures from other landraces. Wheat matures in June in these areas at elevations of 550 to 600 masl. The expedition continued in the foothill area. Many farmers cultivate local landraces on their own fields up to one hectare. Since in these areas wheat is planted in the spring, we could not collect mature spikes from the fields, and took 1-to-2-kg samples of seed saved by the farmers from their last year's harvest.

We surveyed fields in the highland areas of Yakkabog and Kamashi districts of the Kashkadarya region, where wheat is cultivated under rainfed conditions. Kzyl bugday is the most frequently cultivated landrace in these areas compared to Korakiltik and Tuyatish (camel teeth) landraces. However, its production had been reduced because of low productivity. We also found a few 'nameless' landraces similar to Kzyl bugday or representing mixtures of different landraces. These nameless wheat landraces were collected for identification of landrace type and possible molecular genetic analyses. Altogether, in this area, landraces were grown on 150 to 170 ha with yields of 1.5 to 2.0 t/ha.

Figure 3 Fields with landrace Kzyl bugday near Gumatak village, Boysun district (N: 38.35986; E 067.07070, 2,174 masl)

In the third trip, conducted near the end of August 2010, we visited the Pulkhokim, Duoba, Gumatak, and Kurgancha villages, Boysun district, of the Surkhandarya region. The landraces found were mainly Kzyl bugday, Boboky, and Kayraktash. The village of Pulkhokim is located near the district center where the commercial cultivars Surkhak and Tezpishar (early maturing) are mainly grown. But, Kzyl bugday and Boboky landraces are cultivated in highland fields.

The Duoba and Kurgancha villages are located at 2,100 to 2,200 masl and are 35 to 40 km from the Boysun district center. The villagers are primarily engaged in production of livestock and alfalfa seeds as well as wheat. Farmers traditionally grow landraces such as Boboky, Kzyl bugday, Kayraktash, and Korakiltik in smaller fields (around 1 to 2 ha), but in the larger fields, they grow commercial wheat cultivars such as Intensivnaya and Krasnovodopadskaya. In that region, farmers start growing wheat in March and harvest at the end of August. A yield of 2 t/ha is considered average. Gumatak village is at a higher elevation. One family here has cultivated the Kzyl bugday landrace for more than 100 years, never changing to other varieties (Fig. 3).

During these three 2010 expeditions to remote regions of Uzbekistan, we collected samples of local wheat landraces such as Boboky, Kzyl bugday, Korakiltik, Tuyatish, and others. We learned that Jaydari bugday and Kal bugday were, in fact, modern commercial cultivars which had been renamed by local farmers.

EXPEDITIONS AND LANDRACE COLLECTION IN 2013

The purpose of these expeditions was to continue observation of the status of wheat landraces cultivated in Surkhandarya, Kashradarya, and Jizzakh regions to determine their approximate area, carry out phenological observations, evaluate the degree of contamination of landraces with other cultivars, and estimate the resistance of landraces to diseases, pests, and abiotic stresses. We also grew the landraces collected in 2010 in the experimental fields at the Galla-Aral Institute of Cereals for making crosses with commercial varieties for breeding purposes as well as for producing clean seed of each accession in order to return them to farmers.

In May 2013, we organized an expedition to the rainfed areas of Bakhmal and Galla-Aral districts in the Jizzakh region. In the Galla-Aral district, mainly commercial cultivars such as Surkhak, Tezpishar, Krasnovodopadskaya, and Intensivnaya were cultivated. In Yonbosh and Muzbulak villages, landraces Ak bugday and Greacum were cultivated. These landraces were very similar to each other, but differed morphologically from the easily identifiable commercial cultivars. Farmers in these areas prefer to plant the landraces because of their larger grain size, white flour, and high bread-making quality with longer shelf life. We observed weeds and some crop damage by yellow rust in the wheat-growing areas.

The second expedition was to the Altinsay district of the Surkhandarya region at the end of July 2013. We visited Luka village, at 1,300 masl, and Vakhsh village, at 1,400 masl. In these villages, we conducted a survey of local growers on the cultivation of wheat and other crops. The main wheat landrace cultivated here was Kzyl bugday with an average yield of 2.5 t/ha. While mostly hand-sowing and hand harvesting are practiced, there are some large fields around 20 ha where harvest is done by combine.

The last expedition was organized in September 2013 to Uzun and Sariaziya districts of Surkhandarya region. These districts border with Tajikistan and are located at 1,600 to 1,700 masl. This region is mainly engaged in animal husbandry. The wheat landraces under cultivation were Pashmak, Kzyl bugday, and Khivit in small fields up to a hectare in size. Interestingly, sowing time of Khivit begins in June or July of one year and it is harvested in June, July, or sometimes August of the next year. This landrace differs from other old varieties by the excellent quality of bread made from it and its relatively high yield, large grains, strong straw, and most importantly, excellent winter hardiness. The list of the landraces collected in 2013 is presented in Annex 1. The main places of wheat landrace cultivation at the present time in Uzbekistan are shown in Fig. 4.

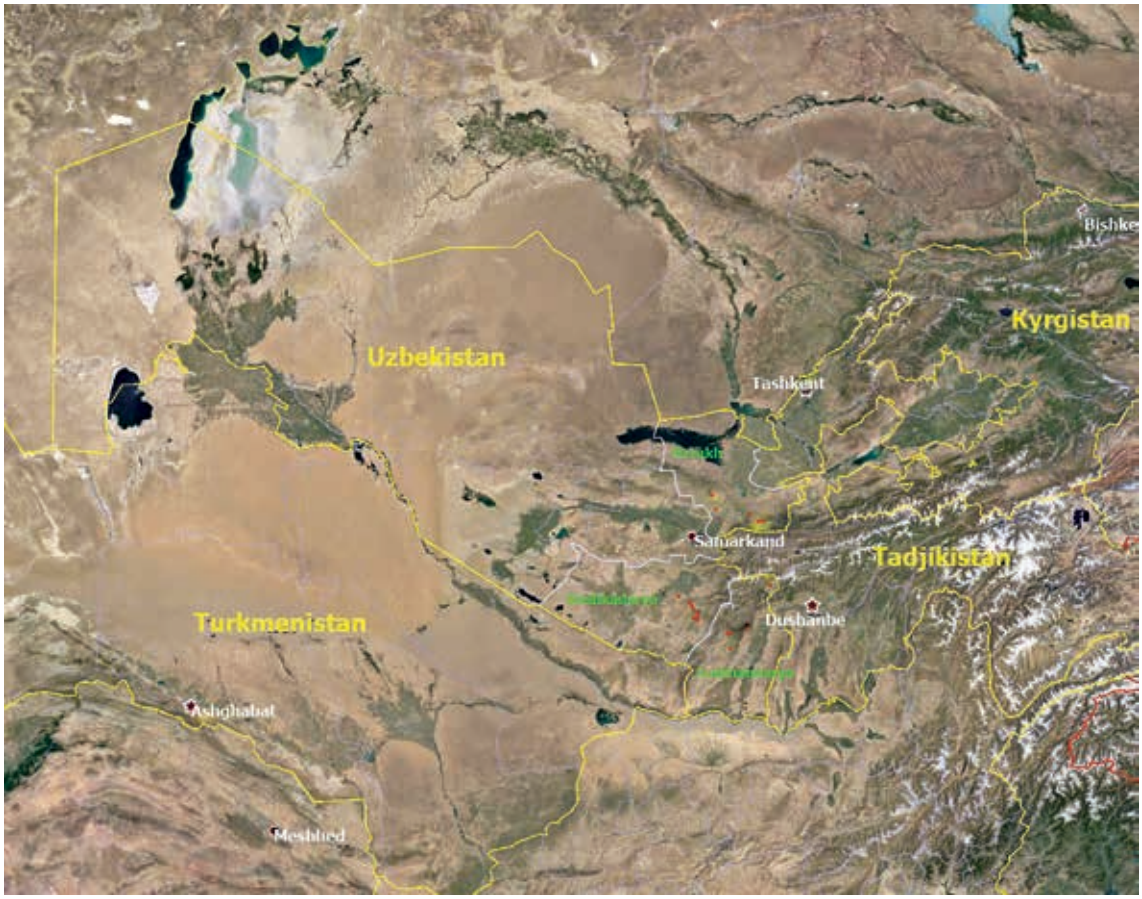

Figure 4. The main locations of wheat landrace cultivation in Uzbekistan (red dots)

CHARACTERISTICS OF COMMERCIAL CULTIVARS AND LANDRACES COLLECTED FROM FARMERS' FIELDS

In many spring wheat areas of Uzbekistan, the commercial bread wheat cultivar **Surkhak** is grown. It was released in the 1940s as a selection from a landrace. It is relatively tolerant to drought and high temperature. Its spike has awns, white glumes without pubescence, and red grain, matching the *erythrospermum* botanical variety characteristics. Awns are rough, slightly divergent at the base, thickened, brittle, and of medium length. Plant height ranges from 110 to 140 cm. It is resistant to shattering, difficult to thresh, and not resistant to lodging. Grains are egg-shaped, glassy, and large with a 1,000-kernel weight of up to 50 g. It is cultivated in areas with growing seasons of 210 to 240 days. Winter hardiness is weak, but in the conditions of Uzbekistan, it holds up well in winter. Its bread-making quality is good. In years with optimal conditions, yield reaches 3 t/ha. On many farms, plantings of this cultivar were highly mixed and impure. It is mainly planted in large cooperative farms and in many small private farms located close to these large farms.

Bread wheat landrace **Kzyl bugday** (red wheat) is grown on small farms in remote areas of the country from 1,500 up to 2,500 masl. In awn, glume, and grain color characteristics, it matches botanical variety *erythrospermum*. It is relatively tall at 120 to 140 cm in height and high-yielding. In years with optimal conditions, yield reaches 3.5 t/ha. Grain is red and large with a 1,000-kernel weight of 55 to 60 g. Spikes are long, up to 14 cm, with awns of medium length. In the environmental conditions of Uzbekistan, this landrace is winter hardy, but normally it is sown in spring in the middle of March and harvested in August. The growing season for spring sowing reaches 140 to 150 days.

Another common bread wheat landrace is **Ak bugday** (white wheat), in some areas called Greacum, with white glumes, white awns, and white, relatively large grains (1,000-kernel weight of 45 to 48 g) matching the characteristics of botanical variety *greacum*. Plant height is 95 to 100 cm and, under rainfed conditions, it does not lodge. This landrace is mainly found in the Kamashi district of the Kashkadarya region and in the Galla-Aral district of the Jizzakh region. The landrace is well conserved, morphologically relatively homogeneous, and has good baking quality. In years with optimal conditions, yield reaches 3 t/ha. Straw is very delicate, highly prized as a building material for finishing the inside of houses, and also used as animal fodder.

Bread wheat landrace **Boboky**, morphologically similar to Kzyl bugday, matching botanical variety *erythrospermum*, is found mainly in the mountainous areas of the southern regions of the country. It is very tall, 150 to 160 cm. The stem is solid and under rainfed conditions does not lodge. The spikes are large, grains are red, large, and oblong. This landrace is morphologically homogeneous, has good quality, and high yield.

Bread wheat landrace **Kayraktash** is relatively rare. It fits the characteristics of botanical variety *greacum*. It has white, glassy, medium-sized grains and has very good bread-making quality. It is of medium height and tolerant to lodging even under irrigation. The spikes are medium sized, with white glumes.

Durum wheat landrace **Korakiltik** is rare and has long, black awns and small spikes and is relatively compact compared to other landraces. It fits the characteristics of botanical variety *affine*. According to the grower survey results, this landrace used to be widely cultivated in the rainfed areas of the Kashkadarya region and had good quality and high yields. Unfortunately, it is now only found as a contaminant with other landraces.

Bread wheat landrace **Tuyatish** is very rare, grain is large, plants are tall, but it differs from how the landrace is described by old people, matching now the characteristics of botanical variety *erythrospermum*. According to the surveyed growers, this cultivar was very high-yielding with coarse grains, had a good baking quality, but was sown in small areas, mainly in private households.

Among our collected samples we came across several without names. This may be because people did not pay attention to them or perhaps each year, they selected and propagated what they liked for their own needs without considering any relationship to what others regard as named landraces. Often landraces were given names of commercial cultivars such as Muslimka, Krasnovodopadskaya, Intensivnaya, Surkhak, and so on. However, they do not match the morphology of the commercial cultivars whose name they were given, so more thorough analyses are needed to determine what they are.

In summary, we found that in the Jizzakh region, white-grained wheat landraces were preferred, while in the Surkhandarya region, mainly red-grained wheat landraces were grown. In Kashkadarya region, both white- and red-grained wheats were cultivated. Despite superior breadmaking quality of the landraces, absence of a seed production system leads to the gradual decrease of their area even though many farmers prefer to cultivate them for their home needs.

SOCIO-ECONOMIC SURVEY

In addition to collecting wheat landraces, we sought to clarify landrace growing conditions, *in situ* or on farm, and determine who cultivates them and why. For this purpose we carried out a socio-economic survey developed by IWWIP in Turkey for a national landrace inventory (Annex 2). We began in the Galla-Aral district of the Jizzakh region where the Galla-Aral Institute of Cereals is located. The majority of Uzbek wheat breeders used to work at this institute. During the 1920s and 1930s many wheat cultivars were generated here deriving from local wheat landraces. The total arable area in Galla-Aral district is about 7,000 ha with 1,000 ha of wheat grown mainly under rainfed conditions. Cultivar Surkhak and landrace Ak bugday are the main wheats cultivated. The acreage of individual farms is relatively large, reaching 100 ha. Among the farmers was Mr. **Amanov Khusan** from Yonbosh village who had 300 ha of land and mainly cultivated Surkhak wheat using machinery. In a neighboring farm, the Ak bugday landrace was cultivated on 10 ha and yield reached 3 t/ha. The quality of this wheat was higher than other wheat landraces collected by us. This village of 600 people and 120 families is not far (25 km) from the town of Galla-Aral.

Muzbulak village is located in the mountains, 50 km away from the district center, Bakhmal village (Bakhmal district, Jizzakh region), with 1,500 residents (300 families). Here, seven farmers grow wheat on 800 ha, but some also cultivate wheat landrace Ak bugday on 1 to 2 ha for their own needs. We surveyed 10 villages in that region and found that cultivar Surkhak and landrace Ak bugday were the main wheats cultivated.

We found the majority of wheat landraces grown in two districts (Yakkabog and Kamashi) of the Kashkadarya region in the mountains and foothills. In the foothill village of Navruz (Yakkabog district), landrace Korakiltik was cultivated in small fields. There are 150 families with 550 residents in this village with one school, one private mill, about 2,000 ha of arable land including 1,000 ha of irrigated land. About 500 ha of wheat are cultivated under rainfed conditions. There are two small villages, Terakli and Guldara, in the mountain areas of this district. In the village Guldara, there are 300 families, a school, mills, and several tractors. The main activity of the village is forestry and wheat landraces are cultivated for farmers' needs on small fields. We found some landraces with names of cultivars Surkhak, Krasnovodopadskaya, and Sanzar-4 and a few were nameless, most of which morphologically were similar to the old landrace Ak bugday. In the high mountain area of the Kamashi district, there are several small villages cultivating rare landraces, such as Tuyatish and Kzyl bugday, and nameless landraces and modern cultivars Krasnovodopadskaya and Sanzar-4. In addition to wheat, this village also cultivates barley as a forage crop, chick-pea, and safflower and other oil crops.

Within a 35-km distance from the center of the Boysun district (Surkhandarya region), there are several villages, like Duoba, Kurgancha, and Gumatak, where old wheat

landraces Boboky, Kzyl bugday, Kayraktash, and others are grown. Most agricultural production here is for livestock, forestry, and horticulture, but in small areas certain farmers cultivate wheat landraces for their own needs. This district does not grow any modern wheat cultivars at all. Mainly it is landrace Kzyl bugday, which in several villages is called Boboky, that is cultivated. This landrace had been cultivated for more than 100 years on several farms. In the foothill areas of this district in village Pulkhokim there are about 100 ha of rainfed wheat. Landraces Kayraktash and Kzyl bugday are cultivated here. Most all landraces grown in this area have red grain.

The survey results (Annex 2) indicate that villages maintaining landraces are remotely located from the district centers and nearest markets. Given the quality of rural roads it is difficult to access new seed and inputs as well as to sell grain and other products outside. It appears that these are mostly subsistence farmers who are growing landraces. The average age of the farmers normally exceeds 50 years indicating an aging rural population in these villages. Farmers grow the landraces from generation to generation by utilizing their own seed. The grain from the landraces is used entirely for bread normally baked at home as described by Ranum et al. (2006). There are three main reasons for the maintenance of landraces: a) large grain size, excellent bread-making quality, and suitability for home baking using the tandyr oven; b) specific adaptations allowing stable and reliable yield in harsh highland environments including spring planting; and c) straw yield and quality as animal feed and construction material. The majority of the farming communities grow both landraces and modern commercial varieties. Normally, grain from the modern varieties is sold to the markets while grain from the landraces is kept for home consumption.

EVALUATION OF LANDRACES COLLECTED IN 2010

Spikes of the landraces collected in 2010 were divided into groups according to their botanical description (Table 1) and then headrows were planted in the fall of the 2010-2011 season at Tashkent under modern agronomy practices and in the Boysun district at one of the mountain sites where landraces are grown. Superior progeny were selected from the headrows at both locations and these were planted in a twice-replicated trial in fall of the 2011-2012 season in Tashkent under irrigation as well as in a twice-replicated trial in spring of 2013 in Tashkent without irrigation (the season of 2012-2013 was not used for evaluation). Subsequently the same landraces were evaluated in twice-replicated fall-planted trials in the 2013-2014 and 2014-2015 seasons. Two check bread wheat cultivars were used in the trials: Krasnodar-99, a short-statured cultivar with high yield potential for irrigated conditions, widely grown across the country, and Tezpishar, a drought-tolerant cultivar for rainfed conditions originating from a cross with Bezostaya-1, released in the country in 1980, and still cultivated today in mountain regions. As reported in Annex 3, days to heading, plant height, yield, and 1,000-kernel weight were recorded in each trial. In addition, resistance to stripe rust and to leaf rust were evaluated under natural infection in two trials, and gluten content was determined in two trials. The landrace evaluation and testing scheme is presented in Figure 5.

The spring planting at Tashkent in March, 2013 demonstrated that all the landraces have either a spring or facultative growth habit. They all headed, proving that under farmers' conditions their planting date can be very flexible. The fall-planted lines under irrigation were a little taller with larger grain size, and higher yield compared to this spring-planted trial. Four seasons of trials allowed a very good evaluation of the landraces. The variation in days to heading in the landraces was within 7 to 8 days; some were earlier and some later compared to the irrigated check. As expected the landraces were taller than the modern varieties. Some of them (Cat# 3, 16, 17, and 19, Annex 3) exceeded 125 cm in height compared to 80 cm for the Krasnodar 99 check in the 2013-2014 trial. The majority of the landraces were higher yielding compared to the rainfed check Tezpisar under nonirrigated conditions in the spring-planted trial of the 2012-2013 season as well as in the last two seasons under irrigation. In these trials the landraces were also superior to Tezpisar in 1,000-kernel weight and gluten content. Only the durum wheat landrace, Korakiltik (Cat# 13), demonstrated resistance to stripe and leaf rust. All bread wheat landraces were generally susceptible to rusts. Yield performance of the landraces under irrigation compared to Krasnodar 99 varied from year to year: in the 2011-2012 season, they were all superior in yield; in the 2013-2014 season, they were similar to the check, and in the 2014-2015 season, they were all inferior to the check. This relative performance depends on weather conditions. In the 2014-2015 season, landraces suffered from a late

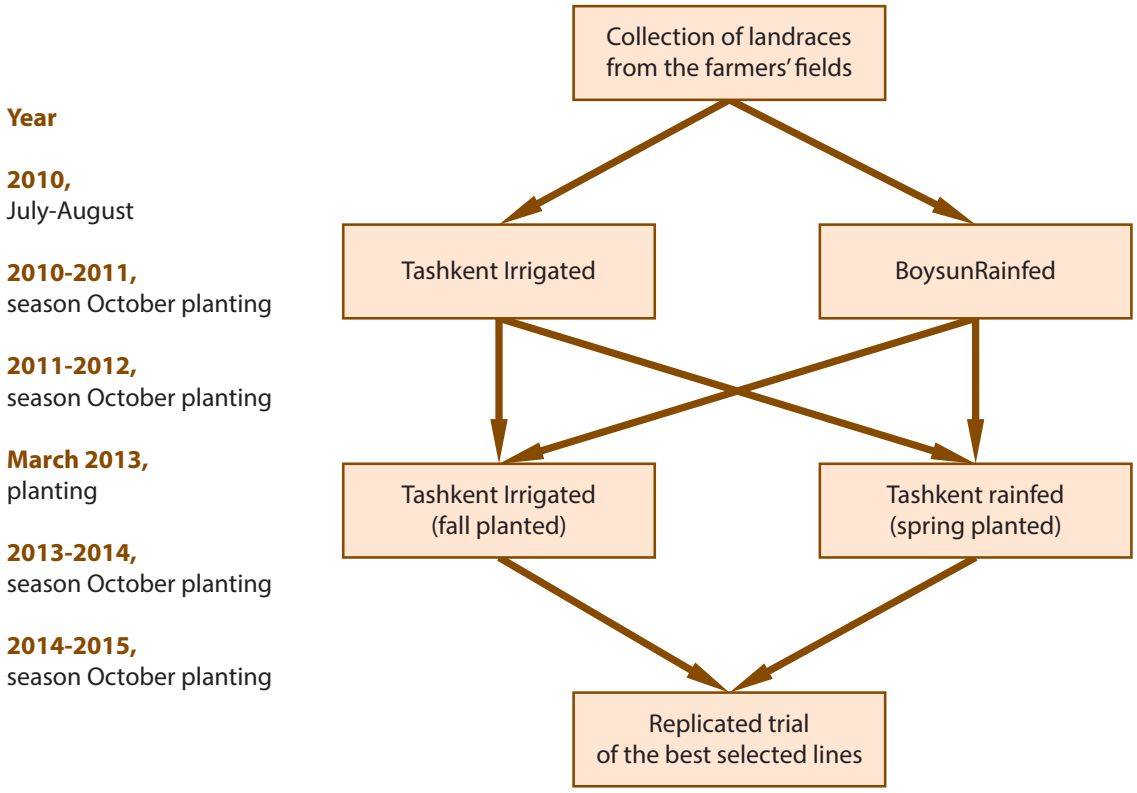

Figure 5. Evaluation scheme for landraces collected in 2010

frost in April and were lower yielding compared to Krasnodar 99. Though generally, yield under irrigation is not relevant for the landraces which are grown in the mountains under rainfed moisture-limited environments, some selections from Kzyl bugday (Cat# 1, 3, and 5) were higher yielding compared to other landraces. Kzyl bugday (Cat# 1, 3), Surkhak (Cat# 11), and Ak bugday (Cat# 15) were higher yielding compared to the check Tezpisar under the nonirrigated spring-planted conditions of the 2012-2013 season. The landraces were also characterized by higher 1,000-kernel weights and gluten content. All the commercial wheat cultivars under intensive irrigated cultivation in Uzbekistan possess moderate grain quality with 24 to 25% gluten content. It is known that grain quality with 28% gluten content is most suitable for the baking industry and many landraces exceed this value. Improving bread-making quality of wheat cultivars in Uzbekistan is an important task for plant breeders. Wheat landraces can be used as a resource for improved grain quality in wheat breeding programs.

One of the tasks of the project was also to collect and restore threatened landraces, reproduce them, and return to farmers. We succeeded in restoring the threatened Kayraktash landrace which has drought tolerance, high gluten content, average plant height, and moderate resistance to yellow rust. In 2014, we planted this landrace on a 0.3 ha rainfed field from which we harvested 0.8 t of seed. The harvested seed was cleaned and treated with fungicides. The seeds were distributed for growing under rainfed conditions of the mountain and highland areas of Boysun and Altinsay districts (Surkhandarya region). This selection is also being prepared for submission to the State Cultivar Testing Committee for possible release as a new cultivar.

CURRENT STATUS OF WHEAT LANDRACES IN UZBEKISTAN

The results of the survey and collections demonstrated that bread making quality of wheat landraces was the main reason for their continued cultivation on small farms. Over the last decade, increased intensive production of wheat cultivars in irrigated lands in Uzbekistan has resulted in a double to triple increase in crop yield up to 4 to 5 t/ha. However, development and adoption of new wheat cultivars for rainfed conditions occur very slowly. In the main rainfed wheat-growing areas, wheat cultivar Surkhak, which was released in the 1940s, is still widely grown. Most of the farms in mountain and foothill areas cultivate landraces Kzyl bugday and Ak bugday. Increased production acreage devoted to wheat as a food crop in the irrigated lands of Uzbekistan and the development of improved transportation systems linking the distant regions of the country resulted in a reduction in the area devoted to growing wheat landraces. In addition, seed production from wheat landraces for distribution suffers from low yield and contamination which has meant decreased availability of wheat landrace seed. Observations from previous years showed that high quality wheat landraces had been mixed with other nonlandrace wheat cultivars. This led to a further decrease of farmers' interest in planting wheat landraces.

As usual, in the release and adoption of new cultivars, the main attention is focused on productivity, resistance, and bread-making quality of the grain. All new cultivars for intensive production are high yielding, but do not always have good bread-making quality. Landraces cultivated in Uzbekistan and elsewhere in Central Asia cannot compete in terms of productivity with commercial cultivars. However, these landraces retain more value as a resource for improving grain quality possibly leading to new cultivars enhanced with micronutrients and other ingredients useful for human health.

FUTURE ACTIVITIES FOR ON-FARM CONSERVATION OF LANDRACES AND THEIR USE IN BREEDING PROGRAMS

The following tasks need to be undertaken to conserve and use wheat landraces in Uzbekistan:

- Detailed description and evaluation for agronomic traits, genomic analysis to develop passport data to accompany the seeds deposited in the National Gene Bank;
- Selection of the best components of the landraces, their evaluation in the landrace production regions, identification of superior selections, their multiplication, and subsequent provision of seed to farmers;
- Study of the genetic diversity of the currently collected landraces and Uzbek landraces from the Gene Bank based on morphological and agronomic traits, DNA markers to distinguish among landraces, and the identification of a core set of landraces for future studies, conservation, and use;
- Biochemical characterization and genotyping of landraces for gliadin and gluten proteins and to establish their relationship with bread-making quality;
- Initiation of crossing programs of landraces with commercial cultivars in order to combine the useful traits in new genotypes; and
- Preparation and publication of scientific papers and reports to publicize Uzbek wheat landraces for the global wheat research community.

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Annex 1. Geographic location and description of wheat landraces[1] collected

Cat#	Village, District	Latitude	Longitude	Elevation (masl)	Landrace name	Month of planting	Mixture or pure line	If mix, % of different types	Grain color	Plant height (cm)
— 2010 collection —										
Surkhandarya region										
1	Duoba, Boysun	38.32121	067.38181	1,391	Kzyl bugday	March	Mixture	2% different	Red	120
2	Duoba, Boysun	38.32480	067.36566	1,544	Boboky	March	Pure line		Red	120
3	Duoba, Boysun	38.32025	067.36594	1,431	Kzyl bugday	March	Pure line		Red	130
4	Kurgancha, Boysun	38.37921	067.41462	1,633	Kzyl bugday	March	Mixture	5% red spike	Red	120
5	Gumatak, Boysun	38.35699	067.37737	2,136	Kzyl bugday	March	Pure line		Red	130
6	Gumatak, Boysun	38.35986	067.07070	2,174	Kzyl bugday	March	Mixture	5% barley	Red	130
7	Gumatak, Boysun	38.35057	067.42538	2,143	Kzyl bugday	March	Pure line		Red	100
8	Pulkhokim, Boysun	38.16484	067.38905	1,050	Boboky	October	Pure line		Red	140
Kashkadarya region										
9	Guldara, Yakkabog	38.78582	066.81014	1,159	Ak bugday	March	Pure line		White	120
10	Guldara, Yakkabog	38.77369	066.82451	1,270	Greacum	March	Mixture	20% Surkhak	White	120
11	Terakly, Yakkabog	38.75540	066.81783	1,634	Surkhak	November	Pure line		Red	130
12	Terakly, Yakkabog	38.75934	066.82558	1,500	Ak bugday	November	Pure line		White	120
13	Navruz, Yakkabog	38.90100	066.64225	585	Korakiltik	November	Mixture	40% Surkhak	Red	90
14	Kuga, Kamashi	38.66376	066.92626	2,249	Ak bugday	March	Pure line		White	120
15	Kuga, Kamashi	38.63243	066.94461	1,988	Ak bugday	March	Pure line		White	90
16	Kzyltom, Kamashi	38.61663	066.93731	1,753	Tuyatish	March	Mixture	15% red spike	Red	120
17	Kuga, Kamashi	38.64701	066.93114	1,731	Kzyl bugday	March	Pure line		Red	120
18	Kzyltom, Kamashi	38.66376	066.92626	2,249	Nameless	March	Mixture	20% red spike	Red	100
19	Kzyltom, Kamashi	38.65243	066.90205	2,147	Nameless	March	Mixture	40% different	Red	100
20	Kzyltom, Kamashi	38.59266	066.91480	1,317	Ak bugday	March	Pure line		White	130
Jizzakh region										
21	Muzbulok, Bakhmal	39.71376	068.12882	1,520	Ak bugday	October	Pure line		White	115
22	Zartepa, Bakhmal	39.70017	068.19329	1,763	Surkhak	March	Mixture	10% barley	Red	120
23	Yonbosh, Galla-Aral	40.12471	067.41983	1,449	Ak bugday	November	Pure line		White	130
24	Lalmikorh, Galla-Aral	39.93540	067.45574	740	Ak bugday	November	Mixture	5% barley	White	110
— 2013 collection —										
Surkhandarya region										
25	Khodja Osmin, Saryazia	38.61500	067.58411	2,008	Pashmak	October	Pure line		White	90
26	Khodja Osmin, Saryazia	38.60202	067.56589	1,650	Khivit	August	Pure line		White	90
27	Khodja Osmin, Saryazia	38.57685	067.58622	1,558	Kzyl bugday	March	Pure line		Red	110
28	Chinar, Altinsay	38.33086	067.65667	1,301	Greacum	October	Pure line		White	105
29	Pas Machay, Uzun	38.31318	067.04989	1,289	Muslimka	October	Mixture	20% different	Red	110
30	Changar-dak, Uzun	38.58531	067.57554	1,615	Kayraktash	March	Mixture	20% different	White	100
31	Changar-dak, Uzun	38.49779	067.69071	957	Kzyl shark	October	Mixture	10% different	Red	110

[1]All landraces listed above have white spike color and are awned; all are bread wheat, except for Korakiltik, which is a durum landrace.

Annex 2. Socio-economic survey responses for villages growing wheat landraces (2010, 2013)

District	Village	Number of families	Elevation (masl)	Dist. to market (km)	Topography	Mean age of farmer	Dominant wheat landrace	Village wheat area (ha)	Village wheat landrace area (ha)	Main reason for landrace cultivation	Years of landrace cultivation	Original seed source
Jizzakh region												
Bakhmal	Muzbulok	300	1,520	50	Valley	45	Ak bugday	1,500	800	Quality, yield	>50 years	Village
Bakhmal	Zartepa	70	1,763	60	Valley	45	Surkhak	2,500	2,500	Quality	>50 years	Village
Galla-Aral	Yonbosh	120	1,449	20	Valley	50	Ak bugday	7,000	1,000	Quality, drought	30 years	Village
Galla-Aral	Lalmikor	1,800	740	25	Valley	50	Ak bugday	500	250	Quality, drought	> 0 years	Village
Kashkadarya region												
Yakkabog	Guldara	300	1,270	45	Mountainous	45	Greacum	100	30	Quality, yield, straw	Forever	Village
Yakkabog	Terakly	45	1,634	50	Mountainous	50	Surkhak	50	50	Quality	Forever	Village
Yakkabog	Navruz	150	585	9	Valley	50	Korakiltik	2,500	20	Quality	Forever	Village
Kamashi	Kuga	80	1,731	60	Mountainous	50	Kzyl bugday	50	20	Quality, yield, straw	Forever	Village
Kamashi	Kzyltom	40	1,753	50	Mountainous	50	Tuyatish	60	15	Quality	Forever	Village
Kamashi	Kzyltepa	75	2,147	80	Mountainous	50	Nameless	200	50	Quality	Forever	Outside
Surkhandarya region												
Boysun	Duoba	70	1,431	35	Mountainous	50	Boboky	500	100	Quality	80 years	Village
Boysun	Kurgancha	220	1,633	45	Mountainous	50	Kzyl bugday	230	130	Quality, straw	100 years	Village
Boysun	Gumatak	70	2,143	33	Mountainous	60	Kzyl bugday	150	20	Quality, straw	>100 years	Own seed
Boysun	Pulkhokim	680	1,050	25	Hillside	50	Kayraktash	500	50	Quality, drought	50 years	Village
Saryazia	Khodja Osmin	700	2,008	80	Mountainous	45	Pashmak	100	1	Quality, cold, straw	Forever	Own seed
Uzun	Changardak	100	1,558	50	Mountainous	50	Khivit	100	3	Quality, straw	Forever	Own seed

Annex 3. Agronomic performance of lines selected from wheat landraces (2010 collection) under irrigated (Tashkent, 2011-2012, 2013-2014, and 2014-2015 seasons, fall planted) and rainfed conditions (Tashkent, 2013 spring planted)

Part 1		Days to heading					Plant height (cm)					Stripe rust (%)		Leaf rust (%)	
Cat#	Line[1]	2012[2]	2013[3]	2014[4]	2015[5]	Mean[6]	2012	2013	2014	2015	Mean	2012	2013	2014	2015
	Krasnodar 99	123	—	127	123	124	70	—	79	77	75	80	—	90	90
	Tezpisar	—	58	123	123	123	—	70	107	114	97	—	0	100	80
1	Kzyl bugday: 2-6T	122	68	127	121	123	115	110	124	92	110	60	20	70	60
3	Kzyl bugday: 3-7T	122	68	125	122	123	110	110	139	100	115	80	50	60	50
4	Kzyl bugday: 9-4T	122	68	129	133	128	115	115	113	111	114	80	20	70	60
5	Kzyl bugday: 5-4T	124	68	127	133	128	110	110	110	107	109	80	40	50	60
6	Kzyl bugday: 11-4T	123	68	127	121	124	115	105	113	112	111	90	10	100	80
9	Ak bugday: 7-3T	120	60	129	117	122	90	90	110	106	99	60	20	70	100
11	Surkhak: 12-3T	123	67	126	123	124	105	105	120	106	109	50	10	90	80
13	Korakiltik: 19-3T	118	60	125	121	121	112	110	112	110	111	0	30	0	0
15	Ak bugday: 8-2T	120	60	129	117	122	90	90	119	105	101	80	50	65	90
16	Tuyatish: 10-4T	123	63	129	125	126	115	115	130	119	120	40	40	70	50
17	Kzyl bugday: 1-4T	124	68	125	121	123	90	110	126	115	110	60	25	60	80
18	Nameless: 13-8T	124	69	127	123	125	110	110	116	107	111	80	10	85	80
19	Nameless: 14-3T	123	68	129	123	125	117	105	129	115	117	80	20	75	60
21	Ak bugday: 16-5T	120	60	123	121	121	105	115	104	105	107	80	20	70	70
22	Surkhak: 15-6T	124	60	128	123	125	110	110	118	110	112	60	20	65	90

Part 2		Yield (g/m²)					1,000-kernel weight (g)					Gluten content (%)		
Cat#	Line[1]	2012	2013	2014	2015	Mean	2012	2013	2014	2015	Mean	2012	2014	Mean
	Krasnodar 99	292	—	568	655	505	38.0	—	51.0	37.0	42.0	30.5	29.2	29.9
	Tezpisar	—	297	260	322	293	—	46.0	44.3	43.5	44.6	—	31.5	31.5
1	Kzyl bugday: 2-6T	432	470	601	260	441	52.0	42.7	49.5	35.0	44.8	33.5	34.2	33.9
3	Kzyl bugday: 3-7T	482	462	673	320	484	52.0	43.0	47.5	37.5	45.0	35.1	29.2	32.2
4	Kzyl bugday: 9-4T	400	262	580	360	401	54.0	37.0	43.8	42.0	44.2	35.0	33.5	34.3
5	Kzyl bugday: 5-4T	454	362	576	331	431	54.0	42.5	44.3	45.0	46.4	22.0	35.6	28.8
6	Kzyl bugday: 11-4T	447	220	462	250	345	50.0	37.0	44.8	40.5	43.1	34.5	29.8	32.2
9	Ak bugday: 7-3T	287	125	446	370	307	44.0	30.0	40.8	43.0	39.4	32.0	28.0	30.0
11	Surkhak: 12-3T	390	410	538	350	422	48.0	43.0	42.0	40.0	43.2	28.0	26.0	27.0
13	Korakiltik: 19-3T	410	285	557	352	401	46.0	40.0	46.0	38.0	42.5	31.5	32.3	31.9
15	Ak bugday: 8-2T	448	420	426	313	402	48.0	39.0	40.5	38.5	41.5	37.5	36.4	37.0
16	Tuyatish: 10-4T	388	301	405	385	370	48.0	37.0	45.5	37.5	42.0	32.0	31.6	31.8
17	Kzyl bugday: 1-4T	421	292	325	310	337	50.0	37.0	42.3	42.0	42.8	29.0	32.0	30.5
18	Nameless: 13-8T	272	360	492	432	389	42.0	40.5	47.3	39.0	42.2	40.5	39,6	40.5
19	Nameless: 14-3T	440	300	417	458	404	52.0	35.0	44.0	44.5	43.9	35.0	32.4	33.7
21	Ak bugday: 16-5T	417	339	416	471	411	48.0	44.5	43.8	44.0	45.1	35.0	36,0	35.0
22	Surkhak: 15-6T	391	302	440	385	380	48.0	41.5	47.3	43.0	44.9	35.5	29.6	32.6

[1]Krasnodar 99 and Tezpisar are the bread wheat check cultivars in each trial. For the landraces, following the name is the number of the spike selected from the original landrace collection and, after the dash, the number of the pike selected in Tashkent (e.g., 15-6T); [2]Days from January 1 (planted in October 2011); [3]Days from planting date (planted in March 2013); [4]Days from January 1 (planted in October 2013); [5]Days from January 1 (planted in October 2014); [6]Mean for 2012, 2014, and 2015

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