RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
55 (4) 1193-1204, 2023
http://doi.org/10.54910/sabrao2023.55.4.15
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

WINTER WHEAT ASSESSMENT FOR GROWTH, GRAIN YIELD, AND QUALITY PARAMETERS UNDER DIVERSE SOIL AND CLIMATIC CONDITIONS

D. JURAEV[1*], O. AMANOV[1], SH. DILMURODOV[1], N. BOYSUNOV[1], S. TURAEVA[2], N. MAMADJANOVA[3], and D. RAIMOVA[4]

[1]Southern Research Institute of Agriculture, Kashkadarya Region, Uzbekistan
[2]S.Yu. Yunusov Institute of the Chemistry of Plant Substances, Academy of Sciences of Uzbekistan
[3]Andijan Institute of Agriculture and Agrotechnologies, Andijan Region, Uzbekistan
[4]Karshi State University, Kashkadaryo Region, Uzbekistan
*Corresponding authors' emails: di.yor@mail.ru, buronova_1985@mail.ru
Email addresses of co-authors: urugchilik@mail.ru, s.dilmurodov@mail.ru, nurzod.boysunov@mail.ru, saidaicps@gmail.com, nafisamamadjonova@mail.ru, otabek.oripov11@mail.ru

SUMMARY

The presented study aims to select the early-maturing and high-yielding winter wheat genotypes via the assessment of various eco-geographical groups and to illustrate their scientific significance for the diverse environmental conditions of the Kashkadarya Region of the Republic of Uzbekistan. Twenty-four advanced wheat lines underwent selection and evaluation for comparison with six regional and promising cultivars to further improve and use for crossbreeding. Overall, eight cultivars showed promising in the desert zone of the Kashkadarya Region, 24 in the middle area, and 13 in the region's foothills, while selecting five for the desert zone, six in the middle, and 10 in the foothills of Uzbekistan. Seventeen cultivars and advanced lines attained selection for the desert area of District Kasbi with higher protein content (14%), 21 in the middle zone of District Karshi, and 22 in the foothills of District Shahrizabz. Cultivars and advanced lines selected for the desert area of District Kasbi, in the middle zone of District Karshi, and in the foothills of District Shahrizabz numbered 14, 14, and three, respectively, where the gluten content was more than 30%. Weather conditions also affect the wheat genotype yields in the irrigated areas, and due to less rainfall in March-May of 2011, in the desert and foothills, the average yield declined by 0.2–0.23 and 0.15–0.25 t/ha in the deserts and foothills, respectively, compared with other years. The precipitation in March-May strongly correlated *(r = 0.47)* with the grain yield in winter bread wheat.

Keywords: winter bread wheat (*Triticum aestivum* L.), soil, climate, weather condition, cultivars, advanced lines, precipitation, grain yield and quality

Key findings: The present-day study selected early-maturing, highly productive, and good-quality cultivars and advanced lines of winter bread wheat for diverse soil and weather conditions of the Kashkadarya Region, Uzbekistan. Assessing the developmental phases of winter bread wheat in the

Citation: Juraev D, Amanov O, Dilmurodov Sh, Boysunov N, Turaeva S, Mamadjanova N, Raimova D (2023). Winter wheat assessment for growth, grain yield, and quality parameters under diverse soil and climatic conditions. *SABRAO J. Breed. Genet.* 55(4): 1193-1204. http://doi.org/10.54910/sabrao2023.55.4.15.

foothills, middle, and desert regions of Kashkadarya resulted in selecting and identifying early-maturing and high-yielding wheat genotypes suitable for each zone.

Communicating Editor: Dr. Samrin Gul

Manuscript received: March 28, 2023; Accepted: July 11, 2023.

INTRODUCTION

The world's expanding population will demand more grains and grain products soon. Even today, the precise requirements for wheat cultivars are growing. The updated forecasts of Statista show that in 2022–2023, the global wheat production will reach 781.31 million t, which is 0.5% lower than last year's highest figure; however, it was still a high crop production level (Statista, 2023). In 2019, world wheat production was 761.51 million t, with a 3.9% increase over 2018 (Statista, 2023).

With global climate change, grain-producing countries, such as, the United States, Canada, China, India, and Russia, focus on increasing grain yields by developing new wheat cultivars resistant to various abiotic factors (Boysunov and Juraev, 2019; Khan *et al*., 2023). Improving the harvest and quality of cereals, including bread wheat, is one of the vital missions in today's plant breeding and crop production to ensure food security at the regional and global levels (Baboev *et al.,* 2017, 2021; Amanov and Azimova, 2019; Qulmamatova *et al.,* 2022).

During spring and summer, several factors affect wheat cultivars' growth, development, and yield (Amanov and Bolkiev, 2020). Therefore, research on developing high-yielding and good-quality wheat cultivars resistant to external stress factors and evaluating advanced hybrid lines is significant nowadays (Amanov and Jabarov, 2014; Amanov *et al.,* 2019, 2022). Depending on the natural-climatic conditions of each region, it is necessary to develop new wheat cultivars with high yields and good quality that can still grow regardless of the environment (Amanov and Rakhimov, 2016; Amanov and Shoymuradov, 2019; Swailam *et al*., 2021; Tembo, 2021).

By the decision of the State Department for Cultivar Testing of Agricultural Crops of Uzbekistan, more than 40 wheat cultivars have become part of the National List, with more than half being local wheat cultivars (Dilmurodovich *et al.,* 2021). According to past data, more than 200,000 hybrids achieved development under the bread wheat nursery program from 1950 to 2002, and as a result of testing, isolating more than 10,000 advanced lines from hybrid generations under different climatic conditions, with more than 500 new bread wheat cultivars developed and introduced on more than 40 million ha (Rajaram *et al.,* 2002).

In developing countries, 32% of wheat genotypes get exposed to heat stress conditions during the growing season (Amanov *et al.,* 2019). Local wheat cultivars grown in Central Asia are heat-resistant since harmful temperatures lead to protein coagulation in the early phases of the plant growth stages (55 °C to 56 °C) and grain-filling phase (61 °C) (Juraev, 2018; Juraev *et al.,* 2017). Winter wheat cultivars can also have the predominance of individual parameters of the crop structure characterizing them, depending on the type and group of ripening period (Juraev *et al.,* 2020a, b).

In evaluating the wheat grain's attributes, protein content, sedimentation rate, number of free falls, the size and shape of the bread, and the unit of gluten quality are the most important indicators in producing wheat bread and its byproducts (Khazratkulova *et al.,* 2015; Khazratkulova and Juraev, 2018). The gluten amount and quality are the essential factors assessing technological and nutritional richness of wheat grains. On technological quality of wheat grains, the environment growing wheat also significantly impacts the amount of protein, gluten content, and their quality (Juraev and Yusupov, 2020). During the ripening period of wheat, if the temperature is high and the rainfall is low, then the protein and gluten amount in the grain will be high; however, these quality indicators will deteriorate and will be less if precipitation occurs during the ripening period (Dilmurodovich *et al.,* 2021).

As a result of a comprehensive study of the advanced lines adapted to the country's southern regions, some high-yielding advanced lines with good quality characteristics have gained selection, recommending them as donor parents in future hybridization (Juraev *et al.,* 2021a, b). In selecting heat-tolerant genotypes for the southern regions, the high temperature during the spiking-ripening and grain-filling periods greatly influence, decreasing the grain yield and its quality in the sensible cultivars (Juraev *et al.,* 2020a, b; Dilmurodovich *et al.,* 2021). The presented study aims to select early-maturing, high-yielding, and good-quality cultivars and advanced lines of winter bread wheat for various soil and climatic conditions of Kashkadarya Region, Uzbekistan.

MATERIALS AND METHODS

Studies on the developmental phases of winter bread wheat for the foothills, middle, and desert regions and the selection of early-maturing and high-yielding cultivars and advanced lines proceeded in Kashkadarya Region, Uzbekistan. For grain quality parameters, selecting wheat genotypes considered high-protein and gluten contents for the foothills, middle, and desert regions of Kashkadarya. Field experiments ran during 2012–2014 at the Southern Agricultural Research Institute in District Karshi, Uzbekistan. Laboratory experiments and surveys continued through "Determination of technological quality indicators of grain and physiology." Technological quality indicators of winter wheat grain grown in the experimental field received comparative studies in the laboratory, according to "Methodical recommendations for the evaluation of the quality of grain" (Sozinov*,* 1977), "Methods of biochemical research of plants," gluten content comparison by GOST 13586-1-68 (SCSCMU, 1968), grain vitreousness by GOST 10987-76 (SCSCMU, 1977), grain moisture by GOST 13586-5-93 (GR, 1995), grain nature appraisal, according to GOST 3040-55 (SCSCMU, 1956), and weight of 1000 grains, according to GOST 10842-89 (MGPU, 1991).

The basis for developing the field experimental scheme employed the complete block design and alpha lattice design of the Genestat-3 program. During the selection process, 24 advanced lines moved for further use in selection and crossbreeding to study 30 cultivars and advanced lines to compare six regional and promising cultivars. The field experiments transpired in three sites, i.e., desert, middle, and foothill areas of the regions (Districts Kasbi, Karshi, and Shakhrisabz), Uzbekistan, in setting up the agro-ecological varietal testing nurseries. Earlier recording and compiling of the required data ensued before the analysis. Statistical analyses used the method of Dospekhov (1985).

RESULTS AND DISCUSSION

Based on the growing season duration, the wheat breeding material's (cultivars and advanced lines) subdivision included three groups, i.e., early, medium, and delayed ripening. All these three are vital in production, and these genotypes' planting can depend on the available land, type, nature, and the purpose of the crop. The shorter the growth period from germination to full ripening of the crop, the better the crop quality in a short period. In general, early ripening cultivars allow the intensification of farming in all types of soil-climatic regions of the country. Phenological observations ensued to determine the precocity of the studied wheat genotypes, including the growing season duration. The phenological examinations ran as follows:

a. Visual observations performed by one person in the morning or evening.

b. Field monitoring at the three sites (beginning, middle, and end) of the fields where planting each wheat genotype occurred.

c. Observations carried out only unilaterally (on the east or west side of the line).

For evaluation, comparing the wheat cultivars and advanced lines was mainly with the standard cultivar Tanya in terms of yield, with cultivar Kranodar-99 based on quality, and with early-maturing cultivar Yaksart for resistance to drought and disease. From phenological observation, the date the developmental phases began (10%–15%) and the day of the month the full (75%) transition emerged has a unique recording process requiring daily monitoring of the crops. Among the studied bread wheat cultivars, the germination-ripening period in the desert zone had a range of 180–184 days in Entry-6, 100/36, and 200/43; in the middle area (182–186 days), and the foothill areas (185–189 days) for promising wheat genotypes, i.e., Krasnodar-99, 100/37, 200/41, and 200/50. In delayed-maturing cultivars and advanced lines, the said indicator ranges were 195–201 days (desert zone), 196–203 days (middle), and 201–206 days (foothills). The rest of the wheat cultivars had the middle-ranged ripening period (187–195 days) at the three sites. Yield is the most desirable and crucial parameter of crop plants. Grain yield varied from genotype to genotype due to a genetic variation of the crop plant. As a quantitative character, yield receives immense impacts from genotype-environment interactions. Final grain yield depends on the genetic potential of a genotype against biotic and abiotic stresses and the overall performance of an individual plant (Saleem *et al.,* 2018).

Compared to 2012, the high rainfall and lower air temperatures in the spring of 2010 and 2011 caused prolonged tillering and shooting phases, also affecting the germination-ripening period. Results further exhibited that the average growth period of the wheat genotypes during 2010–2012 was 188/188/186, 188/189/190, and 192/194/193 days in the desert/middle/foothills of Districts Kasbi, Karshi, and Shakhrisabz, respectively. Hence, according to the growing conditions of bread wheat cultivars, these enhanced the maximum growth period to a certain level (Table 1). In the analysis results of regions over the years, the average growth periods were 189.5, 190.5, and 189.8 days in 2010, 2011, and 2012, respectively. In the irrigated regions, the bread-wheat growing season fluctuates and depends on annual precipitation, air temperature, and relative humidity. These cultivars showed average resistance levels under hot spot environmental conditions and may perform well under climatic conditions less favorable for leaf rust (Rattu *et al.,* 2009).

Overall, 30 promising winter bread wheat genotypes became choice cultivars from the collection, selection, and control nurseries planted for agro-ecological cultivar testing in the different locations with diverse soil and climatic conditions of Kashkadarya Region, Uzbekistan. For the plant height, the wheat cultivars ranged from 79 to 110 cm in the desert (takyr and bare area conditions) and middle zones (light gray soils); however, the genotypes were significantly not different for the variable (Table 1). At the foothills (typical gray soils), the wheat genotypes ranged from 85 to 113 cm for plant height and were notably 7–10 cm taller than in the desert and middle zones. The rest of the cultivars' plant height appeared higher as the growing site gradually moved from the desert zone to the foothills area.

In the desert and middle areas, the least plant height (79–88 cm) resulted in the genotypes Tanya, Hisorak, Vostorg, and 200/42, while in foothill areas, the genotypes gained one same average range for the plant height (88–92 cm). However, the tallest plants surfaced in wheat genotypes, i.e., Entry-6, 100/36, 100-39, and 200/43 ranging from 100 to 113 cm. Cultivar Nota emerged as the plant with a height of 92 cm in takyr soils, 88 cm in light gray soils, and 93 cm in foothill typical gray soils (Table 1). In three experimental sites, the plant height of 76–90 cm showed from 10 cultivars in the desert condition, 11 cultivars in middle areas, and three cultivars in mountainous and foothill zones. However, the plant's height range of 91–120 cm was in 20 genotypes in the desert, 19 cultivars in the middle, and 27 selections in mountainous and foothill zones.

Table 1. Mean performance of wheat cultivars and advanced lines for growth period and plant height during 2010–2012.

No.	Wheat cultivars & advanced lines	Growth period (days)				Plant height (cm)			
		Kasbi district. (M±m)	Karshi district. (M±m)	Shakhrisabz district. (M±m)	Average district. (M±m)	Kasbi district. (M±m)	Karshi district. (M±m)	Shakhrisabz district. (M±m)	Average district. (M±m)
1	Tanya	188.3±2.5	190.0±0.5	195.7±3.5	191.3±2.8	88.0±2.0	88.0±1.0	91.7±0.5	89.2±1.8
2	Jaykhun	187.0±1.5	189.0±0.5	195.0±0.5	190.3±3.0	90.0±1.5	89.3±0.5	94.7±2.0	91.3±2.7
3	Entry-6	182.0±1.0	183.7±1.0	191.3±1.5	185.7±3.8	110.0±0.5	110.3±0.0	113.3±1.0	111.2±1.5
4	Farovon	181.0±0.5	183.7±0.5	195.3±1.0	186.7±5.8	102.0±1.5	100.3±1.0	109.3±2.0	103.9±4.5
5	Nota	185.7±0.5	188.3±1.5	195.3±1.0	189.8±3.5	92.0±1.0	88.3±3.0	93.0±0.0	91.1±2.3
6	Vostorg	185.0±1.5	187.0±0.5	194.7±4.0	188.9±3.8	82.0±1.0	84.3±0.0	88.0±0.5	84.8±1.8
7	Hisorak	185.7±1.0	186.7±2.0	200.3±2.0	190.9±6.8	80.0±2.0	81.7±1.5	86.3±0.0	82.7±2.3
8	Krasnodar-99	195.7±0.0	197.7±1.0	193.7±1.5	195.7±2.0	93.0±1.0	92.7±1.5	101.3±5.0	95.7±4.3
9	Entry-9-23	185.0±1.0	188.3±2.5	194.3±1.5	189.2±3.0	90.0±1.0	89.3±1.0	94.3±2.0	91.2±2.5
10	Barhayot	181.7±1.0	183.3±0.5	192.3±0.5	185.8±4.5	92.0±1.0	91.3±0.5	99.0±2.0	94.1±3.8
11	Turkiston	186.3±2.5	189.0±1.0	185.3±1.0	186.9±1.8	91.0±1.0	83.7±3.0	91.7±1.0	88.8±4.0
12	Yaksart	187.3±2.0	189.0±1.0	193.0±0.5	189.8±2.0	92.0±1.0	93.7±1.0	97.3±1.0	94.3±1.8
13	Selyanka	185.0±2.0	187.0±1.0	188.0±1.0	186.7±0.5	84.0±1.0	82.3±1.5	91.3±3.0	85.9±4.5
14	Entry-32	187.7±3.0	188.0±0.0	198.3±0.5	191.3±5.2	97.0±1.0	86.3±2.0	111.7±1.5	101.7±7.7
15	Bunyodkor	184.0±0.5	182.7±1.0	191.0±1.0	185.9±4.2	89.0±1.0	88.3±1.0	95.3±3.0	90.9±3.5
16	100/36	184.7+1.0	185.3±1.5	186.3±1.0	185.4±0.5	109.0±1.0	107.3±1.0	111.7±0.0	109.3±2.2
17	100/37	196.7±1.0	196.7±2.0	187.0±0.5	193.4±4.8	101.0±1.0	100.3±2.0	105.0±2.5	102.1±2.3
18	100/38	185.3±2.0	189.0±1.0	188.3±0.0	187.6±0.3	100.0±1.0	100.3±1.5	105.0±1.5	101.8±2.3
19	100/39	188.3±2.5	190.7±1.0	194.0±2.0	191.0±1.7	105.0±1.0	102.3±1.0	108.3±1.5	105.2±3.0
20	100/40	186.7+3.0	190.7±0.0	193.3±1.0	190.2±1.3	10.6.0±1.0	104.3±1.0	107.3±1.0	105.9±1.5
21	200/41	195.3±1.0	197.3±0.0	193.0±1.5	195.2±2.2	87.0±1.0	83.3±1.5	94.3±4.0	88.2±5.5
22	200/42	186.7±3.0	189.0±0.5	192.7±0.0	189.4±1.8	79.0±1.0	79.3±3.0	87.7±2.5	82.0±4.2
23	200/43	182.3±1.0	183.3±1.5	200.7±4.0	188.8±8.7	100.0±1.0	101.3±2.5	110.3±4.0	103.9±4.5
24	200/44	189.7±1.5	190.0±1.0	186.3±2.0	188.7±1.8	96.0±1.0	92.0±2.0	98.7±1.0	95.6±3.3
25	200/45	188.3±0.5	190.3±1.0	193.7±1.5	190.8±1.7	96.0±1.0	89.7±2.0	97.7±1.5	93.4±4.0
26	200/46	186.0±1.5	190.3±0.5	194.0±1.0	190.1±1.8	90.0±1.0	90.3±0.5	95.7±3.0	92.0±2.7
27	200/47	186.7±1.5	189.7±0.5	193.0±0.5	189.8±1.7	94.0±1.0	92.0±2.5	97.7±1.5	94.6±2.8
28	200/48	187.0±2.0	190.0±1.5	194.7±1.0	190.6±2.3	100.0±1.0	99.3±1.5	105.7±2.0	101.7±3.2
29	200/49	186.0±1.5	191.3±1.0	193.0±0.5	190.1±0.8	92.0±1.0	91.3±1.0	95.7±1.0	93.0±2.2
30	200/50	198.7±2.0	201.0±0.5	205.3±0.0	201.7±2.2	97.0±1.0	94.0±1.5	100.3±1.5	97.1±3.2
$LSD_{0.05}$					5.45				2.93

Among the studied wheat genotypes in the desert zone, the standard cultivars Tanya and Krasnodar-99 obtained plant heights of 88 cm and 95 cm, respectively. However, the 12 wheat cultivars, i.e., Entry-6, Entry-32, 100/36, 100/37, 100/38, 100/39, 100/40, 200/43, 200/44, 200/47, 200/48, and 200/50 appeared to be higher than 95 cm in plant height. In the middle region, the cultivars Tanya and Krasnodar-99 had plant heights of 86 and 93 cm, respectively, while 10 more cultivars were notably higher than 93 cm for the trait. Plant height, number of grains per spike, grain weight per spike, 100-grain weight, biological, and grain yield contribute equally to the average grain yield of wheat crops (Khan, 2016). When both direct and reciprocal crosses showed better performance over parents for a particular trait, their selection is sure and shall move to the next collection generation. Phenotypic correlations of plant height with grains per spike and 100-grain weight were significant and positive (Kashif and Khaliq*,* 2004).

The plant height varied by 3–4 cm, and the spike length also varied, based on having a positive association with plant height *(r* = 0.47) for every 100 m of elevation above sea level from the desert region. The grains per spike also differed; in the middle spikelets, the grains were vast, while in the upper and lower spikelets, these were smaller. In the three zones (desert, middle, and foothills), the 1000-grain weight contrasted in the genotypes, i.e.,

Table 2. Mean performance of wheat cultivars and advanced lines for 1000-grain weight and grain yield during 2010–2012.

No.	Wheat cultivars & advanced lines	1000-grain weight (g)				Grain yield (t/ha)			
		Kasbi distri ct. (M±m)	hi distri ct. (M±	hrisa bz distri ct. (M±	age distri ct. (M±	Kasbi distri ct. (M±m)	hi distri ct. (M±	hrisa bz distri ct. (M±	age distri ct.)M±
1	Tanya	37.4±1.0	39.1±0.5	39.8±0.5	38.8±03	5.05±0.7	5.51±0.3	6.25±0.6	5.61±0.7
2	Jaykhun	41.2±0.4	42.2±0.9	42.7±0.6	42.0±0.3	5.38±0.3	6.41±0.8	5.26±0.1	5.68±0.8
3	Entry-6	39.2±1.0	39.4±0.5	39.6±0.1	39.4±0.1	5.66±0.1	6.01±0.6	6.52±0.1	6.06±0.6
4	Farovon	41.5±0.6	42.3±0.9	42.2±0.6	42.0±0.1	6.57±0.9	6.77±0.6	7.55±0.2	6.96±0.9
5	Nota	38.3±0.9	39.4±0.5	39.6±0.4	39.1±0.1	4.88±0.3	5.24±0.9	5.70±0.9	5.28±0.3
6	Vostorg	39.1±0.6	40.5±0.5	40.2±0.5	39.9±0.1	5.31±0.3	5.69±0.9	5.93±0.1	5.64±0.2
7	Hisorak	38.8±0.6	40.3±0.9	40.9±0.4	40.0±0.3	5.51±0.2	6.16±0.1	6.79±0.2	6.15±0.1
8	Krasnodar-99	39.6±0.6	40.4±0.3	41.2±0.5	40.4±0.4	5.29±0.6	5.84±0.8	6.67±0.5	5.93±0.2
9	Entry-9-23	38.5±0.6	40.4±0.1	40.1±0.5	39.7±0.2	6.51±0.5	6.45±0.8	6.97±0.3	6.65±0.6
10	Barhayot	40.5±0.6	41.3±0.5	42.2±0.4	41.3±0.5	6.43±0.5	6.62±0.2	6.70±0.2	6.58±0.4
11	Turkiston	36.7±0.7	37.6±0.1	37.8±0.6	37.4±0.1	5.13±0.6	5.32±0.9	5.55±0.1	5.34±0.2
12	Yaksart	40.2±1.1	40.9±0.4	41.1±0.5	40.7±0.1	6.36±0.4	6.56±0.9	7.42±0.9	6.78±0.3
13	Selyanka	35.2±0.4	36.1±0.0	36.7±1.1	36.0±0.3	5.38±0.2	5.43±0.3	6.16±0.9	5.66±0.6
14	Entry-32	39.2±0.4	40.2±0.3	40.8±0.5	40.1±0.3	5.62±0.8	6.56±0.3	6.77±0.8	6.32±0.1
15	Bunyodkor	40.1±0.5	40.8±0.3	41.4±0.4	40.8±0.3	6.19±0.8	6.64±0.3	7.19±0.5	6.67±0.8
16	100/36	38.2±0.4	39.6±0.5	40.3±0.2	39.4±0.4	5.87±0.5	6.09±0.4	6.95±0.1	6.31±0.3
17	100/37	39.5±0.6	39.8±0.6	40.5±0.6	39.9±0.3	5.25±0.1	5.63±0.3	6.02±0.3	5.63±0.2
18	100/38	40.2±0.8	40.8±0.4	41.4±0.5	40.8±0.3	5.59±0.4	6.92±0.6	6.95±0.3	6.48±0.1
19	100/39	38.5±0.4	39.6±1.3	39.9±0.6	39.3±0.2	5.33±0.6	5.84±0.7	5.68±0.2	5.62±0.8
20	100/40	37.6±0.3	38.8±0.1	38.7±0.6	38.4±0.1	5.74±0.4	5.78±0.1	6.36±0.9	5.96±0.9
21	200/41	39.5±1.0	40.3±0.2	40.4±0.8	40.1±0.0	5.62±0.7	6.35±0.2	6.69±0.5	6.22±0.7
22	200/42	38.9±0.4	39.7±0.9	39.3±0.4	39.3±0.2	5.04±0.2	5.44±0.1	5.64±0.3	5.38±0.1
23	200/43	39.8±0.6	40.4±0.6	40.9±0.4	40.4±0.3	5.60±0.2	5.95±0.2	6.28±0.4	5.95±0.6
24	200/44	38.7±0.6	39.8±0.2	40.6±0.3	39.7±0.4	5.43±0.9	5.98±0.6	6.62±0.5	6.01±0.2
25	200/45	39.5±0.5	40.2±0.3	41.2±0.4	40.3±0.5	5.78±0.9	6.48±0.8	6.73±0.2	6.33±0.2
26	200/46	37.4±0.8	39.8±0.6	39.4±1.0	38.9±0.2	5.15±0.3	5.90±0.9	6.00±0.7	5.68±0.5
27	200/47	38.5±0.0	39.2±0.4	40.1±0.6	39.3±0.4	5.66±0.4	6.53±0.3	6.34±0.1	6.18±0.1
28	200/48	39.6±0.8	40.3±0.3	41.1±0.3	40.3±0.4	5.23±0.4	6.03±0.4	6.52±0.5	5.93±0.5
29	200/49	38.5±0.2	40.6±0.1	40.7±0.6	39.9±0.0	5.50±0.5	5.86±0.1	6.18±0.9	5.85±0.6
30	200/50	44.1±0.7	46.4±0.2	46.5±0.6	45.7±0.1	6.34±0.3	6.89±0.6	6.50±0.3	6.57±0.9
$LSD_{0.05}$					0.55				4.27

cultivar Krasnodar-99 (39.6, 40.4, and 41.2 g), Farovon (41.5, 42.0, and 42.1 g), Barkhayot (40.5, 41.3, and 42.2 g), Bunyodkor (40.1, 40.8, and 41.4 g), and in advanced line 100/38 (40.2, 40.8, and 41.4 g). However, wheat genotype 200/50 with bolder grains revealed the highest 1000-grain weight (44.1, 46.4, and 46.5 g) (Table-2).

According to average productivity during 2010–2012 under three types of soil and climate conditions, the cultivar Tanya produced a yield of 5.02, 4.80, and 5.34 t/ha in the desert zone, 5.72, 5.53, and 5.28 t/ha in the middle, and 6.13, 6.26, and 6.37 t/ha in the foothills (Table 2). Cultivar Krasnodar-99 provided the yield of 5.53, 5.01, and 5.32 t/ha in the desert, 5.91, 5.88, and 5.72 t/ha in the middle, and 6.42, 6.64, and 6.94 t/ha in mountainous and foothill zone conditions. In the standard cultivars Tanya and Krasnodar-99, a sharp decrease occurred in yield due to drought susceptibility in the desert zone; however, the drought-resistant cultivar Yaksart provided an average yield of 6.06 t/ha during the three years. Phenotypic correlations of yield per plant were highly significant and favorable with the number of productive tillers per plant, spikelets per spike, and grains per spike, while substantial with spike length and noteworthy but negative with plant height (Ahamd *et al.,* 2010).

On average, the highest yield recordings came in five winter wheat cultivars, i.e., Bunyodkor (6.19 t/ha), Barhayot (6.43 t/ha), Farovon (6.57 t/ha), lines Entry-9-23 (6.53 t/ha), and 200/50 (6.34 t/ha). Among the cultivars, in light gray soils (middle zone) conditions during 2010–2012, yield was 5.72, 5.53, and 5.28 t/ha in cultivar Tanya, 5.91, 5.88, and 5.72 t/ha in cultivar Jaykhun, and

6.7, 6.39, and 6.57 t/ha in cultivar Yaksart, compared with cultivars, i.e., Bunyodkor, Hisorak, Farovon, Barhayot, 200/50, 200/45, and Entry-32 which gave higher yields during the three years.

The drought-tolerant cultivar Yaksart became a substitute in the middle zone due to a sharp yield decrease in standard cultivars Tanya and Krasnodar-99. During the three years of studies, the average highest harvest was 6.56 t/ha in cultivar Yaksart, 6.77 t/ha (Farovon), 6.62 t/ha (Barhayot), 6.56 t/ha (Entry-32), 6.64 t/ha (Bunyodkor), 6.92 t/ha (100/38), and 6.89 t/ha in advanced line 200/50 line and manifested superiority over the standard cultivars (Table 2). In foothill zones, during the average three years of studies, benchmark cultivars Tanya and Krasnodar-99 have 6.25 and 6.67 t/ha, respectively.

The highest grain yield also resulted in advance lines and cultivars, i.e., 100/38 (7.29, 6.74, and 6.81 t/ha), 200/41 (7.32, 7.45, and 7.88 t/ha), Entry-9-23 (6.82, 7.02, and 7.08 t/ha), Bunyodkor (7.42, 7.22, and 6.93 t/ha), Farovon (7.32, 7.45, and 7.88 t/ha), Barhayot (6.62, 6.52, and 6.96 t/ha), Hisorak (6.82, 6.97, and 6.57 t/ha), and Yaksart (7.22, 7.61, and 7.42 t/ha). Comparing 30 cultivars and advanced lines in three different soil and climatic conditions, the cultivars Tanya and Krasnodar-99 yielded 5.6 and 5.93 t/ha, respectively. Among the studied wheat cultivars and advanced lines, the highest yield came from cultivars Farovon (6.96 t/ha), Bunyodkor (6.67 t/ha), Entry-9-23 line (6.64 t/ha), Barhayot (40.5 g, 41.3 g and 42.2 g), and 200/50 (6.58 t/ha). However, nonsignificant differences occurred among the sites (Table 2).

However, on average productivity over the years and in locations, the yield was higher by 3.6–5.8 t/ha in the middle zone compared with the desert, with the foothills higher (7.8–8.5 t/ha) than the desert and by 2.5–4.9 t/ha more than the middle area. The comparative studies on cultivars and advanced lines for their selection and adaptation to each site indicated the grain yield was higher in 11 genotypes, i.e., 100/36, 100/38, 200/41, 200/50, Entry-9-23, Entry-32, Bunyodkor, Farovon, Barhayot, Hisorak, and Yaksart in foothill zones than standard cultivars. Six cultivars in the middle sector, such as, Farovon, Barhayot, Entry-32, Bunyodkor, 100/38, and 200/50, had higher grain yields compared with standard cultivars. However, in the desert region, five cultivars, i.e., Bunyodkor, Barhayot, Farovon, Entry-9-23, and 200/50, occurred as higher-yielding versus standard cultivars. On average, during three years of studies under three soils and climatic conditions, the regular cultivars Tanya, Krasnodar-99, and Yaksart yielded 5.60, 5.93, and 6.36 t/ha, respectively. Overall, 17 cultivars and advanced lines were higher-yielding than standard cultivars. Similarly, six cultivars and lines (Farovon, Entry-9-23, Barhayot, Bunyodkor, 100/38, and 200/50) gave higher yields and better grain quality traits under different soil and climatic conditions compared with cultivar Yaksart. Results authenticated that these promising genotypes require further studies in these areas for future improvement. Grain yield showed highly significant with biological harvest while non-significantly positive with days to heading, maturity, plant height, grain weight per spike, and 100-grain weight (Saleem M. *et al.,* 2003).

After using the agrotechniques in irrigated lands of the Kashkadarya Region, the yield of winter bread wheat increased from 3.6 to 8.5 t/ha with the rise from takyr and barren soils to light gray and typical gray soils. Furthermore, weather conditions in irrigated areas also affected the increase in winter bread wheat yields. During the study seasons, due to less rainfall in March-May of 2011 in the desert and foothills, the average harvest decreased by 2–2.3 t/ha in the desert zone and 1.5–2.5 t/ha in the foothills (Table 3). In irrigated areas of the Kashkadarya Region, the rainfall of less than 10 mm in March-May decreased winter bread wheat yields up to 0.2 t/ha in takyr and barren soils and up to 0.22 t/ha in typical gray soils, when less than 40 mm. The rainfall during March-May has a strong positive correlation (r = 0.47) with grain yield (Table 4).

Table 3. Effect of weather conditions on the wheat genotypes' productivity over the years and sites (March–May months).

Sites and years	Air temperature (℃)	Rainfall (mm)	Relative humidity (%)	Mean productivity (t/ha)
Kasbi (2010)	19.6	21.8	65.2	5.67
Kasbi (2010)	19.0	10.2	47.2	5.47
Kasbi (2010)	17.6	20.5	53.7	5.7
Karshi (2010)	18.1	54.4	64.2	6.17
Karshi (2010)	18.1	54.3	44.9	6.05
Karshi (2010)	17.5	52.5	56.3	6.06
Shakhrisabz (2010)	17.1	75.0	64.6	6.45
Shakhrisabz (2010)	17.3	37.8	53.1	6.3
Shkahrisabz (2010)	16.8	83.6	55.9	6.55

Table 4. Correlation between weather conditions and average productivity of the wheat genotypes over the years and sites (March–May).

Indicators	Air temperature (°C)	Rainfall (mm)	Relative air humidity (%)
Amount of rainfall (mm)	-0.71		
Relative air humidity (%)	0.02	0.27	
Average productivity (t/ha)	-0.80	0.92	0.28

In cultivars Tanya and Vostorg, the grain protein content was 12.7% and 13.7% in the desert, 14.9% and 14.0% in the middle, and the same for both cultivars (14.6%) in the foothill zones, respectively. In cultivars Turkiston and Entry-6, the grain protein percentages were 13.0% and 14.3% in the desert, 15.1% and 14.9% in the middle, and 14.8% and 14.8% in the foothill sectors, respectively. The cultivar Yaksart and advanced line 200/50 had grain protein contents of 14.2% and 14.5% (desert), 14.9% and 16.6% (middle), and 15.9% and 15.4% (foothill), respectively. In wheat cultivars and landraces, based on three-year averages, the recorded grain protein content notably varied under different soil and climatic conditions, i.e., with ranges of 11.8%–15.5% (desert zone), 12.9%–17.8% (middle area), and 12.1%–16.8% (foothills) (Table 5).

In Central Asia, especially in the southern regions of Uzbekistan, several factors negatively influence the winter soft wheat grain yield. A sharp rise in temperature in the spring months negatively affects grain formation, which leads to a significant decrease in grain yield. The heat occurrence in June adversely weakens the grain filling period, confirming that the selection of heat-tolerant cultivars should be a top priority in winter wheat breeding programs (Morgounov *et al.,* 2013).

Wheat adapts well to drought- and heat-stress conditions, affecting plant height, biomass, canopy temperature, and aging rate during grain filling. The study showed that with additional irrigation and rainy conditions, the day before mating and plant height altogether significantly altered the grain yield in winter wheat (Lopes *et al.,* 2014). Modern cultivars grown with combined crop potential, grain quality, and disease resistance adapted well to the region. However, some exotic winter wheat cultivars from Mexico, Russia, Turkey, the USA, and other countries are also under cultivation in the area (Morgounov *et al.,* 2005).

During 2010–2012, the average growth period of wheat cultivars and advanced lines in the desert was 188/188/186 days, in the middle zone (188/189/190 days) and the foothills (192/194/193 days), which showed that the maximum growth period also enhanced to a certain level as the growing conditions of wheat rose above the sea level. In irrigated regions, it provided that the wheat's extended- and short-growing periods depended on the annual precipitation, air

Table 5. Mean performance of wheat cultivars and advanced lines for grain protein and gluten content during 2010–2012.

No.	Wheat cultivars and advanced lines	Protein content (%)				Gluten content (%)			
		Kasbi district. (M±m)	hi district. (M±	hrisabz district. (M±	age district. (M±	Kasbi district. (M±m)	hi district. (M±	hrisabz district. (M±	age district. (M±
1	Tanya	12.7 ±0.5	14.9±0.4	14.8±0.0	14.1±0.2	26.4±0.4	29.8±0.3	28.6±0.5	28.3±1.1
2	Jaykhun	13.9±0.0	15.7±0.9	15.3±0.0	14.8±0.4	28.9±0.6	28.2±0.6	26.4±0.8	27.8±1.3
3	Entry-6	14.3±0.2	14.9±0.5	14.9±0.1	14.7±0.0	30.6±0.2	30.2±0.7	21.5±0.9	27.4±0.8
4	Farovon	14.2±0.3	14.7±0.7	14.7±0.3	14.6±0.2	31.6±0.7	29.7±0.9	29.3±0.7	30.2±0.9
5	Nota	15.4±0.4	17.1±0.7	16.3±0.1	16.2±0.6	29.2±0.6	28.8±0.8	27.7±0.4	28.6±1.2
6	Vostorg	13.7±0.4	14.0±1.0	14.6±0.1	14.1±0.3	29.1±0.7	28.4±0.6	28.7±0.2	28.7±0.7
7	Hisorak	14.8±0.5	13.9±0.1	15.2±0.3	14.7±0.8	29.6±0.8	30.7±0.7	28.3±0.7	29.5±0.1
8	Krasnodar-99	13.7±0.3	12.9±0.4	14.6±0.2	13.7±0.8	27.5±0.6	28.4±0.9	27.7±0.3	27.9±0.4
9	Entry-9-23	15.2±0.4	15.1±0.3	12.4±0.1	14.1±1.5	31.2±0.4	25.2±0.3	21.4±0.8	25.9±0.6
10	Barhayot	14.7±0.3	14.8±0.7	15.4±0.1	14.9±0.3	31.4±0.7	28.3±0.7	27.6±0.8	29.1±0.8
11	Turkiston	13.0±0.1	15.1±0.5	14.9±0.2	14.3±0.1	29.2±0.8	28.8±0.6	27±0.1	28.3±0.4
12	Yaksart	14.2±0.2	14.9±0.8	15.0±0.6	14.7±0.0	31.6±0.7	30.5±0.9	29.6±0.5	30.6±1.5
13	Selyanka	13.2±0.2	13.7±0.3	13.9±0.2	13.7±0.2	30.8±0.5	28.7±0.8	28.9±0.4	29.5±1.1
14	Entry-32	15.0±0.1	13.1±0.5	13.0±0.4	13.7±0.1	31.6±0.6	26.2±0.5	23.6±0.2	27.1±1.7
15	Bunyodkor	14.9±0.5	15.5±0.9	15.9±0.5	15.4±0.3	30.9±0.4	30±0.6	28.6±0.6	29.8±0.7
16	100/36	14.3±0.2	14.0±0.9	14.5±0.4	14.3±0.3	30.1±0.6	34.8±0.1	29.9±0.9	31.6±0.8
17	100/37	11.8±0.9	13.2±0.5	12.5±0.0	12.4±0.5	25.4±0.7	31.4±0.8	28.5±0.2	28.4±0.6
18	100/38	12.4±0.4	13.2±0.9	12.6±0.0	12.7±0.4	25.7±0.8	29.4±0.5	28.6±0.4	27.9±0.5
19	100/39	12.2±0.0	13.5±0.1	13.0±0.1	12.8±0.5	25.5±0.6	28±0.8	28±0.6	27.2±0.3
20	100/40	14.7±0.2	16.1±0.3	15.8±0.0	15.5±0.3	30.7±0.5	35.4±0.6	30.1±0.1	32.1±1.1
21	200/41	15.5±0.2	16.1±0.2	15.7±0.4	15.7±0.3	31.8±0.9	32.4±0.3	29.7±0.3	31.3±0.6
22	200/42	13.8±0.2	14.8±0.4	15.2±0.0	14.5±0.0	28.7±0.6	30.4±0.9	29.2±0.5	29.4±0.1
23	200/43	12.5±0.1	13.5±0.1	13.5±0.2	13.1±0.1	26.1±0.8	30.1±0.1	26.8±0.7	27.7±0.3
24	200/44	14.1±0.0	15.6±0.2	14.2±0.3	14.6±0.8	29.2±0.7	29.3±0.4	27.9±0.4	28.8±0.9
25	200/45	12.3±0.0	14.2±0.0	13.9±0.4	13.4±0.3	25.8±0.4	30.4±0.6	28.7±0.6	28.3±0.7
26	200/46	14.7±0.3	14.8±0.4	15.6±0.1	15.1±0.4	30.8±0.3	33.6±0.7	30.6±0.4	31.7±0.5
27	200/47	13.5±0.2	14.8±0.4	14.9±0.5	14.3±0.2	28.8±0.6	30.2±0.5	29.8±0.3	29.6±0.6
28	200/48	14.2±0.2	15.1±0.0	14.9±0.5	14.6±0.3	30.1±0.7	30.8±0.8	29.1±0.6	30±0.2
29	200/49	14.4±0.3	15.7±0.2	14.7±0.1	14.9±0.6	30.5±0.8	27.9±0.2	29.2±0.2	29.2±0.1
30	200/50	14.5±0.3	16.6±0.1	15.2±0.6	15.5±0.6	30.6±0.6	29.2±0.3	30.2±0.6	30±0.9
$LSD_{0.05}$					1.09				3.02

temperature, and relative humidity. When analyzed in terms of the average years in the studied sites, it was 189.5 days in 2010, 190.5 days in 2011, and 189.8 days in 2012. According to the three-year data from the assessed locations, the plant height increased to 3–4 cm for every 100 meters rise above the sea level. Similarly, the spike length varied according to the plant height *(r* = 0.47).

Weather conditions also affect and manage the variations in winter bread wheat yields in the irrigated areas of the region. Negative correlations between plant height and growth period of wheat cultivars appeared *(r* = -0.33), between growth period and number of plants per one m^2 *(r* = -0.11), with the strongest positive correlation between the grain yield and productive stems *(r* = 0.54) and between plant height and spike length *(r* = 0.48). A positive correlation *(r* = 0.40) was notable between the spike length and spikelets per spike, spikelets per spike and the grain yield *(r* = 0.20), spike length and grain yield *(r* = 0.11), with the strongest positive correlation observed between 1000-grain weight and the grain yield *(r* = 0.87).

With the positive correlation of 1000-grain weight and grain nature with grain yield, a significant increase resulted in the grain yield of the cultivars. Thus, an increase in 1000-grain weight and grain nature will surely increase grain yield. Similarly, a positive correlation occurred between the 1000-grain weight and the grain protein content *(r* = 0.61) and between the protein and gluten content in the grain *(r* = 0.66). According to the correlation of plant height with yield components, a positive correlation emerged with spike length *(r* = 0.48), spikelets per spike *(r* = 0.39), grain nature *(r* = 0.70), 1000-grain weight *(r* = 0.67), spike weight *(r* = 0.54), grains per spike *(r* = 0.45), grain weight per spike *(r* = 0.38), and productivity *(r* = 0.30).

CONCLUSIONS

Based on the presented study, high-yielding and good-quality winter wheat cultivars and advanced lines suitable for desert, middle, and foothill areas of the Kashkadarya Region, Uzbekistan, stood out. The average productivity of the tested wheat cultivars and advanced lines comprised 6.05 t/ha, while the standard cultivar Krasnodar-99 with productivity of 5.93 t/ha. The 17 cultivars and advanced lines proved to have higher productivity than the regular cultivars. The candidate wheat cultivars Farovon, Barhayot, and Bunyodkor yielded significantly more than standard cultivars, hence, selected in this regard. In the irrigated areas of the Kashkadarya Region, using agrotechniques, the winter wheat yield increased to 0.36–0.85 t/ha with the rise from takyr and barren soils to light gray and typical gray soils.

ACKNOWLEDGMENTS

The authors express deep gratitude to Dr. Alexey Morgunov for his valuable ideas and advice in this research.

REFERENCES

Ahamd B, Khalil IH, Iqbal M, Rahman H (2010). Genotypic and phenotypic correlations among yield components in bread wheat under normal and late plantings. *Sarhad J. Agric*. 26(2): 259-265.

Amanov BK, Muminov K, Samanov S, Abdiev F, Arslanov D, Tursunova N (2022). Cotton introgressive lines assessment through seed cotton yield and fiber quality characteristics. *SABRAO J. Breed. Genet*. 54(2): 321-330.

Amanov OA, Bolkiev ZT (2020). Influence of temperature on fertility and early maturity of durum wheat. *Life Sci. Agric.* (3): 10-13.

Amanov OA, Azimova ME (2019). Influence of sowing rates and fertilizers on field germination of seeds of durum wheat varieties. Fundamental Foundations of Innovative Development of Science. pp. 49.

Amanov OA, Bolkiev ZT, Allaeva DKh (2019). Valuable economic traits of durum wheat of the competitive cultivar test nursery. *Innov. Sci*. pp. 7-8.

Amanov OA, Jabarov FO (2014). The relationship between the yield of durum wheat and the climatic conditions of rainfed agriculture. *The Way of Sci.* pp. 54.

Amanov OA, Rakhimov MA (2016). Valuable economic traits of samples of winter bread wheat. *Agrar. Sci*. 5: 17-18.

Amanov OA, Shoymuradov A (2019). Influence of irrigation norms on grain quality of durum wheat. *Innov. Sci*. pp. 7-8.

Baboev S, Muminjanov H, Turakulov K, Buronov A, Mamatkulov I, Koc E, Morgounov A (2021). Diversity and sustainability of wheat landraces grown in Uzbekistan. *Agron. Sustain. Dev*. 41(3): 1-13.

Baboev SK, Buranov AK, Bozorov TA, Adylov BS, Morgunov AI, Muminzhonov KH (2017). Biological and agronomical assessment of wheat landraces cultivated in mountain areas of Uzbekistan. *Sel'skokhozyaist-vennaya Biol*. 52(3): 553-560.

Boysunov NB, Juraev DT (2019). Selection of seed material by quality indicators. Fundamental Foundations of Innovative Development of Science and Education. pp. 55-58.

Dilmurodovich DS, Bekmurodovich BN, Shakirjonovich KN, Shomiljonovich SS, Raxmatullaevich AJ (2021). Productivity, quality and technological characteristics of bread wheat (*Triticum aestivum* L.) variety and lines for the Southern regions of the Republic of Uzbekistan. *Plant Cell Biotechnol. Mol. Biol.* 22(7-8): 63-74.

Dospekhov BA (1985). Methods of Field Experiment. pp. 231-233.

GR (Gosstandart of Russia) (1995). Method of moisture content determination. GOST 13586.5-93. Moscow.

Juraev DT, Amanov OA, Dilmurodov SD, Boysunov NB, Kayumov NS, Ishankulova GN, Togaeva KR (2021a). The influence of hot-dry wind on farm valuable traits of wheat genotypes in southern regions of Uzbekistan. *Plant Cell Biotechnol. Mol. Biol*. 22(35-36): 34-49.

Juraev DT, Amanov OA, Dilmurodov SD, Boysunov NB, Odirovich JF (2020a). To study the heat resistance features of bread wheat varieties and species for the southern regions of the Republic of Uzbekistan. *Eur. J. Mol. Clin. Med.* 7(2): 2254-2270.

Juraev DT, Amanov OA, Dilmurodov SD, Meyliev AK, Boysunov NB, Kayumov NS, Ergashev ZB (2021b). Heritability of valuable economic traits in the hybrid generations of bread wheat. *Ann. Romanian Soc. Cell Biol.* 25(4): 1134-1142.

Juraev DT, Dilmurodov S, Khazratkulova SU, Azimova ME, Juraev ST (2017). The influence of hot-dry winds observed in the southern regions of the Republic of Uzbekistan on the productive elements of bread wheat. *Int. J. Appl. Pure Sci. Agric.* 2: 84-92.

Juraev DT (2018). The dependence of the productivity of winter bread wheat on hot-dry winds observed in the southern regions of Uzbekistan. *Bull. Sci. Pract*. 4(10): 122-129.

Juraev DT, Togaeva KhR, Yusupov NKh (2020b). The importance of yield and growing season in the creation of new varieties of wheat. *Life Sci. Agric.* 2(3): 35-42.

Juraev DT, Yusupov ShE (2020). The amount and value of iron and zinc elements in bread wheat varieties (*Triticum aestivum* L.). *Life Sci. Agric.* 3(7): 25-34.

Kashif M, Khaliq I (2004). Heritability, correlation and path coefficient analysis for some metric traits in wheat *Int. J. Agric. Biol*. 6(1): 138-142.

Khan A (2016). Performance of different bread wheat varieties for yield and yield attributes under diallel combinations. *Ann. Agrar. Sci.* 14(2): 25-34. ISSN 1512-1887, https://doi.org/10.1016/j.aasci.2016.03.001.

Khan I, Gul S, Khan NU, Fawibe OO, Akhtar N, Rehman M, Sabah N, Tahir MA, Iqbal A, Naz F, Haq I, Rauf A (2023). Stability analysis of wheat through genotype by environment interaction in three regions of Khyber Pakhtunkhwa, Pakistan. *SABRAO J. Breed. Genet*. 55(1): 50- 60. http://doi.org/10.54910/sabrao2023.55.1.5.

Khazratkulova ShU, Juraev DT (2018). Influence of agroecological factors on productivity and grain quality of winter wheat varieties. Fundamental and Applied Scientific Research: Achievements and Innovations. pp. 136-138.

Khazratkulova ShU, Sharma RC, Amanov A, Ziyadullaev Z, Amanov O, Alikulov S, Muzafarova D (2015). Genotype × environment interaction and stability of grain yield and selected quality traits in winter wheat in Central Asia. *Turk. J. Agric. For.* 39(6): 920-929.

Lopes MS, Saglam D, Ozdogan M, Reynolds M (2014). Traits associated with winter wheat grain yield in Central and West Asia. *J. Integr. Plant Biol.* 56(7): 673-683.

MGPU (1991). Ministry of Grain Products of the USSR (MGPU). Cereals, pulses and oilseeds. Method for determination of 1000 kernels or seeds weight. GOST 10842-89. 1991. Moscow.

Morgounov A, Haun S, Lang L, Martynov S, Sonder K (2013). Climate change at winter wheat breeding sites in Central Asia, Eastern Europe, and USA, and implications for breeding. *Euphytica* 194(2): 277-292.

Morgounov AI, Braun HJ, Ketata H, Paroda R (2005). International cooperation for winter wheat improvement in Central Asia: Results and perspectives. *Turk. J. Agric. For*. 29(2): 137-142.

Qulmamatova DE, Baboev SK, Buronov AK (2022). Genetic variability and inheritance pattern of yield components through diallel analysis in spring wheat. *SABRAO J. Breed. Genet*. 54(1): 21-29.

Rajaram S, Borlaug NE, Van-Ginkel M (2002). CIMMYT international wheat breeding. Bread wheat improvement and production. FAO, Rome, pp. 103-117.

Rattu AR, Ahmad I, Fayyaz M, Akhtar MA, Zakria M, Afzal SN (2009) Virulence analysis of *Puccinia triticina* cause of leaf rust of wheat. *Pak. J. Bot.* 41(4): 1957-1964.

Saleem K, Mehnaz G, Waqas K (2018). Evaluation of wheat (*Triticum aestivum* L.) varieties for leaf rust and yield attributing characters. *Agric. Res. Technol.* 16(4): 555997. DOI: 10.19080/ARTOAJ.2018.16.555997.

Saleem M (2003). Response of durum and bread wheat genotypes to drought stress: Biomass and yield components. *Asian J. Plant Sci*. 2(3): 290-293.

SCSCMU (1956). State Committee for Standards of the Council of Ministers of the USSR (SCSCMU). Methods for determining quality. GOST 3040-55. 1956. Moscow.

SCSCMU (1968). State Committee for Standards of the Council of Ministers of the USSR (SCSCMU). Methods for determination of quantity and quality of gluten in wheat. GOST 13586.1-68. 1968. Moscow.

SCSCMU (1977). State Committee for Standards of the Council of Ministers of the USSR (SCSCMU). Methods for determination of vitreousness. GOST 10987-76. 1977. Moscow.

Sozinov AA (1977). Methodological recommendation on the evaluation of grain quality. Russia, pp. 43-52.
Statista.com (2023).
Swailam MA, Mowafy SAE, El-Naggar NZA, Mansour E (2021). Agronomic responses of diverse bread wheat genotypes to phosphorus levels and nitrogen forms in a semiarid environment. *SABRAO J. Breed. Genet.* 53: 592-608. https://doi.org/10.54910/sabrao2021.53.4.4.
Tembo B (2021). Genotype by environment interaction analysis of wheat (Triticum aestivum L.) grain yield under rainfed conditions in Zambia. *SABRAO J. Breed. Genet.* 53(4): 609-619. https://doi.org/10.54910/sabrao2021.53.4.5.