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Heat resistant variety samples, varieties and lines for breeding durum wheat on the rainfed conditions of Uzbekistan.

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Abstract Durum wheat or Triticum turgidum is the second most polar and widespread type of wheat after soft wheat, which is the most common type of wheat in the world. The global production of durum wheat (Triticum durum Desf.) is hindered by a constant rise in the frequency of severe heat stress. One of the main means of drought management is the development of heat-resistant varieties capable of producing stable yields in areas of inadequate and unstable water supply. The article presents the results of study of heat resistance of varieties, vareity samples and lines in rainfed conditions. The heat tolerance of varieties and competitive samples was evaluated by the method of seed heating on a water bath before sowing and by the temperature of coagulation of water-soluble proteins in the leaves of durum wheat. Heat resistance was determined by counting the number of germinated seeds, counting the number of roots, measuring the length of roots and coleoptile in comparison with the control variant after heating the seeds of durum wheat varieties at a temperature of +54 ^{0}C for 20 ^{0}C minutes in laboratory conditions. The difference in the percentage of durum wheat seeds germination after heating during three years of heat tolerance study was from -1 to 8% of the standard. The length of durum wheat coleoptile was from 3.5 cm to 4.7 cm, while that of the norm was 3.8 cm. By results of the research 6 vareity samples (№14 Mrb3*2/Amar, №20 Miki 3, №9 Nemesis 1, №11 Myperno, №11 Pi 277012, №19 MIX 1314), 7 varieties and lines (Marvarid, Kumushdon, RNS-2022 /14, RNS-2022/20, RNS-2022/23, RNS-2022/25, RNS-2022/27), 5 lines (RNS -2022/7, RNS-2022/20, RNS-2022/25, RNS-2022/26, RNS-2022/27) were selected with a high seed germination after heating and based on the coagulation temperature of water-soluble proteins in Durum Wheat leaves.

Keywords. Durum Wheat, variety, variety samples, line, heat resistance, seeds germination, number of roots, roots length, coleoptile length, evaluation, selection, initial materials.

Introduction. In global agriculture, durum wheat is a type of crop of great economic importance, mainly in the food industry, in the production of pasta and confectionery, dietary products, protein-rich cereals for children.

According to analytical data from the International Grains Council, in 2022 the production of durum wheat grain will be 37-40 million tons or 5% of the total wheat crop area [International Grains Council, 2022]. The main cultivation regions of durum wheat being concentrated in few suitable areas such as the Mediterranean Basin, the North American Great Plains, Russia and Kazakhstan (Tidiane Sallet al 2020, Zampieri et al 2020). In these areas, durum wheat is a main staple crop and an important commodity (Rharrabti et al 2001).

Global climate changes observed in recent years (increasing air temperatures) have an impact on the yield and quality of grain of cereal crops. Therefore, in order to further strengthen food security in the face of climate change, the developing new varieties of durum wheat, suitable for the soil and climatic conditions of rainfed lands, heat-resistant, high productivity and grain quality, is one of the urgent tasks facing scientific breeders.

Currently, the main direction of selection of Durum Wheat varieties when developing heat-resistant varieties is aimed at developing early-ripening varieties, since early-ripening varieties must pass a period from grain filling to dough ripening before the onset of dough ripening (Mekonnen,2020).

Due to heat and drought during the flowering phase of wheat, the number of grains in the spike decreases and, in turn, the length of the ear decreases. In some varieties the spike may become empty. High temperatures during the flowering period of wheat cause a decrease in grain yield by 20% (Beknazarov, 1999).

Heat negatively affects the processes of grain formation in the lateral stems of wheat, causing the death of 25-30 percent of their yield (Ilashev, 2011).

Wheat plants, like any living organism, can be damaged by high temperatures. For higher plants, the lethal limit is considered to be a temperature of 58 ^{0}C. Wheat, due to the evolutionary features of its formation, is considered more resistant to heat, so high temperatures rarely cause a lethal effect (Ionova, 2011).

Every year, 12-20 days before the wheat ripens, a flow of dry and hot air enters the territory of the republic. As a result, wheat, which is in the grain harvesting phase, loses 20-30% of its harvest almost every year due to heat (Orinboev, 2013).

Heat resistance is the ability of plants to tolerate high temperatures and overheating. This is a genetically determined trait. The criteria for heat resistance are: the temperature of coagulation of water-soluble proteins in the leaves, the percentage of seed germination after heating the seeds in a water bath (wheat +54^{0}C), the grain size on the spike, the weight of the grain of the spike.

As a result of the research, the most informative trait is “germination”, less indicative are the traits “length of embryonic roots” and “seedling length”. The number of embryonic roots is a fairly stable sign and is not informative under conditions of weak osmotic stress (Bychkova, 2015).

The problem of heat resistance of wheat remains very relevant. One of the main means of combating drought is the developing of heat-resistant varieties capable of producing more or less stable yields in areas of insufficient and unstable water supply (Rabbimov, 2002).

In dry years, plant heat resistance is higher than in relatively humid years. It is interesting to note that the heat resistance and coagulation temperature of water-soluble proteins are characterized by greater constancy during the growing season than the concentration of cell sap. It is necessary to note the high water-holding capacity of wheat leaves in rainfed conditions, since it is of great importance for plant life in arid climates. Retention of 60% of total water and higher in the leaves in the phase of milky-dough ripeness, despite unfavorable environmental factors, is a distinctive feature of “rainfed” wheat and is of interest for breeding for drought resistance (Sripati Sikder, 2016).

The heat resistance of wheat is closely related to the temperature of coagulation of water-soluble proteins in the cell sap of leaves (Karshiboev, 2018).

Plants reprogram gene expression as an adaptive response to survive high temperatures. High temperature or heat stress inflicts damage in various physiological/molecular processes and plant organs, including leaf burn, senescence and abscission, inhibition of root and shoot growth, fruit damage, protein denaturation, and changes in membrane integrity (Wahid, 2007). In order to survive periods of heat stress, plants utilize specialized mechanisms to protect cellular machinery from heat damage, maintain cellular homeostasis and promote thermotoleranc (Wang, 2003).

One of the protective adaptive reactions of plants to high temperatures is an increase in the temperature point of protein coagulation (Genkel, 1956).

For wheat, in the beginning of period of development before the tillering phase, the temperature optimum lies below 20 °C, during the tillering - flowering period - about 25 °C, after flowering - about 30 °C (Rubin, 1987).

The purpose of this study was to study and select varieties, variety of samples and lines of Advanced Yield Trial of Durum Wheat for heat resistance in rainfed conditions.

Materials and methods. The material of the study was 25 durum wheat samples from collection nursery, 27 samples from competitive variety testing of the Institute of rainfed agriculture of Uzbekistan. Heat resistance of samples in laboratory conditions was determined by counting the number of germinated seeds, counting the number of roots, measuring the length of roots and coleoptile in comparison with the control variant after heating the seeds of durum wheat varieties at a temperature of +54 0C for 20 0C minutes in laboratory conditions. After heating and sowing the seeds into Petri dishes lined with filter paper, they were placed in a 25 °C hermetic zone. In each petri dish containing ten seeds, 10 ml of distilled water were poured for the control seeds.

1. <25% not resistant,
2. 25-49% medium resistant,
3. 50-74% resistant,
4. 75-100% highly resistant in terms of percentage of seed germination after heating are distributed into groups.

To evaluate the coagulation of water-soluble proteins in leaves, 27 accessions from the competitive variety trial were sown on rainfed land. Each sample was sown in three repetitions by randomization method. The plot area was 25 m2 and row spacing was 15 cm.

Research results. Heat resistance of durum wheat varieties was assessed by seed germination after heating. The method is based on the different reactions of varieties to heating in a water bath.

Using this technique, it is possible, firstly, to determine the germination of seeds after heating, which makes it possible to divide the studied samples into groups according to resistance, and secondly, to determine the degree of depression of growth processes by the accumulation of dry mass by seedlings, which makes it possible to identify among the most heat resistant samples (Udovenko, 1982).

The number of germinal roots in durum wheat samples was investigated in laboratory conditions in 2022-2023. local variety Lecurum-3 served as a control.
Germination was carried out in the thermostat in earthenware pots on filter paper at a temperature of 18-20 ° C. On the sixth – eighth days in the phase of coleoptile rupture counted seedlings, dividing them by the number of germinal roots. The average number of roots in the studied samples ranged from 3 to 5 with an average of 4.5, and in the control variant the average number of roots was 4.1 pc.

On the results of studying heat resistance after heating the seeds, 6 varieties of durum wheat were identified (Table 1).

Table 1.

Heat resistance of Durum Wheat variety samples on the Collection nursery (Gallaaral 2023).

№	Variety samples	Origin	Germinated seeds (%)	Number of roots, (pcs)	Root length, (cm)	Coleoptile length, (cm)

			Control	+54 ^{0}C	Control	+54 ^{0}C	Control	+54^{0}C	Control	+54 ^{0}C
1	Leukurum-3 (st)	UZ	100	92	4,6	4,2	8,7	5,1	5,0	4,0
2	№4 ig 1523174	LB	97	96	4,7	4,3	8,6	7,1	4,5	4,5
3	№5 Mrb 3/Mna 1	LB	100	98	4,8	3,2	7,8	3,9	4,6	4,4
4	№9 Ouasloukos 1/5	LB	98	96	5,0	4,5	8,4	5,3	4,8	3,9
5	№11 Tilling / ch 17	LB	98	96	4,4	3,8	6,2	5,9	4,5	4,2
6	№12 Tilling / Gil 4	LB	100	91	5,0	4,6	9,6	9,0	5,2	4,7
7	№14 Mrb3*2/Amar	LB	100	99	5,0	4,8	7,8	7,1	5,1	4,6
8	№15 Ouasloukos 1	LB	100	98	5,0	4,7	7,4	6,5	4,8	4,7
9	№18 Ouasloukos/99	LB	100	97	5,0	4,7	7,1	5,2	4,3	3,7
10	№20 Miki 3	LB	100	99	5,0	5,0	8,7	7,9	5,0	4,9
11	№24 Ouasloukos1/5	LB	99	96	4,9	4,4	7,0	4,5	4,8	4,3
12	№3 Genomis 3	LB	100	96	3,7	3,4	6,7	5,2	4,2	3,7
13	№4 Nakuri	LB	97	94	4,8	3,6	6,3	5,2	4,1	4,0
14	№7 Derita	LB	98	95	4,3	3,8	7,9	7,3	4,3	4,1
15	№8 Nemesis 2	LB	96	94	4,5	4,4	8,4	7,0	4,8	4,7
16	№9 Nemesis 1	LB	100	99	5,0	4,7	7,5	5,9	4,7	4,4
17	№10 Ramajan	LB	100	98	4,2	3,4	9,1	5,1	4,8	3,4
18	№11 Myperno	LB	100	99	4,4	4,1	5,3	5,1	3,9	3,6
19	№14 Nachit Kan	LB	96	95	4,6	4,3	6,9	6,2	4,6	4,5
20	№21 Sebanachit	LB	100	98	3,4	3,2	7,2	6,9	4,4	4,3
21	№23 Yopy	LB	97	96	3,4	3,0	4,3	2,6	3,3	3,1
22	№11 Pi 277012	LB	100	99	5,0	4,9	8,3	7,8	5,0	4,4
23	№12 RWG 35	LB	100	96	5,0	4,7	10,3	9,7	5,4	5,2
24	№19 MIX 1314	LB	100	99	4,3	4,0	6,0	5,2	4,2	4,1
25	№11 Pi 277012	LB	98	97	3,4	3,2	7,2	5,6	4,2	3,9

The dataes show, that the germination of durum wheat seeds of the studied variety samples ranged from 91.0% (№12 Tilling / Gil 4) to 99.0% (№14 Mrb3*2/Amar, №20 Miki 3, №9 Nemesis 1, №11 Myperno, №11 Pi 277012, №11 Pi 277012), the standard has 92.0% (Leukurum-3). The length of the coleoptile of Durum Wheat varieties ranged from 3.1 cm (№23 Yopy) to 5.2 cm (№12 RWG 35), for the standard it was 4.1 cm (Leukurum-3).

Coleoptile length is an important characteristic to consider when planting a wheat crop, especially in drier seasons when sowing deep to reach soil moisture. The coleoptile is the pointed protective sheath that encases the emerging shoot as it grows from the seed to the soil surface. Coleoptile length has been found to be influenced by several factors including variety, seed size, temperature, low soil water and certain seed dressings (Jennifer, 2013)

When studying the heat resistance of varieties and lines of Advanced Yield trial of Durum Wheat, 7 varieties and lines with a high percentage of seed germination after heating were identified (Table 2).

Table 2.

Heat resistance of Durum Wheat varieties and lines in the Advanced Yield Trial (Gallaaral 2021-2023).

№	Variety and lines	Length of coleoptile (cm)				Germinated seeds (%)				Difference, (±) (%)
		2021 y.	2022 y.	2023 y.	Average	2021 y.	2022 y.	2023 y.	Average	
1	Leukurum-3 (st)	3,4	3,8	4,2	3,8	76	87	90	84	±
2	Javohir	4,4	4,5	4,6	4,5	78	91	95	88	4
3	Marvarid	4,6	4,8	4,7	4,7	83	92	95	90	6
4	Yoqut-2014	4,3	4,6	4,6	4,5	84	91	92	89	5
5	Billurdon	4,2	4,2	4,4	4,3	81	91	93	88	4
6	Kumushdon	4,0	4,4	4,6	4,3	82	92	96	90	6
7	RNS-2022/7	4,2	4,5	4,6	4,4	78	89	90	86	2
8	RNS-2022/8	4,2	4,3	4,4	4,3	82	88	90	87	3
9	RNS-2022/10	4,1	4,6	5,0	4,6	77	87	91	85	1
10	RNS-2022/11	4,0	4,2	4,2	4,1	80	84	86	83	-1
11	RNS-2022/12	3,8	4,3	4,6	4,2	84	90	92	89	5
12	RNS-2022/14	3,6	4,1	4,8	4,2	92	92	94	93	9
13	RNS-2022/15	3,9	4,5	5,0	4,5	86	90	90	89	5
14	RNS-2022/16	3,2	4,2	4,3	3,9	86	89	90	88	4
15	RNS-2022/17	3,9	4,1	4,4	4,1	83	85	86	85	1
16	RNS-2022/18	3,7	4,5	4,8	4,3	87	88	90	88	4
17	RNS-2022/20	3,1	4,1	4,3	3,8	89	90	91	90	6
18	RNS-2022/21	3,5	3,7	3,7	3,6	80	89	91	87	3
19	RNS-2022/22	3,9	4,1	4,3	4,1	82	90	91	88	4
20	RNS-2022/23	4,0	4,0	4,1	4,0	89	90	90	90	6
21	RNS-2022/25	3,3	4,1	4,2	3,9	90	90	90	90	6
22	RNS-2022/26	3,4	3,6	3,6	3,5	86	87	90	88	4
23	RNS-2022/27	3,8	4,3	4,6	4,2	90	92	94	92	8
24	DNS-2022/15	-	-	4,7	-	-	-	87	-	-
25	DNS-2022/16	-	-	4,5	-	-	-	96	-	-
26	DNS-2022/24	-	-	4,8	-	-	-	92	-	-
27	NP-2022/70	-	-	5,0	-	-	-	95	-	-

According to the table dataes, the difference over three years of studying heat resistance in the percentage of germination of durum wheat seeds after heating ranged 1-8% to the standard. The length of Durum Wheat varieties and lines coleoptile were 3,5 cm (RNS-2022/26) to 4,7 cm (Marvarid), the standard was 3,8 cm (Leukurum-3). Research in bread wheat (Rebate et al. 2012) has suggested that short coleoptiles are due to the RhtB1 gene, and replacement of it with an alternative dwarfing gene, such as Rht18 is required for a longer coleoptile. However, some bread wheats have longer coleoptiles e.g. Harper, Frame, Yitpi and Magenta (Kunesch et al. 2019), which suggests that it is possible to develop longer coleoptile varieties in the Rht-B1 background. Surveys of Australian farmers' fields show that grain yield is reduced by a minimum 10% when short coleoptiles wheats are sown deeper than 5 cm (Reithmuller, 1990). Wheat with longer coleoptiles emerged sooner, produced more plants and had greater early vigour particularly with deep sowing. Semi dwarf wheat has CL 30–40% shorter than non-semi dwarf wheat [Md. Farhad, 2014).

Temperature plays a crucial role in the balance between respiration and photosynthesis in plants. Both these processes are essential for the plant's energy metabolism and nutrient production. Higher temperatures can enhance the rate of photosynthesis up to a certain limit. However, excessive high temperatures can disrupt the balance of this process. The enzymes involved in photosynthesis may become less efficient, leading to a decreased rate of photosynthesis. This can result in a depletion of food production in the plant.

When assessing heat resistance in rainfed conditions of durum wheat varieties of advanced yield trial, a low variation (V = 1.0 - 2.0%) was revealed in the coagulation temperature of water-soluble proteins in the leaves (Table 3).

Table 3.

Coagulation temperature of water-soluble protein in the leaves of Durum Wheat varieties and lines on the Advanced Yield Trial (Gallaaral 2021-2023).

№	Variety and lines	Coagulation temperature of water-soluble protein in leaves (^{0}C)				Difference, (^{0}C) (±)
		2021 y.	2022 y.	2023 y.	Average	
1	Leukurum-3 (st)	58,0	57,0	60,5	58,5	±
2	Javohir	57,5	58,5	62,0	59,3	0,8
3	Marvarid	58,0	60,0	61,5	59,8	1,3
4	Yoqut-2014	60,5	60,0	62,0	60,8	2,3
5	Billurdon	59,5	59,0	61,5	60,0	1,5
6	Kumushdon	60,5	60,5	61,5	60,8	2,3
7	RNS-2022/7	62,0	60,0	62,0	61,3	2,8
8	RNS-2022/8	61,0	60,5	61,5	61,0	2,5
9	RNS-2022/10	59,0	61,0	60,0	60,0	1,5
10	RNS-2022/11	60,0	61,5	61,5	61,0	2,5
11	RNS-2022/12	60,0	61,5	61,5	61,0	2,5
12	RNS-2022/14	61,0	60,0	61,5	60,8	2,3
13	RNS-2022/15	60,0	60,0	61,0	60,3	1,8
14	RNS-2022/16	60,5	61,0	61,0	60,8	2,3
15	RNS-2022/17	60,5	61,0	62,0	61,2	2,7
16	RNS-2022/18	61,0	61,0	61,0	61,0	2,5
17	RNS-2022/20	61,0	61,0	62,0	61,3	2,8
18	RNS-2022/21	60,0	60,5	62,0	60,8	2,3
19	RNS-2022/22	61,0	61,0	61,5	61,2	2,7
20	RNS-2022/23	61,0	60,5	60,5	60,7	2,2
21	RNS-2022/25	61,0	61,5	61,2	61,2	2,7
22	RNS-2022/26	60,5	61,0	62,0	61,2	2,7
23	RNS-2022/27	61,0	61,0	62,0	61,3	2,8
24	DNS-2022/15	-	-	61,5	-	-
25	DNS-2022/16	-	-	60,0	-	-
26	DNS-2022/24	-	-	61,5	-	-

27	NP-2022/70	-	-	62,0	-	-

Dataes show, that the coagulation temperature of water-soluble proteins in durum wheat leaves averaged over three years from 59.3^{0}C (Javohir) to 61.3^{0}C (RNS-2022/7, RNS-2022/20, RNS-2022/27), the standard has 58.5^{0}C (Leukurum-3).

Conclusions. According to heat resistance after heating the seeds, durum wheat variety samples were distinguished №14 Mrb3*2/Amar, №20 Miki 3, №9 Nemesis 1, №11 Myperno, №11 Pi 277012, №19 MIX 1314.

When studying the heat resistance of durum wheat advanced yield trial varieties and lines were selected: Marvarid, Kumushdon, RNS-2022/14, RNS-2022/20, RNS-2022/23, RNS-2022/25, RNS-2022/27 with a high percentage of seed germination after warming up.

Based on the coagulation temperature of water-soluble proteins in durum wheat leaves, the lines RNS-2022/7, RNS-2022/20, RNS-2022/25, RNS-2022/26, RNS-2022/27 were selected.

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