

**Full Translation: Physiological Evaluation of Heat Tolerance in Winter Soft Wheat Varieties and Their F<sub>0</sub> Hybrids**

**Khamraev N.U., Yuldasheva Sh. X.**

Academy of Mamun, Uzbekistan Academy of Sciences, 220900, Markaz-1, Khiva, Khorezm Region, Uzbekistan

Phone: (+998-62) 226-20-27, E-mail: [mamun@academy.uz](mailto:mamun@academy.uz)

Relevance of the Topic

Wheat (*Triticum aestivum* L.) is one of the most widely cultivated cereal crops and plays an important role in ensuring global food security. It ranks second only to rice among cereal crops [1]. Wheat is a temperate crop and sensitive to high temperature: for every 2°C increase above 18°C, its potential yield decreases by about 10% [2]. Wheat is a good source of carbohydrates, vitamins, and minerals. It contains more protein than other cereals, making it a primary source of plant-based protein worldwide.

Annual global wheat consumption increases by 2%, necessitating the development of high-yielding and disease-resistant varieties. Genetic research on wheat has provided useful data for breeding higher-yielding and better-quality varieties [3]. With increasing interest in healthy food, nutritional modification (combination, fermentation, fortification) has attracted attention. Wheat is important in human nutrition and rich in nutrients such as minerals, protein (8%–16%), fat (1%–3%), and fiber (12%–15%) [4].

High temperature affects various physiological, biological, and biochemical processes in wheat [5]. Heat stress is one of the most frequent abiotic stresses and poses a serious threat to yield [6]. It leads to poor germination, shorter grain-filling duration, reduced grain number, decreased photosynthesis and assimilation rates, early leaf senescence, and reduced chlorophyll content. It also adversely affects the starch and protein content of the grain [7].

In our laboratory experiments, we evaluated the physiological heat tolerance of winter soft wheat varieties and the F<sub>0</sub> hybrids obtained through crossbreeding.

Research Methods and Materials

In the experiments, five leaves from F<sub>0</sub> hybrid samples obtained through crossbreeding were placed in a water bath at 40°C for 30 minutes. Then, one leaf from each sample was transferred to a Petri dish filled with cold water. Next, the water bath temperature was increased to 50°C, and after 10 minutes, a second leaf was placed in cold water. This process continued up to 80°C.

After the heat treatments, all samples were placed in Petri dishes containing 0.2N hydrochloric acid (HCl) for 20 minutes. Leaf damage was assessed using F.F. Matskov's method [8], where the appearance of brown spots indicates damage level:

- no brown spots = “–”
- less than 50% of surface = “+”
- more than 50% of surface = “++”
- fully covered = “+++”

The studied wheat varieties were Karavan, Ultra, Grom, ASR, Vassa, and Krasnodarskaya-99.

**Results and Their Analysis.**

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Under different temperature conditions, the degree of leaf damage in wheat variety samples and F<sub>0</sub> hybrid samples obtained through crossbreeding was studied by classifying them into three groups (tolerant, moderately tolerant, and susceptible) (Tables 1 and 2).

At 40°C, no damage was observed in the leaf samples of the studied varieties.

**Table 1.**

### Damage degree of wheat variety leaves under different temperatures

No	Variety Name	Degree of leaf damage under different temperatures				
		40°C	50°C	60°C	70°C	80°C
<b>Tolerant</b>						
1	Karavan	-	-	+	++	++
2	Ultra	-	-	+	++	+++
<b>Moderately tolerant</b>						
3	Grom	-	-	++	++	++
<b>Susceptible</b>						
4	Krasnodarskaya-99	-	+	++	+++	+++
5	Vassa	-	+	+++	+++	+++

At 50°C, the leaves of Karavan, Ultra, and Grom variety samples were undamaged, while the leaves of Krasnodarskaya-99 and Vassa varieties were damaged by less than 50% with brown spots.

At 60°C, the leaves of Karavan and Ultra varieties were damaged by less than 50% with brown spots, while those of Grom and Krasnodarskaya-99 varieties were damaged by more than 50%. It was observed that only the leaf surface of the Vassa variety was completely covered with brown spots.

At 70°C, the leaves of the variety samples were more than 50% and fully covered with brown spots. The varieties with more than 50% but not fully damaged leaves included Karavan, Ultra, and Grom. The leaves of Krasnodarskaya-99 and Vassa varieties were found to be completely covered with brown spots.

**Table 2.**

### Damage degree of F<sub>0</sub> hybrid leaves under different temperatures

No	F <sub>0</sub> Hybrid Name	Degree of leaf damage under different temperatures				
		40°C	50°C	60°C	70°C	80°C
<b>Tolerant</b>						

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1	Karavan × Vassa	-	-	++	++	+++
<b>Moderately tolerant</b>						
2	Vassa × Krasnodarskaya-99	-	+	++	+++	+++
3	Karavan × Ultra	-	+	+++	+++	+++
<b>Susceptible</b>						
4	Karavan × Krasnodarskaya-99	-	++	+++	+++	+++
5	Vassa × Karavan	+	++	++	+++	+++
6	Vassa × Grom	++	+++	+++	+++	+++

At 40°C, among the F<sub>0</sub> hybrids obtained from the studied crosses, the leaves of the hybrids Karavan × Vassa, Vassa × Krasnodarskaya-99, Karavan × Ultra, and Karavan × Krasnodarskaya-99 were found to be undamaged. Meanwhile, the hybrid Vassa × Karavan was damaged by brown spots by less than 50%, and the hybrid Vassa × Grom showed damage by brown spots exceeding 50%.

At 50°C, the leaves of the hybrid Karavan × Vassa were undamaged, while the hybrids Vassa × Krasnodarskaya-99 and Karavan × Ultra were damaged by brown spots by less than 50%. The hybrids Karavan × Krasnodarskaya-99 and Vassa × Karavan showed damage by brown spots exceeding 50%. Only the hybrid Vassa × Grom had its leaf surface completely covered with brown spots.

At 60°C, the hybrids Karavan × Vassa, Vassa × Krasnodarskaya-99, and Vassa × Karavan were found to be damaged by brown spots by more than 50%. All other hybrids had their leaf surfaces completely covered with brown spots.

At 70°C, the hybrid Karavan × Vassa showed damage by brown spots exceeding 50%, while the leaf surfaces of all other hybrids were completely covered with brown spots.

At 80°C, all hybrids were 100% damaged.

#### Conclusions.

At 40°C, no leaf damage was observed in any wheat variety. At 70–80°C, leaves of Krasnodarskaya-99 and Vassa were fully covered with brown spots. At 80°C, Grom and Karavan leaves showed more than 50% but not complete damage, indicating physiological heat tolerance.

Among the F<sub>0</sub> hybrids, Karavan × Vassa was heat-tolerant; Vassa × Krasnodarskaya-99 and Karavan × Ultra were moderately tolerant; Karavan × Krasnodarskaya-99, Vassa × Karavan, and Vassa × Grom were susceptible.

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