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# Adaptive potential of T. monococcum on salt stress resistance

**A. Z. Shikhmuradov [1*], M. G. Muslimov [2], N. S. Taymazova [2], G. I. Arnautova [2], F. P. Tsakhueva [2], M. M. Magomedov [1]**

[1] Dagestan Experimental Station, Federal State Scientific Institution "Federal Research Center of the All-Russian Plant Genetics Resources Institute" named after N.I. Vavilov, RUSSIA
[2] Federal State Budgetary Educational Institution of Higher Education "Dagestan State Agrarian University" named after M. M. Dzhambulatov, RUSSIA
*Corresponding author: A. Z. Shikhmuradov

**Abstract**

The creation and cultivation of intensive varieties leads to the need to pay special attention to the protection of crops from biotic and abiotic adverse environmental factors. Adaptation of plants to new environmental conditions is achieved due to modification and genotypic variability, that is, by restructuring the complex of physiological, biochemical and morphoanatomical characteristics of the plant itself in ontogenesis and the formation of new reaction standards in phylogenesis. A prerequisite for adaptation should be the presence of such a norm of reaction for the genotype to changing environmental factors, which would determine various phenotypic modifications of a body, ensuring its viability in new conditions. More stable varieties most often have reduced productivity because of their reduced metabolic rate. However, production needs sustainable, environmentally plastic and highly productive varieties. It is possible to solve this problem by adaptive variety development that combine high-productivity genetic structures with the systems that ensure minimal yield losses from the effects of negative environmental factors. The study of plant intraspecific diversity resistance of the T. monococcum world collection by salt tolerance showed that this species is characterized by a small spectrum of salinity resistance. The samples with a high degree of salt tolerance were not observed. The number of intermediate forms in this species is much less than the number of sensitive genotypes. Thus, the laboratory analysis of 86 samples of T. monococcum of various ecological and geographical groups showed that T. monococcum is characterized by a significant variety of hereditary variants in terms of resistance to salt stress. The presence of such a huge intraspecific diversity allows us to select the forms contrasting by salt tolerance that are of interest for genetic and selection studies.

**Keywords:** hereditary diversity, adaptive potential, wheat, salt stress

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## INTRODUCTION

The creation and cultivation of intensive-type varieties leads to the need to pay special attention to the protection of crops from biotic and abiotic adverse environmental factors. One of the main abiotic factors that reduce the yield of grain crops in the conditions of Dagestan is the increased concentration of salt in the soil.

Adaptation of plants to new environmental conditions is achieved due to modification and genotypic variability, that is, by restructuring the complex of physiological, biochemical and morphoanatomical characteristics of the plants themselves in ontogenesis and the formation of new reaction standards in phylogenesis. If, with the help of modification variability, plants adapt to those environmental conditions that turn out to be the most significant in the process of their individual development, then the genotypic flexibility of the population and selection provide adaptation to long-term changes in environmental factors (Zhuchenko 1988).

A prerequisite for adaptation should be the presence in the genotype of such a norm of reaction to changing environmental factors, which would determine various phenotypic modifications of an organism ensuring its viability in new conditions.

More stable forms most often have reduced productivity owing to their reduced metabolic rate also. An inverse relationship was found between the degree of stability of an organism and its metabolic rate. However, agricultural production needs sustainable, environmentally plastic and highly productive varieties.

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And modern selection seeks to create such varieties with high productivity, salt tolerance, immunity, winter hardiness and drought tolerance (Zhukovsky 1971).

It is possible to solve this problem by creating adaptive varieties that combine high-productivity genetic structures with systems that ensure minimal yield losses from the effects of negative environmental factors. “Ensuring the integrated resistance of varieties and hybrids to the impact of those environmental factors should be the main goal of integrated hybridization programs” (Zhuchenko n.d.).

The adaptive potential of economically valuable traits in case of intraspecific (intervarietal) hybridizing has a certain limit; therefore, it is necessary to search for new methods of enriching the wheat genotype with new useful traits. One such technique is remote hybridization.

Studying the agrobotanical composition of wheat shows that most of the wild species (T. boeoticum, T. urartu, T. araraticum, T. dicoccoides) and cultivated glumiferous wheats (T. Monococcum, T. macha, T. zhukovskyi, and others) are practically not involved in breeding. The oldest glumiferous species possessing valuable traits for current breeding (high protein content in grain, early maturity, complex resistance to fungal diseases, drought resistance, cold resistance, etc.) were not sufficiently attracted to hybridizing. Very little used in hybridizing are such high immunity species like T. timopheevii and its huskless analogue which is a new kind of T. militinae; immune to powdery mildew and cold tolerant species T. persicum; disease-resistant and artificially created octoploid species T. fungicidum, et al. (Dorofeev 1987).

In this regard, it is necessary to consider the possibility of expanding the hereditary diversity in salt tolerance in wheat due to introgression of the genetic systems that control this trait, from closely related species (El-Hamady 2017, Udovenko et al. 1988). To do this, we first need to evaluate the magnitude of the variability in salinity resistance of samples (T. Monococcum) and identify stable forms for introgressive hybridization.

The aim of this work is to study the hereditary diversity of salt tolerance in samples (T. monococcum).

## MATERIALS AND METHODS

The work was performed at the Dagestan experimental station of the All-Russian Plant Genetics Resources Institute named after N.I. Vavilov (VIR). The material for the study were 86 samples (T. monococcum) from the world collection of VIR (**Table 1**)

Salt tolerance was studied according to the VIR laboratory procedure (1988) using the roll method (Shikhmuradov 2014, Udovenko 1982). For this, the seeds of the samples (40-50 pcs.) were soaked in water in Petri dishes at a temperature of 22 °C. After 72 hours, the germinated seeds were transferred to rolls of filter paper and placed in solutions of salt (NaCl) (with concentration of 9.8 g / l, 0.7 MPa) and water (reference). The length of the seedlings was measured after 7 days. The ratio of the lengths of the tested option to the reference expressed as a percentage was considered as a sample’s salt tolerance indicator (resistance coefficient). Samples with a resistance coefficient above 90% were considered as highly tolerant to NaCl, and with a resistance coefficient less than 60% as sensitive; intermediate forms were classified as medium susceptible.

Statistical data have been processed according to Rokitsky (1978) and Dospekhov (Armor 1985, Shikhmuradov 2011).

## RESULTS AND DISCUSSION

**Small spelt (T. monococcum L.):** It is ecologically confined to mountainous (but not to highland) regions. The crop is spring sown, rarely winter sown. Plants are hispid. Heads are flat. The glume fin is weakly expressed, the main beak is developed, the lateral rib clearly looms ending with a beak. Heads are spinous and single-flowered.

It was widely spread in the early Neolithic period. Nowadays it occurs sporadically in Yugoslavia, Albania, Switzerland, Turkey, and Morocco (Zhukovsky 1971) and occasionally clogs the crops of polyploid wheat in the Transcaucasus (Dorofeev 1987). Useful traits of T. monococcum include immunity to fungal diseases. N.I. Vavilov called T. monococcum “accumulator of complex immunity”, although he noted that some forms of it may be affected by fungal diseases. T. monococcum is an integral part of the Georgian population of Zanduri, which stands out for its immunity to fungal diseases (Vavilov 1964).

Resistance of T. monococcum to diseases is higher than that of wild-growing small spelt. The species of T. monococcum is practically resistant to a number of races of brown, yellow, stem rust, dust smut, and powdery mildew. This immune ability can be used to create varieties of food wheat that are resistant to fungal diseases. However, in some years, rust and powdery mildew can affect representatives of some ecological groups of this species. So, 15 and 20/31 are among the races affecting T. monococcum.

In the course of studying T. Monococcum, it was found to be resistant to specialized smut races, immunity to stem rust in the field conditions and upon artificial infection, and also has a high field race-specific resistance against dust smut.

High protein content in the grain (up to 27.8%) and lysine in the protein (up to 2.78%) were observed in some samples of T. monococcum (Tyuterev 1973, Udovenko et al. 1988).

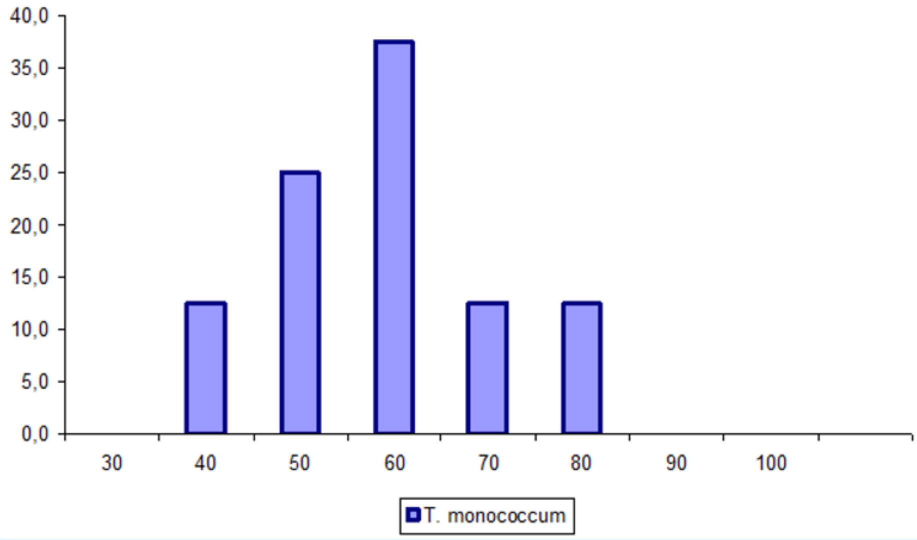


**Fig. 1.** Intraspecific diversity of *T. Monococcum* in salinity resistance

**Table 1.** Characterization of *T. monococcum* with regard to its salinity resistance

| | Resistance, percentage | | The average value of the resistance, percentage | Number of samples | Percentage of total number of samples |
|---|---|---|---|---|---|
| | min | max | | | |
| Highly resistant | - | - | - | - | - |
| Intermediate | 65.0 | 79.0 | 72.0 | 22 | 25.0 |
| Sensitive | 39.2 | 59.0 | 51.0 | 64 | 75.0 |
| In general | 39.2 | 79.0 | 56.3 | 86 | 100.0 |

T. monococcum has a high standing ability: it has a thin-walled, hollow, flexible, elastic, completely non-lodging straw (Dorofeev 1987).

However, a number of negative qualities are also noted, such as: low seed productivity: weakness of hybrid plants (when an endoplast of soft or durum wheat is introduced into the cytoplasm, a CMS occurs).

Many researchers tried to hybridize T. monococcum with other types of wheat in order to obtain useful traits from wild wheat in wheat hybrids, as well as to solve some phylogenetic issues. So, as early as 1882, a hybrid was obtained between an eincorn and a two-grained spelt (T. dicoccum).

Genetic compatibility when hybridizing with wild emmer is absent. In such a combination, sterility of F $_b$ hybrids is observed. When hybridizing with other species having the *AuB* genome, as well as with species having the *AuBD,* T. *monococum* genomes and tetraploid species are also genetically incompatible with the $A^bG$ genomes.

The transfer of T. monococcum nucleus material to wheat is also possible through amphidiploids with their subsequent hybridizing with cultivated wheat. So, A.R. Zebrak created an amphidiploid by hybridization with durum wheat and T. monococcum. Later, when T. monococcum was hybridized with T. persicum, amphidiploids T. dicoccoides *(*$A^uB$*),* T. timopheevii, T. paleo-colchicum, T. durum, T. dicoccum, and T. turgidum were obtained. Amphidiploids with T. dicoccoides *(*$A^uB$*),* T. timopheevii, T. paleo-colchicum, T. durum, T. Dicoccum, as well as T. Polonicum were also obtained at VIR (Dorofeev 1987).

The method of triple species hybrids was used to involve T. monococcum in hybridizing. At the San Angelo plant-breeding station (near Milan), similar hybridizations were used to isolate promising forms on their cold hardiness, early maturity and productivity from a combination (durum wheat X T. monococcum ) X soft wheat (Dorofeev 1987).

In 1970, the amphidiploid T. dicoccum X T. monococcum was successfully crossed with soft wheat. However, this species has not yet been used in plant breeding to improve the immunity of modern varieties of soft and durum wheat due to the difficulty of hybridizing and isolating lines from the hybrid populations with an unbreakable, easily threshed head.

The study of the intraspecific diversity concerning plant resistance of the T. monococcum from world collection in terms of salt tolerance showed that this species is characterized by a narrow spectrum of salinity resistance (**Fig. 1**). Samples with a high degree of salt tolerance were not observed. The number of intermediate forms in this species is much less than the number of sensitive genotypes (**Table 1**).

Thus, laboratory analysis of 86 samples of T. monococcum of various ecological and geographical groups showed that T. monococcum is characterized by a significant variety of hereditary variants in terms of resistance to salt stress. The presence of such a huge intraspecific diversity allows us to select contrasting forms with regard to salt tolerance that are of interest for genetic and selection studies.

**Table 2.** Distribution of *T. monococcum* samples by salt tolerance depending on the place of origin

| Origin | Number of samples | Resistance group | | |
|---|---|---|---|---|
| | | I | II | III |
| Azerbaijan | 6 | - | 2 | 4 |
| Armenia | 3 | - | 1 | 2 |
| Albania | 13 | - | 4 | 9 |
| England | 4 | - | - | 4 |
| Bulgaria | 8 | - | 3 | 5 |
| Hungary | 2 | - | - | 2 |
| Germany | 14 | - | 5 | 9 |
| Greece | 2 | - | - | 2 |
| Georgia | 7 | - | 2 | 5 |
| Spain | 8 | - | 1 | 7 |
| Turkey | 15 | - | 3 | 12 |
| 4 | four | - | 1 | 3 |
| Total: | 86 | | 22 | 64 |

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