Comparative evaluation of varieties of winter hard wheat by the weight of 1000 grains with different morphotype of the germ

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Abstracts. The productivity of plants depends on the weight of 1000 grains (M1000), the density of the productive stalk, the number of grains per ear, cultivation conditions, etc. The aim of the research was to comparatively evaluate M1000 in seeds differing in the morphology of the embryonic part, in varieties of durum winter wheat bred by the Agrarian Scientific Center "Donskoy". The weight of 1000 grains were determined according to the State Standard 10842-89. The most productive and frequently encountered are the seeds with the main morphotypes 2, 3, 4, and 5, and the seeds with minor morphotypes 1a, 1, 6, and 7 make up 5%. An average positive relationship with M1000 of the entire heap of seeds was shown only for seeds of 2 main morphotypes - embryo morphotypes 2 (r = 0.45) and embryo morphotypes 5 (r = 0.42). Indicator M1000 embryo morphotypes 3 is not associated with M1000 of the whole seed heap, and all other embryo morphotypes for this trait have medium and strong negative correlation. Consequently, obtaining a fully formed grain in the dry spring and summer period is ensured by the stability of the filling of seeds of the main morphotypes 2 and 5.

1. Introduction

The heterogeneity of seeds, called heterogeneity, can be caused by environmental factors, the position of the seeds on the plant (matrix heterogeneity), or genetic changes in the seeds [1]. It manifests itself, among other things, in the differences in the weight of caryopses.

The yield of grain crops, and winter wheat, in particular, depends on several basic parameters (density of productive stalk, grain weight per ear, M1000). The seed heap as a whole according to the hosted method determines M1000 values. However, according to the morphology of the embryonic part, wheat seeds can be divided into eight morphotypes, which are present in the seed heap in different proportions. The seeds of these morphotypes differ in germination, resistance to water stress during the germination period, they give seedlings of different vigor and, ultimately, form different productivity in field conditions [2]. However, the study of M1000 in seeds of durum winter wheat with different morphotypes has never been carried out.

For many years, the research was carried out on the parameters of wheat grain, which determine its yield.
In the article "Commercial varieties of winter durum wheat and the peculiarities of their seed production" scientific breeders studied and described the national economic value of winter durum wheat, the reasons for the small share of cultivation, and also analyzed the achievements in this area. In this work, a special attention is paid to the role of the weight of 1000 grains in the formation of the yield [3].

The biological potential of durum winter wheat varieties directly depends on the effective use of cultivation technologies, growing conditions, variety genetics, modern varieties are adapted to resistance to biotic and abiotic environmental factors [4].

Houshmandfar and Asli, who studied different genotypes of winter wheat in the field, came to the conclusion that the wheat grain yield depends on its components, such as agricultural technology, the number of grains per ear and the weight of 1000 grains [5]. The weight of 1000 grains are one of the most balanced indicators of wheat yield, which increase is considered as the basis of selection [6, 7]. The weight of 1000 grains have a high coefficient of heritability and is closely related to the linear dimensions and perimeter of the caryopsis [7, 8, 9].

Abdelkhalik et al. found that wheat genotypes in the process of formation, have a significant level of genetic variability.

The wheat seed material has a high potential due to the dependence of the weight of 1000 grains, size and shape, and productivity [10].

As the result of domestication, modern wheat varieties are characterized by increased linear parameters of the caryopsis in comparison with wild relatives, which are characterized by a wide variety of grain morphotypes [11, 12]. Large-grain coarse seeds have high germination energy, which has a beneficial effect on increasing productivity [13, 14, 15]. In this article, the authors attempted to characterize the varieties of durum winter wheat by the M1000 value, not of the entire lot of seeds, but by individual groups of seeds - by the embryo morphotypes.

The aim of the research was to comparatively evaluate M1000 in seeds differing in the morphology of the embryonic part (different morphotypes), in varieties of durum winter wheat bred by the Agrarian Scientific Center "Donskoy".

2. Material and methods
The object of the study was the purified seeds of the 2019 harvest of seven winter durum wheat commercial varieties bred by the Agrarian Scientific Center "Donskoy" - Aksinit, Amazonka, Christella, Lazurit, Onyx, Yakhont, Yantarina. According to the hydrothermal regime, the period of spring-summer vegetation of winter durum wheat plants in 2019 was characterized as acutely arid, and this made it possible to fairly fully evaluate the varieties according to their ability to form full-weight caryopses of various morphotypes under conditions of water deficit. The weight of 1000 grains were determined according to the State Standard 10842-89 [16]. The embryo morphotype of each seed was determined by the Kasakov and Lysogorenko’s method [17]. Statistical processing of the research results was carried out by using the Excel software package.

3. Results and discussion
The weight of a thousand grains of the cleaned purified seeds of the studied winter durum wheat varieties varied from 40.3 g for the Aksinit variety, to 45.16 g for the Yakhont variety (Figure 1).
Figure 1. Weight of 1000 grains of seven durum winter wheat varieties seed heap. The varieties are ranked in ascending order M1000.

The hierarchy of varieties according to M1000, presented in the diagram, makes it possible to trace the reaction of the studied varieties to external conditions. If we assume that the studied varieties will form the same stalk (4 million units/ha) and will have the same number of kernels in each ear (40 units), then only due to the difference in M1000, the yield between varieties with the minimum and maximum M1000 values will be 12.5%. Therefore, the increase in M1000 by only 1 g will give in our example the increase in yield by 0.168 t/ha, or 2.57%. Thus, the study of the high M1000 values formation patterns is of great practical importance. In this regard, it makes sense to consider the problem of increasing M1000 PRP through the study of M1000 in seeds with different embryo morphotypes.

M1000 in seeds with different embryo morphotypes is shown in Figure 2.

For seeds of all morphotypes, it was shown that their M1000 differs between the studied varieties. Seeds with minor morphotypes 1a and 1 were not represented in all varieties. It should be noted that the maximum M1000 values for seeds with all minor morphotypes (1a, 1, 6, and 7) exceed the maximum M1000 values for seeds with the main morphotypes. That is why seeds with minor morphotypes cannot be removed when cleaning seeds by using traditional methods based on separation by weight and size.

Differences between cultivars in terms of the difference between the maximum and minimum values of M1000 for each morphotype differ in the major and minor morphotypes. Thus, the intervarietal difference in the M1000 values for the main morphotypes 2, 3, 4, and 5 was 5.94, 3.98, 15.3 and 5.49 grams, respectively. And in seeds of minor morphotypes 1a, 1, 6 and 7, it was 15.6, 16.29, 15.2 and 12 grams, respectively. This indicates a greater instability of the processes of filling seeds with minor morphotypes. It is interesting that the intervarietal difference M1000 for seeds of the main morphotypes 2 and 5 has similar low values (5.94 and 5.49 grams), which indicates a high stability of the processes of formation and filling of caryopses of these morphotypes. One can say that the formation of these morphotypes seeds is standard.

The varieties also differ in their position in the ranked M1000 series for each morphotype.
Figure 2: Weight of 1000 caryopses, differing in embryo morphotype, in seven varieties of durum winter wheat (varieties are ranked according to M1000 values for each morphotype).
The analysis of correlations was carried out both between the values of M1000 in seeds with different embryo morphotypes, and between these values and M1000 of the seed heap as a whole for each variety (Table 1).

**Table 1.** Correlation relationships (± r) between M1000 in seeds of durum winter wheat with different embryo morphotypes. Average for seven varieties.

| Morphotypes | Heap of seeds |
|-------------|---------------|
| 1a          | 1 0.41 -0.57 0.17 0.41 -0.3 0.21 0.08 -0.79 |
| 1           | 1 0.04 -0.13 0.87 -0.67 0.92 0.83 -0.53 |
| 2           | 1 -0.72 0.12 0.15 0.21 0.07 0.45 |
| 3           | 1 -0.45 -0.45 -0.27 -0.08 0.01 |
| 4           | 1 -0.33 0.76 0.59 -0.6 |
| 5           | 1 -0.47 -0.52 0.42 |
| 6           | 1 0.93 -0.32 |
| 7           | 1 -0.31 |

Since in this correlation analysis we used the results of determining only M1000 in seeds with different embryo morphotypes, it is not possible to speak here about their contribution to productivity. Rather, the obtained correlation coefficients (their sign and magnitude) may indicate the unidirectionality and/or stability of the filling processes of caryopses with different morphotypes under the conditions of the dry spring-summer growing season of durum winter wheat plants in the year of seed reproduction.

Interesting results were obtained when studying the correlation of M1000 in caryopses of the entire seed heap and seeds with different morphotypes. Thus, the average positive relationship with M1000 of the whole heap was established only for seeds of two main morphotypes - the second (r = 0.45) and the fifth (r = 0.42). M1000 of the third morphotype has no connection with M1000 of the entire seed heap, and all other morphotypes for this trait have an average and strong negative correlation. Consequently, the production of full-weight caryopses in the dry spring-summer period is ensured by the stability of the filling of the main second and fifth morphotypes seeds.

Seeds of minor morphotypes (1a, 1, 6, and 7) according to the M1000 trait have a medium and strong positive relationship with each other. For example, the sixth and seventh morphotypes according to M1000 have a strong relationship r = 0.93, the first and seventh morphotypes have r = 0.83, the first and sixth morphotypes have r = 0.92. The same minor morphotypes with the main second and fifth morphotypes have either an average negative correlation or no correlation. Morphotypes 1a and the second have r = -0.57; the fifth morphotype with the first, sixth and seventh morphotypes has r = -0.67, r = -0.47 and r = -0.52, respectively.

The results of the data analysis on the study of the relationships between the M1000 value in seeds with different morphotypes indicate that the formation and filling of caryopses of minor morphotypes is not a random act for an individual spike, spikelet, or flower in a spikelet as the result of fluctuations in the phytocoenosis of temperature, insolation, or humidity.

Obviously, the observed phenomenon is based on the stability of metabolic processes under specific growing conditions.
4. Conclusions
The revealed correlation between the weight of 1000 grains (hence, the yield) and the studied parameters of the caryopsis indicates that it is promising to select samples with morphotypes 2, 3, 5 of the most productive type and giving the opportunity to obtain the desired increase in yield.

A detailed analysis of the 1000 grains weight structure made it possible to identify the embryo morphotypes weight groups. The weight of 1000 grains with the variation of 3.25 g showed the unstable grouping by fractions. The main embryo morphotype had a hierarchical sequence, that is, there was no strong range in the range of weights, minor embryo morphotype might not be present in the analysis of the weight of 1000 grains, but according to the value of this indicator, the weight of 1 grain was the same as in the main morphotypes.

This phenomenon is due to the genetic heterogeneity of the grain and the degree of manifestation of its potential, not only initially and during the development, but during the formation of the final product. The correlation between the weight of 1000 grains and the yield is expressed precisely in the formation of grain (shape and weight), and only genetic analysis will make it possible to use it to the maximum.

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