The study of indices of the relative and absolute protein percentage in the winter bread wheat grain

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Abstract. The aim of the research was to evaluate the relative and absolute protein content in winter wheat grains, to determine the samples that have the maximum values of the studied traits, and to use the selected genotypes in breeding programs. The trials of the winter bread wheat varieties, sown after maize for grain were carried out in 2018-2020. The objects of the study were 13 winter bread wheat varieties (Triticum aestivum L.) developed in the Agricultural Research Center “Donskoy”. The current research established that when selecting parental varieties for crossing to improve grain quality of winter bread wheat varieties, there should be chosen the forms with the highest relative and absolute protein percentage in grain. These genotypes include Don 107, Ermak and Lidiya, whose relative protein percentage in grain was 12.96%, 13.01% and 13.06% respectively. The varieties Don 107, Ermak, Lidiya, Volnitsa and Zhavoronok were characterized by the maximum absolute protein percentage in grain with 5.43 g, 5.62 g, 5.57 g, 5.56 g and 5.54 g respectively. The 1000 grain weight of these varieties averaged 42.1 g (Don 107), 43.6 g (Ermak), 43.1 g (Lidiya), 43.5 g (Volnitsa) and 44.5 g (Zhavoronok).

1. Introduction
Wheat (Triticum aestivum L.) is one of the main grain crops not only in Russia but throughout the world. One of the primary concerns in breeding has always been the development of varieties with a complex of economically valuable traits, as well as with a high protein percentage in grain. Special attention has been paid to the search of the initial material and its comprehensive estimation [1, 2].

The domestic and foreign researchers have identified that the protein percentage in grain is a hereditary trait of a polygenic nature, but despite this, the protein percentage in grain is the subject to great variability depending on the genotype, the length of the vegetation period, soil and climatic conditions, forecrops, mineral nutrition and other factors [3, 4, 5, 6].

In recent years, there has been a tendency to reduce the production of strong and valuable wheat, which is necessary for the production of high-quality baking flour. In this regard, the development of winter bread wheat varieties with a high protein percentage is of great relevance [7].

The purpose of the current study was to estimate the relative and absolute protein percentage in the winter bread wheat grain, to identify the samples with the maximum values of the studied traits and to use the isolated genotypes in further breeding programs.
2. Materials and methods

The trials of the winter bread wheat varieties, sown after maize for grain were carried out in 2018-2020 at the field of the winter bread wheat breeding and seed production department. The objects of the study were 13 winter bread wheat varieties (Triticum aestivum L.) developed in the Agricultural research center “Donskoy”. The trials were carried out according to the methodology of the State variety testing of agricultural crops [8]. The protein percentage was estimated using IR spectroscopy on a SpektraStar 2200 analyzer. 1000 grain weight was estimated by the methodology of the field trial [9].

The correlation analysis was conducted by using the statistical software “Statistica 10.0” (Stat-Soft Inc., US). The soil of the experimental plot was ordinary calcareous heavy loamy blackearth (chestnut soil) with high carbonate (from 2.5 to 4.0% of CaCO$_3$ in the arable layer of a thick horizon (up to 140 cm)). There were 3.6-4.0% of humus, 20-23 mg of labile phosphorus, 300-380 mg of exchange potassium per kg of soil.

The southern part of the Rostov region is characterized by semi-arid hot summers and moderately mild winters. The sum of positive temperatures during the vegetation period averages 3450 °C, the average annual temperature is +9.7 °C, the average annual precipitation is 588.8 mm, including 480.5 mm during the winter wheat vegetation period.

3. Result and discussion

Wheat grain is an important source of protein in human, animal and bird diet, therefore protein percentage increase in grain is of great economic and social importance.

The protein percentage in grain is one of the main quality indices, which makes it possible to evaluate the breeding material at all stages of variety development. The relative protein percentage (total nitrogen) in grain of the winter bread wheat varieties varied according to the year from 10.69% (Don 107) to 11.40% (Volny Don) in 2018; from 13.05% (Kaprizulya) to 14.81% (Don 107) in 2019; from 11.87% (Lilit) to 14.29% (Ermak) in 2020 (Table 1).

The absolute protein percentage in grain is of great economic and social importance. This indicator on average through three years (5.56 and 5.62 g/1000 grain, respectively).

Over three years of study, all varieties corresponded to the 3rd quality class (not less than 12.0%). The highest protein percentage in grain was identified in the varieties Ermak and Lidiya, which formed the maximum protein percentage in grain (13.01% and 13.06%, respectively).

The value of the variation coefficient (CV < 10.0%) showed insignificant variability of the relative protein percentage in the studied genotypes grain according to the year.

At present, in order to estimate protein percentage in wheat grain, the breeders mainly use the value of the relative protein percentage in grain, but they practically do not estimate its absolute percentage in 1000 grain weight. Meanwhile, we consider this indicator to be of great importance in breeding when developing new varieties because the absolute protein percentage in grain does not depend on productivity. This indicator is of high stability. Such traits as “1000 grain weight”, “relative protein percentage in grain” are subject to significant changes.

The absolute protein percentage in grain of the winter bread wheat varieties changed in 2018 from 4.97 g/1000 grain (Don 107) to 5.92 g/1000 grain (Zhavoronok). In 2019 it ranged from 5.37 g/1000 grain (Polina) to 6.87 g/1000 grain (Volnitsa). In 2020 it varied from 4.39 g/1000 grain (Izyuminka) to 5.43 g/1000 grain (Ermak). The varieties Volnitsa and Ermak showed the highest values of this indicator on average through three years (5.56 and 5.62 g/1000 grain, respectively).

In the trials, there was a slight variation of the absolute protein percentage in grain (CV = 5.2% in 2018, 7.2% in 2019, 6.5% in 2020).

The development of the varieties with a high 1000 grain weight is one of the important issues of the breeding programs, which purpose is to improve the seeds sowing qualities and the grain technological properties (natural weight, flour properties, etc.). In 2018 the trait “1000 grain weight” of the winter bread wheat varieties ranged from 45.5 g (Asket) to 53.0 g (Zhavoronok). In 2019 it varied from 39.4 g (Izyuminka) to 46.4 g (Volnitsa). In 2020 the trait varied from 34.8 g (Krasa Dona) to 38.0 g (Ermak).
Table 1. The relative and absolute protein percentage in the winter bread wheat grain, and 1000 grain weight, 2018-2020.

| Variety     | 2018  | 2019  | 2020 average | 2018  | 2019  | 2020 average | 2018  | 2019  | 2020 average |
|-------------|-------|-------|---------------|-------|-------|---------------|-------|-------|---------------|
| Don 107     | 10.69 | 14.81 | 13.39         | 12.96 | 4.97  | 6.61          | 4.70  | 5.43  | 46.5  | 44.6  | 35.1  | 42.1  |
| Don 93      | 11.06 | 13.94 | 12.05         | 12.35 | 5.47  | 5.85          | 4.49  | 5.27  | 49.5  | 42.0  | 37.3  | 42.9  |
| Ermak       | 10.93 | 13.82 | 14.29         | 13.01 | 5.34  | 6.08          | 5.43  | 5.62  | 48.9  | 44.0  | 38.0  | 43.6  |
| Asket       | 11.17 | 13.75 | 13.17         | 12.70 | 5.08  | 5.54          | 4.61  | 5.08  | 45.5  | 40.3  | 35.0  | 40.3  |
| Izyuminka   | 10.97 | 14.23 | 12.47         | 12.56 | 5.16  | 5.60          | 4.39  | 5.05  | 47.0  | 39.4  | 35.2  | 40.5  |
| Lidiya      | 11.09 | 14.41 | 13.66         | 13.06 | 5.52  | 6.05          | 5.12  | 5.57  | 49.8  | 42.0  | 37.5  | 43.1  |
| Kaprizulya  | 10.90 | 13.05 | 12.40         | 12.12 | 5.25  | 5.72          | 4.43  | 5.13  | 48.2  | 43.8  | 35.7  | 42.6  |
| Lilit       | 10.72 | 13.87 | 11.87         | 12.15 | 5.21  | 5.76          | 4.51  | 5.16  | 48.6  | 41.5  | 38.0  | 42.7  |
| Krasa Don   | 11.16 | 13.86 | 13.21         | 12.74 | 5.71  | 5.82          | 4.60  | 5.38  | 51.2  | 42.0  | 34.8  | 42.7  |
| Volnitsa    | 10.84 | 14.81 | 12.68         | 12.78 | 5.08  | 6.87          | 4.72  | 5.56  | 46.9  | 46.4  | 37.2  | 43.5  |
| Volny Don   | 11.40 | 13.77 | 12.76         | 12.64 | 5.65  | 6.66          | 4.47  | 5.49  | 49.6  | 46.2  | 35.0  | 43.6  |
| Zhavoronok  | 11.16 | 13.69 | 12.80         | 12.55 | 5.92  | 6.09          | 4.62  | 5.54  | 53.0  | 44.5  | 36.1  | 44.5  |
| Polina      | 11.15 | 13.49 | 12.40         | 12.35 | 5.33  | 5.37          | 4.39  | 5.03  | 47.8  | 39.8  | 35.4  | 41.0  |
| Average     | 11.02 | 1.9   | 12.86         | -     | 5.36  | 5.98          | 4.65  | -     | 48.7  | 42.8  | 36.2  | -     |
| CV, %       | 1.8   | 3.6   | 5.2           | -     | 5.2   | 7.2           | 6.5   | -     | 4.2   | 54    | 3.4   | -     |

Throughout three years of the study, the most large-kernelled varieties on average were the varieties Ermak, Volny Don, and Zhavoronok with 43.6 g, 43.6 g, 44.5 g of 1000 grain weight, respectively.

The conducted analysis identified a weak positive correlation between relative protein percentage in grain of the winter bread wheat varieties and 1000 grain weight (r = 0.16) (Figure 1).
Figure 1. Correlation between relative protein percentage in grain of the winter bread wheat varieties and 1000 grain weight, 2018-2020.

A strong positive correlation was also identified ($r = 0.82$) between absolute protein percentage in grain of the winter bread wheat varieties and 1000 grain weight (Figure 2).

Figure 2. Correlation between absolute protein percentage in grain of the winter bread wheat varieties and 1000 grain weight, 2018-2020.
On average through 2018-2020, the maximum values of the relative protein percentage were identified in grain of the varieties Don 107, Ermak and Lidiya (12.96%, 13.01% and 13.06%, respectively). The varieties had almost the same percentage of absolute protein in grain (5.43; 5.62 g and 5.7 g/1000 grain), and 1000 grain weight of these varieties was 42.1 g; 43.6 g and 43.1 g respectively.

4. Conclusions
The current research established that when selecting parental pairs for crossing, in order to improve the quality of winter soft wheat varieties, the absolute protein content in grain should be preferred. The current study established that when selecting parental varieties for crossing to improve grain quality of winter bread wheat varieties, the preference should be given to the forms with the highest absolute protein percentage in grain. The conducted study identified such varieties as Don 107, Ermak, Lidiya, Volnitsa and Zhavoronok whose absolute protein percentage in grain was 5.43 g; 5.62 g, 5.57 g, 5.56 g, 5.54 g per 1000 grain, respectively. The 1000 grain weight of these varieties averaged 42.1 g (Don 107), 43.6 g (Ermak), 43.1 g (Lidiya), 43.5 g (Volnitsa) and 44.5 g (Zhavoronok).

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