Productivity and technological qualities of spring wheat grain in Krasnoyarsk region

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Abstract. The aim of the work was to study the varietal characteristics of yield formation and technological qualities in soft spring wheat grain in the Krasnoyarsk territory. The following tasks were defined as analyzing the technological indicators of grain quality in spring soft wheat varieties and determining the most productive of them in the conditions of the Krasnoyarsk territory for achieving this goal. The objects of research were five selection varieties of the Siberian research institute of crop production and selection. The experience was laid in the forest-steppe zone of the Krasnoyarsk territory. The soil of the stationary field was represented by luvis chernozem. Tillage was carried out in accordance with the requirements of zonal farming systems and generally accepted recommendations for the Krasnoyarsk forest-steppe. Grain was evaluated by the following indicators: weight of 1000 grains (g), nature (g/l), vitreous (%) and yield (c/ha). It is established that the physical characteristics of grain in the research area are characterized by high and medium stability over time and in most cases meet the requirements for high-quality wheat.

1. Introduction

High baking qualities of spring wheat depend on a number of technological indicators determined in the laboratories for technological quality assessment on special devices. Evaluation of physical and chemical and baking qualities in grain is based on the determination of direct and indirect indicators in the grain quality, flour and bread. Indicators of grain quality are its size, shape, vitreous, nature, amount of protein and gluten, flour yield, hardness, and others [1]. The physical properties of grain, flour and bread from strong wheat should correspond to the following indicators: grain nature (g/l) - 750; vitreous (%) - 60; protein content (%) - 14; flour strength (e.a) - 280; the ratio of elasticity to extensibility according to the alveograph 0.8-2.0; water absorption capacity of flour (%) - 70-75; time before liquefaction (min) - 7.0-10.5; volume yield of bread from 100 g of flour (cm³) - 550 [2].

The formation of the spring wheat crop and its quality in the Krasnoyarsk territory is influenced by a complex set of weather conditions and depends on both environmental and varietal characteristics. Baking qualities of spring wheat are determined by the indicators set of grain, flour and bread, determined in the laboratories for technological quality assessment of existing breeding centers. Data processing on qualitative assessment will reveal the nature of their variability, determine stable quality characteristics, and outline ways to improve newly developed varieties [3].

In connection with the above, the goal was set: to identify varietal features in the formation of technological qualities in soft spring wheat in the Krasnoyarsk territory.

In accordance with the intended goal, the following tasks were defined:
• Evaluate samples of soft spring wheat by technological indicators of grain quality.
• Determine the most productive varieties of this crop in the Krasnoyarsk territory.

2. Materials and methods

The work was carried out based on the results of experiments conducted in the forest-steppe of the Krasnoyarsk territory in 2016-2018. Early, mid-early and mid-mature varieties of «Novosibirskaya 15», «Novosibirskaya 29», «Novosibirskaya 31», «Krasnoyarskaya 12» and «Vavenkov's Memory» were considered.

The experiment was conducted according to the method of state testing for agricultural varieties [4, 5]. The soil of the stationary field was represented by luvic medium-humus medium-thick chernozem. Tillage was carried out in accordance with the recommendations of farming systems for the Krasnoyarsk forest steppe.

The previous crop was fallow. Sowing was carried out in the mid-May, with a selection seeder-SSNP-1.6, the seeding rate was 5.0 million germinating grains per hectare, in an ordinary way to a depth of 5 cm. The total area of the plot was 12 m², the accounting area was 10 m², the repetition was four times, the method of placing plots was systematic. Harvesting was carried out during the period of full grain ripeness (early September), using the combine «TERRION SR 2010» by the method of continuous threshing.

Determination of physical indicators in the quality of spring wheat grain and its seed qualities was carried out under laboratory conditions. Grain was evaluated by the following indicators: weight of 1000 grains (g), nature (g/l) and vitreous. These parameters for high-quality wheat must meet the following requirements: the weight of 1000 grains must be higher than 30 g, the nature is not less than 740 g/l, the vitreous content is more than 60 %. Mathematical processing of the results was performed using the EXCEL package. The material was evaluated by SSD, mean value, arithmetic mean error, the magnitude of feature and variation.

3. Results and discussion

Obtaining grain with high technological qualities in Siberia is a very important and far from solved problem. Heavy precipitation in late July and early August, accompanied by strong winds, often lead to mass lodging of bread: the consequences of this are especially unfavorable when a large vegetative mass grows. In some years there is an early July lodging in the beginning phase of grain formation. On flattened grains the filling conditions worsen, which leads to a puny, low-texture grain with poor quality. Lodging is usually accompanied by a prolongation of the vegetation period and such crops can be subject to early frost in autumn.

The 1000 grains mass characterizes the size and completeness of the grain, and the yield depends on it. Observations show that sowing with large seeds provides greater fullness of seedlings, plants are spiked one or two days earlier and are less affected by hard smut. Many researchers note the high resistance of plants grown from large seeds to pests (Hessian, Swedish flies, etc.) and diseases. Before the seedling appears above the ground, the roots and stalk develop due to the seed's nutrient reserves. The greater the supply of these substances in the seed is, the more powerful the primary roots and stem develop. If the seeds are uneven, uneven seedlings are obtained. Some of the weakest, small seeds disappear without giving aboveground shoots; some of the most backward shoots continue to grow, but die later due to lack of light, water, and damage by pests. However, all these weak shoots and plants, without yielding a crop, consume moisture and nutrients from the soil for a certain time and thus worsen the growth conditions of other plants. Sowing with large seeds eliminates these disadvantages.

The weight of 1000 grains for strong varieties should exceed 30 g. From the data in table 8 it can be seen that by the average weight of 1000 grains all varieties except «Novosibirskaya 29» exceeded this threshold.

Estimating the range of variability, it was found that only the standard variety «Novosibirskaya 31» had an average weight of 1000 grains over three years, which was always more than 30 g. The upper limit of the indicator reached 36 g. Varieties «Vavenkov's memory», «Novosibirskaya 29» and
«Novosibirskaya 15» formed a grain size of about 27-28 g in 2016. This can be explained by the fact that in August of this year, the hydrothermal indicator was only 0.4, such weather conditions prevented the flow of plastic substances into the grain. The standard variety, as well as «Vavenkov's memory», «Novosibirskaya 29» and «Krasnoyarskaya 12» differed in the stability of the trait over the years (V 4-8 %).

Table 1. Weight of 1000 grains in zoned wheat varieties, (g).

| Variety                  | 2016 | 2017 | 2018 | Average   | Deviation from the standard | The magnitude of the variability | Variation |
|--------------------------|------|------|------|-----------|-------------------------------|---------------------------------|-----------|
| «Novosibirskaya 31(st)»  | 36.0 | 35.4 | 31.2 | 34±1.0    | -                             | 31.2-36.0                        | 7         |
| «Novosibirskaya 15»      | 27.5 | 37.0 | 30.2 | 32±1.8    | -2.6                          | 27.5-37.0                        | 14        |
| «Novosibirskaya 29»      | 27.4 | 30.2 | 29.3 | 29±0.5    | -5.2                          | 27.4-30.2                        | 4         |
| «Vavenkov's memory»      | 27.8 | 32.1 | 29.8 | 30±0.8    | -4.3                          | 27.8-32.1                        | 6         |
| «Krasnoyarskaya 12»      | 30.9 | 34.4 | 28.7 | 31±1.1    | -2.9                          | 28.7-34.4                        | 8         |
| SSD05                    |      |      |      | 5.1       |                               |                                 |           |

The grain size of these samples did not always reach the required 750 g/l, which is typical for strong wheat (table 2). Considering the average values of the indicator, it can be noted that not all varieties correspond to the characteristics of high-quality wheat, for example, in «Vavenkov's memory» the average nature was 681 g/l.

The standard variety «Novosibirskaya 31» was always stable in this regard, with a grain size from 756 to 771 g/l with a variation of only 1 %.

In some of the most favorable years, «Krasnoyarskaya 12» and «Novosibirskaya 15» are able to form a nature of more than 750 g/l. This indicator is characterized by low variation, which indicates the relative stability of this trait, which is most likely due to genetics. It is considered that the indicator of nature depends on weather conditions directly, in this case, its low variability is clearly due to varietal characteristics [8]. The most stable nature is formed in the varieties «Novosibirskaya 31», «Novosibirskaya 15» and «Novosibirskaya 29».

Table 2. Natural grain weight of zoned wheat varieties, (g/l).

| Variety                  | 2016 | 2017 | 2018 | Average   | Deviation from the standard | The magnitude of the variability | Variation |
|--------------------------|------|------|------|-----------|-------------------------------|---------------------------------|-----------|
| «Novosibirskaya 31(st)»  | 756  | 766  | 771  | 764±2.8   | -                             | 756-771                         | 1         |
| «Novosibirskaya 15»      | 750  | 739  | 760  | 750±3.8   | -14.7                         | 739-760                         | 1         |
| «Novosibirskaya 29»      | 730  | 744  | 708  | 727±6.6   | -37                           | 708-744                         | 2         |
| «Vavenkov's memory»      | 658  | 652  | 734  | 681±16.7  | -83                           | 652-734                         | 6         |
| «Krasnoyarskaya 12»      | 777  | 678  | 752  | 735±18.8  | -29                           | 678-777                         | 6         |
| SSD05                    |      |      |      | 58.9      |                               |                                 |           |
The number of vitreous grains is considered an indirect sign of the protein content in the wheat grain [6]. Strong wheat should form the vitreous content of at least 60 % [7]. All the studied varieties formed such a number of vitreous grains in 2018. On average, the highest vitreous content was in the varieties «Krasnoyarskaya 12» and «Novosibirskaya 31», this value can be explained by the fact that all other samples had different degrees of lodging. In contrast, «Novosibirskaya 15» and «Novosibirskaya 29» developed an average vitreous slightly lower-67-68 %. The lowest vitreous content was in the variety «Vavenkov's memory» - only 59 %.

Table 3. Vitreousness of the grain in zoned wheat varieties, (%).

| Variety               | 2016 | 2017 | 2018 | Average | Deviation from the standard | The magnitude of the variability | Variation |
|-----------------------|------|------|------|---------|------------------------------|---------------------------------|-----------|
| «Novosibirskaya 31(st)» | 74   | 70   | 79   | 74±1.6  | -                            | 70-79                           | 5         |
| «Novosibirskaya 15»   | 53   | 63   | 85   | 67±6.0  | -7.3                         | 53-85                           | 20        |
| «Novosibirskaya 29»   | 69   | 71   | 64   | 68±1.3  | -6.3                         | 64-71                           | 5         |
| «Vavenkov's memory»   | 68   | 50   | 60   | 59±3.3  | -15.3                        | 50-68                           | 14        |
| «Krasnoyarskaya 12»   | 86   | 64   | 76   | 75±4.0  | 1.0                          | 64-86                           | 13        |
| SSD05                 |      |      |      | 8.3     |                              |                                 |           |

When evaluating the range of variability of this indicator, it should be noted that it was the largest in the variety «Novosibirskaya 15», the variation in vitreous was the highest and was recorded at 20 %. The standard «Novosibirskaya 31» and «Novosibirskaya 29» with a variation of 5 % were the most resistant to the influence of biotic and abiotic factors.

The average yield in the Krasnoyarsk territory varies in the range of 20-25 c/ha. The studied varieties in the conditions of the educational farm «Minderlinskoe» are able to produce an average of 27-29 c/ha, which is a fairly high yield. The highest average yield is observed in the varieties «Vavenkov's memory» and «Krasnoyarskaya 12», standard «Novosibirskaya 31», varieties «Novosibirskaya 29» and «Novosibirskaya 15» show the result slightly less -28 and 27 c/ha respectively.

Table 4. Average yield of spring wheat varieties, (c/ha).

| Variety               | 2016 | 2017 | 2018 | Average | Deviation from the standard | The magnitude of the variability | Variation |
|-----------------------|------|------|------|---------|------------------------------|---------------------------------|-----------|
| «Novosibirskaya 31(st)» | 37.0 | 25.2 | 25.0 | 28±2.5  | -                            | 25.0-37.0                       | 21        |
| «Novosibirskaya 15»   | 33.0 | 26.6 | 20.9 | 27±2.2  | -2.2                         | 20.9-33.0                       | 20        |
| «Novosibirskaya 29»   | 35.3 | 25.8 | 23.2 | 28±2.3  | -1.0                         | 23.3-35.3                       | 20        |
| «Vavenkov's memory»   | 35.8 | 28.2 | 23.8 | 29±2.2  | 0.2                          | 23.8-35.8                       | 19        |
| «Krasnoyarskaya 12»   | 34.7 | 29.4 | 24.2 | 29±1.9  | 1.0                          | 24.2-34.7                       | 16        |
| SSD05                 |      |      |      | 1.2     |                              |                                 |           |
For 2018 the lowest yield was shown by the variety «Novosibirskaya 15» – 20.9 c/ha. The maximum yield among all samples was recorded at the standard «Novosibirskaya 31» in 2016 – 37 c/ha. All varieties have a high yield potential, the upper limit of the trait varies from 33 to 37 c/ha. The variability of the trait in all varieties is average—from 16 % in «Krasnoyarskaya 12» and up to 21% according to the standard «Novosibirskaya 31». This is due to the influence of unregulated biotic and abiotic stress factors.

4. Conclusions
Physical indicators of grain in the research area, in particular, the nature of the grain, the mass of 1000 grains, and vitreous are characterized by high and medium stability over time (the coefficient of variation varied from 1 % for the natural mass to 20 % for the vitreous index) and in most cases meet the requirements for high-quality wheat. Cultivated in Siberia spring wheat varieties when cultivated after fallow can form an average yield of 27 – 29 c/ha, and the maximum yield of 33-37 c/ha. Yield as an integral indicator of the element’s combination in the crop structure under the influence of environmental conditions has a high varietal variability over time and varies from 16 to 21 %.

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