Seed qualities variation of spring wheat grain depending on its alignment

V V Keler and O V Martynova
Krasnoyarsk State Agrarian University, 90, Mira Avenue, Krasnoyarsk, 660049, Russia
E-mail: vica_kel@mail.ru

Abstract. Choosing the optimal seed size plays a significant role in obtaining a high grain yield with excellent technological, seed and yield qualities. The obtained experimental material will allow agricultural enterprises to form batches of grain with high food and seed qualities, depending on the grain alignment. The purpose of this work was to assess the impact of seed size on seed quality indicators of soft spring wheat. The role of alignment in the formation of germination energy, growth strength and germination of soft spring wheat seeds was studied. As a result, it was found that the germination energy of spring wheat seeds reached a maximum in fractions of size from 2.5 mm to 3.0 mm and from 3.0 mm and above – 93 %. The variation of the indicator was low 8 %. The strength of seed growth was subject to a high and medium degree of variation in fractions (18-43 %). Not one of the fractions could form seeds with a growth strength of 60 % consistently. Seed germination was close to 100 % for grains with a size of more than 2.5 mm and reached a maximum for seeds with a thickness of more than 3.0 mm. The difference between the germination of the smallest fraction and the other two ones was more than 40 %, and its average value was at the level of 56 %.

1. Introduction
Wheat has one of the leading positions in the grain balance of Russia. Its importance as a world crop culture will continue to grow, since it is a nutritious and economically profitable food crop that can be grown in very diverse natural and climatic conditions [1]. Siberia is one of the largest regions in the Russian Federation for the production of wheat grain. Spring soft wheat is the basic crop on which the strategy for the development of the agro-industrial complex is based. The area of its crops in the Krasnoyarsk territory is 600 thousand hectares or 46 % of all sown areas occupied by agricultural crops. Gross harvest is 1.4 million tons with an average yield of 26 c/ha. One of the main factors of spring wheat yield growth in the Krasnoyarsk territory is considered to be the quality of seeds along with high-quality soil treatment, fertilizers, herbicides and pesticides. In 2020 sowing with varietal seeds of grain crops in the territorial districts of the region was 94 %, of which 18 % were original and elite.
2. Problem Statement

It is established that in the overall increase in crop yield, the share of varieties and seed quality is allocated up to 30-50%. The analysis of world experience shows that the role of seed quality increases in market conditions [2, 3]. Seeds should not only be of high reproductions, but also meet the sowing conditions, have the mass of 1000 grains of at least 40 g, and a laboratory germination rate of at least 92% [4]. Obtaining seeds with high sowing qualities in Siberia is a very important and still far from the solved problem. In conditions of insufficient moisture, well-organized seed production in combination with other agrotechnical factors determines the yield value.

A seed batch can have a high weight of 1000 seeds, but it consists of heterogeneous in size (large and small) seeds with different sowing and yield qualities. It is necessary that the seeds have the high weight of 1000 pcs and the good alignment (not less than 80% for conditioned seeds), as it depends on the uniform development of seedlings. The alignment of seeds depends on the methods of crop growing, meteorological and biotic factors, etc. [5]. Even with good plant development, the alignment of seeds is preserved, which is due to their location in the inflorescence. So, the grain in the middle part of the ear is larger and heavier than that in the upper and lower parts of wheat. Cleaning and sorting of seeds contribute to their alignment significantly. Choosing the optimal seed size plays an important role in obtaining the high grain yield with excellent technological, seed and yield qualities.

3. Research Questions

One of the most popular varieties of soft spring wheat among modern producers – “Novosibirskaya15” included in the State register since 2003, was selected as the object of research. The patent holder is the Siberian research Institute of crop production and breeding of the Siberian branch of the Russian Academy of Agricultural Sciences. Its kind is lutescens. The plant is erect. The stem is made weakly with a strong pubescence of the upper node. The first leaf is with a strong waxy coating. Spikelet is cylindrical, medium density, white. The grain is ovoid, colored; pubescence is short. It is early-maturing variety; the growing period is 75-83 days. It is resistant to lodging. It is medium-drought resistant. Baking qualities are excellent. It is strong wheat. The variety is moderately susceptible to hard smut and highly susceptible to brown and stem rust, powdery mildew. The weight of 1000 grains is 34-36 g [6].

4. Purpose of the Study

The purpose of the work was to assess the impact of the grain size on seed quality indicators of soft spring wheat “Novosibirskaya15”. To solve this problem, the task was set to identify the role of alignment in the formation of germination energy, growth strength and seeds germination in the selected research object.

5. Research Methods

Alignment is uniformity of seeds by weight and size. Sorting for alignment has long been used to improve the quality of seeds. To determine the alignment of grain crops, the seeds bulk of the main crop is divided into fractions by size (in mm): 3.2; 3.0; 2.8; 2.5; 2.2; 2.0. The yield of each fraction is determined in percentage. To calculate the alignment, the highest values are added from two adjacent sieves. The batch is considered aligned if the main mass of seeds remains on two adjacent sieves – about 80% or more.

The main qualitative indicator in seed quality is germination. The ultimate goal of its definition is to establish the value of seeds as seed material. Laboratory methods for its determination have been developed, in which the analysis is carried out under optimal conditions in accordance with State Standard 12038-84 [7], which allows determining this indicator within a week for the main field crops. In parallel with germination, an auxiliary indicator is set - the germination energy, which characterizes the simultaneity and speed of germination, it is taken into account on the third day after the analysis is laid, and germination is calculated on the seventh day. Germination rate and germination energy are the percentage of normally sprouted seeds in the sample taken for analysis. Counting the normally
sprouted seeds is carried out twice: the first time the energy of seed germination is determined, the second-germination.

The sprouted seeds are counted separately for each repetition. When taking into account the energy of germination, normally developed seedlings and clearly rotted seeds are considered (they are removed), when taking into account germination – normally sprouted, swollen and rotted seeds. In spring wheat, the seeds of which germinate with several germ roots, normally sprouted include seeds that have at least two normally developed roots larger than the length of the seed and a sprout of at least half its length with visible primary leaflets that occupy at least half the length of the coleoptile. The following seeds are not sprouted: swollen, which have not sprouted, but have the healthy appearance; rotted (easily crushed with a spatula or have a darkened embryo), abnormally sprouted (there is no root) with a thickened root (with incorrect etching), with thread-like roots without pubescence (with frost resistance), with an ugly sprout (with disease). To calculate germination, we sum up the number of normally sprouted seeds when taking into account the germination energy and germination and express it in percentage to the taken number of seeds. Seed germination is set as the arithmetic mean from the results of four tests, if these results do not exceed the standard deviations [8].

The strength of seeds growth [9] is recommended to determine in addition to germination in order to have a better idea of their ability to germinate in the field. The growth strength characterizes the ability of seedlings to break through to the surface. In these conditions, it is better to identify sick, injured, weakened seedlings. Four samples of one hundred seeds are counted from pure seeds. Seeds are sprouted between strips of moistened filter paper (20x100 cm). Germination is carried out at the temperature of 200 C in the dark for five days. After the end of the germination period, the rolls are unfolded, the upper strip of filter paper is removed and the seedlings are evaluated. First the number of normally developed seedlings that have at least two roots, sprouts – with intact coleoptile, and leaves in the coleoptile occupy at least half of its length is set. Then, from the normally developed ones, strong seedlings are isolated according to the established parameters. The indicator of the seed growth strength is calculated as the arithmetic mean of seedlings strength in four samples and expressed as a percentage. In the future, the reliability of the analysis is established and rounded to an integer.

6. Results

To solve the research tasks, the obtained from field experiments and laboratory analyses materials were grouped and the average value of indicators, the error of the average, and the range of variability were determined. The results of statistical processing are shown in table 1.

Germination energy is not standardized by state standard, but it should be at least 60%, according to the general opinion of agronomists, and the higher the germination energy is, the more complete the seeds are [10]. The maximum germination energy was recorded in the seed fraction of more than 3 mm-99-100 %, it was slightly less low in the fraction from 2.5 to 3 mm (89-96 %). As expected, the lowest energy was observed in the fraction of seeds less than 2.5 mm – the average rate for three years was 52 %.

Table 1. Variation in germination energy of the zoned variety “Novosibirskaya15” depending on the fractional composition, %

| Fraction     | 2017 | 2018 | 2019 | Lim | M±m       | CV |
|--------------|------|------|------|-----|-----------|----|
| 2.0-2.5 mm   | 49   | 51   | 58   | 49-58 | 52.6±1.7  | 8.0|
| 2.5-3.0 mm   | 96   | 89   | 94   | 89-96 | 93.0±1.3  | 3.5|
| more than 3.0 mm | 100   | 99   | 100  | 99-100 | 99.7±0.2  | 0.5|
| 2.0-3.0 mm (st) | 82   | 80   | 84   | 80-84 | 82.0±0.7  | 2.2|
| the smallest significant difference (SSD) 05 | 3.4 |
The smallest significant difference (SSD) was significant with the standard in all three variants, when comparing it, for example, with a fraction of 2.0-2.5 mm. It was found that germination energy in this category of seeds was below 30%. And vice versa the difference of the standard with the category of more than 3.0 mm showed its dominance in 18% (Figure 1). Based on the calculations, it was found that the variation of the indicator for individual fractions was low, since the coefficient of variation was from 0.5 to 8%. The range of variability was also low – from 1 to 9%.

In general, it should be noted that the larger the grain is, the greater its germination energy is and fractions larger than 2.5 mm always form this indicator from 90% and higher. Thus, we found that sowing seeds with a size of 2.5 mm gives the possibility of obtaining seed energy from 93% and higher.

The strength of seedlings growth is the degree of potential embryo ability to use spare nutrients during germination to the full extent, to develop a normal sprout and fruiting plant in the ecological regional conditions of culture cultivation. Thus, according to modern concepts, the strength of seedlings growth should be considered as an obligatory component in the complex of sowing indicators. It is considered that the seeds are really strong when this indicator is at least 60%.

When evaluating the strength of seedlings growth in our experience, the following results were obtained: the highest strength was possessed by seeds with a size from 2.5 to 3.0 mm – 70% in 2017 and 2019. However, in 2018 this figure reached only 43% (table 2). This value can be explained by the unfavorable temperature regime in 2018, when temperatures were observed significantly below the average annual norm typical of the research zone during the entire vegetation period.

### Table 2. Variation in the strength of seeds growth of the zoned variety “Novosibirskaya15” depending on the fractional composition, %

| Fraction       | 2017 | 2018 | 2019 | Lim   | M±m   | CV   |
|----------------|------|------|------|-------|-------|------|
| 2.0-2.5 mm     | 46   | 18   | 54   | 18-54 | 39.3±6.9 | 42.9 |
| 2.5- 3.0 mm    | 70   | 43   | 70   | 43-70 | 61.0±5.7 | 22.9 |
| More than 3.0 mm | 61   | 62   | 55   | 55-62 | 59.3±1.4 | 5.7  |
| 2.0-3.0 mm (st)| 59   | 41   | 60   | 41-60 | 53.3±3.9 | 17.9 |

**SSD**<sub>0.05</sub> 14
Estimating the average value in the strength of seeds growth in this fraction for three years, it was found that it still reached the required 60% for strong seeds. The growth strength was slightly lower for seeds larger than 3.0 mm; the average rate for three years was 59%. Assessing the scope of trait variability and its variation, we concluded that the largest fraction in terms of growth strength had the greatest stability of the indicator and the minimum gap in the value over the years, the coefficient of variation was only 5.7%. The lowest value of the trait on average and by years was recorded in seeds less than 2.5 mm in size – only 39%. For example, in 2018 it was only 18% (Figure 2). The values of the growth strength over the years in this category of seeds never reached 60% and varied from 18 to 54%. The difference with the standard was very significant, as indicated by the value of SSD 05 – 14%.

![Figure 2](image_url)

Figure 2. Variation in the growth strength of the zoned variety “Novosibirskaya15” depending on the fractional composition, %

Seed germination is one of the most important sowing qualities that determine the suitability of seeds for sowing; it is of great production importance. Seeding with aligned seeds gives faster, more simultaneous, full seedlings, uniform plant development and a higher yield than seeding with non-aligned seeds. The emergence time of full seedlings is reduced by 2…3 days. The loss of plants during the growing season due to the high alignment of seeds is minimal: by the time of harvesting, 132…170 more ears are formed on one square meter of crops than from crops with non-aligned seeds.

Table 3. Variation in germination of the zoned variety “Novosibirskaya15” depending on the fractional composition, %

| Fraction         | 2017 | 2018 | 2019 | Lim   | M±m | CV |
|------------------|------|------|------|-------|-----|----|
| 2.0-2.5 mm       | 57   | 52   | 59   | 52-59 | 56.0±1.3 | 5.8 |
| 2.5-3.0 mm       | 99   | 92   | 94   | 92-99 | 95.0±1.3 | 3.4 |
| More than 3.0 mm | 100  | 99   | 100  | 99-100 | 99.7±0.2 | 0.5 |
| 2.0-3.0 mm (st)  | 85   | 81   | 84   | 81-85 | 83.3±0.8 | 2.2 |
| SSD α5           |      |      |      |       |     | 2.9 |

Having determined the germination rate (table 3), we obtained the following results: seed germination approached 100% for grains with a size of more than 2.5 mm and reached a maximum...
for seeds with a thickness of more than 3.0 mm. The difference between the germination of the smallest fraction and the other two ones was particularly noticeable; it was more than 40%. For seeds smaller than 2.5 mm, germination was much lower, on average 56%, the presence of such seeds in the batch reduced the overall germination significantly; and such grains need to be calibrated before sowing.

The permissible minimum germination of spring soft wheat seeds in the forest-steppe zone of the Krasnoyarsk territory according to state standard for the category of reproductive seeds is 82%. Evaluating the seed category of 2.0-3.0 mm (st), we found that it meets the standard for germination. However, the smallest significant difference (SSD)05 indicates that sowing with seeds of fractions of 2.5-3.0 mm or more exceeds the standard significantly and provides germination of the seed material from 95% or higher (Figure 3).

Figure 3. Variation in germination of the zoned variety “Novosibirskaya15” depending on the fractional composition, %

7. Conclusion
The maximum germination energy, germination and growth strength of spring wheat seeds in the zoned variety “Novosibirskaya15” are formed in fractions ranging from 2.5 mm to 3.0 mm and from 3.0 mm and higher. Seeds of fractions from 3.0 mm have the highest germination energy and germination, the average size of indicators is 99.7%

Production suggestion: it is recommended to use seeds of fractions with a size of more than 2.5 mm for sowing the zoned variety “Novosibirskaya15” with high germination, germination energy and growth strength.

References
[1] Pazin M A 2005 Methods for Improving the Quality of Spring Wheat Grain in the Conditions of the Kuznetsk Basin (Novosibirsk)
[2] Bobryshev F I 1999 Seed production has been preserved and will be improved Agriculture 4 21
[3] Pavlov M I 1999 Seed production today and tomorrow Agriculture 2 14-15
[4] Platonova N A 2009 Productivity and Seed Quality of Spring Soft Wheat Varieties and Their Variability in the Conditions in the Steppe Zone of the Republic of Khakassia (Tyumen: Publishing house of Tyumen State Agricultural Academy)
[5] 1969-1978 Great Soviet Encyclopedia 5 (Moscow: Soviet Encyclopedia)
[6] 2019 Characteristics of Plant Varieties First Included in the State Register of Selection Achievements Approved for Use in 2019: Official Publication (Moscow: Rosinformagrotech)
[7] 1986 SS 12038-84. Agricultural seeds. Methods for Determination of Germination: Collection of State Standards (Moscow: Publishing house of standards)
[8] Talanov I P 2018 *Plant Growing. Workshop: Study Manual for Academic Baccalaureate* (Moscow: Yurayt)

[9] 2020 SS 12040-66. *Seeds of Agricultural Crops. Methods for Determining the Strength of Growth* (Moscow: Publishing house of standards)

[10] Keler V V 2012 The role of harvesting periods in the formation of seed qualities in soft spring wheat grain, in: *Agribusiness development in the light of innovative ideas of young scientists* (Saint Petersburg: Saint Petersburg State Agrarian University) pp 76-81