Producing high-quality seeding material of Russian spring soft wheat varieties in Priobskaya zone of Altay forest steppes

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Abstract. A sufficient output of food and feed grain is one of priorities in Russian agribusiness. The reported study aims at the agrobiologic assessing spring soft wheat varieties in conditions of Priobskaya zone of Altay forest steppes. The experiments were carried out on production fields in 2018 – 2019. As an object of research 5 mid-ripening spring wheat varieties are taken. A maximum yield (2.1 t/ha) was produced when growing such varieties as Altayskaya zhntisa and OmGAU 90. The variability of crops is reported to be low (Cv%<10). A high wheat gluten value is detected in the following varieties: Altayskaya zhntisa (36.2%), Altayskaya stepnaya (36.9%), and OmGAU 90 (37.1%). A maximum of grain unit is given by Altayskaya zhntisa (785 g/l). It is recommended to cultivate Altayskaya zhntisa, OmGAU 90, Altayskaya 100 in Priobskaya zone of Altay forest steppes.

1. Introduction
To date, agricultural producers need to confront certain challenges caused by a difficult economic situation in the country. A current import substitution process is imposing its requirements on farmers. The output of agricultural products is to be based on domestically selected varieties and hybrids of cultivated crops.

For agricultural companies these targets are related to the searching for solutions to many problems. For instance, seeds used in production are to be of high quality and meet the State Russian Standard (GOST). High-quality seeding material is the basis for an efficient technological process and a high crop yield.

By nature, wheat is supposed to be an easily-grown crop, and plasticity makes its cultivation possible in many regions of Russia, irrespectively to soil and climate characteristics. The grain represents a principal product of wheat cultivation. The priority goal for agricultural producers in Russia remains a sufficient output of food and feed grain reserves.

In Siberian Federal District spring soft wheat is the most frequently cultivated crop with a total area of fields around 12 million ha. Wheat is a main grain crop of the region. The Altay Territory is a major granary in Siberia. Annually, an area of fields intended for wheat growing is around 2 million ha in the region [1].

Soil and climate conditions in the Altay Region are quite different. In view of these characteristics the territory is divided into 7 climatic zones with typical weather conditions and composition of soils. Generally, the climate in the Altay Region is considered as sharply continental.

Abiotic factors of the environment influence the growth and development of plants. Production use of domestically selected wheat seeds is seen as an element of agricultural technologies responsible for
good harvest and high-quality grain. These varieties are adapted to cultivation conditions and have a positive response to all environmental characteristics of a zone [2]. Therefore, agricultural producers need varieties with a known response to cultivation conditions; moreover, it should be a positive one to provide a good and high-quality yield of a grown crop.

2. Materials and Methods
The study aims at the agrobiology assessing spring soft wheat varieties in Priobskaya zone of the Altay Territory. The objectives of the research are as follows: to determine a vegetation period for varieties, to evaluate a crop yield, to assess a grain quality in each variety, to find a variability range of crops using crop yield values, to detect factors influencing a crop yield in the zone of interest, and to give an economic assessment of the cultivating spring soft wheat varieties in Priobskaya zone of Altay forest steppes.

The experiment was carried out on production fields located in Priobskaya zone of Altay forest steppes in 2018 – 2019. Climate conditions in the region of experimenting are continental. A summer time is short with high temperatures; hot periods may turn into droughty ones unless there is no rain. Once we experimented, favorable weather conditions allowed evaluating objectively spring soft wheat varieties in Priobskaya zone of Altay forest steppes.

On the experimental territory a prevailing type of soils is regular slightly leached medium black-earth soils with a moderate concentration of loams and a humus horizon of 42 – 45 cm [3, 4].

As objects under study we took five mid-ripening varieties of spring soft wheat: Altayskaya 100, Altayskaya zhbitsa, Altayskaya stepnaya, OmGAU 90, and Svetlanka. Altayskaya 100 was accepted a standard variety. An area of a registration plot was 1 m², triple replication [5, 6]. A preceding crop was a grain one. A seeding rate amounted to 500 seeds per square meter. Soils were prepared for sowing in a way accepted in the region. Dates of sowing are as follows 16.05.2018 and 21.05. 2019. On days of sowing we carried out pre-seeding tillage. Within a vegetation period the weeding was done manually.

3. Results
A vegetation period represents a key characteristic of a variety. The crop phenology in the experiment was monitored over the entire plant vegetation period (Table 1).

| Variety              | Sowing sprouts | Sprouts tillering | Tillering – earing | Earing – waxy ripeness | Waxy ripeness – harvesting | Vegetation period, days |
|----------------------|----------------|-------------------|--------------------|------------------------|---------------------------|-------------------------|
| Altayskaya 100       | 9              | 9                 | 21                 | 16                     | 22                        | 26                      | 39                      | 33                      | 15                      | 20                      | 97                      | 95                      | 96.0                    |
| Altayskaya zhbitsa   | 9              | 9                 | 21                 | 16                     | 23                        | 28                      | 38                      | 32                      | 15                      | 19                      | 97                      | 95                      | 96.0                    |
| Altayskaya stepnaya  | 9              | 9                 | 21                 | 16                     | 24                        | 26                      | 41                      | 35                      | 12                      | 17                      | 97                      | 94                      | 95.5                    |
| OmGAU 90             | 9              | 9                 | 21                 | 16                     | 22                        | 26                      | 40                      | 34                      | 14                      | 19                      | 98                      | 95                      | 96.5                    |
| Svetlanka            | 9              | 9                 | 21                 | 16                     | 22                        | 26                      | 41                      | 34                      | 13                      | 19                      | 97                      | 95                      | 96.0                    |
| Average              |                |                   |                    |                        |                          |                         |                         |                         |                         |                         | 97                      | 95                      | 96.0                    |

*2018; ** 2019

A variety yield of all crops i.a. wheat is an integrated parameter highly sensitive to broadly ranging factors.

A variety yield is a sum total of several constituents, such as a number of productive stems per plant, and wheat spike characteristics: length, a number of spikelets per spike, a number of grains per spike and per plant, etc. Table 2 shows constituents of a yield formula.
Table 2. Yield formula of the varieties, 2018 – 2019

| Variety/line | Number of productive stems pcs./pl. | Spike length, cm | Number of grains per spike, pcs. | Grain weight per plant, g | Thousand kernel weight, g |
|--------------|--------------------------------------|------------------|----------------------------------|---------------------------|---------------------------|
| Altayskaya 100 | 1.22 | 7.2 | 28.6 | 34.9 | 1.16 | 1.42 | 40.6 |
| Altayskaya zhnsitsa | 1.41 | 7.8 | 32.7 | 46.1 | 1.26 | 1.78 | 38.5 |
| Altayskaya stepnaya | 1.35 | 6.8 | 26.7 | 36.0 | 1.05 | 1.42 | 39.3 |
| OmGAU 90 | 1.46 | 7.3 | 28.0 | 40.9 | 1.18 | 1.72 | 42.1 |
| Svetlanka | 1.20 | 6.2 | 30.2 | 36.2 | 1.17 | 1.40 | 38.7 |
| Average | 1.33 | 7.1 | 29.2 | 38.8 | 1.2 | 1.42 | 40.6 |

Table 3 summarizes data on an experimental crop yield and its statistical processing.

Table 3. Crop yield of spring soft wheat, t/ha, 2018 – 2019

| Variety | Year, t/ha | Average |
|---------|------------|---------|
| 2018 | +/- vs. standard, t/ha | Cv% | 2019 | +/- vs. standard, t/ha | Cv% | 2017-2018 | Cv% |
| 1* | 1.97 | - | 5/9 | 1.73 | - | 8.8 | 1.9 | 9.5 |
| 2* | 2.13 | +0.1 | 5.4 | 2.00 | +0.1 | 10.0 | 2.1 | 7.9 |
| 3* | 2.23 | 0.0 | 6.8 | 1.77 | +0.1 | 8.6 | 2.0 | 14.5 |
| 4* | 2.17 | +0.2 | 7.1 | 2.10 | +0.3 | 4.8 | 2.1 | 5.7 |
| 5* | 1.93 | -0.2 | 3.0 | 1.67 | -0.1 | 6.9 | 1.8 | 9.3 |
| Average | 2.09 | - | - | 1.85 | - | - | 2.0 |
| HCPg/| 0.22 | - | - | 0.27 | - | - | 0.22 |

*1 – Altayskaya 100; 2 – Altayskaya zhnsitsa; 3 – Altayskaya stepnaya; 4 – OmGAU90; 5 – Svetlanka

To estimate how factors influence the variability of a crop yield we carried out a two-way analysis of variance (ANOVA) of yields, these varieties demonstrated over two years of experimenting (Figure 1).

Figure 1. ANOVA outcomes based on a factor “crop yield” of spring soft wheat, 2018 – 2019

One of key quality characteristics relevant for baking properties of grain is gluten in endosperm (Table 4).
IOP Conf. Series: Materials Science and Engineering 941 (2020) 012037      doi:10.1088/1757-899X/941/1/012037

Table 4. Characteristics of varieties based on the grain quality, 2018 – 2019

| Variety              | Thousand kernel weight, g | Grain unit, g/l | Vitreousness, % | Gluten, % |
|----------------------|----------------------------|-----------------|----------------|-----------|
| Altayskaya 100       | 33.2                       | 774             | 96.1           | 32.3      |
| Altayskaya zhnitsa   | 35.1                       | 785             | 96.1           | 36.2      |
| Altayskaya stepnaya  | 35.4                       | 769             | 98.3           | 36.9      |
| OmGAU 90             | 34.4                       | 765             | 98.4           | 37.1      |
| Svetlanka            | 32.7                       | 751             | 97.0           | 33.8      |

4. Discussion

A tillering – earing period of varieties was minimal both in 2018 and 2019, being 22 and 26 days, respectively (Table 1). The shortest earing – waxy ripeness period of 32 days was registered for a variety of Altayskaya zhnitsa in 2019 году. In 2019 this development stage of all varieties under study was shorter than in 2018 and ranged from 32 days (Altayskaya zhnitsa) to 35 days (Altayskaya stepnaya).

On the contrary, this period was longer for all varieties in 2018, from 38 days (Altayskaya zhnitsa) to 41 days (Altayskaya stepnaya and Svetlanka). In our opinion, it was a result of weather conditions in the years of interest: in 2018 an amount of precipitation was bigger than in the droughty year 2019. The varieties were harvested simultaneously on the same day: 29.08 in 2018 and 02.09 in 2019.

A vegetation period of all crops was different, depending both on a variety and a year of consideration (Table 1). In the droughty 2019 the ripening of plants was quicker. In 2019 all varieties were more fast-growing than in 2018. An average vegetation period in 2019 was 2 days shorter in comparison with 2018, being 95 and 97 days, respectively.

In 2019 Altayskaya stepnaya demonstrated a shorter vegetation period (94 days), a standard – 95 days. In 2018 a vegetation period was 2 – 3 days longer than in 2019, approximately 97 – 98 days. Generally, all varieties under study belong to an early-ripening maturity group in view of a vegetation period.

A productive tillering capacity of a variety develops over the entire period of vegetation under the influence of hydrothermal conditions in the cultivation region. Varieties in the focus of our study developed low but good tillers (Table 2). A value of productive tillering ability was in a range from 1.20 pcs. per plant (Svetlanka) to 1.46 pcs. per plant (OmGAU 90), an accepted standard – 1.22 pcs. per plant. Therefore, a high average tillering ability within a period of consideration was formed by plants of Altayskaya zhnitsa – 1.41 pcs. per plant and OmGAU 90 – 1.46 pcs. per plant, an accepted standard – 1.22 pcs. per plant.

A spike length is an important parameter for many constituents of a yield crop since it is a spike where these elements form. In view of this characteristic Altayskaya zhnitsa and OmGAU were above the standard (7.2 cm), being 7.8 cm and 7.3 cm, respectively. In general, varieties formed a medium length spikes. The variability was recorded ± 0.5…1.6 cm.

A crop yield is closely related to such factor as a number of grains per spike. In our case, there were 29.2 pcs. per spike over the period of experimenting. The deviation from an average value shown by varieties in the experiment varied from 85.6% (OmGAU 90) to 113.1% (Svetlanka). Altayskaya zhnitsa with 32.7 pcs. per spike and Svetlanka with 30.2 pcs. per spike exceeded an average of 29.2 pcs. per plant; furthermore, a value of Altayskaya zhnitsa was maximal in the experiment. Thus, a number of grains per spike in tested varieties ranges from 26.7 pcs. per spike (Altayskaya stepnaya) to 32.7 pcs. per spike (Altayskaya zhnitsa).

A grain weight per spike is an integral characteristic depending on such constituents of a crop yield formula as a spike length, a number of grains per spike and plant, and a thousand kernel weight. An average grain weight per spike registered during 2 years of experimenting was as high as 1.0 g and varied from 1.05 g (Altayskaya stepnaya) to 1.26 g (Altayskaya zhnitsa). A grain weight per plant of Altayskaya zhnitsa was 1.26 g, being a maximal value in the experiment.
A parameter “thousand kernel weight” gives information on grain fineness and a concentration of substances a grain contains. The varieties formed well-filled grains. An average thousand kernel weight within a period of experiment was as high as 40.6 g. OmGAU 90 developed the heaviest grain (42.1 g). This parameter varied from 38.5 g (Altayskaya zhniitsa) to 42.1 g (OmGAU 90).

As seen in the data on a crop yield (Table 3), in 2018 conditions relevant for this parameter were better than in 2019. An average crop yield of varieties in 2018 was 2.09 t/ha, being 14.5% higher than the same characteristic in 2019 (1.85 t/ha).

In 2018 a crop yield varied from 1.93 t/ha (Svetlanka) to 2.23 t/ha (Altayskaya stepnaya). Altayskaya stepnaya produced a maximal crop yield in 2018 and was above the standard (1.97 t/ha) in view of this characteristics. At the standard there was OmGAU 90 (2.17 t/ha) and Altayskaya zhniitsa (2.13 t/ha). A variability of the parameter “crop yield” for all varieties in the experiment was low (Cv%<10), the most stable variety was determined to be Svetlanka (Cv% = 3.0%).

In 2019 a crop yield of varieties was 3-21% lower than in 2018. A crop yield of the standard variety in 2019 (1.73 t/ha) is 11.9% lower than in 2018 (1.97 t/ha). That year OmGAU 90 produced a high crop yield (2.10 t/ha), exceeding the standard (1.73 t/ha) in view of this parameter, the difference with a standard was as much as 0.3 t/ha. Four varieties of five under consideration demonstrated a low coefficient of variation (Cv%<10), they are Altayskaya 100, Altayskaya stepnaya, OmGAU 90, and Svetlanka. Altayskaya zhniitsa had a medium variation level 10>Cv%<20.

An average crop yield within two years of experiments was as high as 2.0 t/ha. No variety was above the standard crop yield (1.9 t/ha). Altayskaya zhniitsa and OmGAU 90 produced a maximal crop yield (2.1 t/ha). The variability of varieties is low (Cv%<10) except for Altayskaya stepnaya (Cv=14.5%).

When exploring an effect of factors on a crop yield of varieties certain trends were found (Figure 1). Such factor as “year” plays the most significant role for a crop yield – 44.56%, the second important factor is “variety” – 29.42%, and their combination results in 26.02%.

A level of gluten in all varieties was above 30% (Table 4). This factor varied from 32.3% (Altayskaya 100) to 37.1% (OmGAU 90). High values of gluten were found in Altayskaya zhniitsa (36.2%), Altayskaya stepnaya (36.9%), and OmGAU 90 (37.1%).

The vitreousness characterizes structural and mechanical properties of grain endosperm. A level of vitreousness in the study was approximately 96-98%. OmGAU 90 and Altayskaya stepnaya showed a maximal level of vitreousness 98.3 – 92.4%.

A grain unit of varieties was quite high and allows producing a good output of flour. Altayskaya zhniitsa had a maximal grain unit (785 g/l) by contrast to the standard (774 g/l). Therefore, Altayskaya zhniitsa and OmGAU 90 have better grain quality.

**Conclusion**

In general, all varieties under study are early-ripening in view of a vegetation period. A high tillering potential within a period of consideration was shown by plants of Altayskaya zhniitsa – 1.41 pcs. per plant and OmGAU 90 – 1.46 pcs. per plant, an accepted standard – 1.22 pcs. per plant. A number of grains per spike in tested varieties were 29.2 pcs. per spike within a period of experiment. OmGAU developed the heaviest grain (42.1 g). The value varied from 38.5 g (Altayskaya zhniitsa) to 42.1 g (OmGAU 90).

An average crop yield of varieties in the years of experiment was 2.0 t/ha. No variety was better than the standard (1.9 t/ha) according to this parameter. A crop yield of all varieties is at the standard. A maximal output was produced by Altayskaya zhniitsa and OmGAU 90 (2.1 t/ha). Except for Altayskaya stepnaya (Cv=14.5%) the variability of varieties is low Cv%<10. A crop yield is most sensitive to such factor as “year” – 44.56%, the second important factor is “variety” – 29.42%, and their combination gives 26.02%.

A level of gluten was above 30%. This factor varied from 32.3% (Altayskaya 100) to 37.1% (OmGAU 90). High values of gluten were found in Altayskaya zhniitsa (36.2%), Altayskaya stepnaya (36.9%) and OmGAU 90 (37.1%). A level of vitreousness in the study was approximately 96 – 98%.
OmGAU 90 and Altayskaya stepnaya showed a maximal level of vitreousness 98.3–92.4%. Altayskaya zhbitsa had a maximal grain unit (785 g/l) by contrast to the standard (774 g/l).

To summarize, such varieties as Altayskaya zhbitsa, OmGAU 90, and Altayskaya 100 are recommended for growing in Priobskaya zone of Altay forest steppes to provide the efficient production of high-quality spring soft wheat grain.

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