Different origin soft spring wheat varieties and lines comparative analysis

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Abstract. This work is devoted to the study of spring soft wheat samples collection material. Eighty collection specimens were evaluated, divided by their origin into four groups. The assessment was carried out according to the limiting characteristics for spring wheat: high productivity, stable over the years, resistance to biotic and abiotic environmental factors. A two-year field test made it possible to compare different groups in terms of yield, and to identify the most promising varieties and lines for the conditions of the Central Non-Black Earth Region. The evaluation of the collection samples of origin various groups showed that the varieties and lines of their own selection were the most adapted to the soil and climatic conditions of the Central Non-Chernozem region. The new lines of spring wheat, along with a high level of yield, showed resistance to biotic and abiotic stressors. Varieties of foreign selection are distinguished by a strong non-spreading stem, high density of the stem, as well as high resistance to the most harmful leaf diseases. Of particular interest are the varieties of the Belarusian selection Darya, Dalech, Viza, Rostan with a high yield potential at the level of 5.0-6.0 t/ha.

1. Introduction
The yield of all grain crops, and in particular, wheat, largely depends on the variety [1, 2, 3]. The degree of source material knowledge determines the efficiency level of its use in the selection process. Lukyanenko noted in his works that "It is possible to successfully select the necessary components for crosses only by systematically studying large collections of wheat, which should include the main ecological types and the widest possible variety of varieties, including the best world and domestic breeding varieties" [4].

In this regard, it is necessary to take a different approach to the evaluation of the collection material. It is necessary to study the samples on the suitability of their use in practical breeding. It is also important to find the right forms of involvement in the selection process of valuable collection samples. The more actively they are involved in breeding, the more diverse the assortment of cultivated crops will be by origin and the less the risk of epiphytotic diseases and crop loss will be [5].

It is possible to confidently predict the breeding value of collection samples only if their genetic potential is known [6].

In this regard, the expansion and deepening of research on collection material aimed at creating and using donors of breeding-valuable traits is an important and urgent task.
2. Materials and methods
A comparative assessment of 80 collection samples of spring soft wheat was carried out in 2019-2020. By origin, they can be divided into IV groups.

The first group includes varieties of spring wheat self-selection of the Federal Research Center "Nemchinovka" (FRC “Nemchinovka”) of the various periods of change of variety currently included in the State register of varieties approved for use on the territory of the Russian Federation (12 varieties) in a separate subgroup I/1 the varieties are also created in FRC “Nemchinovka”, but either did not pass testing (Milturum 63, Suburban 10, Biora 2, Angelina, Nemchinov 1), or going through it now (Lisa, Jubilee 60, Bel, TIM). The next group II is represented by 12 varieties from both the near (Belarus, Ukraine) and far abroad (Germany, Canada, Sweden). The third group includes spring wheat varieties created in the breeding centers of the Russian Federation (17 varieties). Group IV consisted of promising lines of competitive variety testing (28 lines).

The studies were conducted in the laboratory of breeding and primary seed production of spring wheat FRC "Nemchinovka".

Field experiments in conditions of the FRC "Nemchinovka" placed in the second winter wheat crop rotation. Agricultural techniques in the experiments are generally accepted for the zone.

The study of the source material was carried out in accordance with the Methodological Guidelines for the Study of the World Wheat Collection of Federal Research Center "All-Russian Institute of Plant Genetic Resources named after N. I. Vavilov" [7].

In the collection nursery, the varieties were sown in 2-fold repetition by the Wintersteiger selection seeder on plots with the area of 3 m² and with the seeding rate of 600 germinating grains per 1 m², after 10 numbers-the standard variety Zlata.

On each plot after the appearance of full shoots pledged account platform S= 1 m², the rised plants after emergence and kept for harvest of productive stems were counted. Plants with account of the sites were cleaned with the root for the analysis of the yield structure by the following parameters: the plant height, total and productive tillering, grain weight in main spike, grain mass per plant, length of a spike, number of grains per a spike, number of spikelets in a spike, weight of grain, weight of straw, weight of 1000 grains.

Phytopathological assessment for resistance to leaf diseases was carried out according to the method of Geshele [8].

The yield was determined by weighing, taking into account the moisture content of the sample. These yields are given to 14% humidity and 100% purity.

3. Results and discussion
When studying the collection material, special attention was paid to the study of samples according to the limiting characteristics for spring wheat: high, stable productivity over the years, resistance to biotic and abiotic environmental factors.

The yield assessment allowed to compare different groups and identify the most productive varieties and lines.

According to the results of 2019, the most productive (the average for two repetitions) were promising lines of their own selection of 5.43 t/ha. The second place was taken by the varieties of foreign selection, the lowest yield was formed by varieties of group III (4.33 t/ha).

The current weather conditions during the growing season of 2019 had a number of features. In the first decade of May, the amount of precipitation significantly exceeded the average long-term data (37.4 mm and 14.7 mm respectively), seedlings were friendly and amounted to 450-500 plants per 1 m², which is most typical for varieties of the Western ecotype and further positively affected the yield of varieties of this group, the Darya variety with a yield of 5.67 t/ha was among them. Among domestic cultivars the most productive was the cultivar Idel – 5.63 t/ha of breeding by the "Kazan Scientific Center of Russian Academy Sciences". It should be noted that among the promising breeding lines of the FRC "Nemchinovka" more than 24.8% formed a yield of above 6.0 t/ha.
In the conditions of 2020, the amount of precipitation that fell in the third decade of May exceeded the average long-term data by more than 2 times, while the air temperature was 3-4 degrees below the average long-term data, which contributed to the appearance of late seedlings. Heavy rains during the growing season led to a significant lodging of wheat, which contributed to the formation of yields lower than in the previous year. The greatest yield was obtained in the varieties and lines of the Nemchinovsky selection, primarily due to resistance to lodging and precocity.

In general, for the period 2019-2020, the yield of the I, I/1 and II groups of varieties was at the same level of 3.43-3.48 t/ha. Its promising lines of group IV slightly exceeded it (4.04 t/ha), while the lowest one was noted in the varieties of group III (3.27 t/ha), primarily due to the strong lodging and sparseness of seedlings. Among all the studied varieties by yield, it is necessary to distinguish the following: I group Radmira (4.26 t/ha), Yubileynaya 60 (4.15 t/ha), II group Darya (4.07 t/ha), Dalech (4.04 t/ha) and Rostan (4.09 t/ha) all varieties of Belarusian selection, in the III group the variety Sudarynya (4.27 t/ha) of joint selection of the Verkhnevolzhsky Federal Agricultural Research Center and the Scientific and Practical Center of the National Academy of Sciences of Belarus for Agriculture stood out. Among the lines of group IV, the most interesting are L. 115/3 (4.54 t/ha), L. 4/3 (4.26 t/ha), L. 6/3 (4.53 t/ha), L. 315/2 (5.01 t/ha), L. 325/2 (4.65 t/ha), L. 339/1 (4.87 t/ha) and L.241/2 (4.84 t/ha). Almost all of them are obtained on the basis of the varieties of their own selection Esther, Lada and Zlata with the participation of foreign varieties Trizo, Kanata and Madame.

The productivity of spring wheat is integral, consists of a number of characteristics and should be considered as the result of the variety genotype interaction with the environmental conditions. The study of the relationship between yield and its structural elements components indicates a high variability by year as influenced by the weather conditions, the level of fertility, the extent of damage by diseases and pests, and depending on the genotypes of the original forms.

Varieties I, I/1 and lines of group IV were almost identical in height at the level of 97-98 cm, which indicates the optimality of this indicator for the conditions of the Central Non-Chernozem region. The height of the group III plants was slightly higher and amounted to 101 cm, group II, represented by varieties of foreign selection, had the height of 83 cm, which is characteristic for the Western ecotype varieties.

The task facing the selection of spring wheat in the conditions of the Central Non-Chernozem region is to increase the varieties ability to maintain the stem density of at least 400 pcs per 1 m², even in years with low moisture availability. The greatest number of productive ears per 1 m² was observed in group IV (415 pcs per 1 m²) presented promising lines selection of the FRC "Nemchinovka", which is not surprising since one of the vectors breeding in the area is the increase in stand density over the previously established varieties. In group II, the stem density of foreign-selected varieties was 465 units per 1 m². This is especially true for varieties of Belarusian selection, which largely determines their high level of yield [9].

The closest positive bond yields in the Central black earth long-term data are marked with the following elements structure: the number of productive stems per 1 m² (r = 0.37...0.72) and the weight of grains in spike (r = 0.30...0.70).

The highest grain weight per ear (1.2 g) was observed in the promising breeding lines of the FRC "Nemchinovka" and varieties of its own selection (1.1 g). The highest water content of the ear is also noted in the varieties and lines of their own selection (from 32.1 to 33.6 pcs), which indicates a certain orientation of the forms selection that are most adapted to specific soil and climatic conditions of cultivation. According to the weight of 1000 grains, promising breeding lines of the FRC "Nemchinovka" (35.7 g) were distinguished, which indicates the correctness of the selection vector in the direction of grain size.

The climatic conditions of the Central Non-Chernozem zone of Russia favor the spread of many leaf diseases. At the same time, only stable varieties can produce stable and high yields here. The dependence of the yield level on disease damage is negative, with the variation in the epiphytotic years from r = -0.25 to r = -0.70 and higher. The most harmful leaf diseases for spring wheat in the conditions of the Central Non-Chernozem region are brown rust, powdery mildew, septoria, and in
recent years, stem rust. The most valuable is the creation of varieties with group resistance (damage is not more than 20%).

In the conditions of 2019-2020, no epiphytosis was observed for any of the leaf diseases, which did not allow to reliably identify forms with group resistance to the most harmful pathogens. However, against the general background (the maximum lesion in 2019 is up to 50%), the varieties of group II (5-10% lesion) were distinguished in terms of resistance to septoriosis, which allows to use most of them as donors of group resistance to leaf diseases, given that in previous years the varieties of this group (Cub, Sober, Eta) were highly resistant to powdery mildew and brown rust.

According to the indicator of precocity in each group of varieties, it is possible to distinguish both varieties and lines (Kanata, Saturn, Saratovskaya 62, L.460/2-15, L.495/3-15, L.456/3-15, L.211/4-17), which were hatched almost simultaneously with the precocious variety Zlata. The center of the Non-Chernozem zone of Russia is the zone of changing moisture conditions over the years: from arid to excessively moist ones. The closest relationship between the level of yield and moisture availability is shown in May and June (from $r = 0.39$ to $0.57$). The analysis of the dependence of the yield level on the elements of the structure for the period allows to conclude that almost every second year there was a positive correlation between the yield and the number of productive stems preserved for harvesting per 1 m$^2$.

In precocious varieties, even in years with dry springs, it is possible to form a high density of the stem due to the use of the remnants of winter moisture. This has a positive effect on the level of yield. The greatest dependence of the yield on the stem density can be traced in the II group of foreign varieties, in particular the Western ecotype ($r = 0.46$). The ability to maintain a high stem density for harvesting due to this group varieties resistance to leaf diseases and lodging, especially of the Belarusian selection, and thereby form a high level of yield, allows to use them as the sources of resistance to environmental stress factors.

The analysis of the yields correlation from the major elements of the structure in 2020 showed that almost all group varieties to the greatest extent determined the weight of grains in spike and weight of 1000 grains. Slightly lower this dependence was in the stand density, the number of kernels in a spike, height and, as a consequence, resistance to lodging. The length of the ear and lateral development practically did not affect the yield level. The greatest dependence on grain weight with spike traced the perspective lines ($r = 0.57$) and varieties I/1 subgroup ($r = 0.67$), which again confirms the importance of this element of structure for spring wheat in Central regions and allows to involve varieties of selection of the FRC “Nemchinovka” in breeding process as donors of grain size. Increasing the grain size is one of the main directions in the selection of spring wheat in the FRC “Nemchinovka” and involves the use of one or more winter components when creating new varieties, due to biological characteristics, the indicator of grain weight per ear and weight of 1000 grains is higher in winter varieties.

4. Conclusion
The evaluation of the collection samples of origin various groups showed that the varieties and lines of their own selection were the most adapted to the soil and climatic conditions of the Central Non-Chernozem region. When creating new breeding material, they are used as one of the parent forms, most often the mother form. The new lines of spring wheat, along with a high level of yield, showed resistance to biotic and abiotic stressors, and also selected material with high indicators for the main elements of the crop structure: the weight of grain per ear, the weight of 1000 grains and the density of the stem.

The main part of the material created in other research institutions in Russia is characterized by high stress resistance, as well as high adaptability to differences in soil and climatic conditions, which allows to use them as sources of these characteristics. Of particular interest are the varieties of Madam, Idele, Yoldyz. Varieties of foreign selection are distinguished by a strong non-spreading stem, high density of the stem, as well as high resistance to the most harmful leaf diseases. Of particular interest
are the varieties of the Belarusian selection Darya, Dalech, Viza, Rostan with a high yield potential at the level of 5.0-6.0 t/ha.

In each group, there are varieties that differ in the main economically valuable characteristics, but a certain vector of orientation of selection in different groups allows to use them as the initial forms of the missing characteristics.

References

[1] Voronov S I, Pleskachev Yu N and Ilyashenko P V 2020 Fundamentals of production of high-quality winter wheat grain *Fertility* 2(113) 64-66

[2] Voronov S I, Pleskachev Yu N and Chernomorov G V 2020 Productivity of winter wheat depending on leaf application of CAS and growth regulators *Problems of Development of the Agro-Industrial Complex of the Region* 1(41)19-22

[3] Pleskachev Yu N, Chernomorov G V, Bugreev N A, Panov A A and Skorokhodov E A 2019 Economic efficiency of methods of basic soil treatment and fertilizers in the cultivation of winter wheat *Problems of Agricultural Development in the Region* 2(38) 135-140

[4] Lukyanenko P P 1960 On the selection of high-yielding varieties of strong wheat in the Krasnodar Territory *Bulletin of Agricultural Science* 5 32-39

[5] Nettevich E D 1983 The problem of grain crops selection in the Non-Chernozem region *Bulletin of Agricultural Science* 5 108-112

[6] Dragavtsev V A 2008 Fundamentals of future high-tech breeding technologies for the genetic improvement of polygenic, economically important properties of plants *Genetic Foundations of Breeding Ufa* 40-60

[7] Dorofeev V F, Rudenko M I, Shitova I P and Korneychuk V A 1977 *Methodological Guidelines for the Study of the World Wheat Collection* (Leningrad: Federal Research Center All-Russian Institute of Plant Genetic Resources named after N. I. Vavilov) p 27

[8] Geshele E E 1978 *Fundamentals of Phytopathological Evaluation in Plant Breeding* (Moscow: Kolos) p 205

[9] Davydova N V, Kazachenkov A A, Shirokolava A V, Rezepkin A M, Gracheva A V, Sharoshkina E E, Nardid V A and Romanova E S 2018 Features of spring wheat cultivation in the Non-Chernozem zone of Russia *Innovative Developments in the Selection and Technology of Crop Cultivation* pp 83-90