Source material for accelerated breeding of new commercial varieties of spring soft wheat

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Abstract. The aim of the studies based on the modeling of hybrid genotypes of spring wheat is to study collection varieties of various origin at several test sites, different in soil and climatic conditions, in order to identify the best of them with high adaptive potential. Hybrids created using the set of limiting traits of varieties distinguished in three test points were involved in the biotechnological process to obtain dihaploid forms in order to accelerate the breeding process. Based on them, a new source material has been created. Using the optimized method of haploproducer Z.mays on the basis of a hybrid combination (Visa x Amir), the new variety of spring soft wheat Lisa was created, with a yield potential of 7.5-8.0 t/ha, resistant to lodging, meeting quality requirements in terms of quality to strong wheat. The variety is recommended for cultivation in 2 (North-West), 3 (Central) and 7 (Middle Volga) regions of the Russian Federation.

1. Introduction

Food export, in particular grain, is one of the indicators of the economic well-being of the state and at the same time strengthens the country's weight and international authority. To compete in the global market, new varieties are needed that meet the requirements of modern production, with the ability to realize their potential regardless of the influence of biotic and abiotic stress factors (disease and pest damage, drought and heat resistance, acid resistance). To create such varieties using traditional breeding methods, it takes 8-10 years, which is unacceptable in modern conditions. Therefore, it is necessary to search for new forms of source material, including biotechnology methods, to create new, competitive varieties of wheat in 4-5 years. Prospects for the intensification of the breeding process are opened by the methods of biotechnology in combination with hybridization and selection [1, 2].

2. Material and methods

The research material was varieties of both our own breeding and leading research institutions of Russia, as well as modern varieties of spring soft wheat from Belarus and Ukraine.

3. Research Results

In 2009-2017 at the Nemchinovka Federal Research Center (Moscow Region, hereinafter referred to as Nemchinovka), the Ryazan Agricultural Research Institute (Ryazan Region, hereinafter - Ryazan) and the Vladimir Agricultural Research Institute (Vladimir Region, hereinafter referred to as Vladimir) conducted a parallel assessment of the collection numbers of spring soft wheat by a complex of economically valuable traits and ranking them by yield level (table 1).
Particularly important for modern production is the ability of the variety to form a high and stable crop in various agro-climatic conditions [3-6]. When assessing varieties at three test points, it was found that the level of productivity of varieties under Nemchinovka conditions reliably \((r = 0.68 \pm 0.15)\) corresponds to the results of the assessment in Vladimir and positively, but with a low degree of significance \((r = 0.38 \pm 0.27)\) to the results obtained in Ryazan. According to the assessment of the parameters of ecological plasticity and stability, the varieties Lada, L.505, Saratovskaya 68, Omskaya 33, Visa were distinguished as the most responsive to improving cultivation conditions \((\text{bi}> 1.0)\). By the value of the indicator \(\text{Puss} \%)\) proposed by Nettevich E.D. and allowing to simultaneously take into account the level of yield and stability of the variety, the most interesting are the varieties: Moskovskaya 35, Southeast 4, Dalech and Visa, as capable of forming a consistently high level of yield in various cultivation conditions.

Table 1. Productivity \((t / \text{ha})\) and adaptive properties of spring soft wheat varieties.

| Variety         | Productivity, t / ha | % to average | \(\text{Cv, \%}\) | \(\text{Sd,}^2\) | \(\text{bi}^*\) | Puss** \% | Ranks\(^3\) |
|-----------------|----------------------|--------------|----------------|--------------|---------------|-----------|-----------|
|                 | 1        | 2        | 3        | average |           |            |           |           | A       | B       |
| Lada            | 4.44    | 3.83    | 3.28    | 3.86    | 0.0        | 30.4      | 4.99      | 1.19      | 100.0   | 16      | 4       |
| Moscow 35       | 4.48    | 3.83    | 3.78    | 4.03    | 3.1        | 18.1      | 8.96      | 0.73      | 179.6   | 9       | 2       |
| Priokskaya      | 4.29    | 4.23    | 3.99    | 4.17    | 6.4        | 12.1      | 13.8      | 0.50      | 275.9   | 4       | 1       |
| L.503           | 3.03    | 3.49    | 2.85    | 3.12    | -13.6      | 38.7      | 2.93      | 1.31      | 58.8    | 28      | 8       |
| L.505           | 4.13    | 4.78    | 3.30    | 4.07    | 4.9        | 29.4      | 5.68      | 1.20      | 113.9   | 7       | 1       |
| Saratov 68      | 3.81    | 5.15    | 2.60    | 3.85    | 4.4        | 28.5      | 5.82      | 1.16      | 116.6   | 17      | 4       |
| Southeast 2     | 3.99    | 4.34    | 3.27    | 3.87    | -0.8       | 20.9      | 7.20      | 0.81      | 144.1   | 15      | 3       |
| Omskaya 24      | 4.34    | 4.63    | 3.30    | 4.09    | 7.9        | 19.2      | 9.26      | 0.81      | 185.5   | 6       | 2       |
| Omskaya 28      | 3.87    | 4.77    | 3.24    | 3.96    | 2.8        | 25.5      | 6.33      | 1.02      | 126.9   | 10      | 3       |
| Omskaya 32      | 4.20    | 3.53    | 3.42    | 3.71    | -4.4       | 18.4      | 7.57      | 0.69      | 151.6   | 21      | 6       |
| Omskaya 33      | 4.38    | 4.67    | 3.50    | 4.18    | 7.2        | 29.8      | 5.71      | 1.25      | 117.2   | 3       | 1       |
| Collective 1    | 4.04    | 4.84    | 3.00    | 3.96    | 5.1        | 24.4      | 6.89      | 1.00      | 138.0   | 11      | 2       |
| Collective 3    | 4.53    | 4.15    | 3.47    | 4.05    | 5.4        | 21.3      | 7.93      | 0.88      | 158.9   | 8       | 1       |
| Far away        | 5.32    | 4.18    | 4.00    | 4.50    | 39.7       | 17.3      | 17.17     | 0.94      | 343.8   | 2       | 3       |
| Visa            | 5.23    | 4.23    | 2.92    | 4.13    | 36.9       | 20.1      | 14.15     | 1.08      | 283.4   | 5       | 2       |
| Rostan          | 5.74    | 5.57    | 4.70    | 5.34    | 56.4       | 15.9      | 23.48     | 0.97      | 392.3   | 1       | 1       |

\(^1\) - Nemchinovka, 2 - Ryazan, 3 - Vladimir;  
\(^2\)A - for all varieties, B – inside originating institutions;  
\(^*\) - the calculation was carried out according to S. Eberhart and V. Russell (1966);  
\(^*\) - according to E.D. Nettevich and A.I. Morgunov (1985).

An assessment of the share of the influence of the variety genotype and agroclimatic conditions on the most significant economically useful traits showed that the level of productivity and the number of grains in an ear are largely determined by genotypic dependence [7.8]; the number of spikelets in the spike and the mass of 1000 grains - by the action of agroclimatic conditions; grain mass from a spike - a joint influence of factors [9], Figure 1.
Figure 1. The shares of the influence of factors on the level of development of economically useful traits, 2009-2016, where: 1 - productivity, g/m²; 2 - plants height, cm; 3 - the number of spikelets in the spike, pcs.; 4 - the number of grains in the spike, pcs.; 5 - grain weight per spike, g; 6 - weight of 1000 grains, g.

The results of field studies and their subsequent analysis by the method of orthogonal regression, as well as by the Lemme-Zede index estimation method (1981), made it possible to distribute varieties according to a set of economically useful traits (table 2).

Table 2. Comparative characteristics of economically useful traits in spring wheat varieties by index assessment method.

| Variety          | Productivity–Plant Height | The number of grains in a spike - the mass of grain in a spike | Sum of Index Ratings |
|------------------|----------------------------|-------------------------------------------------------------|----------------------|
|                  | G¹ | ln² | G  | In | ln  | G  | In | ln  |                           |
| Rostan           | II |  5  | I  |  5 |  5  | II |  5 |  5  |  15                        |
| Collective 3     | II |  5  | I  |  5 |  5  | II |  5 |  5  |  15                        |
| Far away         | II |  5  | I  |  5 |  5  | II |  5 |  5  |  15                        |
| Visa             | II |  5  | I  |  5 |  5  | II |  5 |  5  |  15                        |
| Lada             | I  |  4  | IV |  3 |  5  | I  |  4 |  4  |  11                        |
| Southeast 2      | I  |  4  | IV |  3 |  4  | I  |  4 |  4  |  11                        |
| Omskaya 32       | III|  3  | II |  4 |  4  | II |  4 |  4  |  11                        |
| Saratov 68       | III|  3  | II |  4 |  4  | III|  3 |  5  |  11                        |
| Mironovskaya Yar.| I  |  4  | IV |  3 |  3  | I  |  4 |  3  |  10                        |
| Thassos          | III|  3  | II |  4 |  4  | III|  3 |  2  |  10                        |
| Etta             | III|  3  | III|  2 |  5  | III|  3 |  2  |  10                        |
| Omskaya 33       | I  |  4  | III|  2 |  3  | I  |  4 |  3  |  9                         |
| Esther           | I  |  4  | IV |  3 |  2  | I  |  4 |  2  |  9                         |
| Collective 1     | III|  3  | III|  2 |  4  | III|  3 |  2  |  9                         |

¹G - group of distribution of the orthogonal regression.²ln – Lemme-Zede index method estimation (1981).
Compared with the Lada variety, characterized by high spike grains (38.20 pcs.) and a mass of 1000 grains (40.3 g.) and having a total index score of 12, the following varieties were distinguished by the level of structural elements: Rostan, Collective 3 (sum of index ratings 15), Dalech (the sum of index estimates 14) and Visa (the sum of index estimates 13), which suggests their use in the breeding process as sources of determining characteristics when forming the productivity level of spring soft wheat.

In the conditions of the Central Non-chernozem region, the yield of spring wheat largely depends on the defeat of powdery mildew \( (r = -0.60 \pm 0.10) \) and brown rust \( (r = -0.50 \pm 0.12) \) in the phase of exit into the tube and into the phase of earing \( (r = -0.46 \pm 0.15) \) and \( (r = -0.58 \pm 0.10) \), respectively. Varieties with integrated resistance to these pathogens in the field were identified: MIS, Esther, Saratovskaya 68, Collective 1, Omskaya 33, Visa, Eta and Thassos.

Hybrids created using the set of limiting traits of the varieties distinguished in three test points were involved in the biotechnological process to obtain dihaploid forms in order to accelerate the breeding process, Figure 2.

**Figure 2.** The use of new source material in the selection of spring wheat.

Haploidy is now increasingly attracting the attention of geneticists and breeders. This is due to the fact that in haploid tissues of plants it is possible to catch useful and eliminate lethal and reducing viability recessive somatic mutations. Thus, the breeder has the opportunity to reduce the duration of genetic analysis and more accurately determine the breeding value of hybrid combinations, while reducing the time for creation of the new varieties [10-13].

In Nemchinovka, an optimized biotechnology was developed for mass production of diploidized material in vitro of the spring soft wheat in the Zea mays mays haploproducer system [14, 15, 16].

Assessment by the index of integrated productivity assessment (IIPA) of the obtained dihaploid lines (DG lines) made it possible to establish that their selection value is largely determined by the recombination ability of the initial forms. So, the largest number of highly productive DG lines was created on the basis of the hybrid (Visa x Amir) F1 - 9.3% (table 3).

**Table 3.** Index of the integrated assessment of the productivity of the initial forms of spring wheat using diploidized haploid lines.

| Crossbreeding Combination | Highly productive DG lines, % | The average productivity of the lines relative (%) | IIPA², % |
|---------------------------|-----------------------------|----------------------------------|---------|
|                           |                             | the best parent | the standard variety |         |
|                           |                             |                   |                     |         |

4
1 - Highly productive line - DG-line of spring wheat, superior in yield to the standard variety by more than 20% (the percentage of lines is calculated from the total number of distinguished DG-lines - 41 pcs.); 2 – IIPA - the index of the integrated assessment of the productivity of lines obtained on the basis of haploidy was determined by the method of E.D. Nettevich, V.N. Chistyakova and V.P. Smolin (1997).

Studying of the created DG lines (C3 – C4) allowed suggesting that in order to increase the accuracy and reliability of the assessment by a set of economically useful features, it is necessary to test them in several agroclimatic zones. Estimation of the DG-lines using the Puss indicator (%) allows the accurate differentiation of families and to highlight the lines adaptive to specific soil and climatic conditions [17, 18].

**Table 4.** Characteristics of the best DG-lines for economic useful traits, 2012 – 2017.
Average yield of DG lines in competitive variety testing in 2012-2017 amounted to 4.35 t / ha, for the standard variety Lada - 3.76 t / ha. Based on the assessment of the complex of limiting features in the conditions of the Central Non-chernozem region, the S-21 DG line [(Saratovskaya 68 x Visa) F₁ x (Tulaykovskaya 10 x Thassos) F₁] F₁ with good baking qualities, as well as the DG line: H00706/1 and H00706/4, created on the basis of a hybrid combination (Visa x Lada), the yield level of which was 5.26 t / ha and 5.27 t / ha, grain weight per spike - 1.36g and 1.54g, the protein content in grain is 16.45% and 16.51%, gluten in flour is 37.2% and 37.4%; having the quality of gluten GSM (Gluten Strain Measuring) - 75 units of scale and 77 units of scale, sedimentation level - 11.0 ml and 10.4 ml. (table 4). Sister DG-lines H00706/1 and H00706/4, obtained on the basis of Viza and Lada varieties, have an erectoid form of leaf blade arrangement, which is an indirect sign of drought resistance in spring common wheat. The DG-line data of spring wheat are further evaluated in a competitive variety test and are involved in the selection process as a source material.

| Indicators                                      | Lim (max - min) |
|------------------------------------------------|-----------------|
| Productivity in competitive variety testing, t / ha | 6.73 - 3.27     |
| The increase to the average standard, t / ha      | 2.1 - 0.40      |
| Resistance to lodging, score                      | 9               |
| Height, cm                                       | 75 - 53         |
| The defeat of loose smut (artificial background),% | 1.2 - 0         |
| The defeat of covered smut (artificial background),% | 12.2 - 7.5     |
| The defeat of brown rust,%                       | 40 - 20         |
| Gluten content in flour,%                         | 36.4 - 30.9     |
| GSM, units of scale                               | 82 - 56         |
| Strength of flour, units of device                | 370 - 298       |
| Volumetric yield of bread, cm³                    | 1190 - 970      |
| Mass of 1000 grains, g                            | 44.2 - 36.2     |

4. Conclusion
The practical result of the work based on the modeling of hybrid genotypes of spring wheat using the ecological and geographical principle of selection of parental pairs (varieties), identified by a set of limiting characters for the conditions of the Central Non-chernozem region of the Russian Federation, and the application of the optimized method of haploproducer Z. mays, is to create a hybrid combination (Visa x Amir) of a new competitive variety of spring soft wheat Lisa and promising new lines of spring soft wheat involved in breeding process as in Nemchinovka, and in the Ryazan and Vladimir.

The variety Lisa (l. 271) created in Nemchinovka using the haploidy method from a hybrid population (Visa x Amir) is currently undergoing the State variety test (table 5). Patent No. 7369 dated 06/05/2014 was obtained for it. The lutescens variety. The mid-season variety, with a yield potential of more than 7.5 t / ha, has a shortened straw (53-75 cm). Resistant to lodging. Significantly weaker than the standard variety, might be affected by loose and covered smut, both in vivo and during artificial infection. Relatively resistant to powdery mildew and septoria. Resistant to shedding and germination of grain in the spike. It has a consistently high grain quality. The volumetric yield of bread is 970-1190.
cm³, the strength of the flour is 298-370 units of device, the gluten content in the flour is 30.9-36.4%. Grain is aligned, with a high yield of conditioned seeds. It is recommended for cultivation in 2, 3 and 7 regions [19, 20].

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