Choosing of the basic material in the millet breeding based on the recombination ability assessment

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Abstract. The recombination ability of the breeding material is an important feature that must be taken into account when cultivars involve in hybridization. The recombination ability of the basic seed millet material was established based on the analysis of long-term data on cross-breeding combinations and the output of promising lines in a competitive test. The analysis showed that not all varieties of the Orenburg breeding, both in direct and reverse crosses, had a high coefficient of recombination potential. Based on the results obtained, the varieties that are better included in the hybridization as the mother line were identified, since the coefficient of recombination ability is higher in direct crosses. Also there were varieties which is advisable to inclusion in the breeding process only in reverse crosses.

1. Introduction
Grain production is an important direction in the implementation of the main task of the agro-industrial complex of the Russian Federation, which is ensuring the food independence of the state. Further increase in grain production is associated with the improvement of the scientific and production base of agriculture on the basis of the development and introduction of high-yielding varieties into production, optimization of the machine system, effective use of crop protection and biostimulation, development of cultivation technologies adapted to the conditions of different zones and subzones. Breeding is the main way to solve the problems of better crops adaptation to the conditions of natural and agricultural areas. The introduction of a new variety in agriculture remains one of the main means of increasing productivity and improving the quality characteristics of products that do not require additional costs when it introduces into production.

N. I. Vavilov argued that the success of breeding work is largely determined by the basic material. The availability of a variety of basic material is necessary for the creation of new and improved varieties currently in use, for the implementation of various breeding programs. In this regard, the study of the wide potential of the basic material of millet from different countries of the world and the identification of donors of economically valuable traits in various areas of breeding has great theoretical and practical importance. This will allow us to obtain varieties and hybrids that combine high productivity, quality, resistance to diseases and pests, and they are able to ensure crop stability through adaptation and protection from environmental stresses in the conditions of global and local climate change [1,2].

The Russian Research Institute of Plant Breeding World Collection is the main source of genetic material for breeding varieties and hybrids of various agricultural crops, including millet [3,4].

Many breeding institutions (the P. N. Konstantinov Volga Research Institute of Breeding and Seed
Production, the Kabardino-Balkar Research Institute of Agricultural Research, the V. V. Dokuchaev Voronezh Research Institute of Agricultural Research, etc.) study the numbers of the world millet collection from Russian Research Institute of Plant Breeding and other sources in order to identify samples with the necessary characteristics. But in the future, the question arises how to use the selected material. In the conditions of the steppe zone of Kabardino-Balkaria, when comparing direct and reverse crosses, it was found that it is better to use a local drought-resistant, heat-resistant variety as the mother form, and foreign varieties with less heat resistance, drought resistance, but with high productivity, resistance to diseases, lodging and other valuable characteristics as the father crop [5,6].

The basic gene pool for the creation of new millet varieties for many years has been hybrids created on the basis of local material in Federal Agrarian Scientific Center of the Southeast. The vast majority of varieties of non-district breeding are not used in hybridization, because they do not have the necessary level of adaptability (including heat and drought resistance) and for this reason most often they serve as destroyers of coadaptive blocks of genes that control a complex of the most important and complex traits [7,8]. The predominant use of local breeding material in hybridization is also noted in the works of N. I. Tishkov [9]. He notes that the success of breeding work largely depends on the recombination ability of a particular variety. The author notes that, in almost all cases, when breeding zoned varieties, one of the components in the crosses is a variety with a sufficiently high recombination ability.

The aim of the work was to evaluate the recombination ability of the parent lines of seed millet and to identify valuable forms for creating a hybrid material.

2. Materials and methods
For the analysis, varieties of millet of the Orenburg breeding and samples from the world collection of the Russian Research Institute of Crop Breeding named after N. I. Vavilov were taken. Breeding work was carried out on the basis of the Center for Collective Use of the Federal State Budgetary Scientific Research Center of of Biological Systems and Agrotechnologies of the Russian Academy of Sciences in accordance with the methodology of the state variety testing. The recombination potential coefficient was determined by the method proposed [9]. The method is based on the frequency of participation of the parent form in the creation of a new line that has entered the competitive variety testing. The recombination capacity of the basic starting material was determined based on the analysis of long-term data on cross-breeding combinations. All crosses were grouped relative to the varieties by type of crossing (direct, reverse), indicating the number of promising cultivars obtained from crossing with the participation of a particular parent form and reached, on the basis of an assessment of productivity, stability, plasticity and phenotypic data, to the competitive test. The value of the ratio of the number of promising lines to the number of crosses in each particular case served as a criterion for evaluating the recombination ability of the parent variety - CRP as in equation (1).

\[ \text{CRP} = \frac{\text{Pl}}{\text{Cs}} \]  

where: Cs – the number of crosses combinations with the participation of the parent form, from which promising lines are selected, Pl – the number of promising lines that have reached the competitive test. The grading and evaluation of the recombination potential is presented in table 1.

| Value of the CRP coefficient | Degree of manifestation |
|-----------------------------|-------------------------|
| before 0.10                 | very low                |
| 0.10 – 0.29                 | low                     |
| 0.30 – 0.50                 | medium                  |
| more than 0.50              | high                    |

3. Evaluation of the combinational ability of the parent forms of millet included in simple crosses
The results of the analysis of simple crosses combinations and the entry of promising lines into competitive testing are shown in table 2.
**Table 2.** Results of the simple crosses analysis and the coefficient of recombination potential of millet varieties.

| №  | Grade           | Number of combinations (units) direct | CRP  | Number of combinations (units) reverse | CRP  |
|----|----------------|--------------------------------------|------|----------------------------------------|------|
|    |                | total extant to the CT<sup>a</sup>     |      | total extant to the CT<sup>a</sup>     |      |
| 1  | Barnaul 80     | 13                                   | 0    | 0.0                                    | -    |
| 2  | Baganskoe 88   | 15                                   | 0    | 0.0                                    | 15   | 9    | 0.6 |
| 3  | Blagodatnoe    | 17                                   | 0    | 0.0                                    | 15   | 3    | 0.2 |
| 4  | Belgorod       | 14                                   | 0    | 0.0                                    | 12   | 0    | 0.0 |
| 5  | Volgogradskoe 4| 17                                   | 14   | 0.82                                   | 17   | 2    | 0.12|
| 6  | Volnoye        | 17                                   | 0    | 0.0                                    | 15   | 0    | 0.0 |
| 7  | Gorlinka       | 15                                   | 0    | 0.0                                    | 14   | 2    | 0.14|
| 8  | Danila         | 25                                   | 5    | 0.2                                    | 22   | 1    | 0.05|
| 9  | Dobroye        | 16                                   | 6    | 0.38                                   | 16   | 0    | 0.0 |
| 10 | Dolinskoe 111  | 16                                   | 6    | 0.38                                   | 16   | 0    | 0.0 |
| 11 | Zaryana        | 15                                   | 9    | 0.6                                    | 14   | 4    | 0.29|
| 12 | Zolotistoye    | 26                                   | 4    | 0.15                                   | 29   | 6    | 0.21|
| 13 | Ilyinovskoe    | 21                                   | 8    | 0.38                                   | 17   | 1    | 0.06|
| 14 | Crupnoscoroeye | 10                                   | 0    | 0.0                                    | 19   | 2    | 0.11|
| 15 | Kinelsko 92    | 19                                   | 2    | 0.11                                   | 19   | 0    | 0.0 |
| 16 | Coloritnoye 64 | 14                                   | 4    | 0.29                                   | 14   | 0    | 0.0 |
| 17 | Kamyshinskoe 95| 16                                   | 0    | 0.0                                    | 17   | 2    | 0.12|
| 18 | Cvartet        | 16                                   | 3    | 0.19                                   | 14   | 4    | 0.29|
| 19 | Crestyanca     | 19                                   | 3    | 0.16                                   | 16   | 3    | 0.19|
| 20 | Orenburg 3     | 27                                   | 6    | 0.22                                   | 30   | 3    | 0.1 |
| 21 | Orenburg 9     | 97                                   | 5    | 0.05                                   | 99   | 8    | 0.09|
| 22 | Orenburg 14    | 12                                   | 0    | 0.0                                    | 14   | 2    | 0.14|
| 23 | Orenburg 20    | 51                                   | 28   | 0.55                                   | 47   | 24   | 0.51|
| 24 | Orenburg 42    | 34                                   | 1    | 0.03                                   | 33   | 8    | 0.24|
| 25 | Orenburg       | 33                                   | 0    | 0.0                                    | 22   | 2    | 0.09|
| 26 | Krasnoekomovoe | 29                                   | 3    | 0.1                                    | 26   | 0    | 0.0 |
| 27 | Spultic        | 16                                   | 0    | 0.0                                    | 15   | 0    | 0.0 |
| 28 | Slavyanskoe    | 14                                   | 0    | 0.0                                    | 13   | 5    | 0.38|
| 29 | Saratovskoe 10 | 27                                   | 5    | 0.19                                   | 26   | 3    | 0.12|
| 30 | Saratovskoe 8  | 32                                   | 2    | 0.06                                   | 29   | 3    | 0.1 |
| 31 | Saratovskoe 6  | 16                                   | 1    | 0.06                                   | 13   | 3    | 0.23|
| 32 | Saratovskoe 3  | 11                                   | 0    | 0.0                                    | 17   | 10   | 0.59|
| 33 | Stabilnoye     | 13                                   | 0    | 0.0                                    | 13   | 0    | 0.0 |
| 34 | Kharkovscoye 56| 13                                   | 0    | 0.0                                    | 15   | 0    | 0.0 |
| 35 | Chernomorskoye | 13                                   | 0    | 0.0                                    | 13   | 0    | 0.0 |
| 36 | Yarkoe 3       | 15                                   | 6    | 0.4                                    | 16   | 0    | 0.0 |
|    | TOTAL          | 774                                  | 121  | 742                                    | 110  |

<sup>a</sup> CT – competitive testing
Over a 25-year period, 36 varieties were involved in hybridization. The recombination potential (CRP) differed depending on the variety and varied in direct crosses from 0.03 to 0.82, in reverse crosses from 0.06 to 0.6. High CRP in direct crosses was noted in varieties Volgogradskoe 4 – 0.82, Zaryana – 0.6, average in varieties Yarkoye 3 – 0.4, Ilyinovskoe – 0.38, Dobroye – 0.38, Dolinskoe 111 – 0.38. Out of 36 varieties, 16 of them had zero. In the reverse crosses, the following varieties had a high coefficient of recombination potential: Baganovskoe 88 – 0.6, Saratovskoe 3 – 0.59, and the average: Slavyanskoе – 0.38. Out of 35 varieties, 12 in the reverse crosses had a zero CRP. It should be noted that the use of the same variety for different types of crosses gives a different value of the coefficient of recombination ability. Thus, the millet variety Volgogradskoe 4, having a high CRP in direct crosses, did not have a high recombination potential in reverse crosses, and Barnaul 80, with a very high CRP in reverse crosses, did not give promising offspring when used as a maternal line. The Orenburg 20 variety had a high recombination ability, and this applies both to direct (CRP – 0.55) and reverse (CRP – 0.51) crosses.

4. Conclusion
Evaluation of the prospects of the basic material for the release of breeding numbers in the competitive test, can be an additional tool in the selection of parent forms for hybridization by type of crossing. Based on the results obtained, it was revealed that the varieties exhibit different recombination ability depending on the type of crossing (direct or reverse).
To increase the efficiency of the breeding process in obtaining new hybrids, it is necessary to attract varieties with a high and medium level of CRP. Varieties Volgogradskoe 4, Zarya, Yarkoye 3, Ilinovskoe, Dobroye, Dolinskoe 111 should be used as the mother form, and varieties Baganovskoe 88, Saratovskoe 3, Slavyanskoе as the father form. Orenburg 20 as a basic material, is a universal variety. It can be used as a parent form for both direct and reverse crosses.

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