

# Selection of the source material for the creation of black currant varieties with complex resistance to diseases and pests

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**Abstract.** The requirements of new intensive technologies for newly created varieties of berry crops are increasing every year. Therefore, there is a need to involve new donors and sources of economically valuable traits in the breeding process. The successful implementation of the breeding program is largely determined by the correct selection of parental forms, and for the successful solution of this task, constant screening of both newly created material and existing material is necessary. Over the years of research, work has been done to obtain, study and isolate the most promising genotypes of black currant for use in breeding for resistance to biotic factors. The article presents the results of the evaluation of potential black currant donors of the VNIISPK selection. As a result of the study, donors were identified not only with complex resistance to biotic factors, but also donors with high productivity.

## 1 Introduction

Changes in soil and climatic conditions, deterioration of environmental ecology, improvement of production technologies contribute to changing and increasing the evaluation criteria for the created agricultural crop varieties.

The main role in plant breeding is assigned to the selection of original genotypes, which must have certain qualities and meet modern requirements. Based on the task that the breeder faces, certain parent forms are selected.

The leading role is given to donors and sources, and both wild species and currently created forms of black currant can be used as them. It should be remembered that the use of wild ancestors does not always have a positive effect, since seedlings are often given unnecessary traits.

In the breeding practice of black currant, a limited number of varieties are used, of which the European subspecies (*Ribes nigrum ssp. europaeum* Yancz) and the Siberian subspecies (*Ribes nigrum ssp. sibiricum* Wolf.) of black currant, dikuscha currant (*Ribes dikuscha* Fisch. ex Turcz.), few-flowered currant (*Ribes pauciflorum* Turcz. ex Pojark), wild black currant (*Ribes americanum* Mill.) and nutmeg currant (*Ribes glutinosum* Benth) [1, 2, 3].

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In this way, for example, the seedlings obtained from *Ribes glutinosum* derivatives at the initial stage had small berries and were not adapted to the conditions of the Orel region [4]. Consistent implementation of saturating crosses with various donors of valuable traits and strict selection at all stages of the breeding process allowed to identify a number of genotypes adapted to the region conditions and then varieties on their basis (Arapka, Blagoslovenie, Gamma, Kipiana, Nadya, Narianna) that had a complex resistance to biotic factors [4; 5; 6].

The search for new donors of resistance to the most dangerous diseases and pests is of great importance for black currant breeding.

## 2 Materials and methods

As experimental material, selected forms of black currant obtained in VNIISPK from targeted crosses were studied. During the growing season, at different stages of plant development, they determined the berry weight, yield, and degree of damage by main pests and diseases. To determine all the indicators, we were guided by the method of selection and variety study of fruit, berry and nut crops [7, 8].

In the field, the degree of disease damage was assessed on a five-point scale.

American powdery mildew:

0 - no damage;

1 - very weak: single leaves are affected, up to 1% of berries;

2 - weak: up to ¼ of shoot length are affected, up to 25% of leaves, 1-3% of berries;

3 - medium: from ¼ to ⅓ of shoot length are affected, 26-50% of leaves, 4-10% of berries;

4 - severe: from ⅓ to ½ of shoot length are affected, 51-70% of leaves, 11-20% of berries;

5 - very strong: more than ½ of shoot length are affected, more than 70% of leaves, more than 20% of berries.

Anthraxnose and Septoria spot:

These diseases develop simultaneously and have similar symptoms.

0 - no damage;

1 - very weak damage of single leaves;

2 - weak: up to 10% of leaves are affected;

3 - medium: up to 30% of leaves are affected;

4 - severe: up to 50% of leaves are affected;

5 - very strong: more than 50% of leaves are affected.

The degree of studied forms resistance to columnar rust was taken into account visually according to the same scale as for anthracnose.

The assessment of resistance to the currant gall mite was carried out in the spring before budding. The damage degree was determined visually by plots in scores:

0 – no signs of damage;

1 - very weak damage to single buds;

2 - weak damage: up to 10% of buds are infected with mite;

3 - moderate: up to 30% of buds are affected;

4 - severe: from 30 to 50% of buds are affected;

5 - very strong: more than 50% of buds are affected.

To study the inheritance of resistance to powdery mildew, initially in a hybrid nursery, artificial infection of seedlings with powdery mildew conidiospores was carried out by shaking-off the spores on the wet surface of the leaves during the active growth of seedlings at the age of 6 – 8 true leaves. After artificial infection, a 2-fold screening was carried out. All affected seedlings were subject to rejection, regardless of the degree of disease development. Resistant seedlings were once again evaluated for resistance in the field at the breeding plot in the first and second year of the growing season. The identified seedlings susceptible to powdery mildew were also subject to rejection.

The correspondence of the expected and actual cleavage was evaluated according to the Pearson criterion.

### 3 Results and discussions

An important direction in the breeding work on black currant in the VNIISPK is the creation and identification of the necessary donors and sources. The following issues and tasks are solved:

- analysis and involvement of currently known donors in breeding process;
- identification of necessary donors among wild species and their derivatives;
- creating donors with necessary traits;
- creation of donors with resistance to 2 or more pathogens;

In recent years, more than 500 forms of black currant of the VNIISPK breeding have been studied as potential donors and sources.

Based on the fact that in the conditions of the Orel region the most harmful disease is *Sphaerotheca mors-uvae*, *Cronartium ribicola*, *Pseudopeziza ribis* Kleb, *Septoria ribis*, and the most dangerous pest – *Cecidophyopsis ribis* (Fig. 1,2,3), the main goal in the selection of potential donors and sources are genotypes that combine resistance to these pathogens. Therefore, at the initial stages of the breeding process, in addition to the strict selection of donors of resistance to certain diseases and currant gall mite, a number of crossbreeding combinations were also performed and genotypes combining these traits were selected.



**Fig. 1.** Black currant leaf affected by American mildew.



**Fig. 2.** Black currant leaf affected by columnar rust.



**Fig. 3.** Black currant plant affected by currant gall mite.

A significant contribution to black currant breeding for the creation of disease- and pest-tolerant genotypes was made by the involvement of descendants of nutmeg currant as parental forms in the breeding process, which exhibit group resistance to American mildew (*Sph<sub>3</sub>* gene), columnar rust (*Pe* gene) and currant gall mite (*Ce* gene) [9]. Since the derivatives of glutinous currant taken in the breeding process were small-fruited and low-yielding, high-yielding, large-fruited samples were used as reciprocal parent forms, which after 2-3 generations allowed to select genotypes resistant to diseases and pests with a high level of economic traits.

Another effective donor of resistance to *Sphaerotheca mors-uvae* is *Ribes scandinavicum* derivatives. Among the studied samples, Sunderbyn II variety (*R* gene) showed the highest resistance to the disease and the ability to transmit this trait to offspring. But at the same time, the Sunderbyn II variety and in many cases its derivatives had a restrained growth, and were also affected by columnar rust and currant gall mite. This circumstance made it necessary to select the parent forms, when crossing with which samples with the required characteristics were cleaved.

Since the derivatives of nutmeg currant had a high level of tolerance to *Cronartium ribicola* and *Cecidophyopsis ribis*, they were quite intensively involved in the breeding process with the Sunderbyn II variety. In addition to the fact that plants with the necessary properties were selected in such crossing combinations, it is very important that some seedlings combined the *Sph<sub>3</sub>* and *R* genes in one genotype. This, we assume, will allow the created varieties to remain immune to powdery mildew for a longer time. Since there were no phenotypic traits that allow visually to select plants that combine the *Sph<sub>3</sub>* and *R* genes, a number of analytical crosses were performed with varieties susceptible to powdery mildew. Genotypes combining the *Sph<sub>3</sub>* and *R* genes were selected based on hybrid offspring cleavage.

To date, more than two thousand crossbreeding combinations have been carried out in breeding studies to create varieties with group resistance to diseases and pests using derivatives of Sunderbyn II nutmeg currant.

Table 2 shows the most promising donors and sources, selected according to a set of traits that were multiplied and studied in detail at the primary variety study plot. As it can be seen, the selected forms combine not only resistance to American mildew at a high level, but also to columnar rust and currant gall mite.

It should also be noted that the potential donors listed in the table are more or less affected by leaf spots (anthracnose, Septoria blight). This is primarily due to the fact that no effective donors of oligogenic resistance to these diseases have been found, and the donors of polygenic resistance used do not give the expected effect.

**Table 1.** Evaluation of the most promising potential complex donors of black currant of the VNIISPK breeding.

Form	Average yield, c/ha	Berry weight, g	American mildew, score	Columnar rust, score	Leaf spots, score	Currant gall mite, score
1	2	3	4	5	6	7
<i>R</i> gene						
3226-47-44	75.0	1.2	0	0	2.0	0
2083-32-158	30.0	0.7	0	0	2.5	0
3031-13-218	70.2	1.0	0	0	1.0	0
3808-54-108	50.7	1.1	0	0	2.0	0
3803-46-60	42.0	0.9	0	0	2.0	0
3550-16-87	44.0	1.2	0	0	1.0	0
3803-45-152	40.2	0.9	0	0	1.0	0
3807-47-146	60.6	1.0	0	0	2.5	0
3825-45-172	105.0	1.0	0	0	1.0	0
4361-7-46	45.0	0.9	0	0	1.0	0
1	2	3	4	5	6	7
<i>Sph<sub>3</sub></i> gene						
3216-41-203	120.0	1.5	0	0	2.0	0
3320-51-210	98.0	1.2	0	0	2.0	0
3187-4-176	80.1	1.1	0	0	2.5	0
3569-15-6	56.0	1.2	0	0	2.0	0
3184-41-124	42.0	0.8	0	0	3.5	0
3212-16-46	42.0	0.9	0	0	1.5	0
3223-41-173	102.0	0.8	0	0	1.5	0
3206-41-4	42.0	0.9	0	0	1.5	0
3190-44-144	45.5	1.0	0	0	1.5	0
Kipiana	76.6	1.1	0	0	2.0	0
1448-14-20	57.0	1.1	0	0	2.0	0
3353-48-118	77.0	0.9	0	0	2.5	0
3353-48-152	42.0	1.0	0	0	2.0	0
4407-8-77	42.0	1.0	0	0	1.5	0
4407-8-84	40.0	1.0	0	0	2.5	0
4413-6-42	42.0	0.9	0	0	1.5	0
<i>Sph<sub>3</sub></i> + <i>R</i> gene						
3007-3-107	21.0	0.8	0	0	1.0	0
3007-3-167	68.8	0.9	0	0	2.0	0
3586-14-117	63.8	1.2	0	0	1.0	0
4042-57-20	80.5	0.9	0	0	2.5	0
4379-7-3	61.2	0.8	0	0	2.0	0
3325-51-147	89.2	1.0	0	0	1.0	0
3007-2-75	36.0	0.8	0	0	2.0	0
3007-9-127	57.7	0.9	0	0	2.0	0
3008-54-96	54.0	0.9	0	0	2.0	0
3049-17-46	50.1	1.0	0	0	2.5	0
3325-51-77	63.0	1.0	0	0	2.0	0
3518-12-72	70.0	1.0	0	0	1.5	0
3360-50-111	42.0	0.8	0	0	2.5	0
4007-8-91	40.0	0.9	0	0	2.0	0
4372-7-50	52.0	1.0	0	0	3.0	0
4372-7-52	42.0	0.9	0	0	1.0	0
1	2	3	4	5	6	7
4373-7-2	54.0	0.9	0	0	2.0	0
4414-6-124	60.6	1.0	0	0	1.5	0

of different genetic origins						
2032-36-176	30.0	1.0	0	0	1.5	0
2039-29-131	30.0	0.8	0	0	3.5	0
3172-43-159	49.0	0.9	0	0	2.5	0
3187-4-76	49.0	0.9	0	0	2.5	0
3586-16-111	63.0	1.3	0	0	3.0	0

Donors with a yield of more than 50 c/ha - 3007-9-127, 3049-17-46, 3353-48-118, 3518-12-72, 3586-16-111 are of particular interest. It is also worth noting the form 2839-9-122, which, in addition to resistance to American mildew, columnar rust and currant gall mite, is practically not affected by leaf spots – 0.5 score.

Donors are characterized by a fairly high yield, in most forms it is more than 50 c/ha. The maximum yield for three years was obtained from the form 3216-41-203, on average it was 120.0 c/ha, and from the form 3320-51-210 - an average yield is 98.0 c/ha. The minimum yield value was observed in the forms 3190-44-72, 3803-46-60 - 42.0 c/ha, and 3339-49-216 - 43.0 c/ha.

High average weight of berries was observed in forms 3216-41-203 – 1.5 g and 3172-43-124 – 1.4 g. In other forms, the weight of the berry ranged from 0.8 g to 1.2 g.

A number of analyzing crosses were performed with some forms, and as the analysis of hybrid offspring shows, they transmit the necessary traits quite well by inheritance, which will allow many of them to be recommended as donors in the future.

**Table 2.** The cleavage of the resistance to American mildew in hybrid offspring.

Crossing combination	Number of seedlings, pcs.			Expected cleavage	$\chi^2$
	total	resistant	susceptible		
1	2	3	4	5	6
Gamma × 2083-32-158	120	85	35	3:1	1.1
Kipiana × 3793-54-75	87	50	37	1:1	1.94
3007-3-107×Exotica	92	50	42	1:1	0.68
3190-44-144 × Yadrenaya	56	32	24	1:1	1.14
3353-48-118 × Yadrenaya	84	50	34	1:1	3.04
3550-16-87 × Lentiay	130	70	60	1:1	0.66
4372-7-52 × 4372-7-52	72	60	12	3:1	2.66
3031-13-218 × Exotica	64	38	26	1:1	1.12
3353-48-118 × 3353- 48-118	98	72	26	3:1	0.12
1448-14-20 × Lentiay	115	60	55	1:1	0.10

$\chi^2$  – Pearson criterion.

Many isolated donors, such as 4042-57-20, 3353-48-118, 3353-48-152, 2083-32-158, 3808-54-108, 3803-46-60 with group resistance, they are widely used in the breeding process when creating varieties with a high level of adaptation to biotic factors.

**Table 3.** Effectiveness of using *Sph3* and *R* gene donors (2008-2020)

Donors	Crossing combinations performed	Number of studied seedlings, pcs.	Isolated, pcs.			
			selected forms	donors and sources	elite seedlings	varieties
<i>Ribes glutinosum</i> - <i>Sph<sub>3</sub></i> derivatives	70	2100	25	15	30	3
( <i>Sunderbyn II</i> ) - <i>R</i> derivatives	31	942	12	9	15	3
combining <i>Sph<sub>3</sub></i> and <i>R</i> genes	20	484	10	5	8	4

## 4 Conclusion

1. According to the complex of economically important traits, resistance to biotic factors, more than 500 forms of black currant were evaluated as potential donors of high group resistance.

2. Complex donors of resistance to American mildew, columnar rust and currant gall mite with a potential yield of more than 50 c/ha were identified in the hybrid offspring obtained from derivatives of nutmeg currant (*Sph<sub>3</sub>* gene) and *Sunderbyn II* variety derivatives (*R* gene).

3. Isolated donors, such as 4042-57-20, 3353-48-118, 3353-48-152, 2083-32-158, 3808-54-108, 3803-46-60 with complex resistance, are widely used in the breeding process when creating varieties with a high level of adaptation to biotic factors.

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