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Ribes sanguineum Pursh. as donor of leaf fungal disease resistance in blackcurrant breeding

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Breeding of blackcurrants resistant to leaf fungal diseases there was carried out by intersectional crossing. *R. nigrum* (*Eucoreosma*) cultivars were crossed with *R. sanguineum* (*Calobotria*). In the interspecific crossing combinations within blackcurrant cultivars and clones, the berry set fluctuated from 14.3 to 62.7%. Cultivars that were linked to apomixes started more germs, but during the first weeks more of them fell down. In all the combinations of interspecific crossings there was a small amount (3.8–8.2) of seeds in berry. Among the interspecific hybrids, the amount of plants resistant to powdery mildew (*Sphaerotheca mors-uvae*), Septoria leaf spot (*Mycosphaerella ribis*) and anthracnose (*Pseudopeziza ribis*) increased significantly. Interspecific *R. nigrum* × *R. sanguineum* F_1–F_2 hybrids most often distinguished themselves by a larger number of berries per cluster in comparison with blackcurrants. Berries were of medium size equal to that in blackcurrant cultivars of standard assortment. Berries of the interspecific hybrids had less seeds. There was no dependence between seed number and berry size.

Key words: *R. nigrum*, *R. sanguineum*, interspecific hybridization, fungal diseases

INTRODUCTION

Valuable cultivars of all species of crop plants are the most important carriers of biological and technological progress of fruit production. New cultivars with improved traits will better serve the needs of processing industry and consumers and reduce the cost of fruit production. All blackcurrant cultivars are sensitive to anthracnose [1–3]. Distant hybridization between different species provides qualitatively new information for currant breeding [4–7]. As Keep [8] has reported, *R. sanguineum* may be a source of resistance to anthracnose.

The aim of this work was to create interspecific hybrids between blackcurrant cultivars and wild species *R. sanguineum* Pursh., also to evaluate resistance to fungal leaf diseases and quality of berries in the interspecific hybrids.

MATERIALS AND METHODS

The work was performed at the Department of Orchard Plant Genetic and Biotechnology in Lithuanian Institute of Horticulture in 2000–2006. The following cultivars were used for crossing: 'Klusonovskaja' (Belarus), 'Laimiai' (Lithuania), 'Ben Tirran' and 'Ben Lomond' (Scotland), also clones No. 79-197-0 (Lithuania), PC–73 (Poland), the interspecific hybrid *R. americanum* × *R. nigrum* No. 47 (Lithuania) with the wild species *R. sanguineum* Pursh. (Rn 1549) of the section *Calobotrya* of the genus. As the maternal crossing component we selected blackcurrants which distinguished themselves by a larger amount of seeds and a shorter trunk of the pistil. For crossing combinations, 32–210 flowers of the *R. nigrum* mother plant were emasculated. The collected seeds were stratified and then seeded in a greenhouse. Two-year old F_1 hybrids from the greenhouse were planted in a breeding plot at a distance of 3 × 1 m and grown without using a fungicide. F_2 hybrids were obtained from F_1 plants selected according to resistance to fungal leaf diseases and berry mass after open pollination. The extent of leaf damage caused by fungal diseases was evaluated on a 0–5 scale, 0 denoting undamaged leaves and 5 denoting 100% of leaf surface. Symptoms of powdery mildew (*Sphaerotheca mors-uvae*), Septoria leaf spot (*Mycosphaerella ribis*) and anthracnose (*Pseudopeziza ribis*) was evaluated in a natural infected background in the field. Berry size was tested during the first and the second cropping seasons.

Data were analysed by analysis of variance (ANOVA) and grouped by the Duncan test. Standard errors were calculated.

RESULTS

On average 69.2% flowers of hybrids (*R. nigrum* × *R. nigrum*) yielded berries and there were about 40.8 well-developed seeds in each berry (Table 1). In the interspecific crossing combinations, depending on the employed blackcurrant cultivars and clones, the berry set fluctuated from 14.3 to 62.7%. In the

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crossing combinations *R. nigrum* × *R. nigrum*, all the germs produced berries, while in the interspecific crossings the number of berries was less than the registered number of germs two weeks after pollination, but the difference was significant only in two combinations from six. This shows that in genetically different maternal plants not the same output of germs is obtained. The further development of germ up to berry ripening depends on a crossing combination. Cultivars prone to apomixes started more germs, but in the first weeks more of them fell down.

In all the berries of interspecific crossing combinations there was a small amount of seeds. The number of seeds in a berry fluctuated from 3.8 to 8.2. In the crossing combinations *R. americanum* × *R. nigrum* No. 47 of the section *Eucoreosma*, the berry set was equal to that in crossing combinations of *R. nigrum* × *R. sanguineum*. The number of hybrid seeds in a berry in this combination didn't differ from that in other hybrids obtained in the other combinations of *R. nigrum* × *R. sanguineum* crossings.

Seed germination (Fig. 1) in the interspecific hybrids was two and more times less than in the intercultivar blackcurrant hybrids.

Fungal diseases differently damaged interspecific hybrids (Table 2). Among the blackcurrant intercultivar hybrids there

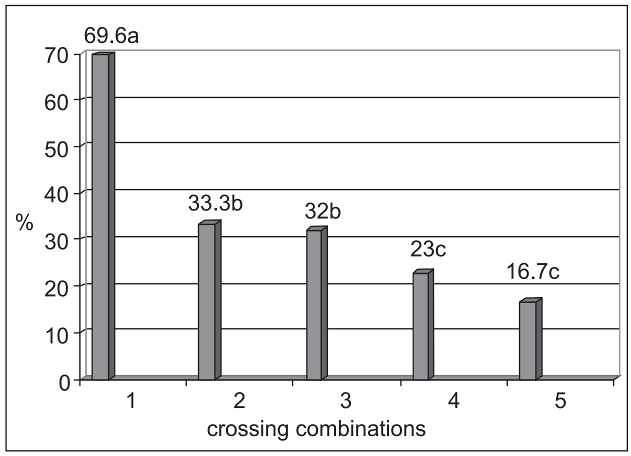

Figure. Seed germination of interspecific F_0 hybrids (*R. nigrum* × *R. sanguineum*).
1 – *R. nigrum* × *R. nigrum*; 2 – *R. nigrum* (No 79-197-0) × *R. sanguineum*;
3 – *R. nigrum* 'Laimiai' × *R. sanguineum*; 4 – *R. nigrum* 'Ben Tirran' × *R. sanguineum*;
5 – *R. nigrum* 'Ben Lomond' × *R. sanguineum*.
Means marked with the same letter do not differ significantly (1% LSD).

Table 1. **Results of *Ribes nigrum* interspecific crossings with *Ribes sanguineum* (2000–2002)**

Crossing combination	Number of flowers	Obtained germ %	Berry set, %	Number of seeds in a berry **
R. nigrum × *R. nigrum**	210	69.2 ± 0.8	69.2 ± 0.8	40.8a
R. nigrum (No. 79-197-0) × *R. sanguineum*	90	42.3 ± 6.9	41.3 ± 7.0	3.8c
R. nigrum 'Klusonovskaja' × *R. sanguineum*	100	32.7 ± 3.8	12.7 ± 1.2	5.5bc
R. nigrum 'Laimiai' × *R. sanguineum*	106	65.7 ± 5.8	62.7 ± 4.7	8.2b
R. nigrum 'Ben Tirran' × *R. sanguineum*	130	61.6 ± 3.5	24.3 ± 1.2	6.0bc
R. nigrum (PC–73) × *R. sanguineum*	94	15.3 ± 3.0	14.3 ± 3.8	5.2bc
R. nigrum 'Ben Lomond' × *R. sanguineum*	86	75.8 ± 3.8	49.7 ± 6.9	4.4c
(*R. americanum* × *R. nigrum* No. 47) × *R. sanguineum*	32	–	18.8. ± 2.00	5.5bc

* Pulled data of four crossing combinations.
** Means marked by the same letter do not differ significantly (1% LSD).

Table 2. **Resistance of interspecific hybrids *R. nigrum* × *R. sanguineum* (F1–F2) to fungal leaf diseases (2005–2006, rating based on 0–5 scale)**

Pedigry	No. of plants	Powdery mildew		Septoria leaf spot		Anthracnose	
		Average damage (points)	Uninfected plants (%)**	Average damage (points)	Uninfected plants (%)**	Average damage (points)	Uninfected plants (%)**
R. nigrum × *R. nigrum* F1*	348	1.8 ± 0.9	20.1e	3.0 ± 0.2	0.0g	2.9 ± 0.7	0e
R. sanguineum × *R.sanguineum* F1	22	0	100a	0	100a	0	100a
R. nigrum (No. 79-197-0) × *R. sanguineum* F1	16	0.2 ± 0.0	90b	1.6 ± 0.3	0g	0.8 ± 0.0	50d
R. nigrum 'Laimiai' × *R. sanguineum* F1	13	0	100a	0.5 ± 0.2	54e	0.7 ± 0.2	60c
R. nigrum 'Ben Tirran' × *R. sanguineum* F1	11	0	100a	0.6 ± 0.1	71d	0.5 ± 0.0	86b
R. nigrum 'Ben Lomond' × *R. sanguineum* F1	5	1.1 ± 0.3	42d	1.0 ± 0.1	42f	0.3 ± 0.1	63c
(*R. americanum* × *R. nigrum* Nr. 47) × *R. sanguineum* F1	22	0.3 ± 0.0	73c	0.3 ± 0.1	82c	0	100a
R. nigrum (No. 79-197-0) × *R. sanguineum* F2	12	0	100a	0.1 ± 0.0	93b	0	100a
R. nigrum 'Ben Tirran' × *R. sanguineum* F2	26	0.6 ± 0.0	78c	1.2 ± 0.2	52e	2.0 ± 0.3	0e

* Pulled data of four crossing combinations.
** Means marked by the same letter do not differ significantly (1% LSD).

Table 3. **Performance of selected interspecific hybrids *R. nigrum* × *R. sanguineum* (F1–F2) regarding berry traits (2005–2006)**

Pedigry	Number of berries in a cluster	Average mass of berry (g)	Average number of seeds in a berry
R. nigrum x *R. nigrum**	5.9 ± 1.0	1.4 ± 0.1	40.8 ± 7.8
R. nigrum (No. 93-197-0) × *R. sanguineum* No. 3 F1	7.0 ± 0.6	1.1 ± 0.1	27.7 ± 3.2
R. nigrum (No. 93-197-0) × *R. sanguineum* No. 11 F1	7.0 ± 0.6	0.8 ± 0.0	21.7 ± 2.4
R. nigrum (No. 93-197-0) × *R. sanguineum* No. 16 F1	5.8 ± 0.5	0.9 ± 0.1	32.5 ± 3.8
R. nigrum 'Ben Tirran' × *R. sanguineum* Nr. 21 F1	7.5 ± 0.3	0.7 ± 0.0	–
R. nigrum 'Ben Tirran' × *R. sanguineum* No. 22 F1	8.0 ± 0.6	0.7 ± 0.0	27.67 ± 0.9
R. nigrum (No. 93-197-0) × *R. sanguineum* No. 12a F2	7.2 ± 0.5	0.9 ± 0.0	14.50 ± 2.2
R. nigrum (No. 93-197-0) × *R. sanguineum* No. 3a F2	6.7 ± 1.2	1.1 ± 0.2	21.37 ± 5.6
R. nigrum 'Ben Tirran' × *R. sanguineum* No. 21a F2	8.5 ± 1.1	0.5 ± 0.1	17.00 ± 4.2
R. nigrum 'Ben Tirran' × *R. sanguineum* No. 22a F2	9.0 ± 0.9	0.6 ± 0.0	24.65 ± 3.2

* Pulled data of four crossing combinations.

were 20% of plants resistant by powdery mildew, but no plants resistant to Septoria leaf spot and anthracnose were found. All the plants of the species *R. sanguineum* were resistant to the leaf fungal diseases under study. Among the interspecific hybrids, the amount of plants resistant to powdery mildew increased significantly. Among the crossing combinations there were 42 to 100% of such plants. In two crossing combinations F_1 from five, all the plants were healthy. They passed this trait to F_2. In all the hybrid families there were plants both injured and not injured by Septoria leaf spot, with the exception of the crossing combination *R. nigrum* (No. 79-197-0) × *R. sanguineum* F_1, in which all the plants were sensitive to Septoria leaf spot. In other families, 42–82% of F_1 plants were resistant to this fungal disease. A similar ratio of healthy and injured plants remained also in F_2. Among the interspecific hybrids, the number of plants resistant to anthracnose took an intermediate position between *R. nigrum*, in which all the plants were injured, and *R. sanguineum* in which all the plants were resistant. In most crossing combinations, the number of not injured plants was more similar to that in the resistant *R. sanguineum*. All the interspecific hybrids (*R. americanum* × *R. nigrum* No. 47) × *R. sanguineum* with *R. americanum* cytoplasm were not injured by anthracnose. The resistance of F_2 plants of two hybrid families to anthracnose was diametrically different: in one family all the plants were injured and in the other all were resistant. This shows a complicated inheritance of the trait.

Interspecific *R. nigrum* × *R. sanguineum* F_1–F_2 hybrids most often produced a larger number of berries in a cluster in comparison with blackcurrant (Table 3). Berries were smaller than in the intercultivar blackcurrant hybrids, but of sufficient size and equal to these of the blackcurrant cultivars of standard assortment. Berries of the interspecific hybrids had less seeds. No dependence between seed number and berry size was found.

DISCUSSION

When the program of currant interspecific crossings was started, blackcurrants were crossed with the related *R. petraeum* and *R. uva-crispa* cultivars [9] and wild species of the *Eucoreosma* section [10, 11]. Most hybrids obtained in these crossing combinations showed resistance to powdery mildew, single plants showed themselves with resistance to Septoria leaf spot, and no plants fully resistant to anthracnose were obtained. This shows that the species used in hybridization have no donors suitable to induce resistance to anthracnose. Keep with coauthors [12] presented the idea that in order to preserve the resistance to diseases and predators in one individual, it would be useful to combine the resistance genes of different nature from phylogenetically more remote species. This idea has been confirmed by the results of the investigation of plant resistance to diseases, when after crossing the interspecific hybrid *R. americanum* × *R. nigrum* No. 47 of the section *Eucoreosma* with *R. sanguineum* all the progeny of F_1 were resistant to anthracnose.

The final resistance of the developed hybrids depends on the compatibility among the crossing components. Blackcurrant cultivars we used are very different and of various genetic nature. This may explain resistance differences among the hybrids of various families. The results of interspecific hybridization show that *R. nigrum* and *R. sanguineum* phylogenetically are rather related species. They cross relatively easily, and as soon as in F_2 it is possible to distinguish seedlings not only resistant to diseases, but also producing quality berries. This shows that *R. sanguineum* is a good donor of resistance to diseases.

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RIBES SANGUINEUM PURSH – ATSPARUMO LAPŲ LIGOMS DONORAS JUODĮJŲ SEERBENTŲ SELEKCIJOJE

Santrauka

Vykdant grybinėms lapų ligoms atsparių juodųjų serbentų selekciją atlikti tarpsekcijiniai kryžminimai: *R. nigrum* (*Eucoreosma*) veislės sukryžmintos su *R. sanguineum* (*Calobotria*). Priklausomai nuo panaudotų juodųjų serbentų veislių ir klonų tarprūšinėse kryžminimo kombinacijose uogų mezgimas svyravo tarp 14,3–62,7%. Pastebėta, kad į apomiksę linkusios veislės užmezga daugiau užuomazgų, bet per pirmąsias savaites didesnė dalis jų nubyra. Visose tarprūšinių kryžminimų kombinacijose gautas mažas (3,8–8,2) sėklų kiekis uogoje. Tarprūšinių hibridų šeimose ženkliai padidėjo miltligei (*Sphaerotheca mors-uvae*), šviesmarge (*Mycosphaerella ribis*) ir deguliams (*Pseudopeziza ribis*) atsparių augalų kiekis. Tarprūšiniai *R. nigrum* × *R. sanguineum* F_1–F_2 hibridai dažniausiai turėjo daugiau uogų kekėje nei juodieji serbentai. Uogos buvo pakankamo dydžio ir prilygo standartinio asortimento juodųjų serbentų veislėms. Tarprūšinių hibridų uogos buvo mažiau sėklingos, priklausomybė tarp sėklų skaičiaus ir uogos dydžio neišryškėjo.

Raktažodžiai: *R. nigrum*, *R. sanguineum*, tarprūšiniai hibridai, grybinės ligos