Genetic Control and Combining Ability of Resistance to American Mildew, Septoria Leaf Spot and Gall Mite in Black Currant

T. ŠIKŠNIANAS

Lithuanian Institute of Horticulture, LT-4335 Babtai, Kaunas District, Lithuania

E-mail: bronius@lsdi.lt

Abstract

The character of gene interaction determining resistance to fungal diseases and gall mite was investigated by topcrossing method in black currant cultivars and forms of different genetic nature. For crossings three maternal varieties (testers) and seven paternal varieties and forms of different resistance to American mildew, Septoria leaf spot and gall mite were employed. Eleven cultivars and forms were assessed that differed in combining ability of resistance to fungal diseases and gall mite. Resistance to American mildew (*Sphaerotheca mors-uvae*) and Septoria leaf spot (*Mycosphaerella ribis*) is determined by genes with additive effects. In genetic control for resistance to gall mite (*Cecidophyopsis ribis*) important are both genes – with additive and non-additive (dominant and epistatic) effects. Black currant form D16/1/-25 was ascertained to be a donor of resistance to American mildew and Septoria leaf spot and cultivar Ben Gairn – a donor of resistance to gall mite.

Keywords: black currant; combining ability; genetic control; *Sphaerotheca mors-uvae*; *Mycosphaerella ribis; Cecidophyopsis ribis*

INTRODUCTION

In big commercial currant plantations favorable conditions are created for spreading of fungal diseases and gall mite. Earlier developed varieties lost resistance to newly formed mildew strains (OGOLCOVA 1992). The most black currant cultivars from West Europe are very sensitive to gall mite. It damages buds that cause decrease of productive shoots and racemes, besides, it transferes the most harmful disease – reversion (TRAJKOVSKI & ANDERSON 1992; BRENNAN *et al*. 1993; MISEVICIUTE 1995). The efficient way to reduce harm incurred by diseases is development of resistant varieties. When for creation of new varieties crossing components are selected according to phenotype, usually, desirable results are not obtained (ZURAWICZ *et al*. 1996). In this case breeding value of varieties utilized in crossings could be successfully established by assessing their combining ability and genetic control of traits (PLUTA *et al*. 1993). If genetic control of individual traits and their combination and heritability regularities are known it is possible to select crossing components deliberately, prognose parameters of future varieties and at the same time felicitate the breeding work and speed up variety development.

The aim of the work was to assess the combining ability of black currant varieties of different genetic character, to establish genetic control resistance to fungal diseases, gall mite and productivity, inheritance regularities and identify donors.

MATERIAL AND METHODS

The investigation was carried out in the Horticultural Plant Breeding Department of the Lithuanian Institute of Horticulture in 1998–2000. Trial currant plantation was established in the spring of 1995 with one-year-old plants. The soil was sod gleyic, mechanical composition – medium loam on loam, reaction – close to neutral. In the years of investigation meteorological conditions were close to average multiannual records and averagely favorable for currant. Most favorable conditions for fungal diseases were in the vegetation period of 2000. For top crossings three maternal varieties (testers) and seven paternal varieties and forms of different genetic character and different resistance to American mildew, Septoria leaf spot, gall mite were employed (Table 2). Interspecific hybrids were obtained in 21 crossing combinations. Forty hybrids from each combination were investigated planted at 3 × 1 m distances in a randomized block system in four replications. Hybrids were investigated for resistance to gall mite in the artificially infected background, in the field. The artificial infection was create by putting strongly infected shoots near every bush (RAVKIN 1987). The currant plantation was established and operations conducted according to intensive orchard and berry plantation management technologies (KVIKLYS 1986), but chemical plant protection means were not applied. Plant infestation by fungal diseases and gall mite was estimated according to a scale of 6 points (0 – uninfected plants, 5 – infected over 75% leaves or buds). Differences between varieties and forms applied in crossings were evaluated by variance analysis method (DOSPEHOV 1985). For assessment of black currant combining ability and establishment of trait genetic control and heritability Masiukova's methodology was employed (MASIUKOVA 1979).

RESULTS

After variance analysis of combining ability (Table 1) significant differences ($P < 0.01$) of general combining ability were revealed between all investigated varieties and forms according to resistance to mildew and leaf spot and resistance to gall mite – between female parent (testers) ($P < 0.05$). Resistance to mildew and leaf spot in the group of varieties employed in crosses was determined by genes with additive effects because means squares of GCA significantly – from 3.1 till 10.1 times – exceed means squares of SCA and the effect of SCA is not reliable.

After variance analysis of combining ability was established significant ($P < 0.01$) GCA differences within investigated varieties and forms. The ratio of GCA and SCA mean squares (from 3.7 to 5.9 times) demonstrates that berry yield is determined to a higher degree by genes with additive effects and dominant and epistatic genes impact on yield is significant as well.

Effects of general combining ability (Table 2) show that in breeding for improvement of American mildew resistance the most suitable form is 65-59-4. In breeding for Septoria leaf spot resistance the variety Minaj Shmiriov and forms 65-59-4 and D16/1/-25 are most valuable because GCA effects of these varieties are highest with negative sign. Variety Vakariai is not resistant to fungal diseases but transmits the gall mite resistance to their progenies. The highest values of BKG throughout the whole investigation period were found in varieties Minaj Shmiriov and Ben Gairn. These varieties firstly should be employed in crosses for development of more productive forms. The lowest GCA effect had form 65-59-4.

Comparison of GCA and SCA variances (Table 3) reveals that additive genes are more important for inheritance of American mildew and leaf spot resistance because GCA variances of all investigated varieties exceed SCA variances significantly. Resistance to gall mite, in most investigated varieties, is mainly determined by genes with additive effects therefore additive and nonadditive genes are very important for control the resistance to gall mite in black currant varieties Vakariai and Beloruskaya sladkaya. Comparison of variances of individual varieties shows that genes with additive effects control to a greater degree productivity of most varieties. Productivity of their progeny will be similar to paternal components. SCA variance of Inercontinental for yield, within investigated varieties, is higher than GCA variance and it shows that the role of dominant and epistatic genes in genetic control of productivity is sufficiently important and its progeny will be more or less productive than paternal forms.

Table 1. Combining ability of black currant resistance to fungal diseases, gall mite and yield

Trait	Mean squares			GCA/SCA	
	GCA, maternal varieties (testers)	GCA, paternal varieties	SCA	Maternal varieties	Peternal varieties
American mildew	2.09**	1.79**	0.30	6.97	5.97
Leaf spot	7.00**	2.17**	0.69	10.14	3.14
Gall mite	0.73*	0.24	0.28	2.61	0.86
Yield ∑ 1998–2000	2.30**	1.45**	0.39*	5.90	3.72

**$P < 0.01$, *$P < 0.05$

Table 2. GCA effects ($\hat{g}_i$) of black currant resistance to fungal diseases, gall mite and yield

Varieties	American mildew	Leaf spot	Gall mite	Yield ∑ 1998–2000
Maternal varieties (testers)				
Minaj Šmyriov	0.27	–0.28	0.14	0.16
Vakariai	0.01	0.58	–0.18	0.17
65-59-4	–0.28	–0.30	0.03	–0.33
LSD_{01}	0.235	0.270	0.181	1.30
Paternal varieties				
65-59-5	0.23	0.18	–0.07	–0.24
Beloruskaya sladkaya	0.58	–0.19	–0.16	–0.43
Storklas	–0.10	0.52	0.15	0.14
Polar	–0.13	0.54	0.16	–0.34
Intercontinental	0.01	0.11	–0.09	0.05
D16/1/-25	–0.68	–0.52	0.13	0.33
Ben Gairn	0.09	0.40	–0.12	0.48
LSD_{01}	0.407	0.467	0.313	0.225

Table 3. GCA and SCA variances of black currant for resistance to fungal diseases, gall mite and yield

Varieties	American mildew		Leaf spot		Gall mite		Yield ∑ 1998–2000	
	δ^2 gi	δ^2 si	δ^2 gi	δ^2 si	δ^2 gi	δ^2 si	δ^2 gi	δ^2 si
Maternal varieties (testers)								
Minaj Šmyriov	0.06	0.00	0.07	0.05	0.02	–0.02	0.02	–0.01
Vakariai	–0.01	0.00	0.32	0.02	0.03	0.04	0.02	0.05
65-59-4	0.07	–0.05	0.08	0.00	0.00	0.01	0.11	0.05
Paternal varieties								
65-59-5	0.03	0.04	0.00	0.04	–0.01	–0.01	0.04	0.01
Beloruskaya sladkaya	0.32	–0.03	0.01	–0.02	0.01	0.15	0.17	0.10
Storklas	–0.01	0.08	0.24	–0.04	0.01	0.10	0.01	0.01
Polar	–0.01	0.09	0.26	0.25	0.01	0.02	0.10	0.01
Intercontinental	–0.02	–0.02	–0.02	0.10	–0.01	0.00	–0.01	0.24
D16/1/-5	0.44	0.03	0.24	0.20	0.00	–0.01	0.10	0.03
Ben Gairn	–0.01	–0.02	0.13	0.20	0.00	0.02	0.22	0.04

DISCUSSION

Genetic control and inheritance regularities of important traits for black currant breeding were established by topcross method. Additive genes determine American mildew and Septoria leaf spot resistance and when creating black currant varieties resistant to fungal diseases crossing components can be successfully selected according to phenotype. Thus, crossing components can be successfully selected according to phenotype and hybrids practically will not differ in these traits from paternal forms. The trait that breeders and currant growers are most preoccupied – berry yield – largely depends on genes with additive effects, but the effect of non additive (dominant and epistatic) genes is very important as well. In breeding for productivity improvement certain progress can be achieved by selecting crossing pairs according to phenotype but selection of crossing components will be significantly more effective if prior to it progeny productivity is estimated. It has to be noted that in selection of currant seedlings results will be better in favorable for currant years because at that time the importance of dominant and epistatic genes for berry yield is higher. Black currant form D16/1/25 was ascertained to be a donor of resistance to American mildew and Septoria leaf spot and cultivar Ben Gairn – a donor of resistance to gall mite.

References

BRENNAN R.M., LANHAM P.G., MCNICOL R.J. (1993): Ribes breeding and research in the UK. Acta Hortic., **352**: 267–275.

DOSPEHOV B.L. (1985): Methods of field trials. Moscow, Agropromizdat. (in Russian)

KVIKLYS A. (1986): Intensive technologies of horticultural plant growing. Vilnius. (in Lithuanian)

MASIUKOVA O. (1979): Mathematical analyses in breeding and genetics fruit crops. Kishiniov, Shtinica. (in Russian)

MISEVICIUTE A. (1995): Development of black currant breeding at the Lithuanian Institute of Horticulture. Tasks and Perspectives of Orchard Plant Breeding: 55–58. (in Lithuanian)

OGOLCOVA T.P. (1992): Black currant breeding. Tula, Priokskoye Knzhnoye Izdatelstvo. (in Russian)

PLUTA S., MÀDRY W., ZURAWICZ E. (1993): Phenotypic and breeding value of few black currant cultivrs in central Poland. Acta Hortic., **352**: 455–462.

RAVKIN A.S. (1987): Black currants. Moscow, Izdateľstvo MGU. (in Russian)

TRAJKOVSKI V., ANDERSON M. (1992): Breeding black currant for resistance to powdery mildev, gall mite and reversion disease. Balsgard-Verksamhetsberattelse: 181–189.

ZURAWICZ E., MÀDRY W., PLUTA S. (1996): Variation and heritability of economically importat traits in black currant (*Ribes nigrum* L.) evaluated in a diallel cross design. Euphytica, **91**: 219–224.