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CHEMICAL COMPOSITION OF BERRIES OF INDUCED ALLOTETRAPLOID FORMS *RIBES NIGRUM L.* × *GROSSULARIA RECLINATA* MILL

Igor Buchenkov, Viktar Lemiasheuski, Alla Chernetskaya

Faculty of Environmental Medicine,
International Sakharov Environmental Institute of Belarusian State University,
23/1 Dolgobrodskaya Street, Minsk, 220070, Belarus
e-mail: butchenkow@list.ru

Abstract

Interspecific reciprocal crosses of *Ribes nigrum* × *Grossularia reclinata* were carried out. The morphological and biological characteristics of the hybrids were determined. Perspective forms were selected and transferred to the polyploid level. The chemical composition of polyploid berries was determined.

Key words: gooseberry, black currant, hybridization, plant breeding, polyploids

INTRODUCTION

Fruits and berries are the source of substances that are necessary for the adequate human nutrition. They contain a large number of organic and mineral compounds such as sugars, acids, potassium, calcium, iron, iodine, bromine, various vitamins, as well as tannins, pectins, aromatic and other substances. Currently, due to the environmental degradation, the requirements for the quality of consumed berries are increasing, especially concerning biologically active substances in them. In this regard, in the conditions of intensive fruit cultivation, the variety is of particular importance, since in the specific conditions of production, the varieties determine the economic efficiency of orchards and berry plantations.

The method of remote hybridization, which allows obtaining new plant organisms with a favorable combination of valuable features of the original parent forms, is of particular importance in the creation of the initial breeding material. The effectiveness of the remote crossing method in the development of theoretical biology and the practical transformation of nature is currently well proven by the works and

achievements of both domestic and foreign scientists (Dubrovsky 2010, Makarkina et al. 2010, Pershina 2009, Podgaetsky 2012).
The method of polyploidy, which causes profound and accomplished changes in the characteristics and properties of plants, is of great importance for increasing the hereditary variability in obtaining the initial breeding material. Despite the fact that polyploidy is not a fast way to s select plantssuccessfully, and the induced polyploids rarely find practical application without serious selection works, this method can undoubtedly serve as a powerful factor for further radical improvements of the existing assortment of berry crops (Dubrovsky 2010, Makarkina et al. 2010, Pershina 2009, Podgaetsky 2012).

MATERIAL AND METHODS

Among the berry-producing shrubs grown in Belarus, currants (*Ribes* L.) and gooseberries (*Grossularia* Mill.) are important plant cultures. Their berries, rich in a valuable variety of vitamins, mineral salts, and enzymes, play an essential role in the rational nutrition of a human.
The research was carried out at the agrobiological station of the Belarusian Pedagogical University named after Maxim Tank in the Minsk region (Central Belarus) in the years 1999-2008) and on the experimental field of the Polessky State University in the Pinsk (southern Belarus) in 2009-2017.
Crossings, field experiments, observations, description of traits were carried out according to the Program and methodology for the study of varieties of fruit, berry and nut crops (Sedov and Ogoltsova 1999).
Distant intergeneric reciprocal crosses of *R. nigrum*×*Gr. reclinata* were aimed at combining in a hybrid form the features of high crop productivity, immunity, winter hardiness, the length of raceme, large fruitiness, high vitamin content, and hornless shoots.
In total, 1921 flowers were pollinated in 6 reciprocal combinations of crosses; 484 hybrid seeds were sown; 41 plants were grown. As a result of the research, the intergeneric hybrids-amphigaploids (*R. nigrum*×*Gr. reclinata, Cr. reclinata*×*R. nigrum*) combining the genomes of two parent forms were obtained.

RESULTS AND DISCUSSION

New formations are the distinctive feature of hybrids; their occurrence can be explained by the rearrangement of individual chromosomes and their parts. A lot of features are valuable. High winter hardiness, an increase in the number of flowers in the racemes, simultaneous flowering, and the absence of thorns are the characteristics for reciprocal hybrids F_1*R. nigrum*×*Gr. reclinata*.
All hybrid forms are distinguished by heterosis, which manifests itself in large flower sizes, the formation of long replacement shoots, and high winter hardiness. At the same time, despite the presence of economically valuable features in the selected

forms, stable sterility does not allow them to be used directly for practical purposes. The sterility of distant hybrids is caused primarily by chromosomal abnormalities in micro-and macrosporogenesis, namely, by the lack of conjugation between several pairs of chromosomes, which is due to the partial homology of chromosomes of different species.

One of the most promising and reliable methods of overcoming the sterility of distant hybrids is allopolyploidy.

In order to obtain allotetraploid forms, the apical buds of the obtained distant hybrids were treated with a 1% solution of colchicine in water by applying gelatin capsules at an exposure of 36 hours. After treatment, the buds were washed with a 0.001% solution of heteroauxin, and after the development of shoots, they were cut off and rooted. At the end of the first vegetativeperiod, the selection of allotetraploid forms was carried out according to morphological characteristics, and in the second year – on the basis of counting of the chromosomes in the cells of the root tips on the colored pressed preparations.

Colchicination of sterile hybrids allowed to obtain amphidiploids, among which there are *R. nigrum*×*Gr. reclinata* (Naslednitsa×Belorusskyi Sakharnyi, Naslednitsa×Masheka, Belorusskaya Sladkaya×Masheka, Klussonovskaya×Belorusskyi Sakharnyi) – 8 plants; *Gr. reclinata*×*R. nigrum* (Masheka×Belorusskaya Sladkaya, Belorusskyi Sakharnyi×Klussonovskaya, Belorusskyi Sakharnyi×Naslednitsa) – 5 plants.

A comparative analysis of the nature of the manifestation of signs with a doubling of the number of chromosomes of each parent showed the following: amphiploids, which genotypes contain one genome from each of the parental forms, are completely sterile. They bloom annually, but do not bear fruit. The resulting amphidiploids are the new forms of the berry plant. They are normally fertile. Their genetic system is stable and produces the constant tetraploid offspring.

The analysis of morpho-anatomical and biological features of amphidiploids has made it possible to identify the features that distinguish them from the corresponding amphigaploids.

Amphidiploids of *R. nigrum*×*Gr. reclinata* have heterotic and thornless bushes; they differ from amphigaploids in the nature of the surface and color of the shoots, the density of the bud scales, the size of the leaves and flower racemes. The plants form late-maturing berries weighing up to 1.4 g, of an intermediate type with a fragrant fruit pulp and a matte skin of almost black color. There are 6–8 berries in a raceme. The number of seeds per fruit is up to 10 pcs. Setting of fruit with free pollination is up to 53.42%. The content of normally formed pollen grains is 68.51–71.74%, in contrast to the completely sterile pollen of amphigaploids.

Amphidiploids *Gr. reclinata*×*R. nigrum* have heterotic bushes with sparse thorns at the nodes of the shoots. Amphidiploids differ from amphigaploids in the nature of the surface and color of the shoots, the shape of the buds, the degree of adhesion of the bud scales, the size of the leaves, racemes and flowers. Most of the flowers form large berries up to 2.4 g. The berries are oval, slightly flattened at the poles, arranged in 3–6 on a common long axis. The amount of the seeds in the berries is 11–16 pcs. The

skin of the fruit is thick; the flesh is fragrant. The berries ripen in mid-August. Fruits set has been registered after free pollination from 39,83 to 47,58%. The content of normally formed pollen grains is up to 70.22%.

In order to determine the chemical composition of berries of allotetraploid forms of *Ribes nigrum* × *Grossularia reclinata*, the content of the total amount of sugars, titrated acidity, and vitamin C in the berries of the original diploid varieties and distant hybrids was studied.

The total amount of sugars was determined by the Bertrand method, which is based on the ability of the aldehyde group of sugars to interact with the Fehling reagent and to restore the oxide of copper to cuprous oxide, which precipitates in the form of a red precipitate.

The titrated acidity was determined by titrating the extracts with 0.1 n ofsodium hydroxide solution. The content of ascorbic acid in berries in the phase of full ripeness was determined by the indo-phenolic method in N.A. Bryukhanova's modification.

Analysis of the data on the content of the sum of sugars showed that for the original parent varieties of black currant, it varies in the range of 7.74–11.64%; for gooseberries–8.57–13.68%. In allotetraploids, this indicator ranges from 8.98–13.05% (Table 1).

Table 1

The chemical composition of the berries of varieties *Ribes nigrum*, *Grossularia reclinata* andreciprocal allotetraploid forms *Ribes nigrum*×*Grossularia reclinata*

Variety, the combination of crossing	Ploidy	The amount of sugars,%	Titratable acidity, %	Ascorbic acid, mg/100 g
R. nigrum				
Naslednitsa	2n	7,74-8,54[1] 8,14[2]	2,56-3,06 2,81	154-158 156
Klussonovskaya	2n	7,87-10,11 8,99	2,61-3,38 2,99	98-118 108
Belorusskaya Sladkaya	2n	10,83-11,64 11,24	1,02-1,05 1,04	276-298 287
Gr. reclinata				
Belorusskyi Sakharnyi	2n	8,57-13,68 11,13	1,52-1,89 1,71	19-23 21
Masheka	2n	9,63-10,33 9,98	2,11-2,63 2,37	32-36 34
R. nigrum*×*Gr. reclinata				
Naslednitsa× Belorusskyi Sakharnyi	4n	9,26-13,05 11,15	1,93-2,34 2,14	144-168 156
Naslednica×Masheka	4n	8,98-10,35 9,67	2,40-2,53 2,47	139-171 155
Klussonovskaya× Belorusskyi Sakharnyi	4n	10,92-11,33 11,13	1,90-2,42 2,16	99-117 108

Klussonovskaya×Masheka	4n	9,63-10,11 9,87	2,35-2,63 2,49	99-115 107
Belorusskaya Sladkaya× Belorusskyi Sakharnyi	4n	10,12-12,21 11,17	1,23-1,52 1,38	274-296 285
Belorusskaya Sladkaya× Masheka	4n	9,36-10,22 9,79	1,64-1,75 1,69	273-299 286
Gr. reclinata×R. nirgum				
Belorusskyi Sakharnyi×Naslednitsa	4n	10,21-12,12 11,16	2,02-2,50 2,26	142-164 153
Belorusskyi Sakharnyi×Belorusskaya Sladkaya	4n	10,62-11,66 11,14	1,23-1,52 1,38	274-292 283
Belorusskyi Sakharnyi×Klussonovskaya	4n	10,65-11,73 11,19	2,03,2,67 2,35	100-112 106
Masheka×Naslednista	4n	9,76-10,15 9,96	2,37-2,81 2,59	141-163 152
Masheka× Belorusskaya Sladkaya	4n	9,84-10,09 9,97	1,32-2,09 1,71	277-291 284
Masheka×Klussonovskaya	4n	9,87-10,11 9,99	2,38-2,98 2,68	99-111 105

[1] Fluctuations in indicators by year; [2] Average data.

The indicator of the content of organic acids in the parent varieties of black currant varies in the range of 1.02–3.06%; in gooseberrie–1.52–2.63%; in allotetraploids–1.23–2.98% (Table 1).

The content of ascorbic acid in the berries of the original varieties of black currant varies in the range of 98–298 mg/100 g; in gooseberries–19–36 mg/100 g; in allotetraploid–99–299 mg/100 g (Table 1).

CONCLUSIONS

As a result of studying the chemical composition of the berries of reciprocal allotetraploid forms of *Ribes nigrum* × *Grossularia reclinata* and the original parent varieties of *Ribes nigrum and Grossularia reclinata*, it was found that the inheritance of a characteristic amount of sugars from allotetraploid occurs on the parent varieties of gooseberry and is not dependent if it is a maternal or paternal form in hybridization; the increased content of organic acids in allotetraploids is characterized by intermediate values between the original varieties of black currant and gooseberry represented in the genotype of a hybrid; the content of ascorbic acid in allotetraploid berries is inherited from the parent variety of black currant and also does not depend on the form (paternal or maternal) during hybridization.

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SKŁAD CHEMICZNY JAGÓD INDUKOWANYCH FORM ALOTETRAPLOIDOWYCH PORZECZKI CZARNEJ I AGRESTU *RIBES NIGRUM* L. × *GROSSULARIA RECLINATA* MILL

Streszczenie

Badania przeprowadzono na stacji agrobiologicznej Białoruskiego Państwowego Uniwersytetu Pedagogicznego im. Maksima Tanka w rejonie Mińskim (Białoruś centralna) w latach 1999–2008 oraz na polu doświadczalnym Poleskiego Uniwersytetu Państwowego w Pińsku (Białoruś południowa) w latach 2009–2017. Wykonano krzyżówki reciprokalne międzygatunkowe *Ribes nigrum*×*Grossularia reclinata*. Określono cechy morfologiczne i biologiczne mieszańców. Formy perspektywiczne zostały wyselekcjonowane i przeniesione na poziom poliploidu. Określono skład chemiczny jagód poliploidalnych.

Słowa kluczowe: agrest, czarna porzeczka, hybrydyzacja, hodowla roślin, poliploidy