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ПРОЯВЛЕНИЕ ПРИЗНАКА МНОГОКИСТНОСТИ СМОРОДИНЫ ЧЕРНОЙ

(✉)**Сазонов Ф.Ф.**
Федеральный научный селекционно-технологический центр садоводства и питомниководства
Москва, Россия
(✉)e-mail: sazon-f@yandex.ru

Представлены результаты оценки генетической коллекции черной смородины по признаку многокистности для повышения продуктивности культуры в условиях Брянской области. Изучен показатель числа кистей с плодоношением на одном узле побега. Показано, что в условиях юго-западной части Нечерноземной зоны России (Брянская область) для культуры типично образование в пазухах листьев одной генеративной почки, однако встречаются формы, у которых часть узлов способна формировать 2–3 кисти с плодоношением. Установлено, что из 132 изученных сортов генетической коллекции 116 образцов (87,9%) формировали узлы с 1–2 генеративными почками. В результате исследований отобраны сорта с 3–4 соцветиями на узлах, способных к плодоношению (Дар Смольяниновой, Дебрянск, Брянский Агат, Селеченская 2, Ладушка, Орловский Вальс, Исток, Чудное Мгновение, Юбилейная Копаня, Вера, Чернавка и др.). Их использование в дальнейших скрещиваниях позволит получить более продуктивные генотипы. Выделены наиболее результативные комбинации скрещиваний по выходу потомства, формирующего 2–4 генеративных образования на одном узле (63-35-1 × Литвиновская, Свитязянка × Селеченская 2, Дебрянск × Дар Смольяниновой, Чудное Мгновение × Голубичка, 10-141-2 × Партизанка Брянская, Дебрянск × Литвиновская). Выделены перспективные отборные формы (3-63-01, 5-82-02, 8-69-01, 5-45-02, 4-18-01, 4-94-1, 4-18-02, 2-30-01 и др.), совмещающие признак многокистности с другими хозяйственно ценными показателями (устойчивость к патогенам, крупноплодность, десертный вкус плодов, количество ягод в кисти, их одномерность).

Ключевые слова: смородина черная, селекция, признак, многокистность

MANIFESTATION OF MULTIPLE RACEMES TRAIT OF BLACK CURRANT

(✉)**Sazonov F.F.**
Federal Horticultural Center for Breeding, Agrotechnology and Nursery
Moscow, Russian Federation
(✉)e-mail: sazon-f@yandex.ru

The results of the evaluation of the genetic collection of black currants on the multiple racemes trait for increasing the productivity of the crop in the conditions of the Bryansk region are presented. The index of the number of racemes with fruiting on one shoot node was studied. It has been shown that under the conditions of the southwestern part of the nonchernozem belt of Russia (Bryansk region), formation of one generative bud in the axils of leaves is typical for the crop, but there are forms in which some nodes are capable of forming 2-3 racemes with fructification. It has been found that out of 132 varieties of the genetic collection studied, 116 specimens (87.9%) formed nodes with 1-2 generative buds. As a result of the studies, varieties with 3-4 inflorescences on the nodes capable of bearing fruit were selected (Dar Smolyaninova, Debryansk, Bryansky Agat, Selechenskaya 2, Ladushka, Orlovsky Vals, Istok, Chudnoe Mgnovenie, Yubileinaya Kopanya, Vera, Chernavka, etc.). Their use in further crosses will produce more productive genotypes. The most productive

combinations of the crosses have been identified according to the yield of progeny forming 2-4 generative formations on one node (63-35-1 × Litvinovskaya, Svityazyanka × Selechenskaya 2, Debryansk × Dar Smolyaninovoy, Chudnoe Mgnovenie × Golubichka, 10-141-2 × Partizanka Bryanskaya, Debryansk × Litvinovskaya). Promising selected forms (3-63-01, 5-82-02, 8-69-01, 5-45-02, 4-18-01, 4-94-1, 4-18-02, 2-30-01, etc.), which combine the multiple racemes feature with other economically valuable indicators (resistance to pathogens, large fruits, dessert taste of fruits, number of berries in the raceme, their one-dimensionality) are highlighted.

Keywords: black currant, selection, trait, multiple racemes

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INTRODUCTION

Blackcurrant (*Ribes nigrum* L.) is one of the most popular berry crops in domestic and international horticulture. The widespread cultivation of this crop is attributed to its ease of propagation, high winter hardiness, productivity, early fruiting, medicinal and nutritional value of the fruits. Its cultivation can be practically fully mechanized, including harvest operations[1].

The traditional use of the crop includes processing it into marmalade, juice, jam, preserves, wine, confectionery, and more [1].

The result of meticulous breeding work aimed at increasing the productivity of blackcurrants has been the development of varieties with an average berry weight of 1.5-2.0 grams. When combined with high self-fertility and adaptability of genotypes, these varieties can guarantee competitiveness in commercial production [2]. However, most breeding programs have focused on improving yield, while research on other productivity components, such as the number of fruiting nodes and generative buds on a single node, has been insufficient. Assessments of blackcurrant breeding achievements and directions in modern assortment formation for both commercial and amateur horticulture indicate that increased yield has been achieved through enhanced self-fertility, pathogen resistance, and larger fruit size [3-6]. One understudied component of blackcurrant yield formation is the number of racemes per node. While it is typical for the species to produce a single generative bud in the leaf axils, there are forms in which multiple buds develop, resulting in 2-3 fruit-bearing racemes per node.

Blackcurrant flowers are arranged in inflorescences (racemes) that form on one-year-old or older wood. The racemes hang down and are formed from primary and one or several secondary buds, depending on the variety's characteristics. Therefore, an important factor for increasing blackcurrant productivity is the abil-

[1]*Panfilova O., Tsoy M., Golyaeva O.* Currant growing technology and mechanized harvesting-review // E3S Web of Conferences, Orel, 24–25 февраля 2021. Orel. 2021. P. 07002. DOI: 10.1051/e3sconf/202125407002.

ity to develop 2-3 generative buds per node, capable of developing into racemes[2]. Such forms have been previously identified among the subspecies of the European blackcurrant (*R. n.* subsp. *europaeum* Jancz.) and Siberian blackcurrant (*R. n.* subsp. *sibiricum* (Wolf.) Pav.) by N.M. Pavlova and V.L. Vitkovsky, as well as among *R. dikuscha* Fisch. by N.M. Bochkarnikova. It has been observed that the formation of 3-4 fruit-bearing buds per node is quite common in various forms of *R. dikuscha*[3].

According to the methodology, nodes that produce more than one raceme are considered multi-racemes nodes[4]. The manifestation of multi-racemes traits in modern cultivars is due to the extensive use of varieties such as Slozhnokistnaya and Primorsky Champion[5].

According to T.P. Ogoltsova (see footnote 2), blackcurrant plant productivity can be increased by branching the fruiting cluster, as in the case of the Slozhnokistnaya variety, or by forming main and additional buds on a single node capable of bearing fruit. The occurrence of multi-racemes nodes is associated with accelerated bud development and differentiation. Genotypes created with the participation of the Siberian subspecies of blackcurrant and R. dikuscha often develop several full-fledged generative buds in addition to the main bud by the end of the growing season. The biological mechanisms of multi-racemes formation on a single node in the representatives of the Scandinavian ecotype (*R. nigrum spp. scandinavicum*) differ. Typically, they form a single bud on the node in autumn, from which 5-6 mixed buds emerge in spring, each of which contains a flower cluster. In some buds, the development process does not reach completion, resulting in multiple clusters developing from a single bud.

V.L. Vitkovsky[6] describes deformations of fruit clusters in the variety "Blagodatnaya" as fasciations, which may be associated with changes in the conditions of differentiation of primordial-axillary growth apexes. Whorled arrangement of peduncles - formations in the form of a brush, forming 19 clusters with 129 fruits on one node - has been noted by him.

I.E. Buchenkov and I.V. Ryshkel[7] observe an increase in the length of the floral cluster and the formation of up to 2 buds in the leaf axils and 2 clusters per one raceme in *F1* hybrids obtained from interspecific crosses of *R. Nigrum* L. × *R. Rubrum* L. Similar results were obtained by I.P. Chuvashina[8] when studying offspring from the crosses between red and black currants. Seedlings were selected that were phenotypically similar to black currants, except that they formed multiple growth apexes instead of a single one, and a cluster of racemes grew from them in the spring of the following year, similar to red currants.

The formation of 2-3 racemes on one node[9] is typical for the varieties "Dikovinka," "Naryadnaya," "Seyanets Golubki," "Minai Shmyryov," "Brödtorp," "Stakhanovka Altaya," and "Öjebyn." Considering how actively these varieties were involved in the breeding programs implemented by domestic scientists, it becomes evident that multi- racemes trait should manifest in a number of their offspring. It is known

[2]*Ogoltsova T.P.* Selection of black currant - past, present, future. Tula: Priokskoe book publishing house, 1992. 384 p.

[3] *Bochkarnikova N.M.* Black currants in the Far East. - Vladivostok: Far East Book Publishing House, 1973.183 p.

[4]*Knyazev S.D., Bayanova L.V.* Currant, gooseberry and their hybrids // Program and methodology of the varietal study of fruit, berry and nut crops. Orel: VNIISPK, 1999. pp. 351–373.

[5] *Ogoltsova T.P., Sedova Z.A*. Study of the Far Eastern forms of black currant as source material for selection in the middle zone of the RSFSR // Selection, varietal study, agrotechnics of fruit and berry crops. Orel: Orel Branch of the Prioksky Book Publishing House, 1979. Vol. 9, Part 2. pp. 59–73.

[6]*Vitkovsky V.L.* Budding neoplasms in black currant // Botanical Journal. Moscow, 1962. Vol. 47. N 3. pp. 35–40.

[7]*Buchenkov I.E., Ryshkel I.V.* Hybridization of black currant (*Ribesnigrum* L.) and red currant (*Ribesrubrum* L.) // Agriculture - problems and prospects. 2016. pp. 43–50.

[8]*Chuvashina I.P.* Neoformations in the structure of the mixed buds of distant currant hybrids // Morphogenesis of plants. Moscow, 1961. Vol. 2. pp. 256–258.

[9]*Kopan K.N., Kopan V.P.* Selection of black currants for productivity and fruitfulness // Collection of scientific articles. "Selection and varietal study of black currant". Michurinsk, 1988. pp. 57–63.

that the varieties "Labilnaya," "Orlovsky Vals," and "Nara"[10] are capable of forming 4-5 clusters on one node. Mention can be found in the literature about the French variety "Noirde Bourgogne," which is capable of forming up to 6 racemes on one node (see footnote 2). There is information that the maximum level of manifestation of this trait (up to 6 racemes on one node) is found in the variety "Ocharovanie" of the Orlovsky selection [7].

Some researchers[11] [8] believe that the manifestation of the multi-racemes trait in black currants largely depends on the fertility level of the site and compliance with agronomic requirements. V.F. Severin[12] demonstrated through experiments that properly balanced mineral nutrition and a high agrophone of a commercial plantation positively affect the length of the raceme and the formation of multi-racemes nodes on the shoot.

The purpose of the research is to assess the existing assortment and hybrid offspring of black currants in terms of the manifestation of the multi-racemes trait, as well as to search for donors and genetic sources of this productivity component.

MATERIAL AND METHODS

The work was carried out in the experimental plots of the Kokino experimental station (ES) of the Federal Horticultural Center for Breeding, Agrotechnology and Nursery (FRC of Horticulture) where 132 collection samples of foreign and domestic breeding have been studied from 2007 to 2022. The creation of the hybrid collection was carried out in accordance with the methodology[13]. Field observations and plant counts in collection plantings and hybrid seedlings were conducted according to the requirements of the methodology "Program and methodology for studying the varieties of fruit, berry, and nut crops" (see footnote 4). The statistical analysis of the obtained data was performed using Microsoft Office Excel.

The collection and breeding plots where the research was conducted are represented by gray forest soils. The soil-forming rocks are loess-like loams and loesses with a homogeneous coarse-grained granulometric composition. The content of available phosphorus in the soil is 25-35 mg/100 g of soil, potassium - 9.8-14.1 mg/100 g of soil, humus - 3.8%. The reaction of the soil solution varies from slightly acidic to acidic (pH = 4.9-6.1). The cultivation agronomy of black currants is the one that is generally accepted in the nonchernozem zone.

RESULTS AND DISCUSSION

The conducted evaluation of 132 black currant varieties in the collection plantings of the Kokino Experimental Station of the Federal Research Center of Horticulture allowed for differentiation of the original forms based on the studied trait. Despite the information found in scientific literature stating that the formation of only one raceme per node is typical for most black currant varieties[14], our research revealed that the group of varieties that do not produce multi-racemes nodes is small in number.

Thus, the group of varieties consistently maintaining the trait of single-raceme nodes throughout the entire research period includes Arabka, Gamma, Gamayun, Glarioza, Gracia, Gulliver, Dabradzea, Debut, Degtyarevskaya, Dessertnaya Ogoltsovoj, Divo Zvyaginoj, Diamant, Dobry Djinn, Dobrynya, Gold of the Incas, Kazkova, Carmelita, Klussonovskaya, Lybed, Mashenka, Nymfa, Nyura, Nezhdan-

[10]Zatsepina I.V. Productivity of black currant varieties // Adaptive potential and quality of production of varieties and varietal-podstock combinations of fruit crops. Orel, 2012. pp. 100–106.

[11] *Shavyrkina M.A., Knyazev S.D.* Evaluation of black currant samples on morphostructural components of productivity // Bulletin of Orel State Agrarian University. 2015. N 5 (56). pp. 46–50.

[12] *Severin V.F.* Effect of mineral fertilizers on the laying of vegetative-generative buds, the formation of the number of brushes in the buds and flowers in the brushes of black currant // Siberian Herald of Agricultural Science, 1993. N 3. pp. 21–28.

[13]*Ogoltsova T.P., Kuminov E.P.* Selection of black currant // Program and methodology of selection of fruit, berry and nut crops / Under the general editorship of E.N. Sedov. Sedov. Orel: VNIISPK, 1995. pp. 314–340.

[14]*Kanshina M.V.* Black currants: selection, genetics, varieties. Chelyabinsk: NPO "Sad i ogorod". Chelyabinsk Press House,2013. 160 p.

chik, Nanny, Orlovskaya Serenada, Pamyati Potapenko, Pamyati Vavilova, Partizanka Bryanskaya, Gift of Kalinina, Ragneda, Snow Queen, Solomon, Trilena, Uslada, Charovnitsa, Chernookaya, Shaman, Shalunya, Elevesta, Ben Gairn, Ben Sarek, Big Ben, Bona, Black Magic, Black Magic Carbon.

The majority of the studied black currant varieties (87.9%) formed 1-2 racemes per node. When the number of the generative buds in the nodes changed, the formation of two-racemes formations was more frequently observed. The formation of 2 racemes per node was observed in 53% (70 varieties) of the studied varieties. These include Ametist, Amirani, Annadi, Bagira, Barmaley, Belorussotchka, Vernisazh, Voevoda (Fortuna-17), Vymplel, Galaktika, Zaglyadenie, Zelyonaya Dymka, Iskushenie, Katyusha, Kipiana, Kaskad, Krynichka, Delikates, Kudesnik, Kudmig, Kupalinka, Lentyay, Lider, Litvinovskaya, Malenkiy Prints, Minusinskaya Sladkaya, Myth, Mriya, Mriya-3, Mriya-5, Monisto, Dachnitsa, Nadina, Nadya, Sensei, Ocharovanie, Perun, Podarok Astakhova, Pamyati Ravkina, Tamerlan, Pigmy, Selechenskaya, Rita, Sevchanka, Podarok Veteranam, Slastena, Nara, Orloviya, Sudarushka, Solovinaya Noch, Azhurnaya, Oriana, Strelets, Tatyana's Day, Izyumnaya, Favorit, Fortuna, Charodey, Chereshneva, Cherny Zhemchug, Etude, Exotika, Sharovidnaya, Yadryonaya, Ben Alder, Ben Tirran, Ben Hope, Tiben, Tisel, Triton.

Much less frequently, genotypes forming up to 3 racemes on a single node were observed. Under favorable conditions for plant growth, such generative formations were noted on the shoots of the following varieties: Dar Smolyaninovoy, Debransk, Bryansky Agat, Selechenskaya 2, Slavyanka, Sokrovishche, Sofievskaya, Ladushka, Lukomorye, Orlovsky Vals, Istok, Chudnoe Mgnovenie, Yubileinaya Kopanya. The varieties Chernookaya and Sofievskaya form branched racemes similar to the variety Slozhnokistnaya, with elongated cluster-like inflorescences. Among the wide variety of studied samples, only the varieties Vera and Chernavka exhibited the formation of 4 inflorescences in the nodes.

If multi-racemes nodes are formed on a shoot, they account for a certain proportion of the total number of fruiting clusters on the fruiting wood. The table shows the level of manifestation of the multi-racemes trait using the genotypes that we most frequently used in breeding as the original forms based on a complex of economically significant traits. For example, for the Debransk variety, on average over the observation period, multi- racemes nodes accounted for 25.0% of their total number, Bryansky Agat – 23.2%, Kudmig – 22.6%, Selechenskaya 2 – 17.2%, Rita – 15.3%, and so on. At the same time, the assessment and recording of the number of inflorescences showed that for the Debransk variety, 20.8% of nodes were three-racemes, 25.0% were two- racemes, and 54.2% were single- raceme. The Bryansky Agat variety formed 15.7% three- racemes nodes, 23.5% two- racemes, and 60.8% single- raceme. On average, 22.6% of nodes for the Kudmig variety were two- racemes, and the remaining nodes were single- raceme. For the Charodey and Etude varieties, two- racemes nodes accounted for 7% of the total number. This indicates a significant variation of the studied trait among the different varieties.

The conducted series of crosses, carried out in 2009-2011, using the original forms that have the ability to develop multiple generative buds in a single node suitable for normal inflorescence development, allowed the identification of several combinations that produced multi- racemes seedlings in the offspring [9]. The majority of such hybrids (30.4-42.0%) were selected in the families Nara × Yadryonaya, Yadryonaya × Exotica, Nara × (Yadryonaya × Exotica), Kipiana × Glarioza, and Kipiana × Debransk. In the first three combinations, seedlings that formed up to 4 clusters on a single node were identified. These selections include 43-8-05 (Nara × Yadryonaya), 85-03-3 (Yadryonaya × Exotica), and 2-49-01 [8-4-1 (Yadryonaya × Exotica) I_1].

The best results in selecting multi-racemes offspring were obtained in the cross combination of Chudnoye Mgnoveniye × Golubichka, where up to 43.1% of seedlings formed more than one raceme on a single node. This can be

Оценка смородины черной по уровню проявления признака многокистности (2018–2022 гг.)
Evaluation of black currant by the level of manifestation of the multiple racemes trait (2018-2022)

Variety, selection	Number of nodes with fruiting on shoots		Number of racemes per node	Percentage of multi-racemes nodes on a fruiting shoot, %
	$X_{ср} \pm m$	V, %		
Barmalei	48,3 ± 5,7	10,3	1–2	14,5
Bryansky Agat	51,0 ± 8,0	12,6	1–3	23,2
Dar Smolyaninovoy	37,3 ± 8,7	23,4	1–3	10,7
Debryansk	48,0 ± 8,2	17,1	1–3	25,0
Kipiana	38,7 ± 5,5	14,8	1–2	13,2
Kudmig	44,3 ± 6,0	13,6	1–2	22,6
Lentyay	40,0 ± 4,0	10,0	1–2	7,5
Litvinovskaya	46,3 ± 6,0	13,0	1–2	12,9
Myth	53,0 ± 11,8	12,1	1–2	15,1
Nezhdanchik	45,3 ±7,6	16,7	1	–
Podarok Veterana	47,3 ± 7,6	19,9	1–2	12,7
Rita	39,3 ± 4,0	10,3	1–2	15,3
Selechenskaya 2	40,7 ± 10,1	24,8	1–3	17,2
Strelets	37,0 ± 5,0	14,3	1–2	10,8
Charodey	42,7 ± 3,8	8,9	1–2	7,0
Chereshneva	47,7 ± 8,1	17,0	1–2	10,5
Chernavka	39,0 ± 3,6	9,3	1–4	10,3
Etude	43,0 ± 7,6	17,6	1–2	7,0
BenHope	51,0 ± 7,9	9,0	1–2	9,8
BenTirran	31,0 ± 8,5	27,6	1–2	12,9
Tiben	42,0 ± 8,9	21,0	1–2	9,5
Tisel	37,3 ± 2,5	6,7	1–2	10,7
1–29–02	39,0 ± 4,4	12,5	1–3	10,3
4–18–01	36,3 ± 4,0	11,1	1–3	8,3
10–141–2	39,3± 9,5	24,5	1–3	12,7
20–69–1	41,7 ± 6,0	14,5	1–3	14,4
63–35–1	45,3 ± 7,1	9,1	1–3	15,5
5–37–02	49,7 ± 2,5	5,1	1–4	10,1
2–49–01	45,7 ± 5,1	11,2	1–4	10,2
43–8–05	36,0 ± 8,5	23,7	1–4	15,3
4–5–2	46,3 ± 5,0	10,9	1–4	15,1
$LSD_{0,05}$	9,87	–	–	–

explained by the fact that the Chudnoe Mgnovenie variety is a third-generation derivative (*F3*) of the Primorsky Champion variety, which has proven itself as a donor of multi- racemes, and an *F2* of a descendant of the Scandinavian subspecies variety Brödtorp, which also effectively transmits multi-racemes to the offspring, as repeatedly confirmed by domestic scientists (see footnote 14). The paternal form in this cross combination is represented by the Golubichka variety, which is also an *F3* descendant of the Brödtorp variety and an *F2* of the Primorsky Champion variety [10]. Among the studied forms selected for multi- racemes from this

family, the best selections were 15-11/01 and 73-32-12, which formed up to 3 inflorescences on individual nodes and had aligned, non-shattering fruits with an average weight of 1.4 g.

The study of hybrid fund made it possible to select the forms combining multi-racemes trait with other economically valuable traits (large-fruitedness, one-dimensional berries, resistance to fungal diseases, etc.). For example, dessert selection No. 4-5-2, isolated in the family SC-7 × Exotica, forms on average 15.1% of multi-racemes nodes on the shoot, among which four-racemes nodes are found. Three-racemes nodes were observed in the forms 1-29-02 [(Dar Smolyaninovoy × Litvinovskaya) × Mriya-3], 10-141-2 (Sagittarius × Golubichka), and 20-69-1 (Nara I_1). A large-fruited hybrid 63-35-1, forming berries weighing more than 5.0 g and about 15% three-racemes nodes, was isolated in the family Lentyay × Debryansk, with the participation of large-fruited initial forms. Further inclusion of some of the presented selections in hybridization has allowed us to evaluate their donor qualities.

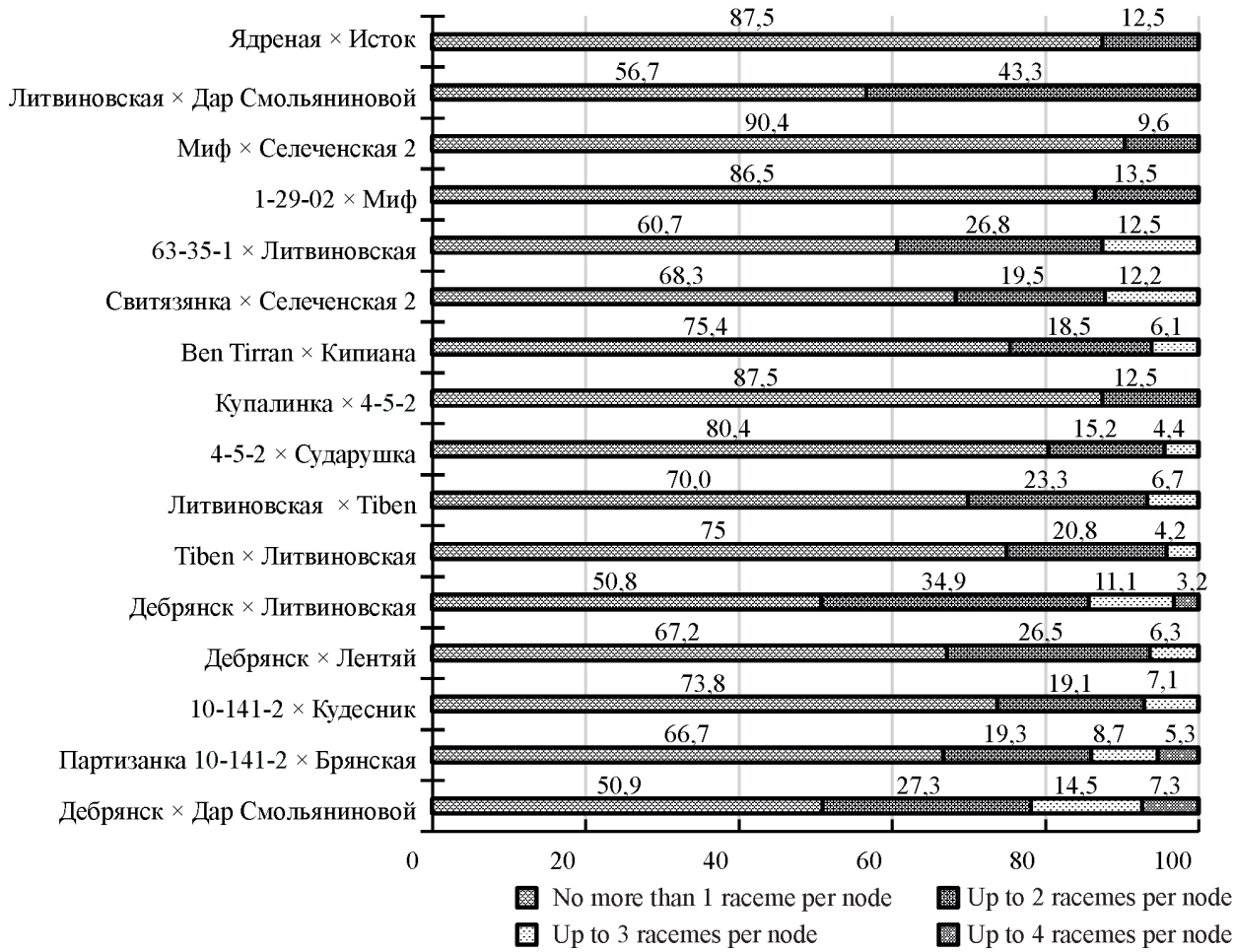
During the selection for multi-racemes traits, preference was given to the genotypes previously identified that combined this characteristic with other economically valuable traits such as large fruit size, long racemes, dessert-like berry taste, etc. Hybridological analysis of seedlings from varieties and selected forms that differed in the number of fruit-bearing clusters on a single node showed a predominance of offspring where multi-racemes nodes were not observed. Even in the families involving multi- racemes original forms, such as Tiben × Selechenskaya 2, Selechenskaya 2 × Dar Smolyaninovoy, Orlovsky Vals × Partizanka Bryanskaya, Mriya × Dar Smolyaninovoy, Istok × Dar Smolyaninovoy, Podarok Veteranam × Dar Smolyaninovoy, Bryansky Agat × Dar Smolyaninovoy, Tamerlan × Bryansky Agat, no hybrids capable of forming more than one raceme on a single node were selected in the offspring.

In the study of the hybrid gene pool, the families were identified in which seedlings with multi-racemes nodes on the shoots were selected. The successful combination of such multi-racemes varieties as Selechenskaya 2 and Debransk in the crossbreeding combinations like Svitzyanka × Selechenskaya 2 and Debransk × Lentyay allowed for the selection of the progeny with 31.7% to 32.8% of seedlings forming 2-3 racemes on a single node (see the figure). Productive combinations were found involving multi- racemes selected forms. For example, in the families 4-5-2 × Sudarushka, 10-141-2 × Partizanka Bryanskaya, and 63-35-1 × Litvinovskaya, 19.6% to 39.3% of hybrids capable of forming 2-3 racemes on a single node were identified.

The use of even less prominent multi-racemes parental forms in hybridization, in combinations such as Ben Tirran × Kipiana, Tiben × Litvinovskaya, and Litvinovskaya × Tiben, allowed the selection of 24.1%, 25.0%, and 30.0% respectively of multi-racemes seedlings, of which 4.2-6.7% of the hybrids formed up to 3 racemes per node. Reciprocal crosses between the varieties Litvinovskaya and Tiben resulted in the selection of promising forms 8-69-01 (Litvinovskaya × Tiben) and 5-82-02 (Tiben × Litvinovskaya) in their progeny, characterized by high resistance to powdery mildew, the formation of 2-3 generative buds per node, and synchronized ripening of the berries within the raceme. In the family of Ben Tirran × Kipiana, seedling No. 3-63-01 was selected, exhibiting 2-3 racemes per node and resistance to anthracnose and leaf spotting. Production of the hybrids exhibiting greater multi-racemes traits than the parental forms indicates the possibility of selecting genotypes with a higher expression of the studied trait in a large analyzed progeny.

However, hybridological analysis shows that the use of multi-racemes parental forms in crosses does not always guarantee the same progeny. The inclusion of varieties such as Selechenskaya 2, Istok, Dar Smolyaninovoy, and the form 1-29-02, capable of forming up to 3 racemes per a node, in certain combinations does not guarantee the segregation of multi-racemes seedlings. This is evident in the families such as Myth × Selechenskaya 2, Litvinovskaya × Dar Smolyaninovoy, Yadrenaya × Istok, 1-29-02 × Myth. In the progeny of the mentioned crosses, all hybrids were single- or double-racemes.

Among the studied cross combinations, the



Расщепление гибридного потомства в комбинациях скрещиваний по числу кистей на узлах, %
Splitting of hybrid offspring in combinations of crosses by the number of racemes at the nodes, %

best results in terms of multi-racemes trait were observed in the progeny of the following families: Debransk × Dar Smolyaninovoy, 10-141-2 × Partizanka Bryanskaya, and Debransk × Litvinovskaya. These families produced seedlings with three or four racemes on a single node. In the Debransk × Litvinovskaya and 10-141-2 × Partizanka Bryanskaya families, 11.1% and 8.7% of the seedlings, respectively, formed up to three racemes on a single node, while the proportion of the seedlings with four racemes was 3.2% and 5.3%, respectively. In the Debransk × Dar Smolyaninovoy family, 14.5% of the seedlings were capable of forming up to three racemes on a single node, and 7.3% of the hybrids had four-racemes nodes. In the presented families, 33.3% to 49.2% of the seedlings formed more than one generative bud on a single node. For example, the progeny of the Debransk × Dar Smolyaninovoy family included selections 5-37-02 and 5-37-03, which combined multi-racemes with dessert-flavored fruits. The form 7-136-3 from the Debransk × Litvinovskaya family not only formed up to 27% of multi-racemes nodes but also had large-sized fruits and uniform berries on the cluster.

Despite the fact that the variety Partizanka Bryanskaya does not form multi-racemes nodes on its shoots, its combination with the multi-racemes elite seedling 10-141-2 allowed for the selection of the genotypes that combined several valuable traits. This may be due to the fact that the selection 10-141-2 was obtained from a broad genetic basis, and its parental forms, Streltsy (Selenchenskaya 2 open pollination) and Golubichka [Izumnaya × (Alfa × Primorsky Champion)], are the derivatives of various subspecies of blackcurrant. From the 10-141-2 ×

Partizanka Bryanskaya family, large-fruited hybrids 4-18-01 and 4-18-02 were selected, which formed 3-4 racemes with dessert-flavored fruits on the nodes. This family also yielded the selection 4-94-1, characterized by multi-racemes, high field resistance to powdery mildew, and a compact and upright bush habitus.

The use of the method of seed sowing from open pollination proved to be effective in analytical selection. In such populations, individual seedlings with multi-racemes trait and the manifestation of several economically valuable traits were identified. These included hybrids resistant to Sphaerotheca, such as 2-26-02 (Chereshneva, open pollination), 3-10-02 (Mriya-5, open pollination), 9-5-01 (6-15-52, open pollination), 9-62-01 (Irmen, open pollination), and 8-10-1 (Izumnaya, open pollination); long-racemes forms 2-30-01 (Selenchenskaya 2, open pollination), 4-14-03 (Vera, open pollination), 5-45-02 (52-42-1, open pollination); selections with dessert-flavored fruits 1-17-01 (Dar Smolyaninovoy, open pollination), 1-9-02, 2-17-03 (Mriya-3, open pollination). The selected form 3-31-01 (Kudesnik, open pollination) was characterized by long racemes (up to 12 berries per cluster) and the ability to form up to 4 racemes on a single node.

Hybridological analysis shows that the Debransk variety is a promising donor of multi-racemes trait. It forms up to 3 generative buds on a single node, and in most cases, hybrids with multi- racemes are obtained in the crosses involving Debransk. In the populations derived from open pollination of the Debransk variety, large-fruited multi-racemes progeny combining this trait with other economically valuable characteristics were identified. For example, form 7-53-01 (Debransk, open pollination) exhibited resistance to fungal diseases (powdery mildew, leaf spotting); selection 37-27-4/05 was resistant to powdery mildew and leaf anthracnose; selected form 7-53-02 produced dessert-flavored fruits; the average berry weight of hybrid 36-27-8/05 was 2.2 g; the new large-fruited variety Kaskad was also derived from this population.

CONCLUSION

As a result of the conducted research, genetic sources and donors of the multi-racemes trait (Dar Smolyaninovoy, Debransk, Bryansky Agat, Selenchenskaya 2, Vera, Chernavka, Nara, Yadryonaya, Exotika, Kipiana, Orlovsky Vals, Istok, Chudnoe Mgnovenie, Litvinovskaya, etc.) have been identified, the use of which in further crosses will allow for the development of more productive forms. The most successful cross combinations in terms of obtaining multi-racemes progeny were 63-35-1 × Litvinovskaya, Svityazanka × Selenchenskaya 2, Debransk × Dar Smolyaninovoy, 10-141-2 × Partizanka Bryanskaya, Debransk × Litvinovskaya, and Debransk (open pollination). Of particular interest are the selected multi-racemes genotypes (63-35-1, 10-141-2, 20-69-1, 2-49-01, 43-8-05, 4-5-2, 4-18-01, 4-18-02, 4-94-1, etc.) from the hybrid population, which deserve active use in the breeding process to create more productive blackcurrant forms.

СПИСОК ЛИТЕРАТУРЫ

1. *Сазонова И.Д.* Биохимическая оценка плодов малины и смородины в условиях юго-западной части Нечерноземья России // Вестник Брянской государственной сельскохозяйственной академии. 2021. № 5 (87). С. 36–44. DOI: 10.52691/2500-2651-2021-87-5-36-44.
2. *Sazonov F.F., Evdokimenko S.N., Sorokopudov V.N., Andronova N.V., Skovorodnikov D.N.* The productivity of new Russian blackcurrant cultivars // ActaHorticulturae. 2020. Vol. 1277. P. 155–158. DOI: 10.17660/ActaHortic.2020.1277.22.
3. *Сорокопудов В.Н., Назарюк Н.И., Габышева Н.С.* Совершенствование сортимента смородины черной в азиатской части России // Вестник Курской государственной сельскохозяйственной академии. 2018. № 7. С. 23–28.
4. *Акуленко Е.Г., Каньшина М.В., Яговенко Г.Л.* Результаты и перспективы селекции смородины черной во ВНИИ люпина // Плодоводство и ягодоводство России. 2020. Т. 63. С. 11–15. DOI: 10.31676/2073-4948-2020-63-11-15.
5. *Родюкова О.С., Жидехина Т.В., Брыксин Д.М., Хромов Н.В., Гурьева И.В.* Генетические

коллекции ягодных культур и их роль в совершенствовании сортимента // Достижения науки и техники АПК. 2021. Т. 35. № 7. С. 10–16. DOI: 10.53859/02352451_2021_35_7_10.
6. *Чеботок Е.М.* Итоги сортоизучения коллекции смородины черной на Среднем Урале // Плодоводство и ягодоводство России. 2020. Т. 60. С. 136–143. DOI: 10.31676/2073-4948-2020-60-136-143.
7. *Тихонова О.А.* Слагаемые компоненты продуктивности черной смородины в условиях Северо-Запада России // Труды по прикладной ботанике, генетике и селекции. 2016. Т. 177, Вып. 3. С. 61–73.
8. *Гусева Н.К., Батуева Ю.М., Васильева Н.А.* Основные показатели продуктивности смородины черной и особенности наследования их в потомстве // Вестник Государственного аграрного университета Северного Зауралья. 2016. № 3 (34). С. 56–61.
9. *Сазонов Ф.Ф.* Селекция смородины черной в условиях юго-западной части Нечерноземной зоны России: монография. М.: ФГБНУ ВСТИСП, 2018. 304 с.
10. *Князев С.Д., Левгерова Н.С., Макаркина М.А., Пикунова А.В., Салина Е.С., Чекалин Е.И., Янчук Т.В., Шавыркина М.А.* Селекция черной смородины: методы, достижения, направления: монография. Орел: ВНИИСПК, 2016. 328 с.

REFERENCES

1. Sazonova I.D. Biochemical assessment of raspberry and currant berries in the south-western part of the Non-Black Earth region of Russia. *Vestnik Bryanskoi gosudarstvennoi sel'skokhozyaistvennoi akademii = Vestnik of the Bryansk State Agricultural Academy,* 2021, no. 5 (87), pp. 36–44. (In Russian). DOI: 10.52691/2500-2651-2021-87-5-36-44.
2. Sazonov F.F., Evdokimenko S.N., Sorokopudov V.N., Andronova N.V., Skovorodnikov D.N. The productivity of new Russian blackcurrant cultivars. *ActaHorticulturae*, 2020, vol. 1277, pp. 155–158. DOI: 10.17660/ActaHortic.2020.1277.22.
3. Sorokopudov V.N., Nazaryuk N.I., Gabysheva N.S. Improvement of the assortment of black currants in the Asian part of Russia. Vestnik Kurskoi gosudarstvennoi sel'skokhozyaistvennoi akademii = *Bulletin of the Kursk State Agricultural Academy*, 2018, no. 7, pp. 23–28. (In Russian).
4. Akulenko E.G., Kan'shina M.V., Yagovenko G.L. Results and outlooks of black currants breeding in the All-Russian Lupin Scientific Research Institute. *Plodovodstvo i yagodovodstvo Rossii = Pomiculture and small fruits culture in Russia,* 2020, vol. 63, pp. 11–15. (In Russian). DOI: 10.31676/2073-4948-2020-63-11-15.
5. Rodyukova O.S., Zhidekhina T.V., Bryksin D.M., Khromov N.V., Gur'eva I.V. Genetic collections of berry crops and their role in improving the assortment. *Dostizheniya nauki i tekhniki APK = Achievements of Science and Technology of AIC*. 2021, vol. 35, no. 7, pp. 10–16. (In Russian). DOI: 10.53859/02352451_2021_35_7_10.
6. Chebotok E.M. Results of variety study of black currant collection in the Middle Urals. *Plodovodstvo i yagodovodstvo Rossii = Pomiculture and small fruits culture in Russia*, 2020, vol. 60, pp. 136–143. (In Russian). DOI: 10.31676/2073-4948-2020-60-136-143.
7. Tikhonova O.A. Elements of the black currant productivity component in the environments of the Russian North-West. Trudy po prikladnoi botanike, genetike i selektsii = *Proceedings on Applied Botany, Genetics and Breeding*, 2016, vol. 177, is. 3, pp. 61–73. (In Russian).
8. Guseva N.K., Batueva Yu.M., Vasil'eva N.A. Basic indicators of blackcurrant productivity and their inheritance features in breed. *Vestnik Gosudarstvennogo agrarnogo universiteta Severnogo Zaural'ya = Bulletin of Northern Trans-Ural State Agricultural University,* 2016, no. 3 (34), pp. 56–61. (In Russian).
9. Sazonov F.F. *Black currant breeding in the southwestern part of the Non-Black Soil Zone of Russia***.** Moscow, FGBNU VSTISP Publ., 2018. 304 p. (In Russian).
10. Knyazev S.D., Levgerova N.S., Makarkina M.A., Pikunova A.V., Salina E.S., Chekalin E.I., Yanchuk T.V., Shavyrkina M.A. *Blackcurrant breeding: methods, achievements, directions.* Orel, VNIISPK Publ., 2016. 328 p. (In Russian).

ИНФОРМАЦИЯ ОБ АВТОРЕ

(✉)**Сазонов Ф.Ф.,** доктор сельскохозяйственных наук, ведущий научный сотрудник; **адрес для переписки:** Россия, 115598, Москва, ул. Загорьевская, 4; e-mail: sazon-f@yandex.ru

AUTHOR INFORMATION

(✉)**Fedor F. Sazonov,** Doctor of Science in Agriculture, Lead Researcher; **address:** 4, Zagorevskaya St., Moscow, 115598, Russia; e-mail: sazon-f@yandex.ru

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