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Blackcurrant Genetic Resources for Breeding and Sustainable Production

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Abstract. Blackcurrant (*Ribes nigrum* L.) is the most widely grown berry crop in Latvia, with organic plantations occupying a large share of production. However, the fruit productivity is limited by the susceptibility to pests, diseases, and environmental stresses of grown cultivars. To identify sources of resistance, 19 local genotypes, including cultivars, breeding selections, and expedition-collected material, were evaluated for yield, fruit quality, and resistance/tolerance to biotic and abiotic stresses. Considerable variability in the resistance of the tested accessions was observed. The cultivars 'Karina' and 'Ritmo' as well as the genotypes VI-2, GEN 233A, GEN 264 and GEN 645 showed the highest levels of resistance to pests and diseases. GEN 758 had good winter hardiness and frost tolerance while GEN 233A was additionally notable for its high nutritional value of its fruit.
Key words: *Ribes nigrum*, genotype, susceptibility, diseases, pests, fruit quality.

Introduction

Blackcurrant (*Ribes nigrum* L.) is the most widely grown berry crop in Latvia, covering over 2300 hectares, of which 70% are organic plantations (Platību maksājumu statistika, Lauku atbalsta dienests, 2025). The fruits are valued for their health-promoting properties, and rich chemical composition (Cortez & Gonzalez de Mejia, 2019; Vagiri, 2012). They are widely used in food processing, particularly in juice production, which serves as a natural food colourant and has been linked to protection against chronic diseases (Woodward *et al*., 2011).

Latvian climate is highly variable, and recent climate change trends include warmer winters and springs, increased precipitation, reduced sunshine, and a longer vegetation period, posing challenges for blackcurrant production (Kampuss *et al*., 2009). The commercial cultivation of blackcurrants is also affected by multiple plant health issues, such as fungal and virus diseases and pests (Petrescu & Hoza, 2024; Vagiri, 2012).

Genetic resources of fruit crops play a key role in preserving biodiversity and cultural heritage (Kikas *et al*., 2022), while also providing a valuable source for developing tolerance to unfavourable weather and soil conditions. Efficient utilisation of blackcurrant germplasm in the applied breeding requires characterisation, genetic diversity evaluation, and identification of plant material (Lācis *et al*., 2021). To accelerate progress in conventional blackcurrant breeding, the selection of suitable parental forms for crossing is essential (Masny *et al.,* 2018).

At the beginning of this century, several expeditions were conducted in Latvia to collect local genotypes, with an emphasis on plant health and adaptation to local growing conditions. The collected material was propagated and established in the collections of the Institute of Horticulture (LatHort).

The aim of this study was to evaluate blackcurrant genotypes obtained from these expeditions, along with local cultivars and breeding selections maintained at the LatHort, in order to identify the most valuable accessions for inclusion in the National Genetic Resources Collection and for use in breeding to improve sustainability.

Materials and Methods

The evaluation of local blackcurrant genetic resources was conducted in the LatHort collection in Pūre, Tukums region (57°02′ N, 22°52′ E) during 2019–2021. In total, 19 genotypes were evaluated, including Latvian cultivars, selected breeding material and genotypes collected during the expeditions. Plants were established between 2014 and 2018, planted in rows with 3.5 m spacing between rows and 1.0 m

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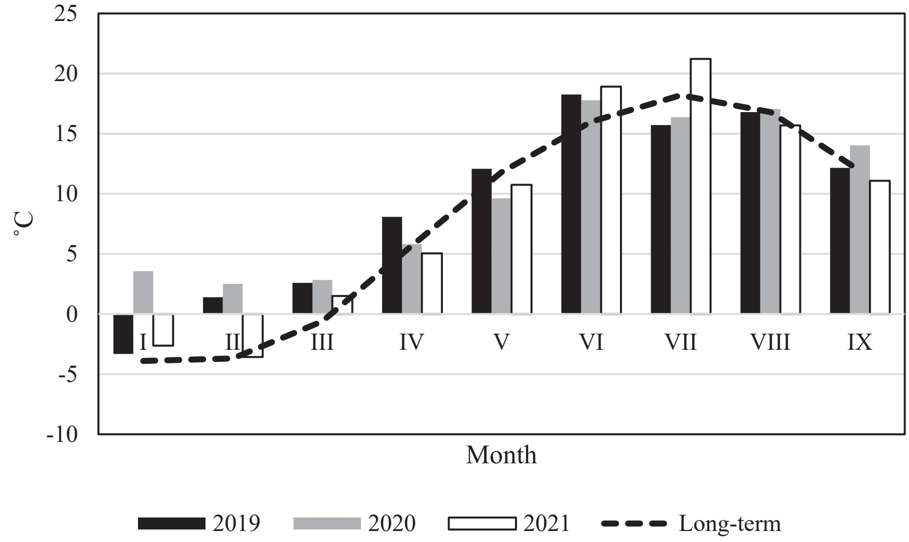

Figure 1. Mean and long-term temperatures in Pūre, 2019–2021; the records of Pūre meteorological station.

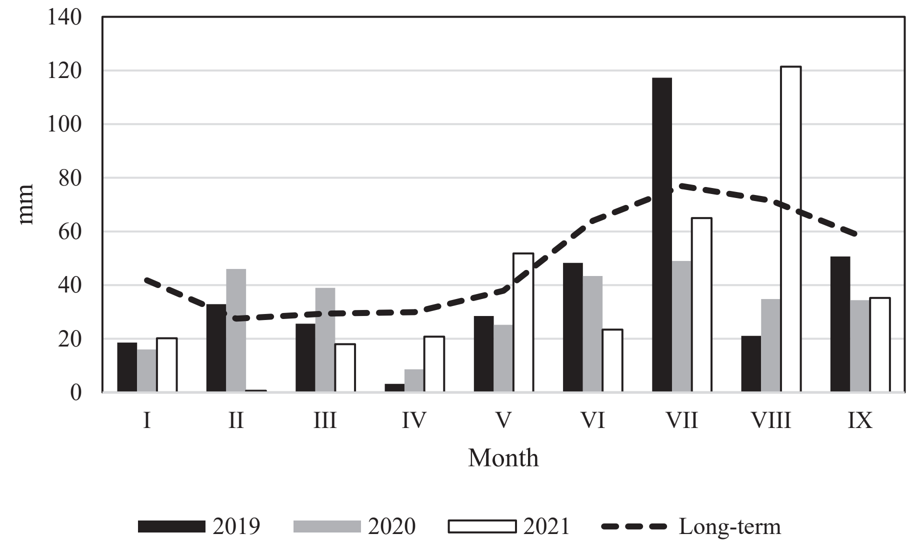

Figure 2. Sum of precipitations in Pūre, 2019–2021; the records of Pūre meteorological station.

between plants within rows. Bare soil was maintained both around bushes and in inter-rows, and no chemical plant protection products against pests or diseases were applied during the evaluation period. Three bushes per genotype were used for evaluation.

The following traits were evaluated: the susceptibility to American powdery mildew *Podosphaera mors-uvae* (Schwein.) U. Braun & S. Takam, septoria leaf spot *Mycosphaerella ribis* (Sacc.) Lindau, anthracnose *Drepanopeziza ribis* (Kleb.) Höhn, grey mould *Botrytis cinerea* on fruits, blackcurrant reversion virus (BRV) disease, white pine blister rust (WPBR) *Cronartium ribicola* J.C. Fisch., gall mites *Cecidophyopsis* spp., and spider mite *Tetranychus urticae*; winter and spring frost damage; yield, and fruit size. The evaluation was done by visual assessment using a ranking score system, according with the blackcurrant characterisation codes, which were used for the evaluation and description of accessions included in the ECPGR *Ribes* and *Rubus* Database (http://www.ribes-rubus.gf.vu.lt/). For susceptibility to diseases, pests, winter and spring frost damage, a 1–9 point scale was used, where: 1 = no damage; 3 = low; 5 = medium; 7 = high; 9 = very high damage. Winter damage and gall mite damage were evaluated in early spring. Blackcurrant reversion virus disease and spring frost damage were assessed during or after flowering. Leaf disease and grey mould susceptibility, and spider mite damage were assessed at the end of summer, during or after fruit harvest. Yield and fruit size were also evaluated using a 1–9 point scale, where for yield: 1 = no yield; 3 = low; 5 = medium; 7 = high; 9 = very high yield; and for fruit size: 3 = small; 5 = medium; 7 = large; 9 = very large fruit.

Biochemical analysis of fruits was conducted only on the most productive genotypes in 2020 and 2021, using frozen fruits. The contents of soluble solids, titratable acids, ascorbic acids (vitamin C), total anthocyanins and total phenols were determined according to the methods described by Kampuss *et al*. (2015).

Weather conditions varied across the study years. In winter 2019, the lowest air temperature was recorded at the end of January (-17.4 °C). During bud burst, sharp temperature fluctuations occurred, with frosts reaching as low as -5.2 °C. Frosts also occurred during flowering, with a minimum temperature of -2.1 °C, combined with low precipitation. Summer was characterised by warm, dry conditions in June and August, and wetter conditions occurring in July (Figure 1, Figure 2).

The 2020 season was also unfavourable for blackcurrants due to weather conditions. The winter was comparatively warm, not exceeding -10 °C, with the lowest air temperature recorded at the end of March (-7.8 °C). Spring frosts of up to -3.9 °C at the beginning of flowering caused damage to flowers.

Table 1

Susceptibility to pests and diseases, spring frost and winter damage, yield and fruit size of blackcurrant genotypes, average results of three years (2019-2021)

Accession name	*SS	SA	SM	SG	SW	SR	SM	SP	WD	SF	Y	FS
Karina	3.9	2.0	1.2	1.8	1.0	1.0	1.3	1.0	2.4	2.2	5.3	8.3
Mara Eglite	6.0	2.0	1.0	2.5	1.0	1.3	1.7	1.3	1.8	2.2	7.0	6.3
Ritmo	4.3	1.4	1.5	1.8	1.0	1.0	1.0	1.0	2.8	3.0	5.2	8.7
VI-2	3.4	1.2	1.4	1.8	1.0	1.0	1.0	1.0	2.3	2.4	3.8	6.0
VIII-11	1.4	2.1	2.5	1.7	1.0	1.7	1.3	1.2	2.8	4.4	3.7	6.0
X-4	2.3	2.8	1.7	1.8	1.0	3.7	1.2	1.0	1.4	2.8	3.5	6.0
XII-26	4.2	2.8	1.0	1.8	1.0	1.4	1.2	1.0	2.1	3.7	3.2	6.3
GEN 7	6.3	1.7	1.0	2.7	1.3	2.3	1.7	1.0	2.0	4.3	2.7	3.3
GEN 29A	5.7	2.5	3.2	3.0	1.0	5.0	2.0	1.0	1.3	4.3	1.8	4.0
GEN 43A	5.3	1.7	2.3	1.7	1.0	8.3	3.7	1.0	1.3	2.3	2.0	3.7
GEN 43F	6.5	2.3	1.0	3.3	1.0	7.0	4.0	1.0	1.3	2.5	1.3	3.0
GEN 49	5.7	1.4	1.8	1.8	1.2	3.7	5.2	1.2	2.3	4.0	1.3	3.0
GEN 233A	3.7	3.8	1.0	3.5	1.0	1.0	1.0	1.3	3.7	3.3	4.0	4.7
GEN 264	6.2	2.3	1.3	2.8	1.0	1.0	1.0	1.1	2.6	2.9	5.0	4.3
GEN 633	5.3	1.7	1.0	2.3	1.0	5.0	1.0	1.0	3.1	3.9	4.9	4.7
GEN 645	5.3	1.0	1.0	2.0	1.0	1.0	1.3	1.0	1.3	3.3	6.3	5.0
GEN 757	3.8	2.8	4.3	2.0	1.9	8.1	4.3	1.1	1.3	2.3	1.0	1.0
GEN 758	4.3	2.1	2.6	2.9	1.0	1.9	1.6	1.0	1.3	2.0	3.1	3.0
GEN 767	6.6	2.1	3.0	3.1	1.0	4.6	1.0	1.0	2.4	2.4	2.8	3.7
Min	**1.4**	**1.0**	**1.0**	**1.7**	**1.0**	**1.0**	**1.0**	**1.0**	**1.3**	**2.0**	**1.0**	**3.0**
Max	**6.6**	**3.8**	**4.3**	**3.5**	**1.9**	**8.3**	**5.2**	**1.3**	**3.7**	**4.4**	**7.0**	**8.7**
Mean	**4.8**	**2.1**	**1.8**	**2.3**	**1.1**	**3.2**	**1.9**	**1.1**	**2.1**	**3.1**	**3.6**	**5.3**
STDEV	**1.4**	**0.7**	**1.0**	**0.6**	**0.2**	**2.5**	**1.3**	**0.1**	**0.7**	**0.8**	**1.7**	**1.6**
CV%	**30**	**32**	**54**	**27**	**20**	**80**	**69**	**11**	**34**	**26**	**48**	**30**

**SS - susceptibility to septoria leaf spot; SA - susceptibility to anthracnose; SM - susceptibility to powdery mildew; SG - susceptibility to grey mould; SW - susceptibility to white pine blister rust; SR - susceptibility to blackcurrant reversion virus disease; SM - susceptibility to gall mites; SP - susceptibility to spider mite; SF - spring frost damage; WD - winter damage; FS - fruit size; Y - plant yield.*

During summer, alternating drought and rainfall affected fruit development.

The winter of 2021 was the coldest of the study period, with the lowest air temperature of -19.2 °C recorded in February. Very low temperatures persisted into early March, and spring frosts were observed occasionally until early May. June was warm and very dry, while heavy precipitation occurred at the end of July and in August. In July, the temperature reached a maximum of 32.2 °C.

All data were analysed by descriptive statistics and analysis of variance (ANOVA), followed by Fisher`s LSD at a level of significance P=0.05, and Pearson's correlation analyse by using Excel data Analyses tool pack.

Results and Discussion

The evaluated genotypes showed considerable variability in the resistance to different pests and diseases (Table 1). Septoria leaf spot was the most widespread fungal disease during the evaluation period, with generally high severity. Disease severity varied significantly between years ($p = 0.003$) and genotypes ($p < 0.000$), with the highest incidence recorded in 2021. None of the evaluated genotypes were resistant to *Mycosphaerella ribis*, while the breeding selections VIII-11 and X-4 showed the lowest levels of leaf symptoms of this disease.

The incidence of anthracnose was low in all years of evaluation, and most tested genotypes showed the low susceptibility to *Drepanopeziza ribis*. No significant differences among genotypes were found for this fungal disease. GEN 645 was the most resistant, showing no damage during the three-year evaluation period.

Historically, powdery mildew was one of the most prevalent blackcurrant diseases in Latvia, causing leaf and shoot damage and reducing yield (Bite & Laugale, 2002). However, due to successful applied breeding, newly released cultivars are now resistant to this pathogen, and the disease no longer causes large problems in commercial plantations. In the present study, powdery mildew also caused only minor damage. The highest resistance to *Podosphaera morsuvae* was observed for the cultivar 'Mara Eglīte', the expedition-collected genotypes GEN 233A, GEN 633, GEN 43F, GEN 645, GEN 7 and the hybrid XII-26. Disease severity varied significantly between years ($p = 0.048$), with the lowest incidence recorded in 2021.

In Latvia, the polygenic fungal pathogen - grey mould (*Botrytis cinerea)* is not considered an important blackcurrant disease of fruits (Lestlande *et al*., 2019). However, in other countries, grey mould is often difficult to control in blackcurrants and can result in considerable losses in yield and fruit quality (Boyd-Wilson *et al*., 2019; Xu, Robinson, & Berrie, 2009). In our collection, grey mould damage on fruits varied significantly between years ($p < 0.000$) and genotypes ($p = 0.001$). The highest incidence of disease symptoms occurred in 2021, while the lowest was in 2020, when low precipitation was recorded. None of the tested genotypes were fully resistant, although most of them showed very low levels of damage. The lowest susceptibility, on average, was observed for VIII-11 and GEN 43A.

White pine blister rust (WPBR) is caused by fungus that can infect *Ribes* species as well as certain susceptible pine species (Moročko, 2003), where five-needled white pines (*Pinus* L. section *strobus* L.) are particularly susceptible to this disease (Maloy, 1997). In the current study, WPBR was found only on a few genotypes and at very low severity. No significant differences in susceptibility among genotypes were observed, probably due to the overall low incidence of the disease during the evaluation years.

Blackcurrant reversion virus (BRV) is specific to currants and is the most damaging virus in *Ribes* spp. plantations worldwide (Adams & Thresh, 1987; Moročko-Bičevska *et al*., 2022; Susi, 2004; Šutic, Ford & Tošic, 1999). This virus causes two main types of disease: European (E) or Russian (R) forms with several morphological distortions and loss of yield, even causing complete plants' infertility (Mazeikiene, Juskyte & Stanys, 2019). The BRV disease was also present in our collection, with genotypes showing different levels of damage. The cultivars 'Karina' and 'Ritmo', hybrid VI-2, and several expedition-collected genotypes (GEN 233A, GEN 264, GEN 645) were the most resistant, showing no visible symptoms of the reversion virus.

Gall mites (*Cecidophyopsis* spp.) are among the most important pests in blackcurrants (Apenite *et al*., 2011). According to research carried out by A. Stalažs and I. Moročko-Bičevska (2016), instead of *C. ribis*, that was believed to be the major pest on currants, four other species were identified and reported to infest *Ribes* in Latvia: *C. alpina*, *C. aurea*, *C. spicata* and *C. selachodon*, all of which are not narrowly specialised to feed on a single host (Moročko-Bičevska *et al*., 2022; Stalažs & Moročko-Bičevska, 2016). Gall mites are mentioned as the main vectors of BRV transmission (Jones, 2002; Łabanowska & Pluta, 2010; Moročko-Bičevska *et al*., 2022). A significant positive correlation was found between the BRV susceptibility and gall mite infestation ($r = 0.57$; $p < 0.01$) in the evaluated blackcurrant collection. The cultivars 'Karina' and 'Ritmo', along with the expedition genotypes GEN 233A, GEN 264, GEN 633 and GEN 767 were the most resistant, with no bud galls observed over the studied years.

Spider mite is a pest of minor importance on blackcurrants in Latvian conditions (Stalažs, 2014). It was also confirmed in our investigation, where the damage was observed only in a few genotypes and at very low severity, with no significant differences among genotypes. This can be explained by unfavourable climatic conditions that inhibited the development of mites as their reproduction is promoted by warm and dry weather (Plīse, 2011).

Latvian winters are characterised by sharp temperature fluctuations, which are particularly harmful to blackcurrants after dormancy, making winter hardiness one of the most important factors limiting cultivation (Strautina & Lacis, 2000). During the evaluation period, winters were relatively mild, with the lowest winter damage to plants of the evaluated genotypes observed in 2020, which was the warmest winter. Nonetheless, significant genotypic differences in winter hardiness were detected ($p = 0.02$). Genotypes GEN 29A, GEN 43A, GEN 43F, GEN 645, GEN 757 and GEN 758 showed the lowest levels of winter damage, while GEN 233A and GEN 633 were the most affected.

Spring frosts occurred during flowering of blackcurrant genotypes in all three years of studies, leading to flower and bud loss, and reduced yields. The most severe frost damage occurred in 2021, when more than 50% of flower buds were damaged for some genotypes. On average over three years, the lowest frost damage to buds and flowers was observed on plants of GEN 758, 'Karina', 'Mara Eglite', GEN 43A, GEN 757, VI-2 and GEN 767. Differences in frost susceptibility of blackcurrant genotypes were also reported and studied in the UK (Carter *et al.*, 1999).

The fruit yield and fruit size (weight) are the key traits of the plant productivity. In this study, the fruit productivity was strongly influenced by the plant health status, spring frost damage and tested genotypes. The cultivar 'Mara Eglite' and GEN 645 produced the highest fruit yields, while GEN 757, heavily infected by BRV, showed no yields in any of the tested years. Other genotypes with high BRV infection also had very low yields and small fruits. The cultivars 'Karina' and 'Ritmo' were notable for producing very large fruits, although their yields were medium-high.

The blackcurrants are well known as a rich source of vitamins and antioxidants, and many previous studies have confirmed that genotypes differ greatly in their content (Kampuss & Pedersen 2005; Kampuss & Strautina, 2004; Kampuss, Strautina & Krasnova, 2015; Siksnianas *et al*., 2006). It was also observed in our study (Table 2).

Sugars and organic acids are the principal soluble constituents of berries and exert a significant influence on fruit taste and ripening (Mikulic-Petkovsek *et al.*, 2013). In the present study, the soluble solids content of blackcurrant fruits ranged from 12.8 to 22.0 °Brix, depending on the genotype and year. Previous research conducted in Latvia reported soluble solids content in fruits of various blackcurrant accessions ranging from 11.0 to 20.2 °Brix (Kampuss, Strautina & Krasnova, 2015), which is comparable to our findings. On averaged over two years, the fruits of genotype GEN 233A exhibited the highest soluble solids content.

Table 2

Fruit biochemical composition of some blackcurrant genotypes, average results over two years (2020-2021) (±STDEV)

Accession	Soluble solids (°Brix)		Titratable acids (%)		Total phenols (mg 100 g^{-1})		Total anthocyanins (mg 100 g^{-1})		Ascorbic acid (mg 100 g^{-1})	
Karina	14.75	±0.38	3.42	±0.02	376.39	±20.81	95.02	±5.34	53.65	±0.85
Mara Eglite	17.11	±0.54	3.28	±0.02	470.78	±30.72	134.62	±3.78	120.62	±2.75
Ritmo	17.08	±0.67	3.05	±0.02	355.34	±20.71	97.03	±8.81	44.22	±1.58
VI-2	17.57	±0.22	3.32	±0.02	393.99	±13.21	139.38	±4.61	53.64	±1.87
VIII-11	16.71	±0.16	4.12	±0.07	409.66	±29.00	161.02	±13.55	98.37	±1.10
GEN 233A	20.27	±0.77	2.80	±0.00	624.44	±49.47	234.73	±4.14	119.33	±0.36
GEN 633	19.55	±0.31	2.31	±0.02	491.59	±34.68	198.29	±5.16	99.21	±1.00
GEN 645	18.27	±0.18	2.91	±0.07	537.87	±17.36	161.39	±9.47	91.96	±0.99
GEN 767	19.58	±0.59	2.56	±0.05	546.91	±18.13	173.39	±10.33	82.22	±0.54

Other genotypes selected during expeditions also had higher soluble solids content than the evaluated cultivars and hybrids. The lowest soluble solids content was recorded in the cultivar 'Karina'. The lowest content of titratable acids was stated for GEN 633, while the highest was for VIII-11.

Phenolic compounds are widely recognised as bioactive constituents with significant health benefits, and blackcurrant fruits are considered a rich source of polyphenols (Karjalainen *et al*., 2009; Kratchanova, Denev & Kussovski, 2005; Scalbert *et al*., 2005; Shahidi & Naczk, 1995; Vagiri, 2012). In the present study, the total phenolic content of the fruits ranged from 272 to 675 mg 100 g^{-1} and differed significantly between years, with lower values observed in 2020. This variation can likely be attributed to differences in weather conditions between the years. Temperature and solar radiation have been identified as the major environmental factors influencing the accumulation and composition of phenolic compounds (Zheng *et al*., 2012). Averaged over two years, fruits of the genotype GEN 233A exhibited the highest total phenolic content among the evaluated genotypes (Table 2). Similar to the results for soluble solids content, other genotypes selected during the expeditions also showed higher total phenolic content than the tested cultivars and hybrids.

Similar to the total phenolic content, fruits of genotype GEN 233A also exhibited the highest total anthocyanin content. The large fruited cultivars, 'Karina' and 'Ritmo' exhibited the lowest total anthocyanin content. It can be explained by the fact that most anthocyanins are located in fruit skin, and the proportion of the skin per weight unit is higher if berries are smaller (Kampuss, Strautina & Krasnova, 2015).

Ascorbic acid (vitamin C) is one of the main nutritional components found in *Ribes*, and blackcurrants are an excellent source of it (Brennan, 1991; Szajdek & Borowska, 2008). Ascorbic acid content in the evaluated black currant genotypes ranged from 40 to 156 mg 100 g^{-1} frozen fruit and differed between years and genotypes, with higher values observed in 2021. It has been confirmed by other researchers that environmental and genetic factors greatly contribute to the different content levels of ascorbic acid in blackcurrant fruit (Mikulic-Petkovsek *et al*., 2013, Woznicki *et al*., 2015). Fruits of GEN 233A contained the highest level of ascorbic acid on average over the two years. The cultivar 'Mara Eglīte' also had a high ascorbic acid content in its fruits, comparable to GEN 233A.

In total, fruits of GEN 233A stood out with the highest biochemical value, containing the highest levels of soluble solids, total phenols, anthocyanins and ascorbic acid.

Conclusions

Valuable accessions and donors for breeding of new cultivars used in the sustainable production were identified in the local blackcurrant genetic resources collection in Latvia, including the local cultivars, breeding selections, and genotypes collected during the expeditions. The accessions 'Karina', 'Ritmo', VI-2, GEN 233A, GEN 264 and GEN 645 were selected as the most valuable for breeding resistance to pests and diseases, while GEN 758 was identified as a donor of cold resistance. In addition, GEN 233A was recognised for the high nutritional value of its fruits.

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