

Phenotypic diversity of *Fragaria vesca* and *F. viridis* in Lithuania

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Variation of nine phenotypic characters measured in a field collection was assessed among ten *Fragaria vesca* L. and five *Fragaria viridis* Weston accessions from diverse native populations across Lithuania. Analysis of variance (ANOVA) revealed significant differences for quantitative characters evaluated at both accession and species levels. The phenotypic characters of plants (number of flowers per inflorescence, flower diameter, length of inflorescence and length of petiole) differed significantly between *F. vesca* and *F. viridis*. The differences in phenotypic characters among accessions were specified by the Scheffe test. Among *F. vesca* accessions, a high variation in the weight of 100 berries and petiole length was established. The accessions of *F. viridis* varied significantly in the majority of their phenotypic characters. The highest variations within accessions of both species were observed in the number of flowers per inflorescence and flower diameter.

Key words: *Fragaria vesca*, *Fragaria viridis*, accession, phenotypic character, phenotypic diversity, analysis of variance

INTRODUCTION

The typical properties of *Fragaria* species, *Rosaceae*, are as follows: they are perennial herbaceous plants with bisexual flowers; the fruit botanically is not a true fruit but a fleshy receptacle. In Lithuania, two species of the genus, *F. vesca* L. and *F. viridis* Weston, occur naturally in the wild and two others, *F. moschata* Weston and *F. × ananassa* Duchesne ex Rozier are found escaped from cultivation [1]. All these species, the authority of which has been recently updated [2], are important as crop wild relatives of extensively cultivated strawberries. The diploid *F. vesca* and *F. viridis* also could be used in the model systems for the studies of phenotypic evolution in plants [3]. In general, *F. vesca* is much better investigated across its distribution range than *F. viridis* is. However, no detailed morphological studies have been performed with the two species in Lithuania so far.

Fragaria vesca, the wild strawberry, grows in forests, forest glades and at forest margins. It is a light-demanding species growing on moderately fertile and not too dry soils and occurring on all the territory of the country. Its fruit are slightly conic to globose, bright red with a strong distinct aroma and sepals reclining back. Much less frequent is *Fragaria viridis*, the green strawberry. It grows on dry sunny slopes and in riverine meadows. Its flowers are straw

white; fruit are oblate, usually greenish white with pink tops, clasped by sepals from which they poorly separate. The fruit have an apple-like aroma. The flowering period of both species is May through June and of fruiting June through July.

There are some references to show that both species were cultivated in Lithuania earlier [4].

The present study aims to evaluate the phenotypic diversity of the native Lithuanian species *Fragaria vesca* and *F. viridis*, collected in the wild and conserved *ex situ* in a field collection as genetic resources of horticultural crops.

MATERIALS AND METHODS

A total of 15 accessions representing two *Fragaria* species and consisting of 9 separate plants each (Table 1) were transferred from different native populations to the field collection of the Institute of Botany in 2003. There was sandy loam soil with a normal groundwater regime in the field collection. Common horticultural practices were applied for the maintenance of the plants, which grew and propagated vigorously. Harvesting and analysis of plant material of 30 individual plants per accession were made in the second year of cultivation. In total, 9 quantitative phenotypic characters of reproductive and vegetative plant development were measured over the course of one growth season.

Table 1. Collecting data on *Fragaria* accessions

No.	Collecting number	Species	Collecting site location	Geographic coordinates
1	EB02030529	<i>F. vesca</i>	Kernavė, Īirvintos municipality	N54°52'27.6" E24°50'28.2"
2	EB03030529	<i>F. vesca</i>	Ēiobiškis, Œirvintos municipality	N54°58'24.9" E24°37'46.5"
3	EB05030529	<i>F. vesca</i>	Mikalauėiėkės, Kaišiadorys municipality	N54°54'50.0" E24°39'58.1"
4	EB06030529	<i>F. vesca</i>	Paparėiai, Kaišiadorys municipality	N54°53'52.1" E24°42'21.9"
5	EB07030529	<i>F. vesca</i>	Naravai, Kaišiadorys municipality	N54°53'45.9" E24°42'15.3"
6	EB08030530	<i>F. vesca</i>	Rykantai, Trakai municipality	N54°45'56.5" E24°53'55.8"
7	EB09030607	<i>F. vesca</i>	Minija Landscape Reserve, Kretinga municipality	N55°56'20.8" E21°29'19.4"
8	EB10030607	<i>F. vesca</i>	Telšiai, Telšiai municipality	N55°59'32.3" E22°30'38.9"
9	SK02030608	<i>F. vesca</i>	Meėkapiėvės forestry district, Prienai municipality	N54°37'88.0" E23°51'39.0"
10	JL01030622	<i>F. vesca</i>	Dūkėtos, Vilnius municipality	N54°48'16.3" E24°54'31.1"
11	EB01030529	<i>F. viridis</i>	Kernavė, Īirvintos municipality	N54°52'27.6" E24°50'28.2"
12	EB04030529	<i>F. viridis</i>	Ēiobiškis, Œirvintos municipality	N54°58'23.8" E24°37'24.8"
13	EB06030529	<i>F. viridis</i>	Paparėiai, Kaišiadorys municipality	N54°53'52.1" E24°42'21.9"
14	BK10030607	<i>F. viridis</i>	Martynaiėiai mound, Kretinga municipality	N55°56'29.5" E21°29'39.6"
15	SK01030529	<i>F. viridis</i>	ėakaliėkiai, Marijampolė municipality	N54°33'14.8" E23°41'09.0"

In order to determine statistically significant differences between the obtained values, a one-way analysis of variance (ANOVA) using the STATISTICA software package was employed. The means of each of the quantitative characters were compared by Scheffe's test for significant differences at both the species and accession levels. For determining the variability of phenotypic characters within accessions, a variation coefficient (CV, %) was calculated.

RESULTS AND DISCUSSION

Table 2 summarizes the results of the quantitative phenotypic assessments and differences observed in the vegetative and reproductive characters of the two species. The analysis of variance revealed significant differences for characters evaluated at both the accession and species levels. The obtained results indicate a high phenotypic diversity of both species and correspond in general with those reported by Sargent et al. [3]. In Table 2, Fisher's (F) criterion indicates the significance of differences between accessions and Student's (t) criterion between species. Thus, the statistical analysis showed that the

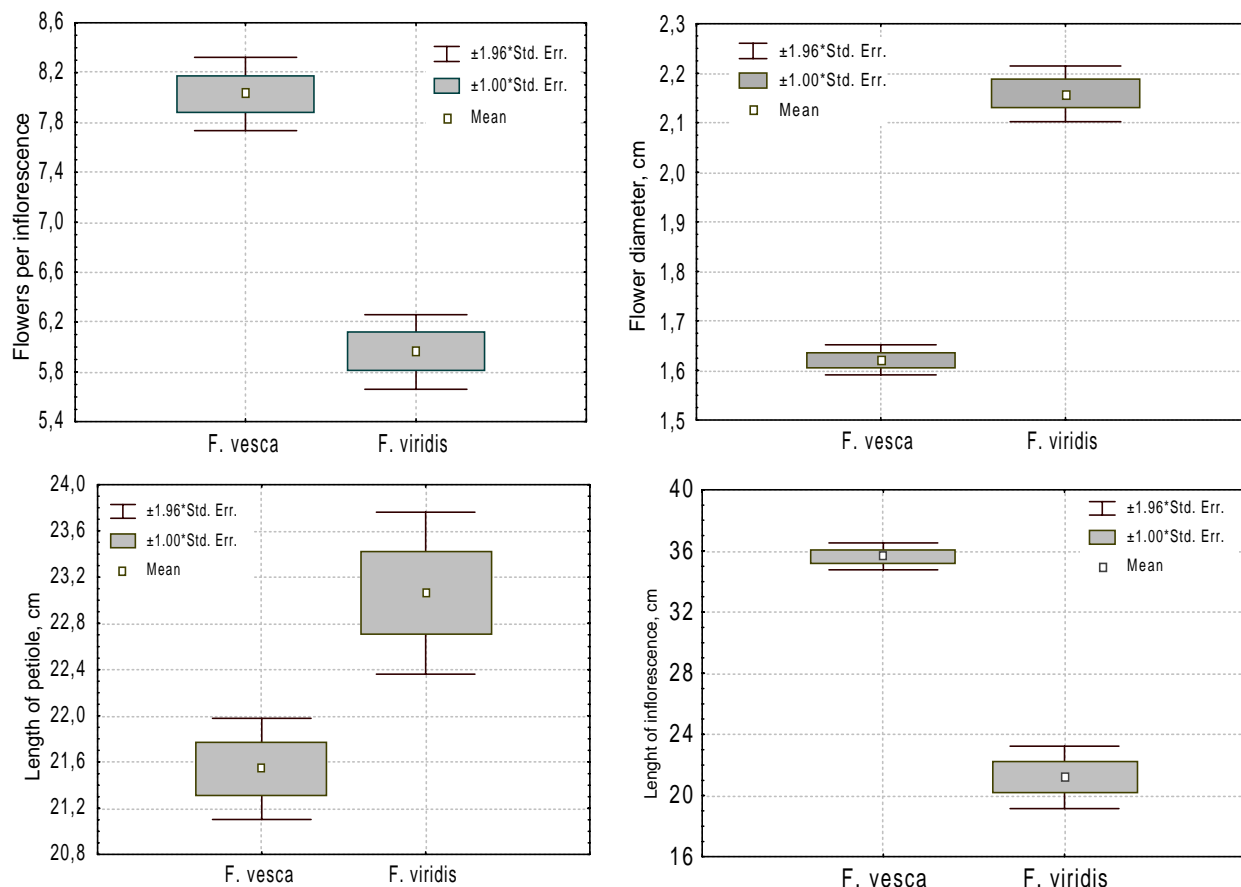
inflorescences of *F. viridis* were composed of 4–7 flowers, while *F. vesca* produced significantly higher numbers (6–12) of flowers per inflorescence (also see Fig. 1). However, the flowers of *F. viridis* were much bigger in diameter (1.91–2.22 cm) than those of *F. vesca* (1.41–1.73 cm). Significant differences between the species were also observed in the length of petioles and inflorescences. The shorter petioles and longer inflorescences were typical for *F. vesca* if compared to *F. viridis*. The peduncle of *F. vesca* was taller than rosette leaves (mean inflorescence length 35.65 cm), while in *F. viridis* the inflorescence was hidden beneath the rosette leaves. This could be a possible reason why no fruiting plants were observed among the accessions of *F. viridis*, although they flowered abundantly.

The analysis of variance revealed highly significant differences ($p < 0.05$) among *F. vesca* and *F. viridis* accessions in the majority of characters studied (Table 2). Peak values of the F statistics were observed for the length of petiole and inflorescence, length and width of leaf, weight of 100 berries. Only the average diameter of flower and the length and width of berry did not differ significantly among the accessions.

Table 2. Summary statistics of *F. vesca* and *F. viridis* characters and the level of differentiation of species and accessions according to each character by ANOVA Fisher's F and Student's t criteria

Character	<i>F. vesca</i> , n = 10			<i>F. viridis</i> , n = 5			t	df
	M	M _{min} - M _{max}	F	M	M _{min} - M _{max}	F		
Length of leaf, cm	7.98	7.28–9.03	7.09*	7.60	6.16–8.68	31.44*	3.05	447
Width of leaf, cm	13.78	12.17–15.39	8.24*	13.46	11.59–15.22	22.94*	1.61	447
Length of petiole, cm	21.54	17.78–25.99	27.35*	23.06	19.30–27.53	24.60*	-3.75*	447
Flowers per inflorescence	8.03	5.98–11.71	9.80*	5.96	4.49–6.98	12.28*	8.63*	888
Flower diameter, cm	1.62	1.41–1.73	1.67	2.16	1.91–2.22	4.40	-16.55*	607
Length of inflorescence, cm	35.65	32.10–40.50	4.53*	21.19	14.40–33.70	42.51*	14.83*	149
Berry length, cm	1.07	0.96–1.16	2.87	–	–	–	–	–
Berry width, cm	1.30	1.15–1.41	2.76	–	–	–	–	–
Weight of 100 berries, g	59.98	41.37–74.47	18.25*	–	–	–	–	–

M – mean; M_{min} – M_{max} – range of mean values within accessions; F – Fisher's criterion; t – Student's criterion; df – degree of freedom; asterisk (*) indicates differences that are significant at $p < 0.05$; no fruiting was observed in *F. viridis*.

**Fig. 1.** Comparison of phenotypic characters of *Fragaria vesca* and *F. viridis*

The differences of phenotypic characters among accessions were specified by the Scheffe test. Fruit size and weight are of primary importance in consumer's selection of strawberries, thus, most breeders are concerned with these characters [5]. Among *F. vesca* accessions, a wide variability in the average weight of 100 berries was established. The

accessions of *F. vesca* fell into four homogenous groups according to the weight of 100 berries (Fig. 2). Most of accessions fell into the group of medium berry weight: 100 berries weighed 61–66 g. The other group had 100 berry weights of 49–52 g. Two single accessions stood out for the largest (100 berries weighed 74 g) and the smallest berries (100 berries

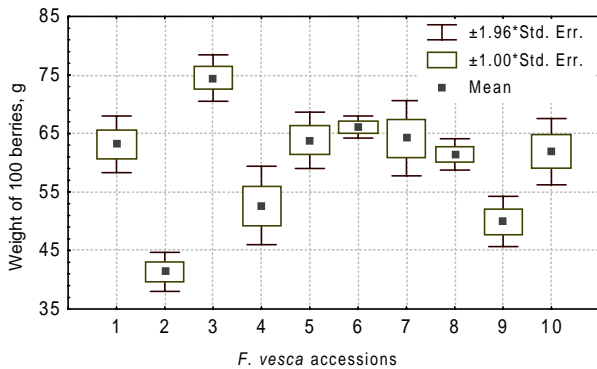


Fig. 2. Variation of weight of 100 berries among *Fragaria vesca* accessions (accession numbers correspond to those in Table 1)

weighed 42 g). The variation in the weight of 100 berries within the accessions was quite low (CV = 2–9 %).

The statistical analysis revealed that accessions of *F. vesca* fell into one homogenous group according to the average berry length and width (0.96–1.16 and 1.15–1.41 cm, respectively). The variation of berry length and width within the accessions was not high: CV = 11–21% and 9–24%, respectively.

Flower diameter was not statistically different among accessions. However, it varied highly within the accessions of both *F. vesca* and *F. viridis*, CV = 10–40% and 9–27%, respectively.

Significant differences were observed in the number of flowers per inflorescence within accessions in both species. The accessions with high numbers of flowers prevailed. Within accessions the highest variation in the number of flowers per inflorescence was observed, CV being 30–55% and 34–47% for *F. vesca* and *F. viridis*, respectively.

According to leaf length and width, two homogeneous groups of accessions might be established in *F. vesca* and three in *F. viridis*. Within the accessions, moderate variations in leaf length (*F. vesca* CV = 11–15%, *F. viridis* CV = 10–17%) and width (*F. vesca* CV = 10–14%, *F. viridis* CV = 9–15%) were observed.

Statistical analysis indicated that petiole length was a highly variable character not only at the species but also at the accession level of the species. The results showed moderate variations within accessions of both species: CV = 12–17% in *F. vesca* and 13–16% in *F. viridis*.

The results showed that the number of flowers per inflorescence, the diameter of flowers, the length and width of berries are relatively constant characters at the accession level and highly variable within the

accessions, indicating a role of genetic factors to be more important than those environmental.

The obtained results confirm a high phenotypic diversity of both *F. vesca* and *F. viridis* and may facilitate identification of genetic diversity of the species as well as selection of the future breeding material.

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FRAGARIA VESCA IR F. VIRIDIS FENOTIPINĖ ĄVAIROVĖ LIETUVOJE

Santrauka

Atliktø tyrimø duomenys rodo didelę paprastuosios (*Fragaria vesca* L.) ir ðlaitinės þemuogės (*F. viridis* Weston) fenotipinę ávairovę. Morfologiniai požymiai ávairuoja ne tik tarp rūðiø, bet ir tarp tos paėios rūðies skirtingø kolekcinø pavyzdþiø. Tirtos rūðys statistiškai patikimai ($p < 0,05$) skiriasi þiedyno ir lapkoėio ilgiu, þiedø skaiėimi þiedyne, þiedø skersmeniu. Požymiø skirtumai tarp kolekcinø pavyzdþiø konkretizuoti Sheffe's testu. Didþiausi *F. vesca* kolekcinø pavyzdþiø skirtumai nustatyti tarp augalø lapkoėio ilgio ir uogø masės. *F. viridis* kolekciniai pavyzdþiai statistiškai patikimai skiriasi daugeliu požymiø. Abiejø þemuogiø rūðiø þiedø skaiėiaus þiedyne, þiedø skersmens, uogø ilgio ir ploėio skirtumai tarp kolekcinø pavyzdþiø nėra dideli, taėiau labai ávairuoja jø viduje. Tai rodo, kad ðie požymiai labiau priklauso nuo augalo genetinø ypatybø negu nuo aplinkos veiksniø.

Tyrimø rezultatai gali bũti panaudoti ávertinant þemuogiø genetinius iðteklius, taip pat selekcijoje.