

Analysis of Vegetative and Generative Characters of *Fragaria vesca* L. (Rosaceae) Populations

**Samira Huseinović^{a*}, Sanida Bektić^a, Kovačević Mirsada^b
and Salkić Besim^b**

^a Faculty of Science, University of Tuzla, Univerzitetska 4, 75 000 Tuzla, Bosnia and Herzegovina.
^b Faculty of Technology, University of Tuzla, Univerzitetska 7, 75000 Tuzla, Bosnia and Herzegovina.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2021/v24i1030263

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/78976>

Original Research Article

Received 18 October 2021
Accepted 20 December 2021
Published 22 December 2021

ABSTRACT

Rose family (Rosaceae) is one of richest and most geographically widespread species of plant families. This family includes herbaceous and woody species, shrubs, and trees; the leaves are different, simple, or differently complex. The genus *Fragaria* (strawberry) includes perennial herbaceous plants. It is characteristic of this genus that the species are intensively vegetatively propagated using overhead stolons. The flowers are with a five-membered perianth and a developed outer cup. The flower has a larger number of anthers and carpels. A sample was taken at each site at least 30 individuals from the population in the flowering and fruiting phenophase. Morphological variability was assessed based on 5 populations and 150 individuals. This paper aims to determine the most variable and most consistent morphological characters that can serve in full and critical taxonomic analysis and revision of this variable taxon as well as related taxa from the family Rosaceae. Determine the forms and levels of individual, population, and interpopulation variability of the species *Fragaria vesca* L. depending on the environmental factors under which develop. Conducted comparative morphological analyzes have shown that the species *Fragaria vesca* L. shows a high degree of variability for all analyzed characters. Vegetative plant characters have a far greater share in overall variability compared to generative ones character. Pold does not belong to the group of those plant parts that vary the most.

Keywords: *Fragaria vesca*; variability; taxa; characters.

*Corresponding author: E-mail: samira.huseinovic1@gmail.com;

1. INTRODUCTION

The study of morphological characteristics of plants and the determination of the constancy of occurrence of a given character, in a large number of units, can present significant scientific data for the description of a certain species. Morphological traits are not always uniform [1,2]. (Nikolic, 2013). If, during the ecological differentiation, there is a break in the genetic communication between the populations that inhabit different habitats, the basic conditions for the emergence of new taxa are acquired. Conclusions on the degree of similarity of individual taxa have some basis only if they take into account many characteristics: from macroscopic characteristics of the external habitus (eg age, branching, hairiness, leaf shape and size, structure and size of flowers, etc.) through physiological-ecological characteristics of life processes to the molecular range of chemical compounds (Ehrendorfer, 1997).

Research on the species *Fragaria vesca* L. has been carried out by many scientists around the world. The most famous publications are: Adams, C. (Jamaican Flowering Plants, 1972); Clapham, A. R. et al. (Flora of the British Isles, 1962); F. Turk and Davis, P. H., ed. (Flora of Turkey and the Eastern Aegean Sea, 1965–1988); Duke, J. A. et al. (CRC Handbook of Medicinal Herbs, 2002); Zander and Encke, F. et al. (Handbook for Plant Determination, 1993); Gleason, H. A. & Cronquist, A. (Manual for the Determination of Vascular Plants of the Northeastern United States Bordering Canada, 1963); Hitchcock, C. L. et al. (Vascular Plants of the Northwest Pacific, 1955–1969); Iwatsuki, K. et al. (Flora of Japan, 1993)

The nomenclature of the species given in the record review is in a project of typified Line plant names housed in the Museum of Natural History in London. 09/03/1999 is a verified species name by ARS Systematic Botanists. The last change in the nomenclature of the species was made on January 14, 2006. The germplasm of the species *Fragaria vesca* L. is stored in the National Germplasm repository for cloning in Corvallis.

According to the degree of biodiversity determined to date, the family Rosaceae is one of the most systematically complex taxa. The family includes 115 genera and over 3000 species. Today's taxonomy most often uses the division of the Rosaceae L family to 4 subfamilies: Spiraeoideae, Rosoideae, Maloideae (Pomoideae) and Prunoideae.

The systematic position of the genus *Fragaria* L. within the family Rosaceae L. is as follows:

Family: Rosaceae

Juss., Gen. 334 (1789): Benth. Hook., Gen., I, 600; Baill., Hist pl., I, 346; Focke in Nat. Pflanzenf., III, 3, 1; Asch. Gr. Son. Mitt. Fl., VI 1, 5; Beck in Reich., Ic. Fl. Germ., XXV 1, 2.

Tribus 1: Dryadeae

Vent., Tabl., III, 346 (1799); DC, Prodr., II, 549; Beck, Fl. Nied. - Öst., 718 et in Reich., Ic. Fl. Germ., XXV 1, 2. - Potentilleae Juss., Gen., 337 (1789); div. Potentillea Spreng, Anl, II 2. 863 (1818); trib, aput Benth.Hook., Gen, I, 603; Focke in Nat. Pflanzenf., III 3, 28; Asch. Gr. Syn. mitt. Fl., VI, 440.

Subtribus: Potentilleae

Beck in Reich., Ic. Fl. Germ., XXV 1, 70.

Genus: *Fragaria*

L., Spec. pl., 494 (1753) et Gen, ed V, 518 no. 58; Benth. Hook., Gen., I, 620; Focke in Engl.

Prantl, Nat. Pflanzenf, III 3, 33; Asch. Gr., Syn. Mitt. Fl., VI, 649; Beck in Reich., Ic. Fl. Germ, XXV 1, 2. - Confer: Solms- Laubach, unber unsere Erbeeren und ihre Geschichte in Bot. Time. (1907) Heft III - IV.

Table 1 shows the status of individual species of the genus (Tutinetal. (Ed), 1964-1993, Flora Europaea).

2. MATERIALS AND METHODS OF WORK

Live material of *Fragaria vesca* L species was collected at selected ecologically different habitats. At each locality a sample of at least 30 individuals from the population in the flowering and fruiting phenophase was taken. Morphological variability was perceived based on 5 populations and 150 individuals. During the collection of plants in the field, the keys for the determination of plant species were used (Domac, 1997),[(3)]. All specimens are neatly stored in the herbarium.

As the collection of plant material was done at the time of flowering and at the time of fruiting, the material collected at the time of flowering (late May and early June) was neatly

herbariumed. Each population and its individual are marked with special numbers.

In addition to morphometric and statistical processing of materials and data, the laboratory part of the research included numerous activities: consulting the relevant literature, collecting, and processing ecoclimatic data, making original illustrations, etc.

Morphological - anatomical research of the species *Fragaria vesca* L. from the localities Vučkovci, Rajska, Zelina Srednja, Svirac and Krečane were realized in the laboratories of the Faculty of Natural Sciences and Mathematics in Tuzla.

3. RESULTS AND DISCUSSION

The taxon *Fragaria vesca* L. has expressed ecological valence in relation to the complexity of ecological factors. Its populations develop very well on the bare parent substrate, on shrubs, fires, and on developed soils of hornbeam, beech, oak, ie. by mixed forest type of forest.

3.1 Variability of Morphometric Characters

Comparative-morphological analysis of the collected floristic material from different habitats showed a significant degree of variability of the character set in the taxon *Fragaria vesca* L.

Table 1 shows significant variations of all observed characters. Following the coefficient of variability, it is noticeable that the characteristics of the width of the outer calyx (50.011%), the length of the flower stalk (41.774%) vary far more than the character of the number of inserts on the middle retinal leaf least variable character.

3.2 Results of Variational-Statistical Analysis

T-test results in a comparison of morphometric characters

Locality 1: Locality 2, 3, 4, 5 Statistically significant differences were found in the comparisons of the following characters (Table 2).

In the comparison of the characters: Total leaf length with the petiole, length of the first lobe of the rosette leaf, length of the flower stalk, length

of the inner calyx, the maximum width of the inner calyx, fruit width, less statistical significance was found.

Minor statistically significant differences were observed for: the length of the first lobe of the rosette leaf, the length of the inner calyx, the length of the petal, the number of teeth on the middle lobe of the rosette leaf on one side, the fruit expands.

Minor differences were found for: height of plant with flowers, the total length of the leaf with petiole, length of leaf stalk of rosette leaf, length of the middle lobe of rosette leaf, length of first lobe of rosette leaf, length of flower stalk, length of inner calyx, maximum width of inner calyx, petal length, length of outer calyx.

The following statistical significance was determined for these localities for: height of the plant with flowers, the total height of the leaf with the petiole, length of the petiole of the rosette leaf, length of the middle lobe of the rosette leaf, length of the inner calyx, the maximum width of the inner calyx, number of teeth on the middle lobe rosette leaf on one side, length of outer calyx leaf, fruit width.

Statistically less significant differences were found for: length of the middle lobe of rosette leaf, length of the first lobe of rosette leaf, length of inner calyx, the maximum width of petals, number of teeth on the middle lobe of rosette leaf on one side, fruit width.

3.2.1 An's analysis

The difference between all locations for all variables together is tested. Testing is performed by Wilks-lambda test, and it is shown that there is a significant difference between variables by location ($p < 0.01$).

Minor statistically significant differences of An's analysis were found when comparing the variables: length of the middle lobe of rosette leaf, the maximum width of the middle lobe of the rosette, length of the first lobe of rosette leaf, length of the flower stalk, length of inner calyx, the maximum width of the inner calyx.

3.2.2 Correlations

A statistically significant correlation was found between the height of the plant with flowers and the total length of the leaf with the leaf stalk. This correlation is greater than 0.80.

Table 1. Comparative presentation of statistical data for the studied characters of the genus *Fragaria vesca* L. in the observed populations

All	Valid N	Mean	Median	Variance	Std. Dev.	Coef. Var.	Stand. Error	Skewness	Curtosis
Plant height with flowers	150	20.571	18.7	38.275	6.187	30.074	0.505	0.851	0.378
Total Leaf Length with Leaf Handle	150	15.825	15.0	25.191	5.019	31.715	0.410	0.770	0.249
The length of the leaf stalk of the rosette leaf	150	11.440	10.8	18.860	4.343	37.961	0.355	0.831	0.613
Length of Middle Lobe Rosette Leaf	150	4.220	4.1	1.588	1.260	29.858	0.103	0.605	0.337
Maximum width of the middle lobe of the leaf	150	2.726	2.6	0.403	0.635	23.292	0.052	0.366	0.165
Length of First Lobe rosette leaf	150	3.390	3.3	0.845	0.919	27.119	0.075	0.512	1.067
Maximum width of the first lobe of the rosette	150	2.259	2.2	0.345	0.587	26.005	0.048	0.716	0.776
Flower Stalk Length	150	3.037	2.8	1.610	1.269	41.774	0.104	1.298	2.935
The length of the inner calyx leaf	150	0.549	0.5	0.030	0.173	31.406	0.014	2.519	17.775
Maximum width of the inner calyx leaflet	150	0.242	0.2	0.006	0.077	31.944	0.006	2.469	17.101
Petal length	150	0.701	0.7	0.051	0.226	32.297	0.018	0.298	0.767
Maximum Drawer Width	150	0.658	0.6	0.049	0.221	33.651	0.018	0.255	-1.156
Number of teeth on the middle lobe of the rosette leaf on one side	150	8.153	8.0	1.889	1.374	16.857	0.112	-0.328	5.769
Width of Outer Calyx Leaf	150	0.298	0.3	0.022	0.149	50.011	0.012	0.052	-1.270
Length of Outer Calyx Leaf	150	0.126	0.1	0.003	0.058	46.197	0.005	2.942	11.851
Fruit length	150	9.522	9.4	3.516	1.875	19.691	0.153	1.073	4.050
Fruit width	150	9.808	9.7	3.202	1.789	18.243	0.146	1.758	7.285

Table 2. Characters for which statistically significant differences were found at locations 2,3,4,5

Locations Variable	Location 1		Lokation 2		Lokation3		Lokation 4		Lokation 5	
	t-value		t-value	p-value	t-value	p	t-value	p	t-value	p
Plant Height With Flowers			0.70	0.488	1.66	0.102	-0.27	0.785	-5.83	0.000
Total Leaf Length With Leaf Handle			0.46	0.650	-0.01	0.994	2.31	0.025	-7.23	0.000
The length of the leaf stalk of the rosette leaf			0.22	0.825	-0.54	0.593	1.65	0.103	-6.27	0.000
Length of Middle Lobe Rosette Leaf			1.13	0.264	1.52	0.134	3.65	0.001	-1.32	0.193
Maximum width of the middle lobe of the leaf			0.84	0.403	1.45	0.151	2.66	0.010	-1.44	0.156
Length of First Lobe rosette leaf			2.12	0.038	-0.54	0.593	-0.14	0.890	-1.47	0.146
Maximum width of the first lobe of the rosette leaf			0.43	0.667	-1.10	0.276	-1.26	0.211	-1.12	0.269
Flower Stalk Length			4.10	0.000	3.19	0.002	3.44	0.001	-1.11	0.270

Locations	Location 1	Lokation 2	Lokation3	Lokation 4	Lokation 5				
Variable	t-value	t-value	p-value	t-value	p	t-value	p	t-value	p
The length of the inner calyx leaf		2.29	0.026	2.57	0.013	1.11	0.271	2.09	0.041
Maximum width of the inner calyx leaflet		1.91	0.061	2.70	0.009	0.65	0.518	0.94	0.352
Petal length		-0.91	0.366	1.26	0.213	-8.02	0.000	-1.95	0.056
Maximum Drawer Width		-0.49	0.627	1.31	0.197	-7.90	0.000	-1.08	0.285
The number of teeth on the middle lobe of the rosette leaf on one side		0.56	0.576	-0.98	0.333	-1.71	0.092	-1.02	0.311
Width of Outer Calyx Leaf		-0.22	0.829	-1.18	0.241	-1.90	0.063	-1.68	0.099
Length of Outer Calyx Leaf		-0.45	0.653	0.68	0.497	-1.75	0.086	-0.41	0.681
Fruit length		-0.12	0.908	0.37	0.713	0.78	0.440	1.08	0.284
Fruit width		-0.48	0.634	-1.21	0.231	-2.80	0.007	0.35	0.725

Table 3. Characteristics for which statistically significant differences were found at locations 1,3,4 and 5

Locations	Location 1	Location 2	Location 3	Location 4	Location 5					
Variable	t-value	p	tt-value	p	t-value	p	t-value	p	t-value	p
Plant Height with Flowers	0.70	0.488			0.80	0.429	-1.11	0.272	-6.62	0.000
Total Leaf Length with Leaf Handle	0.46	0.650			-0.53	0.598	1.69	0.097	-7.33	0.000
The length of the leaf stalk of the rosette leaf	0.22	0.825			-0.73	0.468	1.30	0.200	-6.19	0.000
Length of Middle Lobe Rosette Leaf	1.13	0.264			-0.04	0.965	1.93	0.058	-2.22	0.030
Maximum width of the first lobe of the rosette leaf	0.84	0.403			0.51	0.615	1.75	0.085	-2.19	0.032
length of first lobe rosette leaf	2.12	0.038			-2.56	0.013	-2.00	0.050	-3.06	0.003
Maximum width of the first lobe of the rosette leaf	0.43	0.667			-1.57	0.121	-1.63	0.109	-1.48	0.143
Flower Stalk Length	4.10	0.000			-1.49	0.141	-1.50	0.140	-4.26	0.000
The length of the inner calyx leaf	2.29	0.026			-0.08	0.934	-2.06	0.044	-0.65	0.517
Maximum width of the inner calyx leaflet	1.91	0.061			0.66	0.515	-1.94	0.057	-1.57	0.122
Petal length	-0.91	0.366			2.34	0.023	-6.83	0.000	-0.93	0.356
Maximum Drawer Width	-0.49	0.627			1.89	0.063	-7.46	0.000	-0.55	0.585
The number of teeth on the middle lobe of the rosette leaf on one side	0.56	0.576			-1.90	0.063	-3.22	0.002	-2.25	0.028
Width of Outer Calyx Leaf	-0.22	0.829			-1.06	0.293	-1.84	0.071	-1.60	0.114
Length of Outer Calyx Leaf	-0.45	0.653			1.08	0.286	-1.32	0.193	-0.08	0.938
Fruit length	-0.12	0.908			0.45	0.656	0.89	0.377	1.22	0.227
Fruit width	-0.48	0.634			-0.91	0.000	-2.26	0.028	0.77	0.444

Table 4. Characters for which statically significant differences were found at locations 1,2,4 and 5

Locations Variable	Location 1		Location 2		Location 3		Location 4		Location 5	
	t-value	p	t-value	p	t-value	p	t-value	p	t-value	p
Plant Height With Flowers	1.66	0.102	0.80	0.429			-2.68	0.009	-9.36	0.000
Total Leaf Length With Leaf Handle	-0.01	0.994	-0.53	0.598			2.77	0.007	-8.16	0.000
The length of the leaf stalk of the rosette leaf	-0.54	0.593	-0.73	0.468			2.39	0.020	-6.22	0.000
Length of Middle Lobe Rosette Leaf	1.52	0.134	-0.04	0.965			2.94	0.005	-2.88	0.006
Maximum width of the middle lobe of the leaf	1.45	0.151	0.51	0.615			1.44	0.156	-2.87	0.006
Length of First Lobe rosette leaf	-0.54	0.593	-2.56	0.013			0.34	0.734	-1.03	0.309
Maximum width of the first lobe of the rosette leaf	-1.10	0.276	-1.57	0.121			-0.43	0.667	-0.26	0.793
Flower Stalk Length	3.19	0.002	-1.49	0.141			0.08	0.936	-3.48	0.001
The length of the inner calyx leaf	2.57	0.013	-0.08	0.934			-3.08	0.003	-0.83	0.410
Maximum width of the inner calyx leaflet	2.70	0.009	0.66	0.515			-3.67	0.001	-3.13	0.003
Petal length	1.26	0.213	2.34	0.023			-12.56	0.000	-3.92	0.000
Maximum Drawer Width	1.31	0.197	1.89	0.063			-11.94	0.000	-2.80	0.007
The number of teeth on the middle lobe of the rosette leaf on one side	-0.98	0.333	-1.90	0.063			-0.73	0.471	0.10	0.918
Width of Outer Calyx Leaf	-1.18	0.241	-1.06	0.293			-0.81	0.422	-0.50	0.617
Length of Outer Calyx Leaf	0.68	0.497	1.08	0.286			-2.26	0.028	-0.85	0.398
Fruit length	0.37	0.713	0.45	0.656			0.22	0.827	0.37	0.716
Fruit width	-1.21	0.231	-0.91	0.000			-0.41	0.681	1.38	0.173

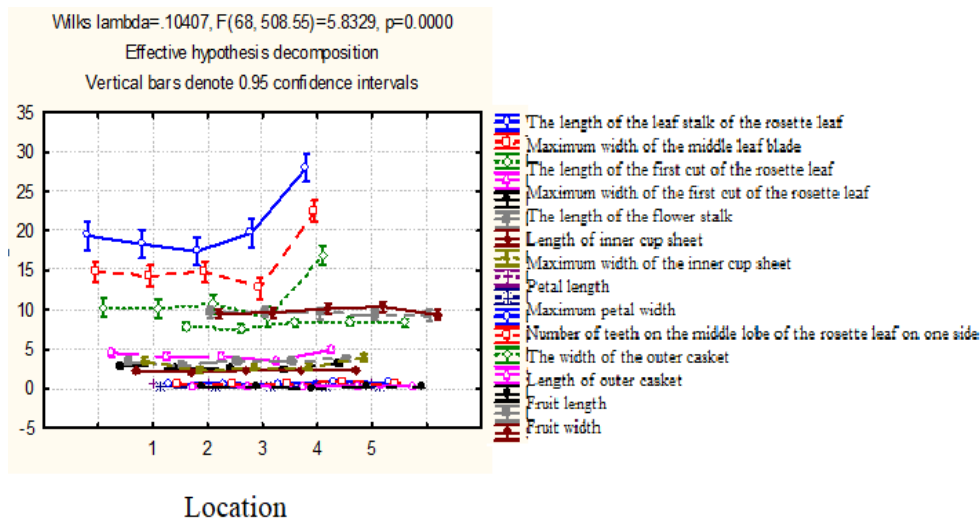
Table 5. Characters for which statistically significant differences were found at sites 1,2,3 and 5

Locations Variable	Location 1		Location 2		Location 3		Location 4		Location 5	
	t-value	p	t-value	p	t-value	p	t-value	p	t-value	p
Plant Height with Flowers	-0.27	0.785	-1.11	0.272	-2.68	0.009			-6.72	0.000
Total Leaf Length with Leaf Petiole	2.31	0.025	1.69	0.097	2.77	0.007			-9.67	0.000
The length of the leaf stalk of the rosette leaf	1.65	0.103	1.30	0.200	2.39	0.020			-7.47	0.000
Length of Middle Lobe Rosette Leaf	3.65	0.001	1.93	0.058	2.94	0.005			-4.68	0.000
Maximum width of the middle lobe of the leaf	2.66	0.010	1.75	0.085	1.44	0.156			-3.90	0.000
Length of First Lobe rosette leaf	-0.14	0.890	-2.00	0.050	0.34	0.734			-1.25	0.215
Maximum width of the first lobe of the rosette leaf	-1.26	0.211	-1.63	0.109	-0.43	0.667			0.15	0.885
Flower Stalk Length	3.44	0.001	-1.50	0.140	0.08	0.936			-3.63	0.001

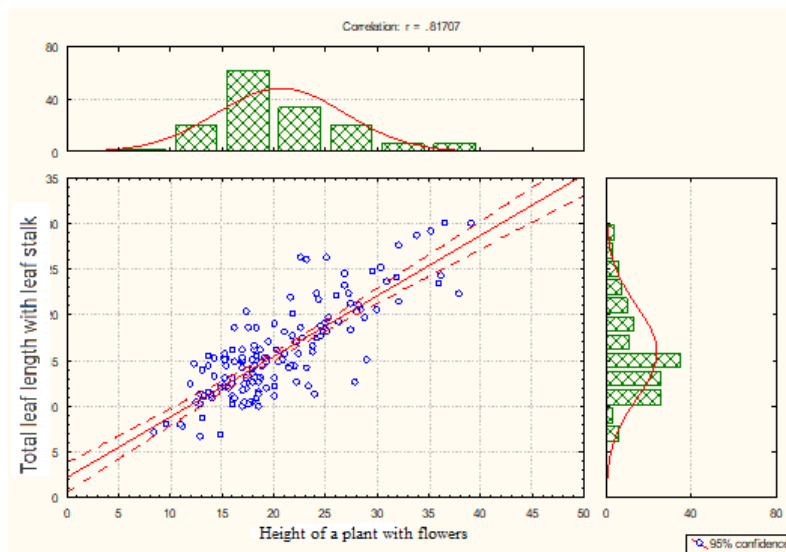
Locations Variable	Location 1		Location 2		Location 3		Location 4		Location 5	
	t-value	p	t-value	p	t-value	p	t-value	p	t-value	p
The length of the inner calyx leaf	1.11	0.271	-2.06	0.044	-3.08	0.003			2.02	0.048
Maximum width of the inner calyx leaflets	0.65	0.518	-1.94	0.057	-3.67	0.001			0.51	0.612
Petal length	-8.02	0.000	-6.83	0.000	-12.56	0.000			6.75	0.000
Maximum Drawer Width	-7.90	0.000	-7.46	0.000	-11.94	0.000			8.17	0.000
The number of teeth on the middle lobe of the rosette leaf on one side	-1.71	0.092	-3.22	0.002	-0.73	0.471			1.09	0.278
Width of Outer Calyx Leaf	-1.90	0.063	-1.84	0.071	-0.81	0.422			0.35	0.730
Length of Outer Calyx Leaf	-1.75	0.086	-1.32	0.193	-2.26	0.028			1.02	0.311
Fruit length	0.78	0.440	0.89	0.377	0.22	0.827			0.17	0.868
Fruit width	-2.80	0.007	-2.26	0.028	-0.41	0.681			2.79	0.007

Table 6. Characters for which statistically significant differences were found at locations 1,2,3 and 4

Locations Variable	Location 1		Location 2		Location 3		Location 4		Location 5	
	t-value	p-value	t-value	p	t-value	p	t-value	p	t-value	p
Plant Height with Flowers	-5.83	0.000	-6.62	0.000	-9.36	0.000	-6.72	0.000		
Total Leaf Length with Leaf Handle	-7.23	0.000	-7.33	0.000	-8.16	0.000	-9.67	0.000		
The length of the leaf stalk of the rosette leaf	-6.27	0.000	-6.19	0.000	-6.22	0.000	-7.47	0.000		
Length of Middle Lobe Rosette Leaf	-1.32	0.193	-2.22	0.030	-2.88	0.006	-4.68	0.000		
Maximum width of the middle lobe of the leaf	-1.44	0.156	-2.19	0.032	-2.87	0.006	-3.90	0.000		
Length of First Lobe rosette leaf	-1.47	0.146	-3.06	0.003	-1.03	0.309	-1.25	0.215		
Maximum width of the first lobe of the rosette leaf	-1.12	0.269	-1.48	0.143	-0.26	0.793	0.15	0.885		
Flower Stalk Length	-1.11	0.270	-4.26	0.000	-3.48	0.001	-3.63	0.001		
The length of the inner calyx leaf	2.09	0.041	-0.65	0.517	-0.83	0.410	2.02	0.048		
Maximum width of the inner calyx leaflet	0.94	0.352	-1.57	0.122	-3.13	0.003	0.51	0.612		
Petal length	-1.95	0.056	-0.93	0.356	-3.92	0.000	6.75	0.000		
Maximum Drawer Width	-1.08	0.285	-0.55	0.585	-2.80	0.007	8.17	0.000		
The number of teeth on the middle lobe of the rosette leaf on one side	-1.02	0.311	-2.25	0.028	0.10	0.918	1.09	0.278		
Width of Outer Calyx Leaf	-1.68	0.099	-1.60	0.114	-0.50	0.617	0.35	0.730		
Length of Outer Calyx Leaf	-0.41	0.681	-0.08	0.938	-0.85	0.398	1.02	0.311		
Fruit length	1.08	0.284	1.22	0.227	0.37	0.716	0.17	0.868		
Fruit width	0.35	0.725	0.77	0.444	1.38	0.173	2.79	0.007		



Graph 1. An's analysis



Graph 2. Significant correlations for the characters total leaf length with leaf stalk and plant height with

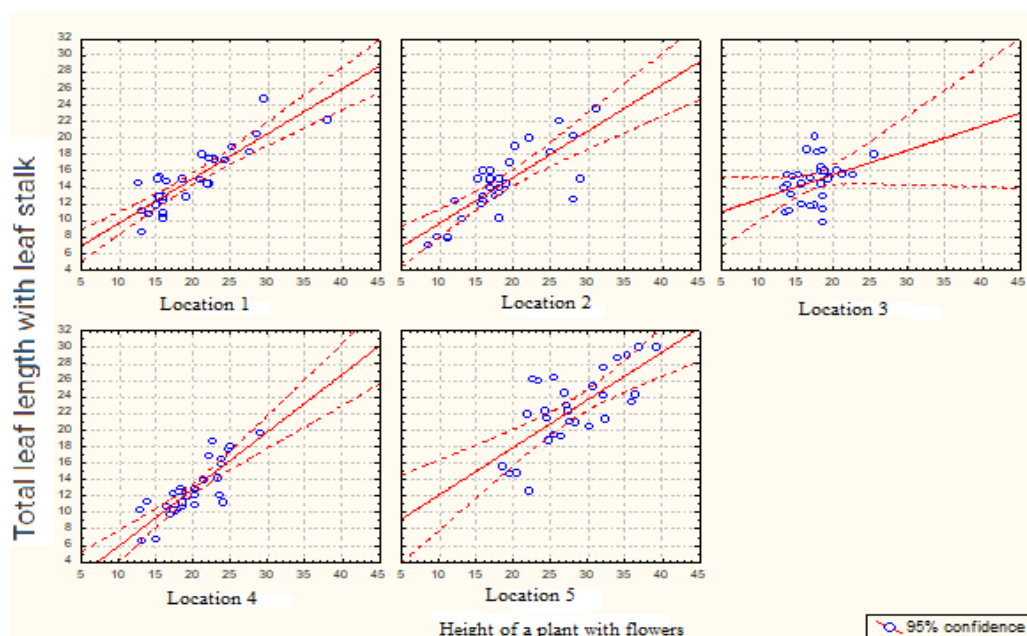
The expressed ability to vary the observed morphometric and meristic characters is the basis of the occurrence of the species *Fragaria vesca* L. in different types of ecosystems. Within the range of variation, trends of character changes in individual populations were monitored.

3.3 Morphological-Ecological Differentiation of Populations

The least variable character is the number of teeth on the middle lobe of the rosette leaf on one side which together with the maximum width of the middle lobe of the rosette and the

maximum width of the first lobe of the rosette leaf. Observing the values of individual characters by localities, certain legitimates can be established. The height of individuals is highest in populations at locality 5 (Krečane) and locality 4 (Svirac).

Strawberry fruits have high resource values and antioxidant potential. It should be emphasized that the size of the fruit follows the overall size of the individual. Fruit height is highest in populations from the Rajska locality (2). In the given locations, in forest conditions, the light was limited. Minor fruit variations are present in other localities.



Graph 3. Significant correlations for the characters total leaf length with leaf stalk and plant height with flower

Fruit width is greatest in populations from Svirac (4) and Krečane (5). These localities represent communities of open habitats and forest edges, which leads to the conclusion that these are communities that provide optimal conditions for strawberry growth with their ecological characters.

Differences among the morphological characteristics of populations stem from differences in the ecological factors prevailing in their habitats.

The determined high degree of variability of the analyzed characters indicates also high interpopulation variability, which further indicates the possible influence of many environmental factors. [4]. Basis of a high degree of variability of genetic determination of *Fragaria vesca* L. A wide ecological valence in relation to the complex of ecological factors, the species acquired by spreading to ecologically very dynamic habitats, most often ecotones, where ecological factors collide two different habitats (eg forests and meadows) [5]. As a specific response of this species to the dynamic (variable) values of ecological factors, the variability of morphological and meristic characters is expressed, which has the function of adapting populations to present ecological factors, ie the function of best utilization of habitat capacity and potential [2].

The highest value of the length of the flower stalk was observed in individuals from the population from locality 3 (Islamovac), while the lowest values were recorded at the localities Palanka (locality 4) and Brezovo Polje (locality 1). According to [1,4,6], the length of the flower stalk is of great importance in adapting the population to the existing habitat conditions. Individuals from locality 2 (Brčko) have the highest value for leaf width, while individuals from locality 1 (Brezovo Polje) have the lowest value of leaf width. The medium value of the length of the flower stalk varies from 2.327 cm at the locality Rajska (2), to 3.910 cm at the locality Krečane (5). The coefficient of variability of this character ranges from 27.243% at the locality Svirac (4), to 51.265% at locality Rajska (2).

3.4 Variabilities Morphometric Characters

3.4.1 Participation of individual characters in total variability

- A comparative analysis of data on the variation of individual characters clearly shows that the width of the outer calyx is one of the most variable characters (KV = 50.011). The next character is the length of the outer (KV = 46.197%), and the next length of the flower stalk (KV = 41.774%), the length of the leaf-stalk of the rosette leaf (KV = 37.961%), the maximum width

of the petal (KV = 33.651%), the length of the petal = 32.297%), maximum width of the inner calyx (KV = 31.944%), total leaf length with leaf stalk (KV = 31.715%), length of the inner calyx (KV = 31.406%), height of the plant with flowers (KV = 30.074%)).

- Characteristics with the lowest coefficient of variability: length of middle lobe of rosette leaf (KV = 29.858%), length of first lobe of rosette leaf (KV = 27.119%), maximum width of first lobe of rosette leaf (KV = 26.005%), maximum width of middle leaf lobe (KV = 23.292%),

3.4.2 Intrapopulation variability

- The highest coefficient of variability at the locality (1) was recorded for the variable width of the outer calyx (62.269%), and the lowest for the character is the maximum width of the middle lobe of the leaf (21.321%).
- At locality (2), the highest coefficient of variability was recorded for the width of the outer calyx leaflet (50.775%), and the lowest (15.821%) for the number of teeth on the middle lobe of the rosette leaf on one side.
- At locality (3) a high coefficient of variability was recorded for the width of the outer calyx (47.229%), and the lowest for the character of the height of the plant with flowers (16.269%)
- At locality (4), the length of the outer calyx varies the most (49.793%), and the maximum width of the petals, KV is 10.578%.
- The highest coefficient of variability at locality (5) was recorded for the length of the outer calyx leaflet (61.967%), and the lowest for the number of teeth on the middle lobe of the rosette leaf on one side (11.474%).

3.4.3 Variability character of fruit

- The highest coefficient of variability for fruit height was recorded at locality (3) 29.081%, and the lowest at locality (2) 13.745%.
- In the variation of fruit width, the highest coefficient of variability was recorded at locality (3) 27,300%, and the lowest is 11,161% and was recorded at locality (4).
- The coefficient of variability for fruit height is 19.691%, and for fruit width 18.243%.

4. CONCLUSION

The study of populations of *Fragaria vesca* L. (*Rosaceae*) covered a total of 5 localities in the municipality of Gradačac, which were different in their ecological characteristics, such as altitude (from 145 to 346), geological background, soil type, etc. Samples were collected in April 2017. in the phenophase of flowering and fruiting. A total of 150 specimens were sampled at the time of flowering for morphometric surveys (external morphology), and 150 specimens in the fruiting phase.

Conducted comparative morphological analyzes showed that the species *Fragaria vesca* L. shows a high degree of variability for all analyzed characters.

- Based on the research it is possible to conclude that vegetative characters plants have a far larger share of the total variability of the generative character
- Based on the above, it can be concluded that the width of the outer calyx and the length of the outer calyx are of great importance in adapting the population to the existing habitat conditions.
- Thus, fruit does not belong to the group of those plant parts that vary the most. However, given the high value of strawberry value, it is necessary to emphasize that the size of the fruit follows the overall size of the individual. Which This indicates that strawberry, in our conditions, thrives optimally in well-lit to somewhat shaded relatively warm habitats of the mountain belt.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Huseinović S, Osmanović S, Terzić Z, Šabanović M. Morphological and ecological differentiation of the fruit of *Fragaria vesca* L. (*Rosaceae*) from different habitats in Bosnia and Herzegovina. *Biologica Nyssana*. 2014;5 (2):75-82.
2. Huseinović Samira, Osmanović Sanida, Šumatić Nada, Bodružić M.: Anatomical and morphological characteristics of

- populations of the species *Fragaria vesca* L. (Rosaceae) in the Tuzla area." II Symposium of Biologists and I Symposium of Ecologists of Republika Srpska. Proceedings Meeting 2012;4 (1).
3. Aichele D. What is blooming there? Cosmos guide. Stuttgart. 2004.
 4. Samira Huseinović, Sanida Osmanović: Morphometric and Meristic Characteristics of the Wild Strawberry (*Fragaria Vesca* L.) on Konjuh Mountain. Acta Agriculturae Serbica. 2010;XV(30):133-140.
 5. Huseinović S, Terzić Z, Osmanović S. Ecological morphological differentiation of populations of *Fragaria vesca* L. in Tuzla and its surroundings. XX conference on biotechnology; 2015. Proceedings, Čačak.
 6. Samira Huseinović. Ecological-morphological differentiation of populations of *Fragaria Vesca* L. (Rosaceae). Master's thesis. Tuzla; 2008.
 7. Beck GM. Flora of Bosnia, Herzegovina and Novi Pazar Sandzak. National printing house. 1903;6–8. Sarajevo.
 8. Bell & Hyman, Limited. Advanced Biology. ISBN London; 1985.
 9. Domac R. Flora of Croatia. Školska knjiga. Zagreb; 1994.
 10. Domac R. Excursion flora of Croatia and neighboring areas. Medical edition, Zagreb; 1964.
 11. Domac R. Small flora of Croatia and neighboring areas. Školska knjiga. Zagreb; 1973.
 12. Grlić Lj. Encyclopedia of wild edible plants. August Cesarec. Zagreb; 1985.
 13. Lakušić R. Mountain plants, "Svjetlost", OOUR Institute for Textbooks and Teaching Aids, Sarajevo; 1982.
 14. Lakušić R. Plant Ecology. IGKRO Svjetlost. Textbook Institute, Sarajevo; 1980.
 15. Lakušić R, Pavlović D, Abadžić S, Grgić P. Prodrum of plant communities of Bosnia and Herzegovina. God. Biol. Inst. Univ. u Sarajevu. 1978;30:5-87.
 16. Nihad Sušić. Anthropogeographical development of the settlement Vučkovci in the municipality of Gradačac. Graduate work. Tuzla; 2010.
 17. Ragib Hodžić. The impact of agriculture on the development of the municipality of Gradačac. Graduate work. Tuzla; 2005.

© 2021 Huseinović et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/78976>