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EDIBLE WILD PLANTS GROWING IN ADJACENT SPONTANEOUS VEGETATION OF ENERGY PLANTATIONS IN SOUTHWEST SLOVAKIA

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ABSTRACT
This paper evaluates the potential and perspectives of wild plant species and macrofungi from short rotation coppice. The research was conducted during the years 2014 – 2018 in stands of short rotation coppice willow and miscanthus grass in southwest of Slovakia. Evaluated wild plant species and macrofungi were divided into four groups (green vegetables, fruits and seeds, flowers and nectar, subterranean parts). The results showed that ground flora of short rotation coppice consisted of 74 edible species from 34 botanical families. *Asteraceae, Rosaceae*, *Poaceae*, *Polygonaceae* and *Cichoriaceae* families were represented the most. From the evaluated categories the most species belonged to the category with consumable aerial parts like leaves and shoots (59 species). The similar representation of species was found in the category of wild fruits and seeds consumed in the raw or preserved state and in category of edible subterranean parts (27 species and 22 species respectively). Principal component analysis showed that the edible parts with the strongest effect on the functional group differentiation were the fruits, seeds and subterranean parts.

Keywords: edible plant; miscanthus; short rotation coppice; SW Slovakia; wild plant

INTRODUCTION
The wild flora has played an essential role in human feeding **(Torija-Isasa and Matallana-Gonzáles, 2016)**. The interest in wild edible plants is not only in terms of increasing dietary balance (sufficient trace elements, vitamins and minerals) but also due to their link to human health **(Tardío, Pardo-de-Santayana and Morales, 2006)**. At present, wild plants play an equally important role in protecting biodiversity and providing various ecosystem services. **Rowe, Street and Taylor (2009)** state that miscanthus and short rotation coppice (SRC) stands have a positive potential impact on biodiversity. Compared to arable land use, they create different structural and functional biotope types with a greater diversity of species due to their longer rotation period, less number of disturbances and chemical inputs and richer spatial structure **(Fry and Slater, 2009; Dauber, Jones and Stout, 2010; Rowe et al., 2011; Verheyen et al., 2014)**.

The benefits that SRC stands can provide consist of provisioning services (production of food, category nutrition – food, crops, wild foods) **(MEA, 2005)**. In the past, wild plant species were collected and used for food, medicine and social issues (during times of famine or conflicts). Nowadays, the increasing interest is based on efforts to provide food security in times of agricultural crisis or use in regional/local cuisine **(Turner et al., 2011; Łuczaj, 2012; Simkova and Polesny, 2015)**. The gathering of wild plants is not only an active living custom **(Christanell et al., 2010)** but it is also a source of cultural identity (cultural services) that is forming an important knowledge about the environment and sustainable living known as traditional ecological knowledge **(Turner et al., 2011)**. While the issues/reviews of the traditional use of edible plants have been evaluated in several works in Slovakia **(Łuczaj, 2012; Stoličná, 2016)** and abroad **(Dogan et al., 2004; Dénes et al., 2012; Di Novella et al., 2013; Guarrera and Savo, 2016; Kuklina and Vinogradova, 2018)**, the prospective use of such species from energy plantations has not yet been studied.

Scientific hypothesis
Taking into account the specific ecological environmental and cultivation-technological conditions of the stands of energy plants, we assumed a high diversity of vascular spontaneous plant species, providing the possibility of occurrence of species with edible parts.

MATERIAL AND METHODOLOGY
The research was carried out on permanent experimental plots established in the agricultural land on a research base of the Slovak University of Agriculture in Nitra in the catastral area of the Kolíňany village (Nitra district area, SW Slovakia). The area belongs to the moderately warm and moderately humid climate region with a sum of

temperatures of 2200 – 2500 °C and an average annual rainfall of 550 – 700 mm. The soil is medium-heavy, the soil type is gley fluvisol. The stands of the species used for energy purposes were established in 2009, consisting of the Swedish willow varieties Tordis (*Salix schwerinii* × *S. viminalis*), Inger (*Salix triandra* × *S. viminalis*) and energy grass (*Miscanthus* ×*giganteus*).

The study of herbaceous species and macrofungi in SRC undergrowth was carried out in the growing periods of 2014 – 2018 at 14-day intervals. The permanent research plots had an area of 2 m x 12 m. The willow varieties were planted from the cuttings in a double-row spacing configuration resulting in a plant density of 8889 plants per ha. The rhizomes of energy grass were planted in 1 x 1 m spacing on an area of 100 m^2 (10,000 plants per ha). A three-year harvest cycle is applied for the willow varieties and the harvest cycle for *M.* × *giganteus* is one year. Based on soil analysis carried out at the beginning of the research period (2014), the soil pH ranged from 7.22 to 7.30. The average humus content was 2.31% and the average nitrogen content was 1479 $mg.kg^{-1}$. The herbicides were applied only prior to the establishment of the research plots in 2009. The vegetation structure was studied using phytocoenological reléves. The presence of species and their relative abundance were assessed using the modified Braun-Blanquet cover-abundance scale for estimating species quantities **(Braun-Blanquet, 1964; Mueller-Dombois and Ellenberg, 1974)**.

Individual identified species were divided into four categories (VEG, FRU, SUB and FLO). The category green vegetables "VEG" consisted of species whose above-ground parts (leaves and stems) were used raw, cooked or fried. Wild fruits and seeds consumed in the raw or preserved form represented the "FRU" category. Plants with edible subterranean parts (rhizomes, roots and tubers) were included in the "SUB" category and species with flowers whose nectar was consumed raw or flowers were added in larger quantities to meals and beverages were categorized as "FLO". In this paper, the classification of species to individual categories was based on a partially modified methodology used in **Łuczaj (2012)** and **Simkova and Polesny (2015)** and the literature sources listed in the References. The nomenclature of the lower and higher plants has been unified according to **Marhold and Hindák (1998)**.

Statistical analysis

Ordination analysis of the species importance in terms of providing edible parts was conducted by the principal component analysis (PCA) in Canoco for Windows version 4.5 and CanoDraw 4.0 **(Braak and Smilauer, 2002)**.

RESULTS AND DISCUSSION

Of the 92 species found in the undergrowth of the trees and plants grown for energy purposes, 74 were edible species. These species represented 73 vascular plants and 1 fungus (Table 1a and Table 1b). The species belonged to 34 botanical families. The list of the edible species included 9 tree species, 4 shrub species, 32 perennial species, 22 annual species and 7 biennial species. The most common families of the edible species were *Asteraceae* and *Rosaceae* (8 species each), *Poaceae* (7 species), *Polygonaceae* and *Cichoriaceae* (5 species each). The most represented was the category of green vegetables with 59 species. The category of fruits (raw or preserved) included 27 species and 22 species belonged to the category of wild plants with edible underground parts (subterranean parts). The least represented was the category of flowers with 17 species.

According to the ethnobotanical review of wild edible plants of Slovakia **(Łuczaj, 2012)**, the most frequently used wild edible plants in Slovakia included the fruits of *Rubus idaeus, Fragaria* spp., *Rubus* subgenus *Rubus, Vaccinium myrtillus, V. vitis-idaea, Fagus sylvatica, Corylus avellana, Prunus spinosa, Pyrus* spp., *Malus* spp., *Crataegus* spp. and the leaves of *Urtica dioica, Rumex acetosa, Chenopodiaceae* species, *Cardamine amara, Glechoma* spp., *Taraxacum* spp. *and Oxalis acetosella*. This species list is similar to our observations (cf. Recorded species of *Rubus* genus, *Prunus spinosa*, *Carataegus* spp., *Urtica dioica*, *Chenopodiacea* species, *Glechoma* spp. and *Taraxacum* spp.) and we can confirm that similar or identical plant species with high edibility potential have been collected for food by local people in Slovakia. The category of green vegetables consisted of plants whose above-ground parts (leaves and stems) are edible raw or cooked, steamed or fried. The most represented were the families *Asteraceae*, *Poaceae* and *Rosaceae* that had the same number of species (6). The second was the family *Cichoriaceae* with 5 species (Figure 1).

Despite the high number of identified species in the category of fruits and seeds (27 species), the most represented family of *Rosaceae* included only 6 species in this category. Other families consisted of two species (fam. *Brassicaceae*, *Poaceae*, *Polygonaceae* and *Solanaceae*) and/or one species with fruits or seeds edible in the raw or preserved state (Figure 2).

The category of edible subterranean parts (roots, rhizomes and tubers) included mostly species of the *Asteraceae* family (4 species). Other families had a similar number of species as the category of fruits and seeds. The families *Brassicaceae*, *Poaceae*, *Rosaceae* and *Violaceae* had two species each. Other families had only one species within this category (Figure 3).

The category of flowers and their nectar eaten raw or flowers added in larger quantities to dishes and beverages consisted of the *Asteraceae* family with three species and the *Violaceae* family with two species. The other families were represented in lower numbers (Figure 4).

The results of the species assessment based on their proportion to the supply of edible parts for human consumption (directly or processed) showed that different species contributed differently in their supply. Differences were apparent also at higher taxonomic levels, e.g. at the genera level and/or the family level. The indirect linear ordination method of PCA (Figure 5) showed that the taxa differentiation was clearly visible on the biplot, therefore the relation detrending was not necessary. The first two component axes of PCA accounted for 65.0% of explained variance. The clusters of species based on the edible part showed that the strongest effect on the differentiation of functional groups (clusters) had the species in the

categories of fruits, seeds and subterranean parts. Categories of flowers and green vegetables showed less effect. The category of flowers was supported by a small number of species (*Capsella bursa-pastoris, Tripleurospermum perforatum* and *Humulus lupulus*). The category of green vegetables was represented by the largest number of species and therefore became a general criterion and not very useful in the formation of functional plant groups (e.g. *Anagallis arvensis, Stellaria media, Lactuca serriola, Mentha longifolia*, etc.). Groups of species were formed also at various transition gradients.

There was a stronger link between the categories of flowers and subterranean parts, while the link was weaker between the categories of green vegetables and fruits. The species of the *Asteraceae* family were scattered relatively evenly but were centred in the axis areas of the VEG, SUB and FLO categories. A similar situation occurred in the case of *Poaceae* species that traced the distribution of *Asteraceae* species in the VEG and SUB categories. However, grasses were surprisingly lacking in the FRU category (edible grains in spikelets are common for the species of the *Poaceae* family). An exception was *Echinochloa crus-galli*. Some typical synanthropic families (e.g. *Chenopodiaceae* and *Amaranthaceae*) have accumulated in the VEG and FRU categories. Representatives of the *Rosaceae* family (*Cerasus, Crataegus, Padus, Prunus, Rosa* and *Rubus* species) behaved similarly, but representatives of the herbaceous species of this family were found in the transition between the SUB and VEG categories (*Geum urbanum* and *Potentilla anserina*). It is an interesting result confirming that there may be different edibility of organs depending on the species lignification even in the same family. Taxa of the *Cichoriaceae* family were typically represented in the VEG category (genera *Lactuca*, *Lapsana* and *Sonchus*).

Our results are in accordance with the synthesis of knowledge on wild food as an ecosystem service in Europe **(Schulp, Thuiller and Verburg, 2014)**. The same is true for Central-Eastern Europe. In the Czech Republic, the use of 175 vascular plant species (the highest number of taxa belonged to families *Rosaceae*, *Asteraceae* and *Ericaceae*) **(Simkova and Polesny, 2015)**, in the part of the Carpathians and the Carpathian Basin (Hungary and adjacent countries) 236 plant species belonging to 68 families **(Dénes et al., 2012)** and in the Pannonian region of Croatia a total of 44 plant taxa belonging to 25 families (the highest number of taxa belonged to families *Asteraceae*, *Lamiaceae* and *Rosaceae*) were recorded **(Žuna Pfeiffer et al., 2019)**. Considering the high number of edible wild plants in the spontaneous vegetation of SRC the perspective of edible wild plants collection is high in comparison with the avarage number of collected edible wild plants in Central-Eastern part of Europe.

Our research evaluated the potential of edible wild plants only but the potential provisioning ecosystem services are not necessarily collected and used by people **(Rasmussen et al., 2016)**. In spite of that, the high value of ecosystem services from small forest patches in agricultural landscapes **(Decocq et al., 2016)** and values of wild foods in agricultural systems **(Bharucha and Pretty, 2010)** are of high importance.

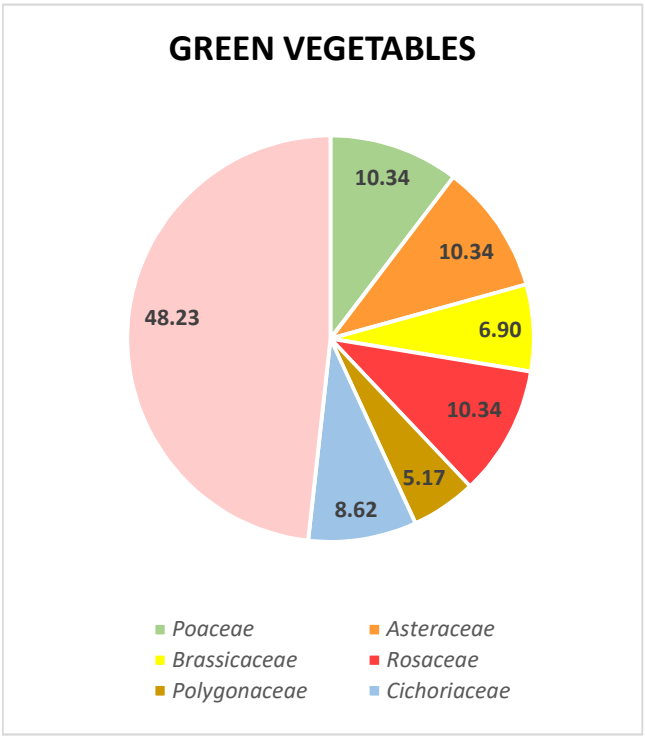

Figure 1 Most representated botanical families in category of green vegetables [in %].

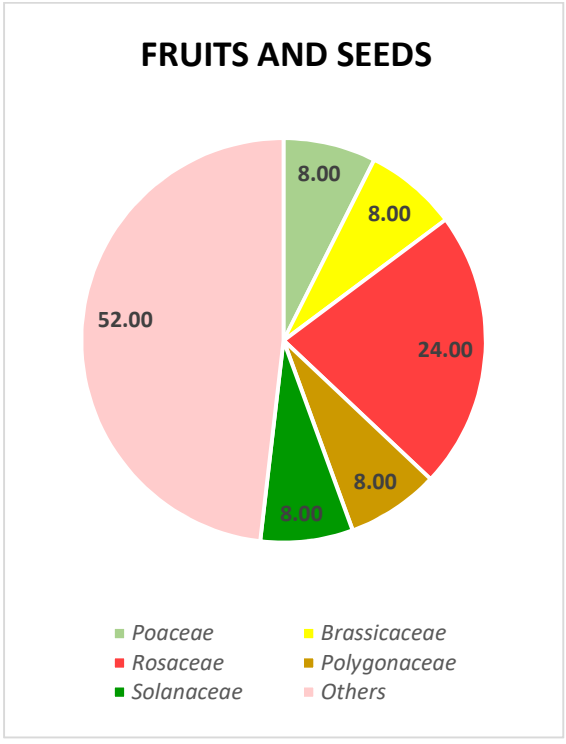

Figure 2 Most representated botanical families in category of fruits and seeds [in %].

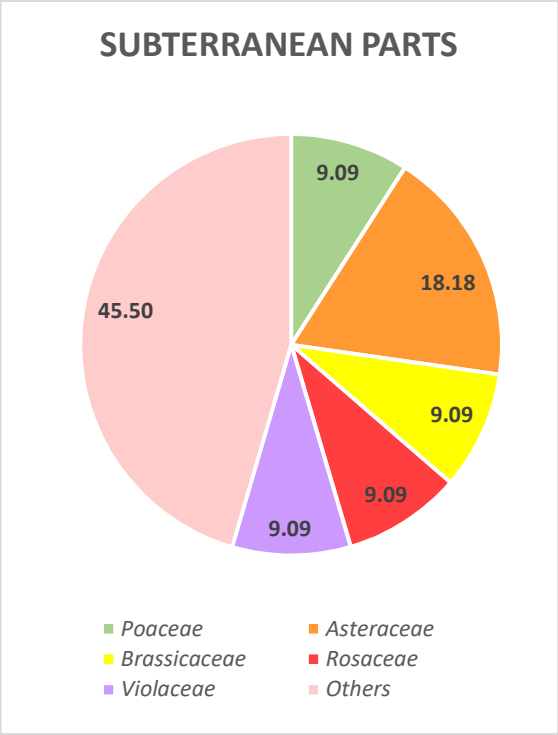

Figure 3 Most representated botanical families in category of subterranean parts [in %].

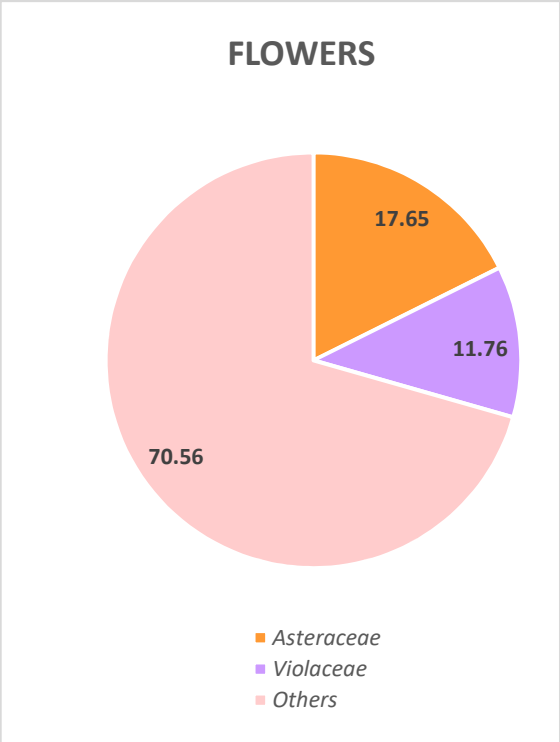

Figure 4 Most representated botanical families in category of flowers [in %].

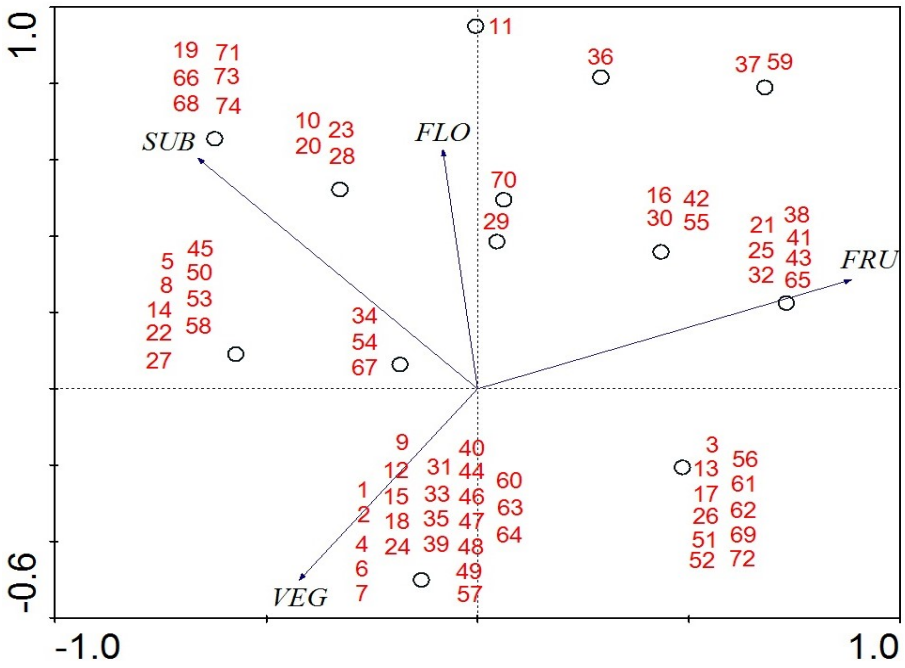

Figure 5 Principal component analysis of functional groups of edible wild plants in energy plantations. The first two axes accounted for 65.0% of explained variance. Note: Ordinal numbers of species are in accordance with Table 1.

Table 1a List of edible wild plants in energy plantations on permanent experimental plots in Kolíňany.

	Species	Family	Use categories
1	*Acer pseudoplatanus*	*Aceraceae*	VEG
2	*Amaranthus powellii*	*Amaranthaceae*	VEG
3	*Amaranthus retroflexus*	*Amaranthaceae*	VEG, FRU
4	*Anagallis arvensis*	*Primulaceae*	VEG
5	*Arctium lappa*	*Asteraceae*	VEG, SUB
6	*Artemisia vulgaris*	*Asteraceae*	VEG
7	*Atriplex patula*	*Chenopodiaceae*	VEG
8	*Bromus sterilis*	*Poaceae*	VEG, SUB
9	*Calamagrostis epigejos*	*Poaceae*	VEG
10	*Calystegia sepium*	*Convolvulaceae*	SUB
11	*Capsella bursa-pastoris*	*Bassicaceae*	VEG, SUB, FLO, FRU
12	*Cardaria draba*	*Bassicaceae*	VEG
13	*Cerasus avium*	*Rosaceae*	VEG, FRU
14	*Cirsium arvense*	*Asteraceae*	VEG, SUB
15	*Clematis vitalba*	*Ranunculaceae*	VEG
16	*Convolvulus arvensis*	*Convolvulaceae*	VEG, FLO, FRU
17	*Crataegus laevigata*	*Rosaceae*	VEG, FRU
18	*Cucubalus baccifer*	*Caryophyllaceae*	VEG
19	*Daucus carota*	*Apiaceae*	VEG, SUB, FLO
20	*Dipsacus fullonum*	*Dipsacaceae*	SUB
21	*Echinochloa cruss-galli*	*Poaceae*	FRU
22	*Elytrigia repens*	*Poaceae*	VEG, SUB
23	*Epilobium hisutum*	*Onagraceae*	SUB
24	*Equisetum arvense*	*Equisetaceae*	VEG
25	*Fallopia convolvulus*	*Polygonaceae*	FRU
26	*Galium aparine*	*Rubiaceae*	VEG, FRU
27	*Geum urbanum*	*Rosaceae*	VEG, SUB
28	*Helianthus annuus*	*Asteraceae*	SUB
29	*Humulus lupulus*	*Cannabaceae*	VEG, SUB, FRU
30	*Hypericum maculatum*	*Hypericaceae*	VEG, FLO, FRU
31	*Chenopodium album*	*Chenopodiaceae*	VEG
32	*Juglans regia*	*Juglandaceae*	FRU
33	*Lactuca serriola*	*Cichoriaceae*	VEG
34	*Lamium purpureum*	*Lamiaceae*	VEG, FLO
35	*Lapsana communis*	*Cichoriaceae*	VEG
36	*Lathyrus tuberosus*	*Fabaceae*	SUB, FRU
37	*Lycium barbarum*	*Solanaceae*	FLO, FRU
38	*Marasmius oreades*	*Tricholomataceae*	FRU
39	*Mentha longifolia*	*Lamiaceae*	VEG
40	*Mercurialis annua*	*Euphorbiaceae*	VEG
41	*Padus serotina*	*Rosaceae*	FRU
42	*Papaver rhoeas*	*Papaveraceae*	VEG, FLO, FRU
43	*Persicaria lapathifolia*	*Polygonaceae*	FRU
44	*Picris hieracioides*	*Cihoriaceae*	VEG
45	*Plantago major*	*Plantaginaceae*	VEG, SUB
46	*Plantago media*	*Plantaginaceae*	VEG
47	*Poa annua*	*Poaceaa*	VEG
48	*Poa pratensis*	*Poaceae*	VEG
49	*Polygonum aviculare*	*Polygonaceae*	VEG
50	*Potentilla anserina*	*Rosaceae*	VEG, SUB
51	*Prunus domestica*	*Rosaceae*	VEG, FRU
52	*Quercus petraea*	*Fagaceae*	VEG, FRU
53	*Raphanus raphanistrum*	*Bassicaceae*	VEG, SUB
54	*Robinia pseudoacacia*	*Fabaceae*	VEG, FLO
55	*Rosa canina*	*Rosaceae*	VEG, FLO, FRU
56	*Rubus caesius*	*Rosaceae*	VEG, FRU

Note: The categories used: VEG – species with edible above-ground parts (leaves and stems), FRU – species with wild fruits and seeds consumed in the raw or preserved form, SUB – plants with edible subterranean parts (rhizomes, roots and tubers), FLO – species with flowers whose nectar was consumed raw or flowers were added to meals and beverages.

Table 1b List of edible wild plants in energy plantations on permanent experimental plots in Kolíňany.

	Species	Family	Use categories
57	*Rumex crispus*	*Polygonaceae*	VEG
58	*Rumex acetosella*	*Polygonaceae*	VEG, SUB
59	*Sambucus nigra*	*Caprifoliaceae*	FLO, FRU
60	*Senecio vulgaris*	*Asteraceae*	VEG
61	*Setaria viridis*	*Poaceae*	VEG, FRU
62	*Solanum nigrum*	*Solanaceae*	VEG, FRU
63	*Sonchus oleracea*	*Cichoriaceae*	VEG
64	*Stellaria media*	*Caryophyllacae*	VEG
65	*Swida sanguinea*	*Cornaceae*	FRU
66	*Symphytum officinale*	*Boraginaceae*	VEG, SUB, FLO
67	*Tanacetum vulgare*	*Asteraceae*	VEG, FLO
68	*Taraxacum* sect. *Ruderalia*	*Cichoriaceae*	VEG, SUB, FLO
69	*Thlaspi arvense*	*Brassicaceae*	VEG, FRU
70	*Tripleurospermum perforatum*	*Asteraceae*	FLO
71	*Tussilago farfara*	*Asteraceae*	VEG, SUB, FLO
72	*Urtica dioica*	*Urticaceae*	VEG, FRU
73	*Viola arvensis*	*Violaceae*	VEG, SUB, FLO
74	*Viola canina*	*Violaceae*	VEG, SUB, FLO

Note: The categories used: VEG – species with edible above-ground parts (leaves and stems), FRU – species with wild fruits and seeds consumed in the raw or preserved form, SUB – plants with edible subterranean parts (rhizomes, roots and tubers), FLO – species with flowers whose nectar was consumed raw or flowers were added to meals and beverages.

CONCLUSION

Based on the results, it can be concluded that:

-SRCs are characterized by a high diversity of species (92 species found), with the vast majority (74 species) of edible species (whole plants or some parts consumable),

-the most numerous were the *Asteraceae*, *Rosaceae* (8) and *Poaceae* (7) families,

the most frequent species (59) were in the VEG category, the above-ground parts of which are edible raw state or processed,

a similar representation of species was found in the FRU (27 species) and SUB (22 species) categories,

the PCA showed that based on the edible part, the most important effect on the differentiation of functional groups had the species in FRU and SUB categories,

a strong correlation was found between the FLO and SUB categories.

The results confirmed the high diversity of vascular plant species (92) with a high proportion of species with edible parts (74).

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