Original scientific paper
DOI: /10.5513/JCEA01/21.1.2534
Journal of Central European Agriculture, 2020, 21(1), p.135-150

Ecogeographical characteristics of red clover local population sites in north-western part of Croatia

Ekogeografske karakteristike lokacija lokalnih populacija crvene djeteline na području sjeverozapadne Hrvatske

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Received: May 23, 2019; accepted: August 21, 2019

ABSTRACT

Red clover, although primarily used for dairy cow feeding, can also repair soil structure, fix atmospheric nitrogen and prevent soil erosion. Until recently, the traditional cultivation of red clover in Croatia prevailed in suitable habitats. Abandoning of agricultural production is the reason of meadows succession process which can cause genetic erosion and threatens the survival of local population of red clover. Determining of sites according to their ecogeographical characteristics could help to improve the direction of action aimed at conservation of biological diversity of species in its natural habitats as well as the preservation of genetic resources and their use in breeding purposes. The aim of this research was to classify the sites of natural habitats of red clover local populations (under extensive agricultural production) in north-western part of Croatia on the basis of their ecogeographical characteristics. Data of geographical, pedological and climatological characteristics and floristic composition were collected at 18 sites and subjected to multivariate analysis. The main differences among sites were detected in geographical, pedological and climatological characteristics. Floristic structure of investigated sites were consisting of 151 plant species, including a large number of species of ruderal vegetation.

Keywords: ecogeographic diversity, site classification, *Trifolium pratense* L.

SAŽETAK

Iako se crvena djetelina prvenstveno koristi za hranidbu mliječnih krava, ona može popraviti strukturu tla, uz pomoć kvržičnih bakterija fiksirati atmosferski dušik i spriječiti eroziju tla. Donedavno je u Hrvatskoj prevladavao tradicionalni uzgoj crvene djeteline. Napuštanje poljoprivredne proizvodnje razlog je procesa pojave sukcesije livada koji može uzrokovati genetsku eroziju i ugroziti opstanak lokalnih populacija crvene djeteline. Utvrđivanje lokacija lokalnih populacija crvene djeteline, prema njihovim ekološkim karakteristikama, moglo bi pomoći u pronalaženju smjera djelovanja u cilju očuvanja biološke raznolikosti vrsta u njenim prirodnim staništima, kao i očuvanja genetskih resursa i njihove uporabe u oplemenjivačkim programima. Cilj ovog istraživanja bio je klasificirati lokacije lokalnih populacija crvene djeteline, koje su pod ekstenzivnom poljoprivrednom proizvodnjom, na području sjeverozapadne Hrvatske na temelju njihovih ekogeografskih karakteristika. Podaci o geografskim, pedološkim i klimatskim karakteristikama i florističkom sastavu prikupljeni na 18 lokacija podvrgnuti su multivarijatnoj analizi. Glavne razlike između lokacija utvrđene su u geografskim, pedološkim i klimatskim karakteristikama. Floristički sastav istraživanih lokacija, čije su lokalne populacije crvene djeteline sastavni dio, sadrži 151 biljnih vrsta, među kojima je veliki broj vrsta ruderalne vegetacije.

Ključne riječi: ekogeografska raznolikost, klasifikacija lokacija, *Trifolium pratense* L.

INTRODUCTION

As a consequence of characteristic ecological, climatic and geomorphological conditions, and geographic position across the dividing lines between several biogeographic regions, Croatia is one of the richest European countries in terms of biodiversity, especially different plant species and local plant populations (Radović et al., 2006; Zachos and Habel, 2011; Nikolić et al., 2014).

During the history, the forest vegetation was cleared in favour of agricultural land and urbanisation (Liamine, 2002). Grasslands were formed and persisted as a result of intensive anthropogenic activities. The grassland agro-ecosystems have survived, not because of cultivation, sowing and fertilizing, but rather as an effect of regular haymaking and grazing once, twice or three times per year. An important compound of the grassland associations are legumes (fam. *Fabaceae*) like clover, alfalfa and other similar species. Among them, red clover is economically the most important species after alfalfa, used for hay making, silage preparation and as a soil conditioner (Greene et al., 2004).

During the past few decades, ecological conditions of natural habitats have been changing, mainly as a result of anthropogenic factors. Abandonment of agricultural production over the last half-century or so (by socioeconomic reasons in Croatia) leads to succession by woody plants and climazonal vegetation that overgrow plant communities of grassland (Ignatavičius et al., 2013). It is cause of loss of refuges for many grasslands species and change in communities' structure and functioning as well as of genetic erosion and a treat for survival of plants with agricultural significance, such as local red clover populations.

Another reason of genetic erosion of intraspecific genetic diversity present in temperate sown grasslands is replacement of the original landraces and ecotypes of grassland species by productive commercial varieties with a more restricted genetic base (Kölliker et al., 2003; Herrmann et al., 2005; van Treuren et al., 2005 cited in Collins et al., 2012).

Collecting and preserving local populations of red clover are a direct contribution in preservation of biodiversity in general, and diversity of natural or cultivated meadows and pastures, as well as conservation of genetic variability of certain species (Kölliker et al., 2003; Lazaro and Aguinagalde, 2006). The aim of this research was to classify sites of red clover local populations in terms of their ecogeographical characteristics.

MATERIALS AND METHODS

The study was conducted in north-western part of Croatia, in elevations (altitude) ranging from 131 to 560 m (Table 1). This part of Croatia has continental Central European type of climate, moderately warm and rainy with mean annual temperatures from 10 °C to 12 °C, and mean annual precipitations from 900 to 1000 mm (Croatian bureau of statistics, 2018). Following climatic characteristics are processed: average monthly and annual air temperature, and total monthly and annual precipitation, all according to the data of the Croatian Meteorological and Hydrological Service for climatological stations Jastrebarsko (for site Hutin), Krapina (for sites Trakošćan and Gornje Jesenje), Pregrada (for sites Desinić and Zagorska Sela), Puntijarka (for site Medvednica), Sošice (for sites Drašći Vrh, Sošice and Sopotski Slap), Stubica (for sites Bedekovčina, Čveki, Lug Zabočki, Lobor, Zlatar Bistrica and Klanječko Jezero), Zagreb-Maksimir (for sites Kupljenovo and Donja Pušća) and Zelina (for site Planina Donja). The ecogeographical characteristics and floral compositions were observed at 18 sites (Figure 1, Table 1).

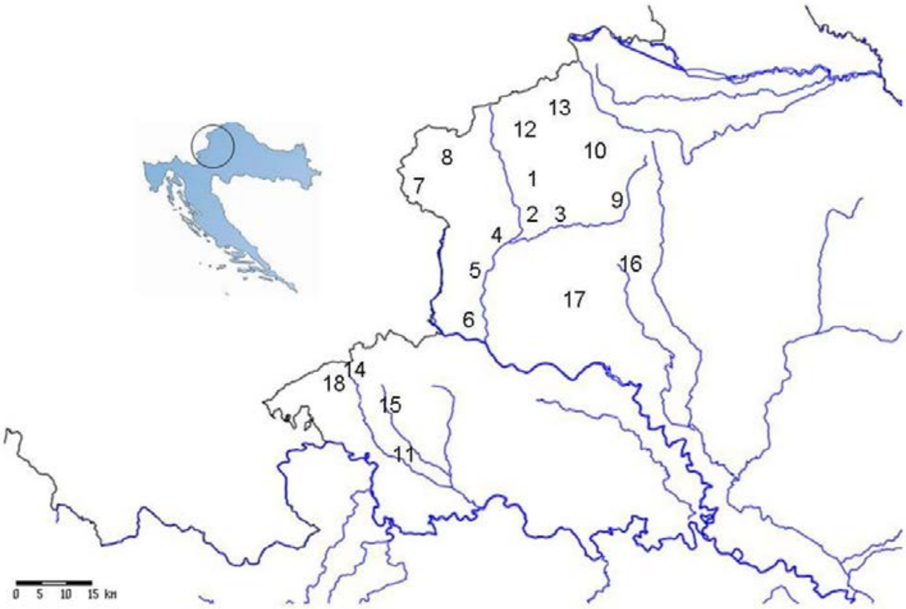

Figure 1. Eighteen sites of red clover local populations in the north-west part of Croatia (numeration shown in Table 1)

Table 1. Geographical and floristic characteristics of observed sites

No	Sites	Abbreviation	Altitude (m)	Exposition (Aspect)	Inclination (Slope %)	No. of species	Clover cover*
1	Čveki	Cvk	162	W	5	37	1
2	Bedekovčina	Bed	172	N	5	37	1
3	Lug Zabočki	Lug	151	SE	5	25	1
4	Klanječko Jezero	Kln	146	NE	5	26	2
5	Kupljenovo	Kup	131	E	5	34	2
6	Donja Pušća	Don	147	W	5	37	1
7	Zagorska Sela	Zag	214	NW	8	40	2
8	Desinić	Des	226	NE	45	16	2
9	Zlatar Bistrica	Zlt	185	W	5	39	3
10	Lobor	Lob	276	SW	30	20	3
11	Hutin	Hut	185	E	10	27	1
12	Gornje Jesenje	Gor	357	NW	5	19	3
13	Trakošćan	Trk	258	NW	10	34	1
14	Sopotski Slap	Sop	549	SE	5	27	1
15	Drašći vrh	Vrh	451	NE	5	53	1
16	Planina Donja	Pln	285	S	10	19	1
17	Medvednica	Med	539	S	8	24	1
18	Sošice	Sos	560	SE	5	29	2

* followed the Braun-Blanquet method (1=1-10%, 2 =10-25%, 3 = 25-50%)

Ecogeographical data (geographical, pedological and climatological data) and floristic composition of investigated sites were collected and analysed in multivariate analysis. Summary passport data are given in Tables 1 and 4. Euclidean distances of standardised ecogeographical data were calculated and normalised according to Roldán-Ruiz et al. (2001).

The ecogeographical distance matrix and tree-plot based on UPGMA algorithm were produced using NTSYS-PC program version 2.21L (Rohlf, 2008).

Sampling of the surface layer of soil at depht of 0-25 centimetre was carried out at 18 locations and pedological analyzes were made according to standard methods. Prior to performing laboratory analyses soil samples were air-dried and sieved through the 2 mm sieve. Preparation of samples with the view of determination their respective physical and chemical characteristics according to HR ISO 11464:2009.

Soil reaction was determined using an instrumental method in a 1:5 (volume fraction) suspension of soil in water (pH in H_2O) and 1 mol/l potassium chloride solution (pH in KCl) according HR ISO 10390:2005. Soil organic matter content was determined as humus content using the Tjurin method, by acid-dichromate ($K_2Cr_2O_7$, c=0.4 M) digestion (JDPZ, 1966).

Soil particle size distribution was determined after Škorić (1982), by pipette-method comprising wet sieving and sedimentation after dispersion with sodium-pyrophosphate ($Na_4P_2O_7$, c=0.4 M), and texture class was determined according soil texture triangle (FAO, 2006). Bulk density was determined according HR ISO 11272:2004, particle density according HR ISO 11508:2004, total porosity, soil capacity for water and air according Gračanin (Škorić, 1982), available soil water and wilting point according HR ISO 11274:2004.

At each site, the species covers (clover cover in table 1) estimated on relevé made by Braun-Blanquet method (1964). Species cover values were converted, according to the Van der Maarel scale (2007) and then subjected to cluster analysis (UPGMA, Similarity ratio) using Syntax 2000 software (Podani, 2001).

RESULTS AND DISCUSSION

The strength of the plants is the most important characteristic for plants to survive in different environments. It depends on growth characteristics (life form, duration of life cycle) and environmental requirements (soil and climate characteristics of the habitat) (Ellenberg, 1952). The strength of the landraces, also known as local populations, provide a valuable resource for plant breeding as well as for preservation of genetic diversity (Kölliker et al., 2003).

Dujmović Purgar (2011) compared morphological and molecular diversity of local populations of red clover (*Trifolium pratense* L.) with ecogeographical characteristics of habitat. In the same way, an essential part of this study is the analyses of ecogeographical characteristics of the sites under research. Red clover should be studied as a part of the complex environment because the development of red clover populations is mainly influenced by altitude (Leto, 1997), or by precipitation and temperature (Graman, 1988).

The investigated sites are located in lowland and hilly-mountainous part of Croatia. All the sites were classified in three groups, according to the altitude: <200 m a.s.l. (eight sites), 200-400 m a.s.l. (six sites) and >400 m a.s.l. (four sites). Three sites were even above 500 m a.s.l. (Medvednica, Sopotski Slap and Sošice). The inclination of investigated sites was within the range 5-45% in all expositions (N, NE, E, SE, S, SW, W and NW).

North-western part of Croatia is characterized by continental Middle European type of climate. According to the Köppen classification, the explored area is located in the Cfwbx'' climatic zone (Penzar and Penzar, 1989), moderately warm and rainy climate with a warm summer without a particularly dry period. For this occasion, we extract data related to average monthly and annual air temperatures and precipitations based on the ten years (1999-2008) period for researched sites (Tables 2 and 3), since these parameters are of the most importance for the morphological and economic properties of red clover (Graman, 1988; Leto, 1997; Frame et al., 1998).

Table 2. The mean monthly and annual air temperature (°C) based on the ten-year average (1999-2008) of researched sites (Source: Croatian Meteorological and Hydrological Service)

Climatological stations	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Jastrebarsko	0.3	2.8	7.1	11.5	16.6	20.2	21.4	20.9	15.4	11.6	6.2	1.4	11.3
Krapina	0.4	2.5	6.9	11.4	16.6	20.1	21.2	20.4	15.3	11.5	6.2	1.3	11.2
Pregrada	-0.5	1.6	6.3	11.0	16.1	19.7	20.7	20.0	14.9	11.0	5.5	0.5	10.6
Puntijarka	-1.6	-1.1	2.2	6.8	12.0	15.1	16.5	16.4	11.5	8.4	3.2	-1.1	7.4
Sošice	0.1	1.1	4.6	8.7	14.3	17.8	18.7	18.6	13.1	9.7	4.8	0.8	9.4
Stubica	0.6	2.5	7.0	11.4	16.6	20.0	21.1	20.4	15.3	11.7	6.3	1.6	11.2
Zagreb	1.1	3.1	7.5	12.0	17.3	20.7	22.0	21.4	16.2	12.2	6.8	2.0	11.9
Zelina	-0.1	2.4	7.0	11.5	16.9	20.5	21.7	21.1	15.5	11.8	6.4	1.9	11.4

Table 3. The mean monthly and annual precipitations (mm) based on the ten-year average (1999-2008) of researched sites (Source: Croatian Meteorological and Hydrological Service)

Climatological stations	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Jastrebarsko	54	50	65	80	82	83	87	80	111	105	90	84	971
Krapina	33	40	60	67	76	81	91	92	88	91	74	65	858
Pregrada	36	45	66	74	80	87	84	92	97	86	70	67	884
Puntijarka	65	73	92	103	93	105	127	115	131	114	108	104	1230
Sošice	52	49	78	95	101	104	125	99	130	107	115	114	1170
Stubica	47	49	64	83	76	91	102	98	102	97	81	71	961
Zagreb	42	38	55	71	65	80	79	82	90	82	69	68	821
Zelina	38	35	61,0	77	67	96	89	91	87	74	65	74	854

The average annual air temperature in the study area ranged from 7.4 °C, recorded at the climatological station Puntijarka which was, according to monthly values the coldest, to 11.9 °C recorded at the climatological station of Zagreb, which was, according to monthly values the warmest (Table 2). Most climatic stations are experiencing an increase in average annual temperatures in recent years. The warmest month is July with average air temperatures ranging from 16.5 °C recorded at the climatological station Puntijarka to 22.0 °C recorded at the climatological station of Zagreb. The coldest month is January with average air temperature ranging from -1.6 °C recorded at the climatological station Puntijarka to 1.1 °C recorded at the climatological station Zagreb.

The average annual precipitation in the study area ranged from 821 mm recorded at the climatological station Zagreb to 1230 mm recorded at the climatological station Puntijarka. Average monthly precipitation for related stations ranged from 33 mm recorded in January at the climatological station Krapina to 131 mm recorded in September at the climatological station Puntijarka (Table 3).

Based on the presented data, it can be concluded that the location of Medvednica is the most humid and coldest while locations Kupljenovo and Donja Pušća are the most arid and the warmest. This is in corresponding with the optimal temperature for red clover growing is between 20-25 °C, but it also grows at temperatures between 7˚C and 40 ˚C (Ruiz, 1973 cited in Frame et al., 1998, p. 183).

Red clover is adapted to wide range of soil pH, soil types and environmental conditions (Smith et al., 1985 cited in Greene et al., 2004, p. 643). The soils in the study are automorphic (colluvial soil at sites Sošice, Lug Zabočki, Bedekovščina and Donja Pušća; rendzina at sites Sopotski Slap, Planina Donja and Medvednica; eutric cambisol at sites Zagorska Sela and Gornje Jesenje; calcocambisol on dolomite skeletonic at site Drašći Vrh; luvisol at sites Desinić and Čveki) and hydromorphic (pseudogley on slope at sites Trakošćan, Hutin, Lobor and Zlatar Bistrica; pseudogley on plain at site Klanječko Jezero and eugley hypogleyic at site Kupljenovo).

Numerous studies showed a close relation between soil reaction (pH of the soil) and floristic composition of vegetation (Horvat, 1949). Soil reaction is essential for red clover and symbiotic nitrogenous bacteria existing on the clover roots. The ideal soil pH value for red clover is within the range 6.5-7.0. In the conditions favourable for red clover, the soil acidity within the range 5-6 is acceptable (Caddel et al., 2004). In our research, the soil pH ranging from 4.6 to 7.3 did not influenced the density of red clover growing. Majority of the soil samples had neutral reaction (pH 6.5 to 7.2), followed by different intensities of acid reaction (pH 4.5 to 6.5), but only the soil at the site Sopotski Slap had alkaline soil reaction (Table 4). The interesting point to emphasize is the high cover of red clover (2 and 3) on the sites lacking the optimal soil pH value, like Lobor (pH 5.0) and Kupljenovo (pH 4.6). On these sites only the meadow flora is present, without other ruderal flora, which has enable the development of red clover. The average pH at the altitudes below 200 m was 7.1, for altitudes ranging from 200-400 m the average pH was 6.8 and for the altitudes above 400 m the average soil pH was 7.5.

The content of humus vary from low (1-3%) at sites Lug Zabočki, Klanječko Jezero, Desinić and Zlatar Bistrica though medium (3-5%) at sites Čveki, Donja Pušća, Zagorska Sela, Hutin Trakošćan, Medvednica and Sošice to high (5-10%) at sites Bedekovčina, Kupljenovo, Lobor, Gornje Jesenje, Sopotski Slap, Drašći Vrh and Planina Donja (Table 4).

The soils with fine texture (silty clay loam and silty clay with more than 35 percentage of clay particles according to FAO 2006) were recorded at sites Zagorska Sela, Zlatar Bistrica, Hutin and Sošice. The soils with coarse texture (sandy loam with more than 60 percentage of sand particles and less than 18 percentage of clay particles according FAO 2006) were recorded at sites Lug Zabočki and Sopotski Slap. (Table 4).

The soils at all sites are porous (45-60% vol.), with the exception of Bedekovčina and Medvednica, where are very porous (more than 60% vol.). Considering that for the ecological suitability of the soil is not important only total porosity, but differential porosity as well, which represents interrelationship between pores with water (micropores) and pores with air (macropores), below we comment this value. Namely the most favorable relationship between micropores and macropores varies from 1:1 to 3:2. According to results of soil water capacity and soil capacity for air it can be concluded that the most favourable differential porosity is determined at sites Medvednica, Lug Zabočki and Zlatar Bistrica and most unfavoruable at sites Zagorska Sela, Lobor and Trakošćan (Table 4).

Although the soil water capacity is medium (35-45% vol. at sites Drašći Vrh, Sopotski Slap, Gornje Jesenje, Zlatar Bistrica, Lug Zabočki and Planina Donja) to high (45- 60% vol. at all other sites), the most available soil water was determined at sites Bedekovčina (65% of soil water capacity) and Klanječko Jezero (even 72% of soil water capacity) and the most unavailable soil water for the plant was determined at sites Zagorska Sela and Kupljenovo (70% of soil water capacity) and at site Hutin (65% of soil water capacity). Determined values correlate with texture of soil (Table 4). Red clover grows less successfully on the soils of low water capacity, as well as in the areas with low rainfall during the year (Smith et al., 1986 in Grljušić, 2003).

During the past ten years (1999-2008) the increase of the mean annual temperatures were recorded on the major part of the areas under the study (Croatian Meteorological and Hydrological Service). It is a consequence of climate change in the recent years.

Table 4. Pedological data of researched sites

Location	pH M-KC	Humus (%)	Sand* (%)	Silt* (%)	Clay* (%)	Texture class**	Total porosity (% vol.)	Soil capacity for (%. vol.)		Available soil water (% vol.)	Wilting point (% vol.)
								water	air		
Cve	7.0	3.3	8.0	68.8	23.2	SiL	51.5	47.1	4.5	28.7	18.4
Bed	6.4	5.0	25.3	64.8	9.9	SiL	61.2	55.5	5.7	36.1	19.4
Lug	7.1	1.6	62.6	26.6	10.8	SL	56.3	41.8	14.6	22.6	19.2
Kln	5.4	2.9	17.6	74.2	8.2	SiL	49.3	46.0	3.3	33.1	12.9
Kup	4.6	6.1	6.2	61.9	31.9	SiCL	59.3	57.4	1.9	23.0	34.4
Don	6.2	4.5	21.6	63.6	14.8	SiL	52.2	47.1	5.1	25.9	21.2
Zag	6.8	4.7	9.0	49.1	41.9	SiC	55.0	53.9	1.1	16.1	37.8
Des	5.1	2.3	42.0	49.6	8.4	L	55.4	46.7	8.7	26.6	20.1
Zlt	6.6	2.5	9.6	50.7	39.7	SiCL	49.3	39.0	10.3	22.5	16.5
Lob	5.0	5.3	12.5	62.4	25.1	SiL	47.0	45.8	1.2	23.3	22.5
Hut	6.0	3.7	16.7	47.7	35.6	SiCL	53.3	47.1	6.2	14.1	33.0
Gor	6.3	5.0	30.0	50.8	19.2	SiL	45.7	43.6	2.1	20.6	23.0
Trk	4.5	3.1	20.8	65.2	14.0	SiL	50.9	49.8	1.1	25.9	23.9
Sop	7.3	5.5	66.8	29.0	4.2	SL	46.2	39.4	6.8	21.7	17.7
Vrh	7.2	5.6	49.1	32.6	18.3	L	53.4	43.6	9.8	23.1	20.5
Pln	6.9	6.6	20.8	63.7	15.5	SiL	48.0	42.3	5.7	23.7	18.6
Med	7.0	4.8	48.4	43.2	8.4	L	66.9	45.3	21.6	27.2	18.1
Sos	6.2	4.6	10.0	52.7	37.3	SiCL	53.9	48.7	5.2	17.1	31.6

* Sand size fraction 2.0-0.063 mm; silt size fraction 0.063-0.002 mm, clay size fraction <0.002 mm.
** SL – sandy loam; L – loam; SiL – silty loam; SiCL – silty clay loam; SiC – silty clay

However, during the growing season the rainfalls at the areas under the study were sufficient for the development of the plant cover. During the growing season from May to October there were more rainfalls comparing to the rest of the year. All these, make possible the development of red clover.

The cluster of researched sites (Figure 2) was constructed on the basis of all ecogeographical characteristics (soil pH, humus content, soil texture, total porosity, bulk density, particle density, soil water and air capacity, available soil water, wilting point, altitude, exposition, inclination, annual rainfall, mean annual temperature).

They are clustered into two main clusters and a few subclusters. The clusters are formed on the basis of altitude. One cluster represents a group of sites above 400 m a.s.l. (Vrh, Sop, Sos, Med), while the other cluster represents all other sites with the altitude below 400 m a.s.l.

The list of meadow flora from the investigated sites in the north-western part of Croatia comprises 151 taxa of vascular flora classified into 34 families (Appendix 1). The number of species per site ranged from 16 (Desinić) to 53 (Drašći Vrh) (Table 1). Large number of species were recorded on the sites previously managed by extensive agricultural production system, but abandoned in the

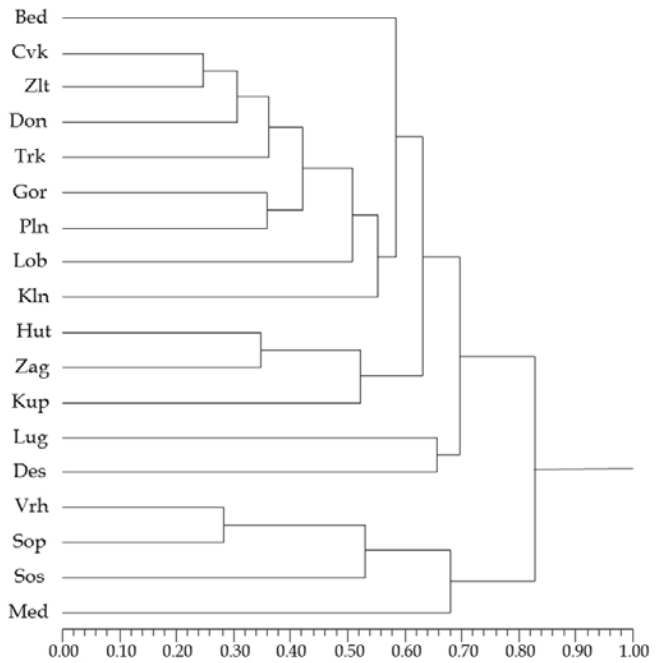

Figure 2. Dendrogram based on ecogeographical characteristics of researched sites (abbrev. – as in table 1)

meantime. These sites were overgrown during the years, as a consequence of production and cultivation abandonment.

Local populations of red clover, but also other grassland species are endangered to extinction as a consequence of succession process and genetic erosion. Krstonošić (2009) and Randić (2007) recorded a large number of species at poorly maintained sites influenced by secondary succession of adjacent vegetation.

In our study the majority of species was recorded at the sites that are obviously overgrown (Drašći Vrh - 53 species, Zagorska Sela – 40 species, Zlatar Bistrica – 39 species, Čveki, Bedekovčina, Donja Pušća – 37 species) (Dujmović Purgar and Bolarić, 2011). Considering the surrounding forest vegetation, all these sites were under increasing secondary successions. Within the spectrum of life forms at these sites the abundance of Hemicryptophytes and perennial herbaceous plants is prevalent. It is usual characteristics of grassland vegetation.

The analysis of the life forms showed that the most of the species found on the researched meadows were Hemicryptophytes (102 species - 67.8%) which correspond to the data from Mitchley and Willems (1995, cited in Hellström, 2004).

The predomination of Hemicryptophytes is in accordance with floral composition of habitats expected in continental climate and Middle European geographical positions and in Croatia (Hulina, 1991).

The spectrum of detected life forms included a large number of Therophytes (25 species – 16.5%), what is in accordance with anthropogenic influence. The presence of Phanerophytes (eight species – 5.3%) at the researched sites indicates successions. The large portion of Hemicryptophytes and Therophytes is a consequence of extensive and traditional meadows management (Hulina, 1991). The variation of their number and species composition may be influenced by the humidity of the habitat (Raunkiær, 1905). The increasing of the Hemicryptophytes is caused by higher habitat humidity, while the higher share of Therophytes is influenced by reduced habitat humidity. In this study we observed the same regularity, with few exceptions (Bedekovčina and Sošice).

The analysis of the spectrum of duration of life cycle of the researched meadows showed the predominance of 75.0% (114 species) of perennial herbaceous plants, followed with annual plants (25 species - 16.5%), woody perennials (9 species – 6.6%), and biennial plants (three species – 2.0%). This is compared to the data of Kovačević (1956), who points out the predominance of perennial herbaceous plants at the grasslands, which are followed by annual and biennial plants. The presence of woody perennials at neglected and poorly maintained meadows indicates successions. The assimilation organs of all herbaceous and woody perennial plants are removed by mowing. Therefore, the more intensive development of woody perennials is expected on abandoned and neglected areas, which are not mowed.

The results based on analysis of floristic composition show the whole cluster divided into subclusters at dissimilarity >0.8 (Figure 3). The locations above 400 m a.s.l. are clustered into two side-clusters (14 – Sopotski Slap, 15 - Drašći Vrh, 16 - Planina Donja, 17 – Medvednica,

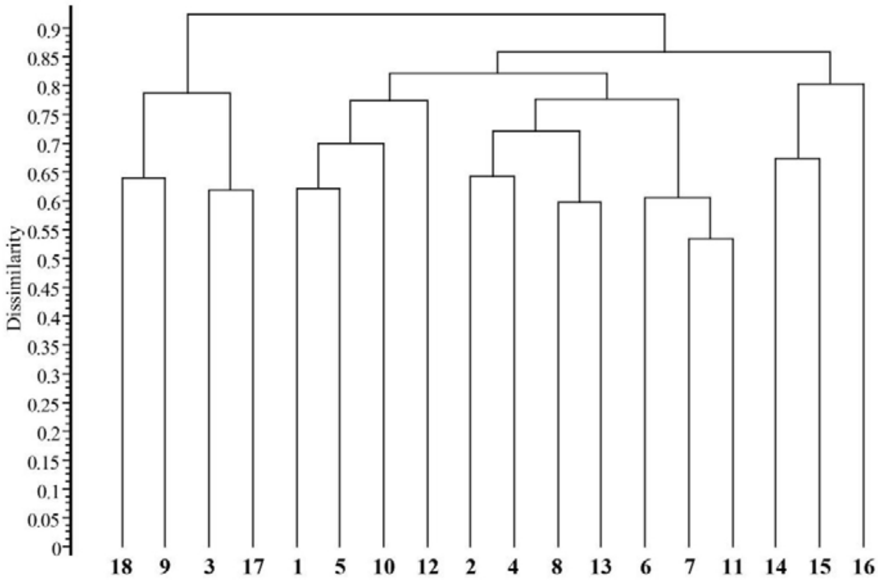

Figure 3. The cluster based on floristic composition (numeral designations correspond to Table 1)

and 18 – Sošice), while the locations of lowest altitudes are grouped into large central cluster (with exception of sites 3 - Lug Zabočki, and 9 - Zlatar Bistrica).

CONCLUSIONS

According to ecogeographical characteristics of local populations sites of red clover, major differences were found due to altitude and exposition (geographical), as well as soil conditions. In the study area a large heterogeneity of soil conditions was found, in the presence of certain types of soil and physical as well as chemical characteristics, what confirms that the red clover is adapted to a wide range of environmental conditions.

Survey of floristic composition revealed that 151 plant species from 34 families were recorded on the meadows, indicating habitat overgrowth and presence of secondary succession. Hemicryptohytes according spectrum of life forms as well as perennial herbaceous plants according to duration of life cycle classification, were dominant on meadows that are usual characteristic of grassland vegetation.

The determination of sites according to their ecogeographical characteristics may help to improve the actions aimed at conservation of biological diversity of the species at their natural habitats, but also the preservation of genetic resources and their use in breeding programmes.

ACKNOWLEDGEMENTS

Results shown in this paper arise from the activities carried out under financial support of the Swedish International Development Cooperation Agency (SEEDNet programme), Ministry of Agriculture, Fisheries and Rural Development (National Programme for the Conservation and Sustainable Use of Plant Genetic Resources), and Ministry of Science, Education and Sports (national research project "Genetic variation of red clover and tolerance to abiotic stresses").

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Appendix 1. The list of plant species on sites with red clover local population in north western part of Croatia

No.	Taxa	Life form[1]	Duration of life[2]	Floral element[3]	Location[4]
	PTERIDOPHYTA; SPHENOPSIDA:				
	Equisetaceae				
1	*Equisetum arvense* L.	G	peren	cosmop	1,6,7
2	*Equisetum telmateia* Ehrh.	G	peren	circ	6,7,16
	Pteridaceae				
3	*Pteridium aquilinum* (L.) Kuhn.	G	peren	euras	15,17
	SPERMATOPHYTA; MAGNOLIOPSIDA:				
	Apiaceae (Umbelliferae)				
4	*Aegopodium podagraria* L.	H	peren	euras	3,4,5,7,13,14
5	*Daucus carota* L.	H	2	euras	1,3,4,5,6,7,9,10,11,13,14,15,17
6	*Heracleum sphondyllium* L.	H	peren	euras	7,10
7	*Pastinaca sativa* L.	H	2	euras	2,3,8,13
8	*Petroselinum sativum* Hoffm.	H	2	euras	1
9	*Pimpinella saxifraga* L.	H	peren	euras	14
	Asteraceae				
10	*Achillea millefolium* L.	H	peren	cosmop	1,2,3,6,7,8,13,14,15,16,17,18
11	*Ambrosia artemisiifolia* L.	T	1	adv	3,7,17
12	*Artemisia vulgaris* L.	H	peren	cosmop	3,4,10,18
13	*Bellis perennis* L.	H	peren	mie	2,6,9,11,14,18
14	*Buphtalmum salicifolium* L.	H	peren	mie	5,15
15	*Centaurea jacea* L.	H	peren	euras	1,2,4,5,6,7,11,12,13,14,15,16
16	*Cirsium arvense* (L.) Scop.	G	peren	cosmop	1,4,9,15
17	*Cirsium oleraceum* (L.) Scop.	H	peren	euras	6,7,9
18	*Conyza canadensis* (L.) Cronq	T	1	adv	6
19	*Erigeron annuus* (L.) Pers.	H	peren	adv	2,3,4,6,7,8,9,10,11,13,15,16,17
20	*Leucanthemum vulgare* Lam. ssp. *triviale* (Gaud) Briq.&Cav.	H	peren	euras	1,2,3,5,6,7,11,13,15
21	*Rudbeckia laciniata* L.	H	peren	adv	13
22	*Senecio jacobaea* L.	H	peren	euras	12
23	*Tanacetum vulgare* L.	H	peren	euras	1,3,9
24	*Tragopogon pratensis* L.	H	peren	euras	4,7,11,13
	Boraginaceae				
25	*Echium vulgare* L.	H	peren	subatl	15
26	*Myosotis arvensis* Hill.	T	1	euras	2,6
27	*Symphytum officinale* L.	H	peren	eur	1,17
	Brassicaceae (Cruciferae)				
28	*Armoracia rusticana* P. Gaertn., B. Mey. et Scherb	H	peren	euras	1,4

No.	Taxa	Life form[1]	Duration of life[2]	Floral element[3]	Location[4]
29	*Cardamine bulbifera* (L.) Crantz	G	peren	subatl	17
30	*Lunaria rediviva* L.	H	peren	adv	17
31	*Rorripa sylvestris* (L.) Bess.	H	peren	euras	2
	Caryophyllaceae				
32	*Cerastium brachypetalum* Pers.	T	1	sue	4
33	*Dianthus gigantheus* D'Urv. ssp. *croaticus* (Borb.)Tutin	H	peren	sue	14,15
34	*Gypsophila muralis* L.	T	1	euras	15
35	*Lychnis flos-cuculi* L.	H	peren	euras	2,5,8
36	*Silene alba* (Miller) E.H.L.	H	peren	euras	18
37	*Silene vulgaris* (Moench) Garcke	H	peren	euras	15,17
38	*Stellaria graminea* L.	H	peren	euras	5
39	*Stellaria holostea* L.	Ch	peren	euras	17
	Cichoriaceae				
40	*Cichorium intybus* L.	H	peren	euras	1,3,5,6,7,10,11,12,13,17
41	*Crepis biennis* L.	H	peren	mie	2,3,4,9,10,15
42	*Lactuca serriola* L.	T	1	euras	6
43	*Leontodon autumnalis* L.	H	peren	euras	2,3,5,6,12,13,14
44	*Leontodon hispidus* L.	H	peren	subatl	7,13
45	*Picris hieracioides* L.	H	peren	euras	1,5,16
46	*Sonchus oleraceus* L.	T	1	cosmop	3,9,16,17
47	*Taraxacum officinale* Weber	H	peren	cosmop	1,2,3,4,6,9,10,11,12,17,18
	Convolvulaceae				
48	*Calystegia sepium* (L.) R.Br.	H	peren	cosmop	1,9,10,12
49	*Convolvulus arvensis* L.	H	peren	cosmop	4,7,10,15,18
	Cornaceae				
50	*Cornus sanguinea* L.	P	w. peren	eur	7,9,15
	Corylaceae				
51	*Coryllus avellana* L.	P	w. peren	eur	15
	Dipsacaceae				
52	*Knautia arvensis* (L.) Coult.	H	peren	euras	6,7,8,11,13,14,16
53	*Knautia drimea* Heuffel	H	peren	ilirb	14
54	*Scabiosa columbaria* L.	H	peren	euras	15
55	*Sucissa pratensis* Moench	H	peren	euras	13
	Euphorbiaceae				
56	*Euphorbia cyparissias* L.	H	peren	eur	15
57	*Euphorbia helioscopia* L.	T	1	cosmop	16
	Fabaceae (Leguminosae)				
58	*Chamaecytisus hirsutus* (L.) Link	P	w. peren	eur	14,15

No.	Taxa	Life form[1]	Duration of life[2]	Floral element[3]	Location[4]
59	*Coronilla varia* L.	H	peren	eur	15
60	*Lathyrus pratensis* L.	H	peren	euras	5,6,7,11,15
61	*Lathyrus tuberosus* L.	H	peren	euras	1,15
62	*Lotus corniculatus* L.	H	peren	cosmop	1,2,3,5,6,7,8,9,10,11,12,13,14,15,16
63	*Medicago lupulina* L.	T	1	euras	1,9,11,17,18
64	*Medicago sativa* L. ssp. *falcata* (L.) *Archangeli*	H	peren	euras	5,6,7,8,13
65	*Medicago sativa* L. ssp. *sativa* L.	Ch	peren	euras	1,5,8,9,10,12,14,18
66	*Onobrychis viciifolia* Scop.	H	peren	eur	15
67	*Ononis arvensis* L.	H	peren	eur	5,6,7
68	*Ononis spinosa* L.	Ch	peren	med	15
69	*Robinia pseudacacia* L.	P	w. peren	adv	15
70	*Trifolium campestre* Schreb.	T	1	cosmop	5,15
71	*Trifolium fragiferum* L.	H	peren	submed	2,3,6,17
72	*Trifolium hybridum* L.	H	peren	eur	1,17
73	*Trifolium pratense* L.	H	peren	euras	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18
74	*Trifolium repens* L.	H	peren	cosmop	1,2,3,4,5,9,11,13,16,17,18
75	*Vicia cracca* L.	H	peren	euras	1,2,4,5,6,7,9,15,16
76	*Vicia grandiflora* Scop.	T	1	submed	1
77	*Vicia sativa* L.	T	1	cosmop	2,9
	Fagaceae				
78	*Quercus cerris* L.	P	w. peren	sue	15
	Gentianaceae				
79	*Centaurium erithrea* Rafn.	T	1	cosmop	13
80	*Gentiana pneumonanthe* L.	H	peren	euras	15
	Geraniaceae				
81	*Geranium columbinum* L.	T	1	euras	15
	Hypericaceae				
82	*Hypericum perforatum* L.	H	peren	euras	10,13,15,16
	Lamiaceae (Labiatae)				
83	*Ajuga reptans* L.	H	peren	euras	2,9
84	*Clinopodium vulgare* L.	H	peren	cosmop	13
85	*Glechoma hederacea* L.	H	peren	circ	9
86	*Glechoma hirsuta* Waldst. et Kit.	H	peren	sue	9
87	*Lamium maculatum* L.	H	peren	euras	3
88	*Lamium purpureum* L.	T	1	euras	18
89	*Mentha longifolia* (L.) Hudson	H	peren	cosmop	9
90	*Mentha pulegium* L.	H	peren	euras	5

No.	Taxa	Life form[1]	Duration of life[2]	Floral element[3]	Location[4]
91	*Origanum vulgare* L.	H	peren	euras	15
92	*Prunella vulgaris* L.	H	peren	cosmop	1,2,3,5,6,7,9,11,12,13,17
93	*Salvia pratensis* L.	H	peren	submed	6,7,11,15
94	*Salvia verticillata* L.	H	peren	sue	13,15
95	*Stachys officinalis* (L.) Trev.	H	peren	eur	5,6,13
96	*Thymus serpyllum* L.	Ch	peren	eur	13,14,15
	Lythraceae				
97	*Lythrum salicaria* L.	H	peren	circ	5,13
	Plantaginaceae				
98	*Plantago lanceolata* L.	H	peren	cosmop	1,2,3,4,5,6,7,8,9,10,12,13,17,18
99	*Plantago media* L.	H	peren	euras	1,3,13,14,15,16,17
	Polygalaceae				
100	*Polygala vulgaris* L.	H	peren	subatl	14,15
	Polygonaceae				
101	*Polygonum lapathifolium* L.	T	1	cosmop	2,4
102	*Polygonum persicaria* L.	T	1	cosmop	18
103	*Rumex acetosa* L.	H	peren	cosmop	2,5,8,9,12,14,15,18
104	*Rumex acetosella* L.	H	peren	cosmop	4,5,6,7,13,14
105	*Rumex crispus* L.	H	peren	cosmop	9,10,18
106	*Rumex obtusifolius* L.	H	peren	euras	2,9,18
	Primulaceae				
107	*Lysimmachia nummularia* L.	Ch	peren	euras	9
108	*Primula vulgaris* Huds.	H	peren	sue	7,11
	Ranunculaceae				
109	*Clematis vitalba* L.	P	w. peren	mie	14
110	*Ranunculus acris* L.	H	peren	cosmop	1,2,4,5,6,7,8,9,11,12,13,14,15,18
111	*Ranunculus repens* L.	H	peren	mie	1,2,7,9,10,18
	Rosaceae				
112	*Agrimonia eupatoria* L.	H	peren	circ	5
113	*Filipendula vulgaris* Moench	H	peren	euras	6,15
114	*Potentilla reptans* L.	H	peren	cosmop	6,9,11,12,14,15,18
115	*Rosa* sp.	P	w. peren	cosmop	15
116	*Rubus caesius* L.	Ch	w. peren	euras	1,6,7,12
117	*Rubus discolor* Weihe et Ness	P	w. peren	subatl	15
118	*Rubus saxatilis* L.	H	peren	euras	9
	Rubiaceae				
119	*Galium cruciata* (L.) Scop.	H	peren	euras	1
120	*Galium mollugo* L.	H	peren	euras	1,2,4,5,7,9,10,11,12,13,14,15

No.	Taxa	Life form[1]	Duration of life[2]	Floral element[3]	Location[4]
121	*Galium verum* L.	H	peren	cosmop	1,4,5,6,7,11,15
	Scrophulariaceae				
122	*Euphrasia officinalis* L.	T	1	submed	13
123	*Lathraea squamaria* L.	G	peren	subatl	16
124	*Linaria vulgaris* Mill.	G	peren	euras	2,9,15
125	*Rhinanthus alectorolophus* (Scop.) Poll.	T	1	eur	15
126	*Veronica chamaedrys* L.	Ch	peren	euras	2
127	*Veronica persica* Poir.	T	1	cosmop	2,9,18
	Urticaceae				
128	*Urtica dioica* L.	H	peren	cosmop	17
	Violaceae				
129	*Viola alba* Besser	H	peren	sue	7,11
	LILIOPSIDA:				
	Cyperaceae				
130	*Carex vulpina* L.	H	peren	euras	5
	Juncaceae				
131	*Juncus effusus* L.	H	peren	euras	5
	Liliaceae				
132	*Colchicum autumnale* L.	G	peren	mie	7,11
	Poaceae (Gramineae)				
133	*Alopecurus pratensis* L.	H	peren	euras	1,5
134	*Arrhenatherum elatius* (L.) P.Beauv. ex J.Presl et C.Presl	H	peren	eur	1,3,6,8,9,11,14,15,16,18
135	*Brachypodium pinnatum* (L.) P. Beauv.	H	peren	euras	15
136	*Briza media* L.	H	peren	euras	7,10,11,14,15,16
137	*Bromus racemosus* L.	H	peren	subatl	2,18
138	*Cynosurus cristatus* L.	H	peren	cosmop	6
139	*Dactylis glomerata* L.	H	peren	euras	2,3,4,7,8,9,10,11,12,13,14,15,16,18
140	*Echinochloa crus - galli* (L.) P.B.	T	1	cosmop	2
141	*Festuca arundinacea* Schreb.	H	peren	euras	7
142	*Holcus lanatus* L.	H	peren	euras	1,2,4,5,6,7,8,9,10,11,13
143	*Lolium multiflorum* Lam.	T	1	med	2,4,6,18
144	*Lolium perenne* L.	H	peren	cosmop	12
145	*Poa annua* L.	T	1	cosmop	17
146	*Poa pratensis* L.	H	peren	circ	2,3,7,9,18
147	*Poa trivialis* L.	H	peren	euras	10,18
148	*Setaria glauca* (L.) P.B.	T	1	cosmop	1,2,4,12,18
149	*Setaria viridis* (L.) P.B.	T	1	euras	17

No.	Taxa	Life form[1]	Duration of life[2]	Floral element[3]	Location[4]
150	*Sorghum halepense* (L.) Pers.	G	peren	cosmop	1
151	*Trisetum flavescens* (L.) P.B.	H	peren	circ	4,8,14,16,18

[1] **Life form: G**-Geophytes, **H**-Hemicryptophytes, **T**-Therophytes, **P**-Phanerophytes, **Ch**-Chamephytes.

[2] **Duration of life: peren**-perennial, **w. peren**-woody perennial, **1**-annual, **2**-biennial.

[3] **Floral element: cosmop**-cosmopolites/widespread plants, **euras**- Euroasian origin, **adv**-Adventive, **eur**-European origin, **sue**-South-European origin, **circ**-Circumholartic origin, **med**-Mediterranean origin, **submed**-Submediteranian origin, **mie**-Middle-European origin, **ilirb**-Illyrian-Balkanic origin, **subatl**-Subatlantian origin.

[4] **Locations:** numeral designations correspond to Table 1.