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ANTIOXIDANT CAPACITY OF MEDICAL PLANTS PRODUCED IN AGROFORESTRY SYSTEM

Dénes BENKE – Eszter VISI-RAJCZI – Tamás HOFMANN

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ABSTRACT

In the present work, we investigated the antioxidant content of three medical plants (common sorrel (*Rumex acetosa* L.), ribwort plantain (*Plantago lancelota* L.) and dwarf periwinkle (*Vinca minor* L.) grown in the agroforestry system of the Bajti Breeding Plant (Hungary). The aim of our research was to examine the seasonal changes in antioxidant content of the species and to find out which soil cover method (control, mulching, bee-pasture and geotextile cover) is the most advantageous for the antioxidant capacity of these species. The antioxidant capacity was examined using the TPC, FRAP and DPPH assays. It was found that the cultivation method resulting in the highest antioxidant content depends on the plant species. In the case of sorrel the highest antioxidant capacities were measured in spring samples with the mulch and bee-pasture covers. In the case of ribwort plaintain, the highest FRAP, TPC and DPPH values were measured in the spring/control samples, none of the investigated soil cover methods contributed significantly to the increase of the antioxidant content. Similarly to plantain, for dwarf periwinkle the tested methods did not affect the antioxidant content in any of the studied seasons, the highest values were measured in spring and the lowest in summer. In general, the highest antioxidant capacity values could be measured in spring for the investigated species. Due to the different selectivity of the applied antioxidant assays, the use different methods is necessary for the comparative analysis of the antioxidant contents. Results contribute to the research of the composition of medicinal plants produced in agroforestry systems and the data will serve as a basis for the planning of experiments on further species.

Key words: agroforestry, antioxidant capacity, common sorrel, ribwort plantain, dwar periwinkle

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1. INTRODUCTION

The increasing impacts of climate change will pose growing challenges for both agriculture (AYDINALP AND CRESSER, 2008) and forestry (GUSTAVSSON et al., 2017). Adapting to climate change will require the introduction of new solutions for agricultural technologies (LÁNG et al., 2011). One possible way to do this is to establish and manage agroforestry systems. The cultivation of crops in such systems has a number of positive effects in addition to carbon sequestration (WILLMOTT et al., 2023). One of the main advantages of agroforestry systems is the possibility to produce quality wood without having to take land out of agricultural cultivation (Kovács et al., 2019). Agroforestry systems allow for a higher utilization of natural resources due to the woody component. This is known as eco-intensification (Rigueiro-Rodríguez et al., 2008). In addition, such systems also provide a number of ecosystem services. Agroforestry systems reduce erosion and deflation, help return organic matter to the soil, increase biodiversity, and protect the agricultural crops from extreme climate impacts (De Jong et al., 2018).

In addition to traditional crops (cereals, legumes, vegetables, etc.), medicinal plants can also be grown in agroforestry systems. The medicinal plants grown this way can be used for the usual purposes, but also to produce extracts and various groups of compounds (Grigore et al., 2015). Medicinal plants contain a wide range of extractives (alkaloids, terpenoids, polypeptides, polyphenols, etc.), many of which have beneficial physiological effects and medicinal value (Ong, 2004) based on their antioxidant properties (Chu, 2011).

Antioxidants are compounds that are present in low concentrations relative to the oxidizable substance and significantly slow or prevent oxidation (Halliwell, 1990). The primary physiological role of these compounds is to protect cellular components from the damaging effects of free radicals generated by biochemical reactions in the living organism (Young and Woodside, 2001), as several diseases are directly related to the presence and excess of free radical (Cena and Calder, 2020). Antioxidant compounds also play an important role in both food and pharmaceutical industries. In the food industry, antioxidants are used for food preservation purposes and medicine antioxidants are applied due to their various beneficial health (e.g. anti-inflammatory, anti-cancer, anti-viral) effects.

The aim of the present work is to investigate the antioxidant content of three medicinal plant species (*Rumex acetosa* L., *Plantago lancelota* L., *Vinca minor* L.) produced using different soil covers and sampled at different stages of the growing season. Antioxidant content was assessed and compared by measuring Folin-Ciocalteu total polyphenol content (TPC), Ferric reducing antioxidant power (FRAP) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays. The aim of the study is to find out if soil covering method and harvesting time have an effect on the antioxidant content of the investigates medicinal plants grown in the agroforestry systems.

2. MATERIAL AND METHODS

2.1. Site description

For the research, the samples were collected in the area of the Bajti nursery garden (North-West Hungary). The garden is under the management of the University of Sopron and the Forest Research Institute (ERTI), and its purpose is forest gene conservation and breeding. In 2021, an agroforestry system was established at the site, in which different herbaceous plant species are cultivated with alley cropping. The agroforestry system covers an area of about 0.5 hectares, which is fenced to exclude wildlife damage. A total of 170 Euramerican poplars (*Populus × euramericana (Dode) Guiner cv. ‹I-214›* L. of the species ‚I-214' are planted in 17 rows (Guti, 2023) to provide shadig and forest cover.

The plants grown under the trees were planted in three different soil covers: geotextile, mulch and bee-pasture. Both the geotextile and mulch have a positive effect on soil water management and compensate for major thermal fluctuations. It also inhibits weed germination. The bee-pasture cover refers to a site which is surrounded from both sides by a territory where herbaceous plants (mainly *Fabales* spp., *Asterales* spp. and *Brassicales* spp.) were grown. The main benefits of the bee-pasture cover are nutrient recycling to the soil and the creation of a more humid microclimate, however its disadvantage is that it can provide potential hiding places for pests (EFOP-3.6.2-16-2017-00018).

The control area is located outside the tree-shaded area, directly exposed to the sun, and no soil covering methods were applied to the herbaceous crops grown here.

2.2 Examined species

Common sorrel (*Rumex acetosa L. NOT Rumex acetosella*) is a herbaceous perennial herbaceous plant of the Polygonaceae family. It is widespread in Europe but has also been introduced into Africa, Asia and North America. It is found naturally in meadows and grasslands, but is also cultivated in many places. The plant is very healthy to consume due to its high mineral and vitamin content, and it also has many health benefits (Bello et al., 2019).

Ribwort plantain (*Plantago lanceolata* L.) is a herbaceous perennial belonging to the plantain family (*Plantaginaceae).* It is a common generalist species worldwide, found in meadows and pastures. It contains a number of biologically active compounds that make its use widespread in traditional medicine (Stewart, 1996).

Dwarf periwinkle (*Vinca minor* L.) is an overwintering perennial in the family *Apocynacae* It occurs naturally in lush woodlands and at their borders, but is also frequently occurs as an ornamental plant. One of the most important substances of the dwarf periwinkle is an alkaloid called vincamine, which is used in pharmaceuticals (Ciorita et al., 2021). The active ingredient of the drug Cavinton® (Richter Gedeon Ltd, Budapest, Hungary) - applied for the treatment of cerebral vasoconstriction - is produced by the structural modification of the dwarf periwinkle extractive, vincamine.

2.3 Sampling and extraction

The samples were collected in the agroforestry area of the Bajti Breeding Plant on three occasions: on 10 October 2022, 5 May 2023 and 13 July 2023. Approximately 200 grams of plant material (leaves, shoots, flowers combined) were collected randomly for each soil covers (control, geotextile, mulch, bee-pasture) for each species. After collection, the samples were freeze-dried (Wave FD260 lyophilizer, Wave Trockensysteme GmbH, Vienna, Austria) and stored in vacuum-sealed bags under refrigeration until processing.

Before extraction, the samples were chopped using a coffee grinder. From the prepared samples, 0.2 g was weighed into 50 ml centrifuge tubes and 40 ml methanol:water 50:50 v/v solution was added. The samples were then placed in an ultrasonic bath for 3x10 min (Elma Transsonic T570 ultrasonic bath, Elma Schmidbauer GmbH, Singen, Germany). Ultrasonic bath water temperature was kept between 26-30 C^o during the extraction process.

2.4 Antioxidant capacity assays

2.4.1. TPC method

Total phenol determination of solutions was performed by the Folin-Ciocalteu method, which is based on the reducing power of the extract (Balogh, 2010). 400 µl methanol:water 50:50 V/V solution was mixed with 100 µl of extract, followed by adding 2.5 ml of Folin-Ciocalteu reagent. After about 1 min, 2.0 ml of 0.7 M Na_2CO_3 solution was added. The mixture was incubated a water bath at 50°C for 5 min, and then cooled to room temperature. The absorbance of the reaction solution was measured at 760 nm. Three parallel measurements were performed for each sample. Gallic acid was used as the standard compound and the results were expressed in mg gallic acid equivalent/g dry weight (mg GE/g dw.).

2.4.2. DPPH method

The radical scavenging activity of DPPH (2,2-diphenyl-1-picrylhydrazyl) radical was determined according to a modified protocol of Sharma and Bhat (2009). 100 µl of extract was mixed with 100 ml methanol:water 50:50 v/v solution and 2.8 ml DPPH solution (80 mM) and incubated at room temperature in a dark place for 30 min. The decrease in absorbance at 515 nm was measured. Three parallel measurements were performed on each sample. The DPPH radical scavenging capacity was expressed in milligrams of trolox equivalents per gram of dry sample (mg TE / g dw).

2.4.3. FRAP method

The FRAP assay was run following the method of Benzie and Strain (1996) at 593 nm, applying 5 min reaction time and using ascorbic acid as standard. Three parallel measurements were performed on each sample. Results were expressed as mass equivalents of ascorbic acid per dry weight of sample (mg AE/g dw).

2.5. Statistical analysis

Statistica 8 software (StatSoft Inc., Tulsa, USA) was used to compare the results. The calculation method was Tukey HSD, p<0.04, and the homogeneity of variances was checked by Bartlett's test.

3. RESULTS AND DISCUSSION

3.1. Common sorrel extracts

The results for common sorrel extractcs are summarized in Table 1. Table 2 shows the statistical evaluation of the obtained data.

Table 1: Antioxidant capacity values (mean ± standard deviation) of TPC (mg GE/g sa), FRAP (mg AE/g sa) and DPPH (mg TE/g sa) of common sorrel samples at different sampling times and for different ground covers. Con: control, Geo: geotextile, Bee: bee-pasture. Control values are indicated in bold.

	TPC (mg GE/g dm.)			FRAP (mg AE/g dm.)			DPPH (mg TE/g dm.)		
	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Con	**22.0 ± 1.1**	**24.2 ± 0.9**	**19.3 ± 0.6**	**14.6 ± 0.4**	**18.2 ± 0.9**	**12.8 ± 0.6**	**15.3 ± 1.2**	**24.4 ± 0.2**	**20.4 ± 0.3**
Geo	17.8 ± 1.1	20.4 ± 0.8	14.6 ± 0.2	11.6 ± 0.3	15.3 ± 0.2	10.7 ± 0.2	11.2 ± 0.4	20.2 ± 1.3	14.7 ± 0.1
Mulch	16.7 ± 0.9	27.1 ± 0.9	14.2 ± 0.5	10.9 ± 0.1	22.1 ± 0.5	10.2 ± 0.1	11.8 ± 2.1	27.4 ± 1.0	14.0 ± 1.5
Bee	18.4 ± 0.6	28.2 ± 0.7	12.9 ± 0.3	13.4 ± 0.4	22.7 ± 0.7	9.3± 0.6	13.3 ± 1.1	30.4 ± 1.1	13.1 ± 0.4

Table 2 Analysis of variance of the antioxidant capacity values of TPC (a), FRAP (b) and DPPH (c) in common sorrel samples. Mean: average value (TPC: mg GE/g s.a., FRAP: mg AE/g s.a., DPPH: mg TE/g s.a.). For each method the mean values indicated with different letters (sets) are significantly different at the p<0.04 level. Con: control, Geo: geotextile, Bee: bee-pasture.

TPC			FRAP			DPPH		
Sample	Mean	set	Sample	Mean	set	Sample	Mean	set
Bee_summer	12.9	a	Bee_summer	9.3	a	Geo_autumn	11.2	a
Mulch_summer	14.2	a	Mulch_ summer	10.2	ab	Mulch_autumn	11.8	ab
Geo_summer	14.6	ae	Geo_summer	10.7	ab	Bee_summer	13.1	ab
Mulch_autumn	16.7	be	Mulch_autumn	10.9	b	Bee_autumn	13.3	ab
Geo_autumn	17.8	bc	Geo_autumn	11.6	bc	Mulch_summer	14	ab
Bee_autumn	18.4	bcd	Con_summer	12.8	cd	Geo_summer	14.7	ab
Con_summer	19.3	cd	Bee_autumn	13.4	de	Con_autumn	15.3	c
Geo_spring	20.4	df	Con_autumn	14.6	ef	Geo_spring	20.2	d
Con_autumn	22	fg	Geo_spring	15.3	f	Con_summer	20.4	d
Con_spring	24.2	g	Con_spring	18.2	h	Con_spring	24.4	e
Mulch_spring	27.1	h	Mulch_spring	22.1	g	Mulch_spring	27.4	ef
Bee_spring	28.2	h	Bee_spring	22.7	g	Bee_spring	30.4	f

For common sorrel, the highest values were measured for the bee-pasture/spring and mulch/spring samples using both TPC and FRAP methods. For DPPH, the bee-pasture/spring sample had the highest antioxidant capacity, with values significantly higher than the corresponding control values. In terms of seasonal variation, plant parts collected in spring contained higher levels of antioxidant compounds than those collected in summer and autumn, both for control and samples cultivated with ground cover.

The antioxidant activity of common sorrel has been investigated by several researchers, who also found a strong antioxidant effect (Tuazon-Nartea and Savage 2013, Shaggjav, 2014). Several publications describe a positive correlation between phenolic components and the antioxidant capacity of some plants (Nazaruk et al., 2008; Wijngaard et al., 2009), which was also confirmed by Wegiera and colleagues (2010). As for polyphenolic compounds, common sorrel contains synapic acid and quercetin in highest amounts (Kucekova et al., 2011; Feduraev et al., 2022, Li et al. 2022). The latter study compared the antioxidant capacity of several species of the genus *Rumex* and concluded that the antioxidant capacity of sheep's sorrel (*Rumex acetosella* L.), a species native to Hungary, is more than five times higher than that of common sorrel. The present results showed significant variation in the antioxidant content of the common sorrel samples (presumably due to biosynthesis of phenolic compounds depending on light, heat and other environmental factors).

It can be concluded that the sorrel plants had the highest antioxidant values in the spring/mulch and spring/bee-pasture samples. These results were also significantly higher compared to the values of the samples grown with different ground covers and to that of control samples.

3.2. Ribwort plantain extracts

Table 3 shows the results of total phenol, FRAP and DPPH antioxidant capacity of ribwort plantain extracts. Table 4 shows the statistical evaluation of the obtained data.

Table 3: Antioxidant capacity values (mean ± standard deviation) of TPC (mg GE/g sa), FRAP (mg AE/g sa) and DPPH (mg TE/g sa) of ribwort plantain samples at different sampling times and for different ground covers. Con: control, Geo: geotextile, Bee: bee-pasture. Control values are indicated in bold.

	TPC (mg GE/g s dw.)			FRAP (mg AE/g dw.)			DPPH (mg TE/g dw.)		
	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Con	**46.0 ± 0.0**	**49.8 ± 0.5**	**32.9 ± 1.4**	**34.6 ± 0.5**	**46.3 ± 3.7**	**26.1 ± 1.1**	**47.8 ± 9.9**	**131.9 ± 5.2**	**47.9 ± 1.1**
Geo	43.1 ± 1.9	34.1 ± 0.7	27.4 ± 0.8	33.6 ± 0.3	29.5 ± 1.2	20.6 ± 1.5	43.8 ±11.1	83.8 ± 5.2	55.0 ± 3.2
Mulch	43.7 ± 1.3	35.0 ± 1.0	21.9 ± 0.5	32. 0 ± 1.1	31.4 ± 0.6	18.0 ± 0.9	48.0 ± 5.9	88.2 ± 1.6	46.9 ± 2.2
Bee	44.1 ± 1.7	31.3 ± 0.8	20.6 ± 1.2	33.2 ± 1.3	26.9 ± 1.3	16.4 ± 1.4	46.3 ± 5.4	79.7 ± 5.2	47.4 ± 1.8

Table 4: Analysis of variance of the antioxidant capacity values of TPC (a), FRAP (b) and DPPH (c) in ribwort plantain samples. Mean: average value (TPC: mg GE/g s.a., FRAP: mg AE/g s.a., DPPH: mg TE/g s.a.). For each method the mean values indicated with different letters (sets) are significantly different at the p<0.04 level. Con: control, Geo: geotextile, Bee: bee-pasture.

TPC			FRAP			DPPH		
Sample	Mean	set	Sample	Mean	set	Sample	Mean	set
Bee_summer	20.6	a	Bee_summer	16.4	a	Geo_autumn	43.8	a
Mulch_summer	21.9	a	Mulch_summer	18.0	a	Bee_autumn	46.3	a
Geo_summer	27.4	b	Geo_summer	20.6	a	Mulch_summer	46.9	a
Bee_spring	31.3	c	Con_summer	26.1	b	Bee_ summer	47.4	a
Con_summer	32.9	cd	Bee_spring	26.9	b	Con_autumn	47.8	a
Geo_spring	34.1	cd	Geo_spring	29.5	bc	Con_summer	47.9	a
Mulch_spring	35.0	d	Mulch_spring	31.4	bc	Mulch_autumn	48.0	a
Geo_autumn	43.1	e	Mulch_autumn	32.0	bc	Geo_summer	55.0	a
Mulch_autumn	43.7	e	Bee_autumn	33.2	bc	Bee_spring	79.7	b
Bee_autumn	44.1	e	Geo_autumn	33.6	bc	Geo_spring	83.8	b
Con_autumn	46.0	e	Con_autumn	34.6	d	Mulch_spring	88.2	b
Con_spring	49.8	f	Con_spring	46.3	e	Con_spring	132	c

In the case of ribwort plantain, the highest values for all three antioxidant capacity measurement methods were measured in the control/spring samples. As for the antioxidant capacity of the samples collected in different seasons, the spring samples had the significantly highest values, but this was only true for the control samples. Among the plants exposed to soil cover, FRAP and TPC values were highest in the autumn samples. The DPPH values showed a completely different trend, with the spring samples performing best, regardless of the type of soil cover. The different „behaviour“ of FRAP, TPC and DPPH in the case of ribwort plantain indicates that it contains antioxidants that are differently selective to the applied methods (Hegedűs and Stefanovitsné, 2012).

Several studies have already researched the chemical composition of ribwort plantain. Out of the more than 200 compounds found in it, chlorogenic acid and verbascolide were found to be most abundant (Beara et al., 2012; Bajer et al., 2015; Bahadori et al., 2020). The high antioxidant capacity of the plant has also been demonstrated earlier (Dalar et al., 2012). Moreover, Nichita et al. (2016) found that there was a direct correlation between the amount of polyphenolic compounds and the antioxidant capacity. In contrast to our measurements, Grigore and colleagues (2017) found that the total phenol and flavonoid content of ribwort plantain increased steadily throughout the year. However, Sanna and colleagues (2022) compared the antioxidant capacity of ribwort plantain samples collected from different areas and also measured the highest values for the spring samples. The discrepancy between the results may be due to the fact that the antioxidant content of plants does not only depend on the season, but may also be influenced by other conditions such as weather (Aries et al., 2011; Chrysargys et al., 2021), soil (Muscolo et al., 2019), or geographic location (Chatoui et al., 2020).

Overall, the highest FRAP, TPC and DPPH values were measured in the spring control samples. It can be concluded that the applied soil cover methods did not significantly contribute to the increase in antioxidant content in studied ribwort plantain samples.

3.3. Dwarf periwinkle extracts

The results of the dwarf periwinkle extracts are summarized in Table 5. Table 6 shows the statistical evaluation of the obtained data.

Table 5: Antioxidant capacity values (mean ± standard deviation) of TPC (mg GE/g sa), FRAP (mg AE/g sa) and DPPH (mg TE/g sa) of dwarf periwinkle samples at different sampling times and for different ground covers. Con: control, Geo: geotextile, Bee: bee-pasture. Control values are indicated in bold.

	TPC (mg GE/g s dw.)			FRAP (mg AE/g dw.)			DPPH (mg TE/g dw.)		
	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Con	**46.0 ± 0.0**	**49.8 ± 0.5**	**32.9 ± 1.4**	**34.6 ± 0.5**	**46.3 ± 3.7**	**26.1 ± 1.1**	**47.8 ± 9.9**	**131.9 ± 5.2**	**47.9 ± 1.1**
Geo	43.1 ± 1.9	34.1 ± 0.7	27.4 ± 0.8	33.6 ± 0.3	29.5 ± 1.2	20.6 ± 1.5	43.8 ±11.1	83.8 ± 5.2	55.0 ± 3.2
Mulch	43.7 ± 1.3	35.0 ± 1.0	21.9 ± 0.5	32. 0 ± 1.1	31.4 ± 0.6	18.0 ± 0.9	48.0 ± 5.9	88.2 ± 1.6	46.9 ± 2.2
Bee	44.1 ± 1.7	31.3 ± 0.8	20.6 ± 1.2	33.2 ± 1.3	26.9 ± 1.3	16.4 ± 1.4	46.3 ± 5.4	79.7 ± 5.2	47.4 ± 1.8

Table 6: Analysis of variance of the antioxidant capacity values of TPC (a), FRAP (b) and DPPH (c) in dwarf periwinkle samples. Mean: average value (TPC: mg GE/g s.a., FRAP: mg AE/g s.a., DPPH: mg TE/g s.a.). For each method the mean values indicated with different letters (sets) are significantly different at the p<0.04 level. Con: control, Geo: geotextile, Bee: bee-pasture.

TPC			FRAP			DPPH		
Sample	Mean	set	Sample	Mean	set	Sample	Mean	set
Con_summer	12.0	a	Con_summer	5.6	a	Mulch_summer	9.9	a
Mulch_summer	13.4	a	Mulch_summer	6.0	a	Geo_summer	10.8	a
Bee_summer	14.8	a	Geo_summer	6.6	a	Con_summer	11.1	a
Geo_summer	15.2	a	Bee_summer	6.9	a	Bee_summer	11.7	a
Bee_autumn	27.6	b	Geo_spring	16.2	b	Bee_autumn	22.5	b
Bee_spring	28.7	bc	Bee_autumn	17.0	bc	Con_autumn	24.3	b
Geo_autumn	29.0	bc	Con_autumn	17.0	bc	Geo_autumn	24.7	b
Geo_spring	29.0	bc	Bee_spring	17.2	bc	Mulch_autumn	25.0	b
Con_autumn	29.3	bc	Geo_autumn	18.2	cd	Geo_spring	31.6	d
Con_spring	30.2	bc	Mulch_autumn	18.8	d	Bee_spring	33.9	cd
Mulch_spring	31.7	c	Mulch_spring	18.9	d	Con_spring	36.9	c
Mulch_autumn	31.9	c	Con_spring	19.2	d	Mulch_spring	38.3	c

In the case of dwarf periwinkle, the soil covers did not affect the antioxidant capacity compared to the corresponding control, according to any of the measurement methods. Again, the antioxidant capacity of the spring samples is the highest and that of the summer samples the lowest.

There is relatively less literature that comprehensively addresses the compounds in dwarf periwinkle and the antioxidant capacity of the plant. Most of the publications deal with indole alkaloids in the plant (Farahanikia et al., 2011; Liu et al. 2016; Dumitrescu et al., 2021), which is not surprising, since the main active ingredient of the plant is vincamine (Smeyers et al., 1991; Al-Rashed et al., 2021). In addition, the plant contains high amounts of chlorogenic acid, caffeic acid and rutin (Sezer and Uysal 2018; Ciorita et al., 2021). Other studies have also shown that dwarf periwinkle has a high antioxidant capacity which was associated with the polyphenol content (Grujic et al., 2015; Neculai et al., 2023).

In the case of dwarf periwinkle, the tested soil covers did not significantly affect the antioxidant content in any of the tested seasons. The highest values were measured in spring and the lowest in summer.

4. CONCLUSION

In the present work, the antioxidant content of three medicinal plant species (common sorrel, ribwort plantain and dwarf periwinkle) grown under different soil covers (mulch, geotextile, bee-pasture) in the agroforestry system of the Bajti nursery garden (North-West Hungary) was investigated.

In common sorrel the spring/mulch and spring/bee-pasture covers had the highest antioxidant capacities, higher than those of the other covers and of the control samples. For ribwort plantain, the highest FRAP, TPC and DPPH values were measured in the spring control samples. We found that the applied soil covers did not significantly contribute to the increase in antioxidant content. Similarly to the ribwort plantain, in the case of dwarf periwinkle, the tested covering methods did not significantly affect the antioxidant content in any of the seasons tested. The highest values were measured in spring and the lowest in summer.

The results showed that the effect of soil covers on antioxidant content is highly species-dependent, with the highest antioxidant capacity values usually being measured in spring. Due to the different selectivity of antioxidant assays the use several different methods is needed for the comparative analysis of the antioxidant content of plants with different composition and for the assessment of the seasonal variations. Results will contribute to the research on the composition of medicinal plants grown in agroforestry systems and the data will serve as a basis for designing further experiments on investigated species.

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Author's address:
Dénes Benke
Dr. Eszter Visi-Rajczi
Dr. Tamás Hofmann
Institute for Environmental Protection and Natural Conservation
Faculty of Forestry
University of Sopron
Bajcsy-Zsilinszky u. 4.
9400 Sopron
Hungary

e-mail: benkedenes@gmail.com
e-mail: hofmann.tamas@uni-sopron.hu
e-mail: visine.rajczi.eszter@uni-sopron.hu

Antioxidačná kapacita liečivých rastlín pestovaných v agrolesníckom systéme

Abstarkt

Táto štúdia skúmala antioxidantový obsah troch liečivých druhov—bežnej šťaveľ (Rumex acetosa L.), přhľavy (Plantago lanceolata L.) a malé periwinkle (Vinca minor L.)—pestovaných v agrolesníckom systéme na Bajti Breeding Plant. Naším cieľom bolo posúdiť sezónne variácie v úrovniach antioxidantov a vyhodnotiť vplyv rôznych metód pokrytia pôdy (kontrola, mulčovanie, včelia pastva a geotextilné pokrytie) na tieto úrovne.Kapacita antioxidantov bola meraná pomocou metód celkového fenolového obsahu (TPC), ferrického redukčného antioxidačného výkonu (FRAP) a 2,2-difenyl-1-pikrylhydrazyl (DPPH). Výsledky naznačili, že najúčinnejšia pestovateľská metóda sa líšila podľa druhu. V prípade šťaveľa boli najvyššie úrovne antioxidantov zaznamenané na jar pod mulčovaním a včelou pastvou. V prípade přhľavy mali najvyššie hodnoty jar/kontrolné vzorky, zatiaľ čo žiadne pokrytie pôdy významne neovplyvnilo obsah antioxidantov. Malé periwinkle tiež neukázalo vplyv pokrytia pôdy; najvyššie úrovne boli zaznamenané na jar a najnižšie v lete. Celkovo vzorky z jari vykázali najvyššie kapacity antioxidantov vo všetkých druhoch. Variabilita v meraniach antioxidantov naprieč rôznymi metódami zdôrazňuje význam použitia viacerých metód na komplexnú analýzu. Tieto zistenia prispievajú cennými informáciami o zložení liečivých rastlín v agrolesníckych systémoch a budú informovať budúce experimentálne dizajny.

Kľúčové slová: agrolesníctvo, antioxidačná kapacita, štiav lúčny, skorocel kopijovitý, Zimozeleň menšia