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ORGANICALLY AND CONVENTIONALLY GROWN PEPPERMINT (*Mentha x piperita* L.) AS AFFECTED BY WEEDS

KOROVI U ORGANSKOM I KONVENCIONALNOM USEVU MENTE (*Mentha x piperita* L.)

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ABSTRACT

This study was performed in order to assess weed flora diversity in organic and conventional peppermint (Mentha x piperita L.*) in the second year of growing, and to compare the effects of the two production systems on peppermint traits of agronomic importance. Weed control was not carried out in a season in which the survey was conducted (2014). Comparatively high weed floristic diversity was noted for organically maintained crop, with even five species that are invasive for Vojvodina region occurring in this system only. Therophyte life form dominated in both crops. Concerning the characteristics that are directly related to yield, conventionally grown peppermint outperformed the organic one, except for leaf essential oil content. In order to provide high yield and quality of organic peppermint, regular mechanical weed control and the use of appropriate organic fertilizers would be of the great importance.*

Key words: *Mentha x piperita, weed flora, organic production, conventional production*

REZIME

Pored negativnih efekata na rast i razvoj biljaka, korovi kod lekovitih, aromatičnih i začinskih biljaka mogu kontaminirati krajnji proizvod i tako mu pogoršati kvalitet. Cilj ovog rada je bila procena diverziteta korovske flore u organskom i konvencionalnom usevu mente (Mentha x piperita L.*), kao i poređenje dva useva u pogledu agronomski značajnih svojstava. Ogled je postavljen na eksperimentalnom polju Instituta za ratarstvo i povrtarstvo u Bačkom Petrovcu. Da bi se dobio potpun uvid u korovsku floru, u godini u kojoj su izvođene analize (2014) nije vršeno suzbijanje korova. Organska parcela je đubrena stajnjakom u jesen 2011, a konvencionalna NPK đubrivom 2012. godine kada je i zasnovan usev. Veći floristički diverzitet je zabeležen kod korova u organskom usevu, gde je identifikovano čak pet vrsta koje su invazivne za region Vojvodine i koje nisu nađene u konvencionalnom usevu. Terofite su dominirale u oba proizvodna sistema. Kod analize ekoloških indeksa, jedina značajna razlika je bila u pogledu hemijske reakcije supstrata; korovi sa organske parcele su uglavnom prilagođeni kiselim, a sa konvencionalne neutralnim zemljištima. Što se tiče svojstava mente koja su u direktnoj vezi sa prinosom, konvencionalno gajena menta je nadmašila organsku, osim u pogledu sadržaja etarskog ulja. Regularno mehaničko suzbijanje korova, kao i đubrenje preparatima koji su dozvoljeni u organskoj proizvodnji su od izuzetnog značaja za postizanje visokog prinosa i kvaliteta organske mente.*

Ključne reči: *Mentha x piperita, korovska flora, organska proizvodnja, konvencionalna proizvodnja*

INTRODUCTION

Due to the great limitations in the application of pesticides, weed control is one of the main challenges in organic agricultural production. This is especially true when it comes to medicinal, aromatic and spice plants, where weed problem includes not only their negative effect on plant growth and development, but also a significant risk for contaminating the final product and therefore seriously affecting its quality (*Adamović et al., 1989; Carrubba and Militello, 2013*; *Matković et al., 2014*). Peppermint is one of the oldest known and most commonly used medicinal plants. Due to the biologically active compounds that contains, peppermint is often used in pharmaceutical, cosmetics, food and other industries (*Rita and Animesh, 2011*). As with other medicinal plants, organically grown peppermint has gained an increasing interest and demand.

The aim of this study was to asses weed flora diversity in organically and conventionally cultivated peppermint, as well as to compare the effects of the two systems on peppermint traits of agronomic importance.

MATERIAL AND METHOD

The study was conducted on organically and conventionally maintained peppermint (*Mentha x piperita* L., Lamiaceae, Lamiales, cv. Danica) crops located in Bački Petrovac (Institute of Field and Vegetable Crops, Novi Sad, Alternative Crops Department). Both organic (0.14 ha) and conventional (0.4 ha) crops have been established in the October of 2012, while the plant and soil analyses were conducted during the vegetation period of 2014.

Organic and conventional plots were fertilized with farmyard manure (15 t/ha, November 2011) and mineral fertilizer (15:15:15 NPK, 400 kg/ha, October 2012), respectively. Except for fertilizing and mechanical weeding during the 2013 vegetation period, other agro technical procedures were not applied. As seen in Table 1 representing the basic soil characteristics, the most striking difference between the two plots was in $CaCO_3$, with samples from organic plots containing significantly higher amounts of the compound.

Table 1. Basic properties of the soil samples from organically and conventionally grown peppermint

Soil property	Organic plot	Conve. plot
pH (KCl)	7.82	7.75
AL-P_2O_5 (mg/100 g)	27.83	29.92
AL-K_2O (mg/100 g)	25.54	25.46
$CaCO_3$ (%)	13.96	3.80
Humus (%)	2.24	2.79
N (%)	0.112	0.140
Coarse sand, 2.0 – 0.2 mm (%)	0.0	0.3
Fine sand, 0.2 – 0.02 mm (%)	39.7	35.6
Silt, 0.02 – 0.002 mm (%)	33.6	34.9
Clay, < 0.002 mm (%)	26.6	29.2
Sand (%)	39.7	35.9
Silt + clay (%)	60.3	64.1
Soil texture	Clay loam	Clay loam

Both peppermint and weed analyses were conducted prior to anthesis, in the first decade of June. Plant sampling and weed observations included crop sections of 4 m^2, which was finally recalculated to 1 m^2. The analyses were performed in three replications. The following peppermint traits were investigated: herb moisture (%), leaf/stem dry weight ratio, number of stems/m^2, stem height (cm), number of leaves/stem and leaf essential oil content (%). As far as weed analysis, the species were identified according to *Josifović* (*1970-1977*) and *Sarić* (*1986, 1992*), with life forms given according to *Ujvárosi* (*1973*). Time of flowering, categorization by habitat (*Čanak et al., 1978*), floral elements (*Gajić, 1980*) and ecological indices and biological attributes (*Landolt, 2010*) were determined. Invasive species in Vojvodina were noted (*IASV, 2011*). The data was processed by analysis of variance.

RESULTS AND DISCUSSION

Taking into account both organic and conventional production systems, weed flora in peppermint crops consisted of

Table 2. Weed flora in organically (O) and conventionally (C) maintained peppermint crops

Plant species	Prod.n system		Biological attributes				Categor. accord. to site	Influence of man on site conditions	Ecological indicator values										
									Climate indicators			Soil indicators							
	O	C	Life form	Root depth	Time of flowering	Seed longevity			T	K	L	F	W	R	N	S	m	H	D
Amaranthus retroflexus L.*	+		T_4	3.5	VI-IX	4	KR	5	4	3	4	2.5	2	3	4	s	m	3	1
Ambrosia artemisifolia L*	+		T_4	3	VIII-IX	4	R	5	5	2	4	2	1	3	4	s	-	3	3
Anagallis arvensis L.	+	+	T_4	1.5	V-X	5	KR	4	4	3	4	3	1	3	3	-	m	3	3
Anagallis femina Mill.	+	+	T_4	1.5	V-VI	5	KR	4	4	4	4	2	1	4	3	-	-	3	3
Bilberdykia convolvulus (L.) Dum.	+	+	T_4	3	VI-IX	4	S	4	3.5	3	4	2.5	1	3	4	-	m	3	3
Bromus sterillis L.	+	+	T_2	-	V-VII	2*	LK, R	4	4	4	3	2	1	3	4	-	-	3	3
Capsella bursa-pasoris (L.) Medik.	+		T_1	2.5	IV-XI	4	KR	3	3	3	4	2	1	3	4	-	m	3	3
Carduus acanthoides L.	+	+	HT	4	VI-X	-	KR	4	4.5	4	4	1	2	3	4	-	-	3	3
Chenopodium album L.	+	+	T_4	2.5	VI-XI	5	KR	5	3	3	4	2	1	3	4	-	ma	3	3
Cirsium arvense (L.) Scop.	+	+	G_3	3.5	VI-VIII	4	KR	3	3.5	3	3	3	3	3	4	s	m	3	1
Convolvulus arvensis L.	+	+	G_3	4.5	VI-IX	4	KR	4	4	4	4	2.5	2	4	4	-	m	3	1
Datura stramonium L*	+		T_4	2.5	VI-IX	4	KR	5	5	2	4	3	1	3	4	s	-	3	3
Erigeron canadensis L.	+	+	T_4	2.5	VI-X	3*	R	5	4	3	4	2.5	1	4	3	-	m	3	3
Fumaria officinalis L.	+	+	T_3	2.5	V-IX	5	KR	4	3.5	3	4	3	2	4	4	-	m	3	3
Geranium dissectum Jusl.		+	T_2	2	V	3	KR	4	4	3	4	3	2	3	3	-	m	3	1
Lactuca serriola L.	+		T_4	3.5	VII-IX	3	KR	4	4.5	4	4	2	1	4	4	s	-	3	3
Lathyrus tuberosus L.		+	G_1	3	VI	2	KR	5	4.5	4	4	2	2	4	3	-	-	3	1
Matricaria chamomilla L.	+	+	T_2	2.5	V-IX	4	KR	5	4	3	4	3	2	4	4	-	-	3	1
Matricaria inodora L.	+	+	T_4	3.5	VI-X	4	KR	4	3.5	4	4	3	1	3	4	-	-	3	3
Papaver rhoeas L.		+	T_2	3	V-VI	4	S	4	4	4	4	2	1	4	3	ss	-	3	3
Plantago major L.	+		H_5	2.5	VI-IX	4	KR, LK	3	3	3	4	3	3	3	4	s	m	3	1
Polygonum aviculare L.	+		T_4	2.5	V-X	5	KR	3	4	2	4	3.5	1	3	4	s	m	3	3
Portulaca oleracea L*	+		T_4	1.5	VI-VIII	4	S	5	4.5	3	4	2.5	2	4	4	s	-	3	1
Rorippa austriaca (Crantz) Bess.		+	G_3	-	VI-VIII	-	LK	3	4.5	5	4	4	3	4	4	s	-	3	1
Senecio vulgaris L.	+		T_1	1.5	III-XI	2	KR	4	3.5	3	4	3	1	4	4	-	m	3	3
Solanum nigrum L.	+	+	T_4	2.5	VI-X	4	KR	4	3.5	3	4	3	1	4	4	-	m	3	3
Sonchus arvensis L.	+	+	G_3	3.5	VII-IX	3	S	4	3.5	3	3	3.5	2	4	4	s	m	3	1
Sorghum halepense (L.) Pers.*	+		G_1	3	VI-VII	3	S	4	5	2	4	2	2	4	4	-	-	3	3
Stachys annua L.	+	+	T_4	1.5	VI-X	3	S	4	4	4	4	2.5	2	4	4	-	m	3	1
Stellaria media (L.) Vill.	+		T_1	1.5	I-XII	4	KR	4	3	3	3	3	1	3	4	-	m	3	3
Stellaria pallida (Dum.) Piré		+	T_1	1	III-VI	-	KR	3	4	3	3	2	1	3	4	s	-	3	3
Stenactis annua (L.) Nes.	+	+	T_4	3	VI-X	-	R	3	4	3	4	2.5	2	3	4	-	m	3	3
Tragopogon dubius Scop.	+		HT	3.5	V-VII	2	R, LK	3	4.5	4	4	1.5	1	4	4	s	-	1	5
Verbena officinalis L.	+		H_4	1.5	VI-VIII	-	R	4	3.5	3	4	3	2	3	4	-	-	3	1
Veronica hederifolia L.	+		T_1	1	III-V	4	KR	3	4	3	3	3	1	3	4	-	-	3	3
Total 35	30	21																	

Legend: * – invasive species for Vojvodina region; Life form: G – geophyte, T – therophyte, HT – hemitherophyte, H – hemicryptophyte; Root depth: 1 (< 25 cm) to 5 (> 200 cm) scale, Time of flowering: I-XII – month of flowering; Seed longevity: 1 (up to one year) to 5 (>100 years); Categorization according to site: KR – weed-ruderal, R – Ruderal, S – Segetal, LK – meadows-pasture; Influence of man on site conditions: 1 (urbanophobous) to 5 (urbanophilous); T – temperature: 1 (alpine and nival) to 5 (very warm colline); K – continentality: 1 (oceanic) to 5 (continental); L –light: 1 (deep shade) to 5 (full light); F – moisture: 1(very dry) to 5 (flooded); W – moisture variability: 1 (little varying) to 3 (strongly varying); R – pH reaction: 1 (extremely acid) to 5 (alkaline); N – nutrients: 1 (very infertile) to 5 (very fertile); S – salt tolerance: s – salt tolerant, ss – salt dependent; m – heavy metal tolerance: m – tolerant; H – humus: 1 (little or no humus) to 5 (high humus content); D – aeration: 1 (bad aeration) to 5 (good aeration)

35 taxa (Table 2). Organic crop was characterized by greater floristic diversity (30 species) when compared to the conventionally maintained (21 species). Sixteen species were common for both systems. The observation is in accordance to often reported (e.g. *Menalled et al., 2001*; *Navntoft et al., 2009*; *Fuller et al., 2005*) comparatively high biodiversity of organic production systems. However,

studies on weeds occurring in basil and dill that were conducted at the same site as our experiment (*Džigurski et al., 2015*; *Ljevnaić-Mašić et al., 2015*) and a study on potato (*Nikolić et al., 2013*) revealed greater diversity in conventional crops. The discrepancies may imply the effect of the crop species, experimental site and season on weed flora; however, further studies are required to confirm the assumption. Out of 35 identified taxa, five those are invasive for Vojvodina region (*Amaranthus retroflexus, Ambrosia artemisifolia, Datura stramonium, Portulaca oleracea* and *Sorghum halepense*) were found in organic crop only, which further implies the need for monitoring and controlling weeds in this type of growing system.

There were no major differences between weeds from organic and conventional crops in terms of their biological attributes. As expected, therophyte life form predominated, with T_4 form being the most abundant. The T_4 form is represented by annual plants whose seeds germinate in spring and mature by the end of the summer, and which are common for the ecosystems under the strong anthropogenic influence (*Džigurski et al., 2012*; *Ljevnaić-Mašić et al., 2013*). A slight difference between the two production systems was observed for weed root depth. Besides the majority of species that belonged to the 2.5 class (25-50 cm, with at most 20 % of the rooting depths of 50-100 cm), deeper root species (class 3, 50-100 cm) were more frequent in the conventional and shallower root species (class 1.5) in the organic crop. The majority of the identified species are moderately urbanophilous, belong to weed-ruderal flora and produce seeds that retain germination ability from 20 to 100 years.

According to the results of the ecological indices analysis, the only significant difference between the weeds identified in the two growing systems was in the index for chemical reaction of the substrate (R). The weeds identified in the organic crops are generally adapted to acid, and those from conventional plots to neutral soils (average R values 1.70 and 3.52, respectively). Although *Džigurski et al.* (*2015*) reported similar relation for average R values in organic and conventional basil, the differences between the two systems were more pronounced in our research on peppermint. On the basis of the analysis of the other ecological indices, weeds occurring in both systems are mostly adapted to warmer sites (average T values 3.90 and 3.88 for organic and conventional system, respectively) and subcontinental (K 3.13, 3.48). The site is well lit (L 3.83, 3.81), fresh to moderately moist (F 2.57, 3.05) with little to moderate moisture variation (W 1.50, 1.62). The identified weeds require fertile soils (N 3.90, 3.71) with high humus content (H 2.93, 3.00), which corresponds to the results of the soil analyses. In oppose to the annual basil (*Džigurski et al., 2015*), the soil under biennial peppermint crop was bad to moderately aerated (D 2.46, 2.1), which may be partly explained by regularly performed plowing of annuals. Concerning salinity, 33.33 % of the weeds from organic and 19.05 % from conventional system are tolerant according to literature sources. One species found in conventional system only (*Papaver rhoeas*) is even salt dependent. According to *Landolt* (2010), no information on salt tolerances of other weed species are available. Regarding the increased soil heavy metal concentration; tolerant species are similarly represented in both organic and conventional systems (56.67 and 57.14 %, respectively), while the reaction of other species is not mentioned in the literature.

Table 3. Traits of organically and conventionally grown peppermint (means with standard errors in the brackets)

Mentha trait	Organic	Conventional	p-value	CV (%)
Herb moisture (%)	73.2 (0.0)	70.0 (0.2)	0.0126*	2.6
Leaf/stem dry weight ratio	1.7 (0.0)	1.1 (0.0)	0.0002**	26.5
Number of stems/m^2	37.9 (0.8)	78.3 (4.7)	0.0137*	40.7
Stem height (cm)	13.9 (1.1)	44.8 (2.6)	0.0082**	61.3
Number of leaves/stem	15.1 (0.3)	33.0 (2.0)	0.0118*	43.6
Leaf essential oil content (%)	2.5 (0.0)	1.7 (0.0)	0.0001**	21.9

*Legend: *, ** – significant at the 0.05 and 0.01 levels of probability, respectively; CV – coefficient of variation*

As shown in Table 3, organically and conventionally grown peppermint differed significantly in terms of all the analyzed traits of agronomic importance. Although herb moisture appeared as statistically different between the crops, the difference has no great practical importance. The assessed traits of the conventionally maintained peppermint mainly fell into the range reported by other authors (*Adamović, 1993*; *Kassahun et al., 2011*; *Santos et al., 2012*). Peppermint grown it this production system outperformed the organic one regarding the characteristics that are directly related to yield; however, leaf essential oil content was significantly higher in organic plants implying the possibility for the cultivation of high-quality crops. A slightly higher phenolic content and antioxidant capacity of the organic sage, lemon balm, peppermint, coriander and fennel was reported by *Trendafilova et al.* (*2010*).

There are a few possible explanations for poor overall performance of the organic crop. Since the aim of this study was to assess weed flora diversity in both production systems, weed control that would otherwise be regularly performed was missing. This allowed the development of the numerous weed species and their large infestation (data not shown), especially in organic system where the weeds dominated over main crop. In addition, although nitrogen and humus content were at the acceptable levels in both systems, the fertility of the conventional plot was, however, higher. Knowing the comparatively high peppermint nitrogen demands and the negative correlation between dry weight and essential oil yield (*Singh et al., 1989*; *Zeinali et al., 2014*), soil nitrogen might be the additional factor affecting the results. The possible negative effects of high calcium in the soil from organic plot (13.96 and 3.80 % for the organic and conventional plot, respectively) should be further evaluated.

Anyway, regular weeding and other agro technical procedures, firstly the application of the allowed fertilizers at the adjusted timing and rate (*Ayyobi et al., 2013*; *Sheykholeslami et al., 2015*), should be performed in order to provide high yield and quality of peppermint grown in organic agricultural systems.

CONCLUSION

Organically maintained peppermint crop was characterized by comparatively high weed floristic diversity. Five species that are invasive for Vojvodina region have been found in organic crop only; therefore there is a need for monitoring and controlling the weeds occurring in this growing system.

Therophyte dominated in both growing systems. Conventionally grown peppermint outperformed the organic one regarding yield-related parameters, except for leaf essential oil content. Regular weeding and appropriate fertilizing is essential for achieving high yield and quality of organic peppermint.

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