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Floristic and ecological analysis of weed flora in organic walnut orchards

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SUMMARY

Organic walnut (*Juglans regia* L.) production in Serbia is becoming increasingly important; however, data on the composition and ecological structure of weed flora in young orchards remain limited. The aim of this study was to determine the floristic composition, biological spectrum, and dominant weed species in an organic walnut orchard in the village of Trmčare (municipality of Kruševac, Serbia).

A total of 59 weed species were recorded, including 32 weed-ruderal, 21 weed, and 6 ruderal species. The flora was dominated by representatives of the class *Magnoliopsida* (50 species), while 9 species belonged to the class *Liliopsida*. Life form analysis showed the predominance of therophytes (52.54%), followed by hemicryptophytes (37.29%), geophytes (8.47%), and therophyte–hemicryptophytes (1.69%).

A high level of weed infestation was recorded, mainly due to the absence of inter-row soil cultivation, as well as the fact that deep plowing (rigolage) was not applied during primary soil preparation before planting, together with the use of uncomposted cattle manure during soil preparation. Immediately after orchard establishment, a massive occurrence of *Rumex obtusifolius* was recorded, which was likely introduced through contaminated organic fertilizer. The most frequently recorded species, in addition to *Rumex obtusifolius* L., were *Lamium amplexicaule* L., *Galium aparine* L., *Taraxacum officinale* Weber, *Agropyron repens* (L.) P. Beauv., *Bromus arvensis* L., *Bromus sterilis* L., *Poa pratensis* L., *Stellaria media* (L.) Vill., *Veronica persica* Poir., *Capsella*

bursa-pastoris (L.) Medik., *Lamium purpureum* L., *Plantago media* L., *Plantago lanceolata* L., and *Plantago major* L.

The results indicate that weed community structure in young organic walnut orchards is strongly influenced by reduced soil tillage intensity, the application of organic fertilizers, and orchard management practices. This study contributes to a better understanding of weed vegetation dynamics in organic walnut production and provides a basis for developing sustainable weed management strategies adapted to local agroecological conditions.

Keywords: Broadleaf weeds, narrow-leaved weeds, organic production, walnut, weed flora.

INTRODUCTION

Walnut (*Juglans regia* L.) cultivation has a long tradition in Serbia due to favorable agroecological conditions that enable successful production in nearly all fruit-growing regions of the country. The greatest concentration of walnut orchards occurs at altitudes between 100 and 400 m above sea level, although in central Serbia walnuts are cultivated at elevations up to 1000 m, while in southern regions production is possible even at altitudes of 1200 m (Cerović et al., 2003). Estimates indicate that Serbia has approximately two million bearing walnut trees, confirming the economic and traditional importance of this fruit species. Historically, walnut has predominantly been propagated generatively, resulting in a highly heterogeneous population in which almost every tree represents a distinct genotype (Cerović et al., 2003; Gološin et al., 2008).

In modern organic agriculture, weeds are considered one of the major limiting factors affecting crop productivity, particularly in perennial plantations where herbicide use is restricted or entirely excluded. Organic walnut orchards represent specific agroecosystems characterized by reduced tillage intensity, absence of chemical weed control measures, and the presence of permanent vegetation cover, all of which favor the development of diverse weed communities. Weed vegetation in these systems has a dual ecological role. On the one hand, it contributes to biodiversity conservation and agroecosystem stability; on the other, it can strongly compete with trees for water, nutrients, and light, especially during orchard establishment and under drought stress conditions (Nikolić et al., 2019).

Research on weed flora in organic walnut orchards in Serbia remains limited. Nevertheless, studies conducted in other perennial and organic agroecosystems provide important insights into weed community dynamics and ecological structure. Investigations carried out in Vojvodina demonstrated that organic production systems are characterized by pronounced floristic diversity and frequent occurrence of invasive alien species, while therophytes dominate the biological spectrum of weed flora. These studies also emphasized the necessity for continuous monitoring of agrophytocenological and ruderal vegetation due to ongoing land-use changes and modern agroecological conditions (Tabašević et al., 2021).

Recent investigations in organic production systems of medicinal plants and other crops in Serbia have revealed high weed-species richness in perennial production areas, with dominant perennial weeds including *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., *Sorghum*

halepense (L.) Pers., and *Agropyron repens* (L.) P. Beauv. (Božić et al., 2025). The prevalence of these species indicates a strong competitive potential of perennial weeds under reduced tillage systems, which is particularly important in organic walnut orchards. Furthermore, studies in organic vegetable production highlight the ecological and phytopathological significance of weeds as reservoirs of plant pathogens and other harmful organisms (Živković et al., 2024; Vasić et al., 2024).

In the broader Balkan region, investigations of weed flora in perennial plantations have mainly focused on olive and hazelnut orchards. Research conducted in Mediterranean orchard systems demonstrated that orchard management practices, fertilization type, soil tillage, and vegetation cover significantly influence weed community composition and diversity. Studies in olive orchards showed that organic fertilization and reduced tillage contribute to increased floristic diversity and alterations in weed community structure (Platis et al., 2023). Similarly, investigations in hazelnut orchards in Turkey indicated that dominant weed species may substantially affect orchard productivity and economic sustainability (Yazlik, 2023). These findings suggest that perennial orchard agroecosystems in the Balkan region are shaped by similar ecological and management factors influencing weed vegetation.

At the European level, increasing attention has been devoted to the ecological role of spontaneous vegetation in organic orchards within biodiversity-oriented and sustainable production systems. Studies conducted in organic apricot orchards demonstrated that the use of cover crops, diversified production systems, and reduced tillage practices contribute to the preservation of wild flora diversity while simultaneously reducing weed infestation (Ciaccia et al., 2022). In line with European agricultural policies promoting sustainable production and biodiversity conservation, interest in studying weed-vegetation dynamics in perennial agroecosystems has increased significantly.

Globally, contemporary research on weed flora in orchards increasingly emphasizes environmentally acceptable weed management approaches, biodiversity conservation, and the implementation of precision agriculture technologies. Modern approaches include the application of remote sensing, machine learning, and deep learning techniques for weed mapping, detection, and classification in orchard systems (Hasan et al., 2021; Kontogiorgakis et al., 2025). These technologies enable more efficient and selective weed management while reducing negative environmental impacts and improving the sustainability of organic production systems.

Although research on weed vegetation in perennial agroecosystems has increased considerably, studies specifically focused on the composition and structure of weed flora in organic walnut orchards remain limited, particularly in Southeast Europe. Therefore, investigating weed communities in organic walnut production is essential for improving knowledge of floristic composition, ecological structure, and dominant weed species, as well as for developing sustainable weed management strategies adapted to local agroecological conditions.

The aim of this study was to identify the most common weed species occurring in walnut orchards managed under an organic production system, considering that comprehensive knowledge of the biological and ecological characteristics of weeds represents a fundamental prerequisite for effective planning and implementation of weed control measures.

MATERIAL AND METHODS

Floristic investigations were conducted in organically managed walnut orchards located in the cadastral area of the village of Trmčare, on the slopes of Mt. Jastrebac, 15 km from Kruševac, during 2024 and 2025. The research was carried out on a total area of 2 ha, consisting of three smaller plots of 30, 80, and 90 ares, within one- and two-year-old orchards. The soil type on the examined plots was Vertisol.

Taxonomic identification of plant species and their classification into families were performed according to Josifović (1970–1977), Jávorka and Csapody (1975), and Sarić (1986). The assignment to higher taxonomic categories followed the system proposed by Takhtajan (2009). Floristic elements and life forms were determined according to the methodologies described by Ujvárosi (1973), Landolt (1977), Gajić (1980), Kojić et al. (1997), Vrbničanin and Božić (2016, 2021), and Živković (2024).

Ecological indices were determined for nine main environmental factors: moisture (F), soil reaction (R), nitrogen and nitrogen compounds content, i.e., nutrients (N), organic matter content, i.e., humus (H), soil aeration (D), salinity (S), light regime (L), temperature (T), and continentality (K), according to the methodology of Landolt (1977), using a scale from 1 to 5. Lower values of a given ecological index indicate lower requirements of a plant species for the respective ecological factor, except in the case of the aeration index (D). Specifically, lower values of the aeration index (D) indicate better-aerated habitats, and vice versa.

Regarding habitat moisture (F), the same 1–5 scale applies. The requirement of plants for increased soil salt concentration, i.e., the ecological index for salinity (S), is expressed by the symbols “+” and “–”. Plant species tolerant of higher soil salinity are characterized by the ecological index S+, whereas species that do not tolerate saline substrates are denoted by the salinity index S (Landolt, 1977).

RESULTS AND DISCUSSION

Floristic investigations of weeds in organic walnut orchards identified a total of 59 weed species (Table 1). The recorded species belong to the division *Magnoliophyta* and the classes *Magnoliopsida* and *Liliopsida*. Broadleaf weeds (class *Magnoliopsida*) accounted for 50 species (84.75%), while narrow-leaved weeds (class *Liliopsida*) comprised 9 species (15.25%).

Table 1. Taxonomic classification of weed flora in walnut orchards under organic production.

Phylum		Class	Order	Family	Genus	Species	%
<i>Magnoliophyta</i>		<i>Magnoliopsida</i>	18	21	37	50	84.75
		<i>Liliopsida</i>	1	1	6	9	15.25
Total	1	2	19	22	43	59	100.00

No soil tillage was performed in the walnut orchards after planting. Weed control was carried out exclusively by mechanical mowing at intervals of 10 to 15 days, from May to

October. Hoeing around young walnut plants was also conducted every 15 to 20 days during the growing season, in order to remove weeds and improve soil aeration. The orchards were irrigated using a drip irrigation system during the summer period, every second or third day, in the evening hours.

Despite regular mechanical weed control measures, diversity of the weed flora was not negligible. Within the class *Magnoliopsida*, representatives of 21 families were identified: Asteraceae, Brassicaceae, Lamiaceae, Scrophulariaceae, Fabaceae, Plantaginaceae, Polygonaceae, Ranunculaceae, Geraniaceae, Primulaceae, Violaceae, Amaranthaceae, Apiaceae, Boraginaceae, Caryophyllaceae, Convolvulaceae, Euphorbiaceae, Lythraceae, Rosaceae, Rubiaceae, and Solanaceae.

Within the class *Liliopsida*, only the family Poaceae was recorded (Tables 1 and 2). The family Poaceae comprised of nine species, accounting for 15.25% of the total weed flora. The families Asteraceae and Brassicaceae were each represented by seven species, contributing 11.87% each to the overall weed flora. The family Lamiaceae included four species and accounted for 6.79% of the total weed flora, as did the family Scrophulariaceae.

The families Fabaceae, Plantaginaceae, Polygonaceae, and Ranunculaceae were each represented by three species, with each family contributing 5.09% to the weed flora. Geraniaceae, Primulaceae, and Violaceae included two species each (3.39%). The families Amaranthaceae, Apiaceae, Boraginaceae, Caryophyllaceae, Convolvulaceae, Euphorbiaceae, Lythraceae, Rosaceae, Rubiaceae, and Solanaceae were represented by a single species each, contributing 1.69% individually to the total weed flora (Table 2).

Table 2. Floristic spectrum of weeds in walnut orchards under organic production.

Family	Number of species	%
Poaceae	9	15.25
Asteraceae	7	11.87
Brassicaceae	7	11.87
Lamiaceae	4	6.79
Scrophulariaceae	4	6.79
Fabaceae	3	5.09
Plantaginaceae	3	5.09
Polygonaceae	3	5.09
Ranunculaceae	3	5.09
Geraniaceae	2	3.39
Primulaceae	2	3.39
Violaceae	2	3.39
Amaranthaceae	1	1.69
Apiaceae	1	1.69
Boraginaceae	1	1.69
Caryophyllaceae	1	1.69
Convolvulaceae	1	1.69
Euphorbiaceae	1	1.69
Lythraceae	1	1.69
Rosaceae	1	1.69
Rubiaceae	1	1.69
Solanaceae	1	1.60
Total	59	100.00

Table 3 presents an overview of the total weed flora recorded in organic walnut orchards. In all analyzed orchards, the most prevalent weed species were: *Rumex obtusifolius* L., *Lamium amplexicaule* L., *Galium aparine* L., *Taraxacum officinale* Weber, *Agropyrum repens* Beauv., *Bromus arvensis* L., *Bromus sterilis* L., *Poa pratensis* L., *Stellaria media* (L.) Vill., *Veronica persica* Poir., *Capsella bursa-pastoris* (L.) Medik., *Lamium purpureum* L., *Plantago media* L., *Plantago lanceolata* L., and *Plantago major* L.

A particularly important finding of this study is the massive occurrence of *Rumex obtusifolius* immediately after orchard establishment. This species had not previously been recorded at the investigated site prior to primary soil preparation, suggesting that its introduction was most likely associated with the application of uncomposted cattle manure. Organic fertilizers, especially insufficiently decomposed manure, are known potential vectors for weed seed dispersal in agricultural systems. In this study, the absence of deep plowing (rigolage), due to fragmented plots and high implementation costs, may have additionally favored the establishment and persistence of perennial weeds by preventing the deep burial of weed propagules and reducing soil inversion effects.

Analysis of weed life forms in the organic walnut production system showed the dominance of therophytes (52.54%), which is consistent with the results reported by Tabashević et al. (2021), followed by hemicryptophytes (37.29%) and geophytes (8.47%), while hemitherophytes were represented by only one species (1.69%) (Table 3). Within the total weed flora of the studied walnut orchards, the highest proportion (54.24%) was recorded for weed-ruderal species, represented by 32 species. Typical weed species accounted for 35.59% of the total flora, with 21 recorded representatives. Ruderal species were the least represented group, with six species (10.17%) (Table 3).

Table 3. Review of weed flora in walnut plantations under organic production.

Family	Life form	Flowering time	Category by habitat	Floral element	Ecological index									
					F	R	N	H	D	S	L	T	K	
Family Amaranthaceae														
<i>Amaranthus retroflexus</i> L.	Terofite 4 Therophytes 4	VII-IX	korovske vrste weed species	adventivni adventitious	2	3	4	3	3	-	4	4	3	
Family Apiaceae														
<i>Daucus carota</i> L.	Terofite 4 Therophytes 4	VI-VIII	korovsko ruderalne vrste weed ruderal species	subevroazijski subeurasian	2	3	2	3	3	-	4	4	3	
Family Asteraceae														
<i>Ambrosia artemisiifolia</i> L.	Terofite 4 Therophytes 4	VIII-IX	korovsko ruderalne vrste weed ruderal species	adventivni adventitious	2	3	4	2	2	+	4	5	3	
<i>Anthemis arvensis</i> L.	Terofite 2 Therophytes 2	VI-IX	korovsko ruderalne vrste weed ruderal species	subsrednjeevropski subcentraleuropean	2	2	4	3	4	-	4	4	4	
<i>Artemisia vulgaris</i> L.	Hemikriptofite 5 Hemicryptophyte 5	VII-IX	ruderalne vrste ruderal species	cirkumpolarni circumpolar	3w	3	4	3	4	-	4	4	3	

<i>Erigeron annuus</i> (L.) Perss.	Terofite 4 Therophytes 4	VI-IX	korovsko ruderalne vrste weed ruderal species	adventivni adventitious	2	3	4	3	4	-	4	4	3
<i>Hypochoeris radicata</i> L.	Hemikriptofite 2 Hemicryptophyte 2	V-VIII	ruderalne vrste ruderal species	subsrednjeevropski subcentraleuropean	3	2	3	4	4	-	4	3	2
<i>Sonchus arvensis</i> L.	Geofite 3 Geophytes 3	VII-IX	korovske vrste weed species	evroazijski eurasian	3w	3	4	4	4	+	3	4	3
<i>Taraxacum officinale</i> Weber.	Hemikriptofite 3 Hemicryptophyte 3	III-X	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3	3	4	3	4	+	4	3	3
Family Boraginaceae													
<i>Myosotis arvensis</i> (L.) Hill.	Terofite 1 Therophytes 1	V-VI	korovske vrste weed species	subevroazijski subeurasian	2	3	3	3	4	-	4	3	3
Family Brassicaceae													
<i>Camelina sativa</i> (L.) Crantz.	Terofite 2 Therophytes 2	V-VIII	korovske vrste weed species	subevroazijski subeurasian	2	3	3	3	4	-	3	4	4
<i>Calepina irregularis</i> (Asso) Thell.	Terofite 1 Therophytes 1	IV-V	korovske vrste weed species	submediteranski sub-mediterranean	1	3	4	3	4	-	4	5	4
<i>Capsella bursa-pastoris</i> (L.) Medic.	Terofite 1 Therophytes 1	I-XII	korovsko ruderalne vrste weed ruderal species	kosmopolitski cosmopolitan	2	3	4	3	4	-	4	3	3
<i>Cardamine hirsuta</i> L.	Terofite 1 Therophytes 1	III-X	korovske vrste weed species	kosmopolitski cosmopolitan	3	3	4	3	4	-	4	4	3
<i>Draba verna</i> L.	Terofite 1 Therophytes 1	III-V	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	2	3	2	3	3	-	4	4	3
<i>Myagrum perfoliatum</i> L.	Terofite 2 Therophytes 2	V-VII	korovske vrste weed species	submediteranski sub-mediterranean	1	4	3	3	4	-	3	5	3
<i>Sinapis arvensis</i> L.	Terofite 4 Therophytes 4	VI-IX	korovske vrste weed species	subevroazijski subeurasian	3	4	4	3	4	-	4	4	3
Family Caryophyllaceae													
<i>Stellaria media</i> (L.) Vill.	Terofite 1 Therophytes 1	III-X	korovsko ruderalne vrste weed ruderal species	kosmopolitski cosmopolitan	3	3	4	3	4	-	3	3	3
Family Convolvulaceae													
<i>Convolvulus arvensis</i> L.	Geofite 3 Geophytes 3	VI-IX	korovsko ruderalne vrste weed ruderal species	kosmopolitski cosmopolitan	2	4	3	3	4	-	4	4	3
Family Euphorbiaceae													
<i>Euphorbia helioscopia</i> L.	Terofite 4 Therophytes 4	III-V	korovske vrste weed species	subevroazijski subeurasian	3	3	4	3	4	-	4	4	3
Family Fabaceae													
<i>Lathyrus tuberosus</i> L.	Geofite 1 Geophytes 1	VI-VIII	korovske vrste weed species	subjužnosibirski sub-southsiberian	2w	4	3	3	5	-	4	4	4
<i>Trifolium pratense</i> L.	Hemikriptofite 2 Hemicryptophytes 2	V-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3	3	3	3	4	-	3	3	3
<i>Trifolium repens</i> L.	Hemikriptofite 2 Hemicryptophytes 2	V-X	korovske vrste weed species	subevroazijski subeurasian	3w	3	4	3	5	+	4	3	3
Family Geraniaceae													
<i>Geranium dissectum</i> Jusl.	Terofite 2 Therophytes 2	V-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3	3	3	3	4	-	4	4	3
<i>Geranium molle</i> L.	Tero-hemikriptofit Thero-hemicryptophyte	IV-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	2	3	4	3	3	-	4	4	3
Family Lamiaceae													

<i>Ajuga genevensis</i> L.	Hemikriptofite 2 Hemicryptophyte 2	IV-VII	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	2	3	3	3	4	-	3	4	4
<i>Lamium purpureum</i> L.	Terofite 1 Therophytes 1	III-X	korovsko ruderalne vrste weed ruderal species	subsrednjeevropski subcentraleuropean	3	4	4	3	4	-	4	3	3
<i>Lamium amplexicaule</i> L.	Terofite 1 Therophytes 1	III-V	korovsko ruderalne vrste weed ruderal species	subevroazijski subeurasian	2	3	4	3	4	-	4	3	3
<i>Prunella vulgaris</i> L.	Hemikriptofite 2 Hemicryptophyte 2	VI-IX	ruderalne vrste ruderal species	subevroazijski subeurasian	3	3	3	3	4	-	4	3	3
Family Lythraceae													
<i>Lythrum salicaria</i> L.	Hemikriptofite 2 Hemicryptophyte 2	VI-VIII	korovsko ruderalne vrste weed ruderal species	adventivni adventitious	4w	3	3	4	5	-	3	4	3
Family Plantaginaceae													
<i>Plantago lanceolata</i> L.	Hemikriptofite 5 Hemicryptophyte 5	IV-VIII	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	2	3	3	3	4	-	3	3	3
<i>Plantago major</i> L.	Hemikriptofite 5 Hemicryptophyte 5	VI-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3w	3	4	3	5	+	4	3	3
<i>Plantago media</i> L.	Hemikriptofite 5 Hemicryptophyte 5	V-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	2	4	2	3	4	-	4	3	3
Family Poaceae													
<i>Agropyrum repens</i> Beauv.	Geofite 1 Geophytes 1	V-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3w	3	4	2	3	+	4	3	3
<i>Alopecurus pratensis</i> L.	Hemikriptofite 2 Hemicryptophyte 2	V-VI	korovsko ruderalne vrste weed ruderal species	Cirkum polarni Circum polar	4	3	4	3	5	-	4	3	3
<i>Bromus arvensis</i> L.	Terofite 2 Therophytes 2	VI-IX	korovske vrste weed species	evroazijski eurasian	2	3	3	3	3	-	3	4	4
<i>Bromus sterilis</i> L.	Terofite 2 Therophytes 2	V-VII	korovsko ruderalne vrste weed ruderal species	subevroazijski subeurasian	2	3	4	3	4	-	3	4	2
<i>Lolium perenne</i> L.	Hemikriptofite 3 Hemicryptophyte 3	V-IX	korovsko ruderalne vrste weed ruderal species	subsrednjeevropski subcentraleuropean	3w	3	4	3	5	-	4	3	3
<i>Poa annua</i> L.	Terofite 1 Therophytes 1	III-X	korovsko ruderalne vrste weed ruderal species	kosmopolitski cosmopolitan	3	3	4	3	4	-	4	3	3
<i>Poa pratensis</i> L.	Hemikriptofite 2 Hemicryptophyte 2	V-VII	korovske vrste weed species	evroazijski eurasian	3	3	3	4	4	-	4	3	3
<i>Poa trivialis</i> L.	Hemikriptofite 2 Hemicryptophyte 2	VI-VIII	korovske vrste weed species	evroazijski eurasian	3w	3	4	3	4	-	3	3	3
<i>Setaria glauca</i> (L.) P. B.	Terofite 4 Therophytes 4	IV-VI	korovske vrste weed species	subevroazijski subeurasian	2	3	4	2	3	-	4	4	3
Family Polygonaceae													
<i>Polygonum aviculare</i> L.	Terofite 4 Therophytes 4	V-X	korovsko ruderalne vrste weed ruderal species	kosmopolitski cosmopolitan	3w	3	4	3	5	-	4	3	3
<i>Rumex crispus</i> L.	Hemikriptofite 3 Hemicryptophytes 3	VI-VIII	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3w	3	4	2	4	+	4	3	3
<i>Rumex obtusifolius</i> L.	Hemikriptofite 3 Hemicryptophyte 3	VI-VIII	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3	3	4	4	4	-	4	3	3
Family Primulaceae													
<i>Anagallis arvensis</i> L.	Terofite 4 Therophytes 4	VI-X	korovske vrste weed species	subsrednjeevropski subcentraleuropean	3	3	3	3	4	-	4	4	3
<i>Lysimachia nummularia</i> L.	Geofite 1 Geophytes 1	V-VIII	ruderalne vrste ruderal species	subsrednjeevropski subcentraleuropean	4w	3	4	3	5	-	2	4	2

Family Ranunculaceae													
<i>Ranunculus acris</i> L.	Hemikriptofite 2 Hemicryptophyte 2	V- X	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	3w	3	3	3	4	-	3	3	4
<i>Ranunculus polyanthemos</i> L.	Hemikriptofite 1 Hemicryptophyte 1	V-IX	korovsko ruderalne vrste weed ruderal species	subpontski subpentic	3w	2	2	4	5	-	3	4	2
<i>Ranunculus repens</i> L.	Hemikriptofite 2 Hemicryptophytes 2	V-IX	korovsko ruderalne vrste weed ruderal species	evroazijski eurasian	5w	3	2	3	4	-	4	2	3
Family Rosaceae													
<i>Geum urbanum</i> L.	Hemikriptofite 5 Hemicryptophyte 5	V- X	ruderalne vrste ruderal species	evroazijski eurasian	3	3	4	3	4	-	2	4	3
Family Rubiaceae													
<i>Galium aparine</i> L.	Terofite 2 Therophytes 2	VI- X	korovsko ruderalne vrste weed ruderal species	subevroazijski subeurasian	3	3	5	3	4	-	3	4	3
Family Scrophulariaceae													
<i>Verbascum nigrum</i> L.	Hemikriptofite 5 Hemicryptophyte 5	VI-IX	ruderalne vrste ruderal species	evroazijski eurasian	2	3	4	3	3	-	3	4	3
<i>Veronica arvensis</i> L.	Terofite 2 Therophytes 2	IV-IX	korovske vrste weed species	submediteranski sub-mediterranean	3	3	4	3	4	-	3	4	4
<i>Veronica persica</i> Poir.	Terofite 1 Therophytes 1	III-X	korovske vrste weed species	adventivni adventitious	3	4	4	3	4	-	4	4	3
<i>Veronica polita</i> L.	Terofite 1 Therophytes 1	II-X	korovske vrste weed species	kosmopolitski cosmopolitan	2	4	4	3	4	-	4	4	4
Family Solanaceae													
<i>Solanum nigrum</i> L.	Terofite 4 Therophytes 4	VI- X	korovsko ruderalne vrste weed ruderal species	kosmopolitski cosmopolitan	3	4	4	3	4	-	4	4	3
Family Violaceae													
<i>Viola arvensis</i> Murr.	Terofite 2 Therophytes 2	V- X	korovske vrste weed species	kosmopolitski cosmopolitan	3	3	3	3	3	-	3	3	3
<i>Viola tricolor</i> L.	Terofite 2 Therophytes 2	V- X	korovske vrste weed species	kosmopolitski cosmopolitan	3	3	3	3	4	-	3	3	3

The results obtained in this study indicate that weed flora in young organic walnut orchards is strongly influenced by agroecological conditions and the applied orchard management practices. In the initial stages of orchard development, therophytes dominate, which is characteristic for agroecosystems with frequent mechanical soil maintenance and pronounced disturbance of the soil surface layer (Kovačević, 2008; Džigurski et al., 2012; Ljevnjaić-Mašić et al., 2013, Tabašević et al., 2021). However, with orchard aging, a gradual dominance of perennial weed species is expected, as their strong regenerative ability and competitiveness enables them to become a stable component of weed vegetation. Their importance is particularly pronounced in organic production systems, where mechanical and chemical weed control measures are limited.

The presence of perennial weeds may negatively affect young walnut trees through competition for water, nutrients, and light, especially during orchard establishment, when plants are most sensitive to environmental stress conditions. Previous studies conducted in Serbia in organic medicinal plant production identified *Cirsium arvense* (L.) Scop., *Convolvulus*

arvensis L., and *Sorghum halepense* (L.) Pers. as dominant competitors under reduced tillage conditions (Božić et al., 2025).

Particularly significant was the massive occurrence of *Rumex obtusifolius* L., as well as the spread of other perennial and ruderal weed species presented in Table 3. Their dominance can be associated with reduced soil tillage intensity, the absence of herbicide application, and the use of organic fertilization, which are key characteristics of organic production systems. In addition, the application of uncomposted cattle manure and the absence of deep plowing (rigolage) likely further favored the introduction and persistence of certain weed species. Similar observations have been reported in other perennial agroecosystems, where reduced tillage and organic farming practices contributed to increased floristic diversity and changes in weed community structure (Tabašević et al., 2021; Platis et al., 2023).

The biogeographical analysis of the weed flora in the walnut orchards showed a high proportion (83.05%) of widely distributed weed species. Among them, twenty Eurasian species (33.90%) were identified, eleven sub-Eurasian species (18.64%), ten cosmopolitan species (16.95%), five adventive species (8.47%), two circumpolar species (3.39%), and one sub-South Siberian species (1.69%).

Plant species with a more narrow geographical distribution accounted for 16.95% of the total flora, including six Central European species (10.17%), three sub-Mediterranean species (5.08%), and one sub-Pontic species (1.69%) (Table 4). Similar results were reported by Nikolić et al. (2019) in their study of weed phytocoenoses in an organic crop production system.

Within the total weed flora of the analyzed walnut orchards, species adapted to different habitat moisture levels were recorded. The highest proportion (32 species; 54.24%) consisted of plants characteristic of moderately moist habitats, classified by the ecological indicator value F3. These were followed by 21 species (35.59%) typical of moderately dry habitats (F2 category) (Figure 1). Two species (3.39%) belonged to the F1 category (dry habitats), while three species were classified within the F4 category (moist habitats) (Landolt, 1977).

The mean ecological indicator value for moisture ($F = 2.66$) indicates that the agrophyto-coenoses in organic walnut production represent habitats with favorable moisture conditions, which is an important prerequisite for walnut cultivation (Cerović et al., 2003, 2010). In the investigated walnut orchard flora, species adapted to slightly acidic to slightly neutral soils (R3) predominated (79.66%), represented by 47 species (Figure 1). Indicators of neutral to alkaline soils (R4) were represented by nine species (15.25%), while species adapted to acidic soils (R2) accounted for 5.08%, corresponding to three species. The mean ecological indicator value for soil reaction ($R_x = 3.10$) indicates that the soil of the studied agrophyto-coenoses is slightly acidic to slightly neutral (Figure 1).

Within the total weed flora of the analyzed walnut orchards, species indicative of fertile soils (N4), i.e., soils with a high content of nitrogen compounds, were the most represented (35 species; 59.32%). These were followed by species adapted to a moderate nitrogen content (N3), comprising 18 species (30.51%). Species indicating soils poor in nitrogen compounds (N2) were represented by five species (8.47%). In addition, only one eutrophic (nitrophilous) species, *Galium aparine* L. (1.69%), was recorded. This species belongs to the N5 ecological

indicator category, which comprises species restricted to soils extremely rich in nitrogen compounds (Figure 1).

Based on the mean value of this ecological index ($N_x = 3.54$), the studied habitat can be characterized, according to Landolt (1977), as moderately to nitrogen-rich, which is highly favorable for walnut production (Cerović et al., 2003, 2010).

The results further indicate that 49 species (83.05%) were indicators of moderately humus-rich soils (H3). Six species (10.17%) were adapted to humus-rich soils (H4), while four species (6.78%) were characteristic of soils with a low humus content (H2) (Figure 1).

Regarding soil aeration in the investigated walnut orchards, species characteristic of moderately to well-aerated soils (D4) predominated, represented by 40 species (67.80%).

Table 4. Review of chorological spectrum of weeds in walnut orchards under organic production.

Group	Floral element	No. species	%	Species
Eurasian	Eurasian	20	33.90	<i>Agropyrum repens</i> Beauv. <i>Ajuga genevensis</i> L. <i>Bromus arvensis</i> L. <i>Geranium dissectum</i> Jusl. <i>Geranium molle</i> L. <i>Geum urbanum</i> L. <i>Draba verna</i> L. <i>Sonchus arvensis</i> L. <i>Taraxacum officinale</i> Weber. <i>Trifolium pratense</i> L. <i>Plantago lanceolata</i> L. <i>Plantago major</i> L. <i>Plantago media</i> L. <i>Poa pratensis</i> L. <i>Poa trivialis</i> L. <i>Ranunculus acris</i> L. <i>Ranunculus repens</i> L. <i>Verbascum nigrum</i> L.
	Sub-Eurasian	11	18.64	<i>Bromus sterilis</i> L. <i>Camelina sativa</i> (L.) Crantz. <i>Daucus carota</i> L. <i>Euphorbia helioscopia</i> L. <i>Galium aparine</i> L. <i>Lamium amplexicaule</i> L. <i>Myosotis arvensis</i> (L.) Crantz. <i>Prunella vulgaris</i> L. <i>Setaria glauca</i> (L.) P. B. <i>Sinapis arvensis</i> L. <i>Trifolium repens</i> L.
	Sub-South Siberian	1	1.69	<i>Lathyrus tuberosus</i> L.

Cosmopolitan	Cosmopolitan	10	16.95	<i>Capsella bursa-pastoris</i> (L.) Medic. <i>Cardamine hirsuta</i> L. <i>Convolvulus arvensis</i> L. <i>Poa annua</i> L. <i>Polygonum aviculare</i> L. <i>Solanum nigrum</i> L. <i>Stellaria media</i> (L.) Vill. <i>Veronica polita</i> Fr. <i>Viola arvensis</i> Murr. <i>Viola tricolor</i> L.
Adventive	Adventive	5	8.47	<i>Ambrosia artemisiifolia</i> L. <i>Amaranthus retroflexus</i> L. <i>Erigeron annuus</i> (L.) Perss. <i>Lythrum salicaria</i> L. <i>Veronica persica</i> Poir.
Circumpolar	Circumpolar	2	3.39	<i>Alopecurus pratensis</i> L. <i>Artemisia vulgaris</i> L.
Central European	Sub-Central European	6	10.17	<i>Anagallis arvensis</i> L. <i>Anthemis arvensis</i> L. <i>Hypochoeris radicata</i> L. <i>Lamium purpureum</i> L. <i>Lolium perenne</i> L. <i>Lysimachia nummularia</i> L.
Pontic–Central Asian	Sub-Pontic	1	1.69	<i>Ranunculus polyanthemos</i> L.
Sub-Mediterranean	Sub-Mediterranean	3	5.08	<i>Calepina irregularis</i> (Asso) Thell. <i>Myagrum perfoliatum</i> L. <i>Veronica arvensis</i> L.

Nine species each (15.25% per group) were indicators of moderately aerated (D3) and well-aerated soils (D5). One species (1.69%) belonged to the D2 group, indicating poorly aerated soils. The analysis also showed that species characteristic of non-saline soils predominated (88.14%), corresponding to 52 weed species. Seven species (11.86%) were characteristic of saline soils. In the studied walnut orchard flora, species adapted to well-lit habitats (L4) dominated (66.10%). Species indicative of moderately illuminated habitats (L3) were represented by 18 species (30.51% of the total weed flora), while only two species (3.39%) were indicators of shaded habitats (L2). The mean light index value ($Lx = 3.63$) indicates that the studied phytocoenoses in the organic walnut production system are well to moderately illuminated (Figure 1).

In addition, the analyzed weed flora was characterized by the dominance of thermophilous species (T4), represented by 30 species (50.85%). These were followed by mesothermal species (T3), with 25 species (42.37%). Three distinctly thermophilous (Mediterranean) species (T5) were recorded (5.08%), as well as one species (1.69%) classified within the T2 category. The mean ecological index value for temperature ($Tx = 3.59$) characterizes the studied habitat as moderately warm to moderately cool (Figure 1), which also represents favorable conditions for walnut production (Cerović et al., 2003, 2010).

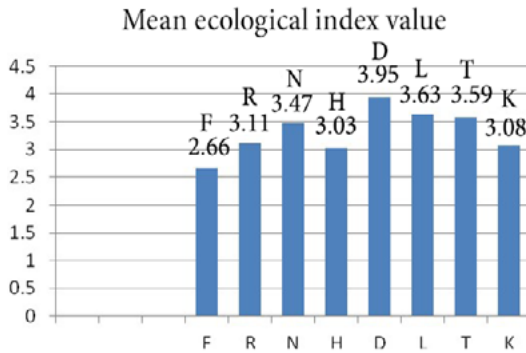


Figure 1. Mean ecological index value.

Within the analyzed walnut weed flora, species characteristic of subcontinental climate conditions (K3) predominated, represented by 46 species (77.97%). These were followed by species classified within the K4 category (moderately continental climate conditions), comprising nine species (15.25%). Four species (6.78%) belonged to the K2 category, indicating suboceanic climatic conditions (Figure 1).

Based on the analysis of bioindicator values of the recorded weed flora in walnut orchards, it can be concluded that the ecological conditions prevailing in the studied area are consistent with the ecological requirements of walnut. However, these same ecological conditions are also favorable for the growth and development of weeds.

The obtained results also confirm observations from European organic orchards that management practices significantly determine weed community composition and biodiversity levels. Studies conducted in organic orchards have shown that reduced tillage and organic fertilization often increase weed species richness and contribute to the development of more complex plant communities (Ciaccia et al., 2022; Platis et al., 2023). Although increased floristic diversity may have a positive role in agroecosystem stability and biodiversity conservation, excessive weed infestation can significantly reduce orchard productivity and complicate agrotechnical management.

However, the interpretation of the results is limited by the scarcity of studies directly addressing weed flora in young organic walnut orchards, both in Serbia and globally. Most available research has focused on other perennial crops such as olive, hazelnut, or medicinal plants, making direct comparisons difficult. Therefore, this study represents an important contribution to the understanding of weed vegetation dynamics in young organic walnut orchards under local agroecological conditions.

CONCLUSION

Floristic investigations of weeds in organic walnut production identified a total of 59 weed species. The weed community consisted of 50 broadleaf and 9 narrow-leaved species. In

all analyzed walnut orchards, the most prevalent weed species were: *Rumex obtusifolius* L., *Lamium amplexicaule* L., *Galium aparine* L., *Taraxacum officinale* Weber, *Agropyrum repens* Beauv., *Bromus arvensis* L., *Bromus sterilis* L., *Poa pratensis* L., *Stellaria media* (L.) Vill., *Veronica persica* Poir., *Capsella bursa-pastoris* (L.) Medik., *Lamium purpureum* L., *Plantago media* L., *Plantago lanceolata* L., and *Plantago major* L. The investigated weed flora showed a clear dominance of therophytes over hemicryptophytes and geophytes. Within the total weed flora, weed-ruderal species showed the highest proportional representation, followed by typical weed species, while six ruderal species were recorded.

The biogeographical analysis revealed a predominance of widely distributed species (Eurasian, sub-Eurasian, cosmopolitan, and adventive species). Based on the ecological indicator values of the recorded weed species, it was determined that walnut orchards under organic production conditions are characterized as moderately warm to moderately cool, and well to moderately illuminated. The soil was found to have favorable moisture conditions, a slightly acidic to neutral reaction, and to be moderately to well supplied with nitrogen compounds and humus.

Since organic production excludes the use of pesticides, including herbicides for weed control, the obtained results provide a valuable baseline for effective weed management in organic walnut orchards. Understanding the dynamics of weed flora, as well as their biological and ecological characteristics, enables the determination of the most appropriate timing and methods for weed control based on improved knowledge of the relationships between weeds and the cultivated crop.

Future research should include long-term monitoring of weed succession, evaluation of different soil management systems, and investigation of environmentally friendly weed control measures adapted to organic walnut production. Furthermore, the application of modern technologies such as remote sensing and precision agriculture tools could contribute to more efficient monitoring and sustainable management of weed vegetation in walnut orchards.

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Florističko-ekološka analiza korovske flore u organskim zasadima oraha

REZIME

Organska proizvodnja oraha (*Juglans regia* L.) u Srbiji ima sve veći značaj; međutim, podaci o sastavu i ekološkoj strukturi korovske flore u mladim zasadima i dalje su ograničeni. Cilj ovog istraživanja bio je utvrđivanje florističkog sastava, biološkog spektra i dominantnih korovskih vrsta u organskom zasadu oraha u selu Trmčare (opština Kruševac, Srbija).

Ukupno je zabeleženo 59 korovskih vrsta, uključujući 32 korovsko-ruderalne, 21 korovsku i 6 ruderalnih vrsta. Flora je bila dominirana predstavnicima klase *Magnoliopsida* (50 vrsta), dok je 9 vrsta pripadalo klasi *Liliopsida*. Analiza životnih formi pokazala je dominaciju terofita (52,54%), zatim hemikriptofita (37,29%), geofita (8,47%) i tero-hemikriptofita (1,69%).

Utvrđen je visok stepen zakorovljenosti, uglavnom usled izostanka međuredne obrade zemljišta, kao i činjenice da duboko oranje (rigolovanje) nije primenjeno tokom osnovne pripreme zemljišta pre sadnje, uz istovremenu primenu nezgorelog kravljeg stajnjaka. Neposredno nakon zasnivanja zasada zabeležena je masovna pojava vrste *Rumex obtusifolius* L., koja je najverovatnije uneta kontaminiranim organskim đubrivom. Pored vrste *Rumex obtusifolius* L., najčešće registrovane vrste bile su *Lamium amplexicaule* L., *Galium aparine* L., *Taraxacum officinale* Weber, *Agropyron repens* (L.) P. Beauv., *Bromus arvensis* L., *Bromus sterilis* L., *Poa pratensis* L., *Stellaria media* (L.) Vill., *Veronica persica* Poir., *Capsella bursa-pastoris* (L.) Medik., *Lamium purpureum* L., *Plantago media* L., *Plantago lanceolata* L. i *Plantago major* L.

Rezultati ukazuju da je struktura korovske zajednice u mladim organskim zasadima oraha snažno uslovljena smanjenim intenzitetom obrade zemljišta, primenom organskih đubriva i sistemom održavanja zasada. Ovo istraživanje doprinosi boljem razumevanju dinamike korovske vegetacije u organskoj proizvodnji oraha i predstavlja osnovu za razvoj održivih strategija suzbijanja korova prilagođenih lokalnim agroekološkim uslovima.

Ključne reči: korovska flora, orah, organska proizvodnja, uskolisni korovi, širokolisni korovi.