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# WEED FLORA IN BASIL (*OCIMUM BASILICUM* L., *LAMIACEAE MARTYNOV 1820, LAMIALES)* GROWN IN CONVENTIONAL AND ORGANIC PRODUCTION*

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***Summary:*** *This study was aimed to compare weeds occurring in basil crops grown under conventional and organic production systems. Weed flora recorded in the conventional production consisted of 16 taxa, with Setaria glauca and Portulaca oleracea dominating. Concerning the organic plots, only seven taxa were noted and dominant species were Sorghum halepense and Amaranthus retroflexus. Unexpectedly lower floristic diversity in the organic agricultural system was caused by omitted application of fertilizers during three consecutive years, still unbalanced agro ecological conditions, partial isolation of the organic plots and the presence of even four invasive weed species.*

***Key words:*** *Ocimum basilicum, organic and conventional production, weeds, ecological analysis.*

## INTRODUCTION

Agro ecological conditions in Serbia can be generally characterized as favorable, and the agricultural producers are experienced and skilled for collection and cultivation of medicinal, aromatic and spice plants; however, those opportunities are often underused.The branch was developing until the end of eighties, regarding both occupied areasand technology of growing. Despite a rich bio fond of these plants, the production is far below those recorded 25-30 years ago. Serbian market demands for medicinal plants are today mostly satisfied by the raw material collected from natural habitats (90%). According to Serbian Chamber of Commerce and Industry, cultivated medicinal, aromatic and spice plants occupied 1,419 ha and 1,337 ha in 2011 and 2012, respectively. Together with spices characterized as vegetables and areas attended for foreign customers, these plants are grown on approximately 20,000 ha (Filipović and Ugrenović, 2014).

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Basil (*Ocimum basilicum* L.) is a medicinal and spice plant belonging to family Lamiaceae and originating from India. It is cultivated for centuries and widespread in many regions. Anti-inflammatory and antioxidant effects of the plant are confirmed by numerous studies, while hypoglycemic effect and possible application in treatment of diabetes remains to be confirmed in further research. Nevertheless, basil is widely used as an antiseptic, preservative, mild sedative, diuretic, against dyspepsia, diarrhea, headache and cough. Basil oil is useful in relieving mental fatigue, colds, cramps, rhinitis, as well as a first aid after wasp sting and snake bite (Özcan and Chalchat, 2002). Therefore, the plant is used as raw material in medical, dental and food industry, pharmacy and cosmetology (Budka and Khan, 2010). The biological activity is due to active compounds, mainly flavonoids and polyphenols (El-Beshbishy and Bahashwan, 2012). The main compounds responsible for typical basil aroma are chavicol methyl ether (estragol), linalool, eugenol, 1,8-cineole and methyl cinnamate. The non-volatile compounds were found to be rich in phenolic acids with the major part of caffeic and rosmarinicacid (Modnicki and Balcerek, 2009).

Basil is an annual plant; the crop establishment is done in the spring and seedlings are produced in warm nurseries (Radanović and Nastovski, 2002). Weed control is the main problem in crop protection. Because herbicides are not allowed in Serbian herb production, mechanical weeding remains as the only solution in both conventional and organic practices. Weeds occurring between rows are controlled with special tools, while those growing inside rows have to be removed by hoeing. Thermal weed control is also allowed in organic herb production; however, special tools such as infrared and burner type flame weeders are required and that equipment is difficult to obtain in our country (Radanović and Nastovski, 2002).

This study was aimed to investigate the weed flora in the basil crops, including its ecology and phyto-geographical analysis, analysis of weed flowering time, and categorization according to habitat, as a necessary prerequisite for the selection of weed control measures adequate for conventional and organic production.

## MATERIAL AND METHODS

The floristic-ecological study of weed flora in organic and conventional basil production systems was carried out during basil growing season of 2014, at the experimental fields of the Institute of Field and Vegetable Crops, Novi Sad, Alternative Crops Department, Bački Petrovac. Sowing was performed on April 28$^{th}$. Preceding crops were onion (*Allium cepa* L.) for organic and maize (*Zea mays* L.) for conventional plots. Organic field was fertilized with farmyard manure in 2011, and mineral fertilizer was applied in the conventional field in 2013 (15:15:15 NPK, rate 400 kg/ha).

Weed species were identified according to Josifović (1970-1977). Table 1 provides an overview of the identified taxa, their life forms (Ujvárosi, 1973), flowering month and categorization by habitat (Čanak et al., 1978), floristic elements (Gajić, 1980) and ecological indices (Landolt, 1977).

## RESULTS AND DISCUSSION

Weed flora in basil consisted of 18 taxa, counting both growing systems (Table 1). Sixteen taxa were recorded in conventional (K), and seven in organic (O) production. Five plant species were found in both growing systems: *Amaranthus retroflexus*, *Bilderdykia convolvulus*, *Chenopodium album*, *Datura stramonium* and *Senecio vulgaris*. Differential plant species found in conventional system were: *Ambrosia artemisifolia*, *Anagallis arvensis*, *Cirsium arvense*, *Convolvulus arvensis*, *Hibiscum trionum*, *Portulaca oleracea*, *Setaria glauca*, *Sonchus arvensis*, *Stachys annua*, *Veronica hederifolia* and *Veronica persica*, with the highest average number of individuals per square meter (ind/m$^2$) counted for *Setaria glauca* (28.00) and *Portulaca oleracea* (8.25). *Polygonum lapathifolium* and *Sorghum halepense* were differential in plots maintained according to organic principles. The highest weed infestation was noted for *Sorghum halepense* and *Amaranthus retroflexus*, with 10.00 and 9.00 ind/m$^2$, respectively.

***Table 1.*** Weed flora in basil in conventional(K) and organic (O) production (with life form, time of flowering, characterization according to the site, floral elements and ecological indices)

| Plant species | K | O | Life form | Time of flowering | Category acc. to site | Floral element | Ecological index | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ind/m$^2$ | ind/m$^2$ | | | | | F | R | N | H | D | S | L | T | K |
| *Amaranthus retroflexus* L. | 3.25 | 9.00 | $T_4$ | VI-IX | KR | Adv | 2 | 3 | 4 | 3 | 3 | - | 4 | 4 | 3 |
| *Ambrosia artemisifolia*L. | 0.25 | - | $T_4$ | VIII-IX | R | Adv | 2 | 3 | 4 | 2 | 2 | + | 4 | 5 | 3 |
| *Anagallis arvensis* L. | 0.25 | - | $T_4$ | V-X | KR | Kosm | 3 | 3 | 3 | 3 | 4 | - | 4 | 4 | 3 |
| *Bilderdykia convolvulus* (L)D | 0.50 | 2.00 | $T_4$ | VI-IX | S | Subevr | 2 | 3 | 3 | 3 | 4 | - | 4 | 4 | 3 |
| *Chenopodium album* L. | 0.25 | 1.00 | $T_4$ | VI-IX | KR | Kosm | 2 | 3 | 4 | 3 | 4 | - | 4 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cirsium arvense*(L.) Scop. | 4.00 | - | $G_3$ | VI-VIII | KR | Subevr | 3 | 3 | 4 | 3 | 4 | + | 3 | 4 | 3 |
| *Convolvulus arvensis*L. | 0.25 | - | $G_3$ | VI-IX | KR | Kosm | 2 | 4 | 3 | 3 | 4 | - | 4 | 4 | 3 |
| *Datura stramonium* L. | 2.50 | 2.00 | $T_4$ | VI-IX | R | Kosm | 3 | 3 | 4 | 4 | 4 | + | 4 | 5 | 2 |
| *Hibiscus trionum* L. | 0.25 | - | $T_4$ | VI-VIII | KR | Pont-e.subm | 3 | 3 | 3 | 3 | 4 | - | 4 | 5 | 4 |
| *Polygonum lapathifolium* L. | - | 1.00 | $T_4$ | VI-IX | KR | Subcirk | 3 | 3 | 4 | 3 | 3 | - | 5 | 3 | 3 |
| *Portulaca oleracea* L. | 8.25 | - | $T_4$ | VI-VIII | KR | Kosm | 3 | 3 | 4 | 3 | 4 | - | 4 | 4 | 3 |
| *Senecio vulgaris* L. | 1.00 | 2.00 | $T_1$ | III-XI | KR | Evr | 3 | 3 | 4 | 3 | 4 | - | 4 | 4 | 3 |
| *Setaria glauca* (L.) P.B. | 28.00 | - | $T_4$ | VI | KR | Kosm | 2 | 3 | 4 | 2 | 3 | - | 4 | 4 | 3 |
| *Sonchus arvensis* L. | 5.00 | - | $G_3$ | VII-IX | KR | Evr | 3w | 3 | 4 | 4 | 4 | + | 3 | 4 | 3 |
| *Sorghum halepense*(L.) Pers. | - | 10.00 | $G_1$ | VI-VII | KR | Kosm | 1 | 2 | 3 | 3 | 3 | - | 4 | 5 | 3 |
| *Stachys annua* L. | 1.00 | - | $T_4$ | VI-X | KR | Subpont-subm | 2 | 4 | 2 | 3 | 4 | - | 4 | 4 | 4 |
| *Veronica hederifolia*L. | 3.00 | - | $T_1$ | III-V | KR | Subse | 3 | 3 | 4 | 3 | 4 | - | 3 | 4 | 3 |
| *Veronica persica* | 3.00 | - | $T_1$ | III-IV(X) | KR | Adv | 3 | 4 | 4 | 3 | 4 | - | 4 | 4 | 3 |

T –Therophyte, G – Geophyte;KR – Weed-ruderal, R – Ruderal, S – Segetal weed; Adv – Adventive,Kosm – Cosmopolitan, Subevr – Subeurasian, Pont-e.subm – PonticEast Submediterranean,Subcirk – Subcirkumpolar,Evr – Eurasian, Subpont-subm – Subpontic-Submediterranean,Subse– Submiddle European.

Similar reduction in weed floristic diversity (eight taxa) was reported by Ljevnaić-Mašić et al. (2014) for basil grown in certified organic farm “Bio salaš Farago” in Orom, North Banat. Three species were common for the two sites: *Amaranthus retroflexus*, *Bilderdykia convolvulus* and *Sorghum halepense*.

Generally, basil crop weed infestation on conventionally maintained plots was approximately 5% and 80% between and inside rows, respectively. Organic plots were infested less than 1% between and approximately 5% inside rows.

The results of this study oppose to the numerous reports (Menalled et al, 2001; Boguzas et al., 2004) on comparatively high weed floristic diversity in organically maintained crops. According to Nikolić et al. (2013), still not fully balanced ecological conditions on the organic plots, as well as their partial space isolation may be the explanation of the reduction in weed variety. Roschevitz et al. (2005) suggested the influence of dissemination from the surrounding area on floristic diversity of conventional plots. In addition, higher infestation of conventional plots is at least partially due to the fertilizing performed in 2013. The applied mineral fertilizer fostered weed development; on the other hand, organic plots remained unfertilized for three consecutive years.

Since invasive plant species may exhibit undesirable effects on autochthonous flora (Vrbničanin et al., 2004; Nikolić et al., 2011), it is important to note even four such plants: *Amaranthus retroflexus*, *Ambrosia artemisiifolia*, *Portulaca oleracea* and *Sorghum halepense*. The possible spreading of this species should be monitored and controlled.

The majority of the analyzed weeds flowers from June to September. Weed species *Senecio vulgaris*, *Veronica hederifolia* and *V. persica* flower in March, while *Anagallis arvensis* flowers in May. The longest vegetation period have *Senecio vulgaris*, *Veronica persica* and *Stachys annua*. Except *Senecio vulgaris*, which grows in both growing systems, the mentioned species were found on conventional plots only and imply longer vegetation period of this vegetation.

Out of 18 taxa recorded in basil crops, 15 are weed-ruderal (83.33%), two (11.11%) are ruderal, and one belong to segetal weeds (5.55%) – *Bilderdykia convolvulus*. The percentages of the categories according to the site are: weed-ruderal K-81.25%, O-71.43%; ruderal K-12.50%, O-14.28% and segetal K-6.25%, O-14.28%.

Concerning the spectrum of areal types; characteristic of weeds, taxa with wide spatial distribution predominate (K-81.25%,O-100.00%). The cosmopolitan floral elements were dominant (K-37.50%, O-42.86%), followed by Adventive (K-18.75%, O-14.28%), Eurasian (K-12.50%, O-14.28%), Subeurasian (K-12.50%, O-14.28%) and Subcirkumpolar (O-14.28%). Taxa with narrow distribution were found in conventional crops only (18.75%), with one taxon of Submiddle European, Pontic East Submediterranean and Subpontic-Submediterraneanfloral element.

Therophyte life form predominates in both production systems (K-81.25%, O-85.71%, Figure 1). $T_4$ therophytes with germinating in spring and seed maturing by the end of summer were the most numerous (K-62.50%, O-71.43%). Therophytes $T_1$ were less abundant (K-18.75%, O-14.28%). Geophytes $G_3$ were represented with 18.75% in conventional and $G_1$ with 14.28% in organic basil production. Such a biological floristic spectrum is probably related to mechanical weed control (hoeing) that favors survival of therophytes, which is a characteristic for the ecosystems under strong anthropogenic influence (Nikolić et al., 2011; Džigurski et al., 2012; Ljevnaić-Mašić et al., 2013). Despite of small differences between the two growing systems, therophyte *Setaria glauca* dominates in conventional and geophyte *Sorghum halepense* in organic crops.

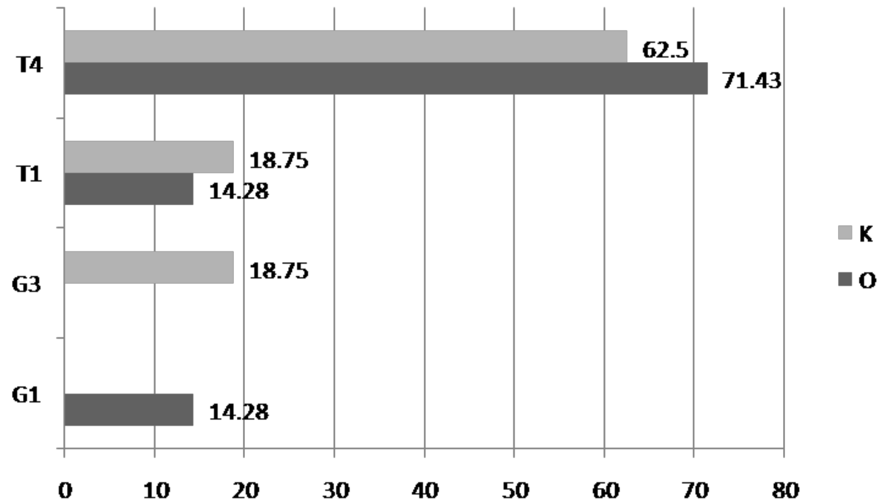


***Figure 1.*** Biological spectrum of weed flora of basil in conventional (K) and organic (O) production

The analysis of ecological indices for the weed flora in terms of humidity showed the domination of mesophytes which are adapted to moderately humid sites ($F_3$) in conventional crops (K-56.25%, O-42.86%). On the other hand, presence of sub xerophytes adapted to moderately dry sites ($F_2$) is almost equal in the two production systems (K-43.75%, O-42.86%, Figure 2). *Sorghum halepense*, adapted to dry sites ($F_1$), was registered on organic plots only (14.28%). The mean values of the ecological index for humidity were 2.56 for conventional and 2.28 for organic plots, indicating somewhat wetter soil in conventional plots, which is related to higher weed infestation.

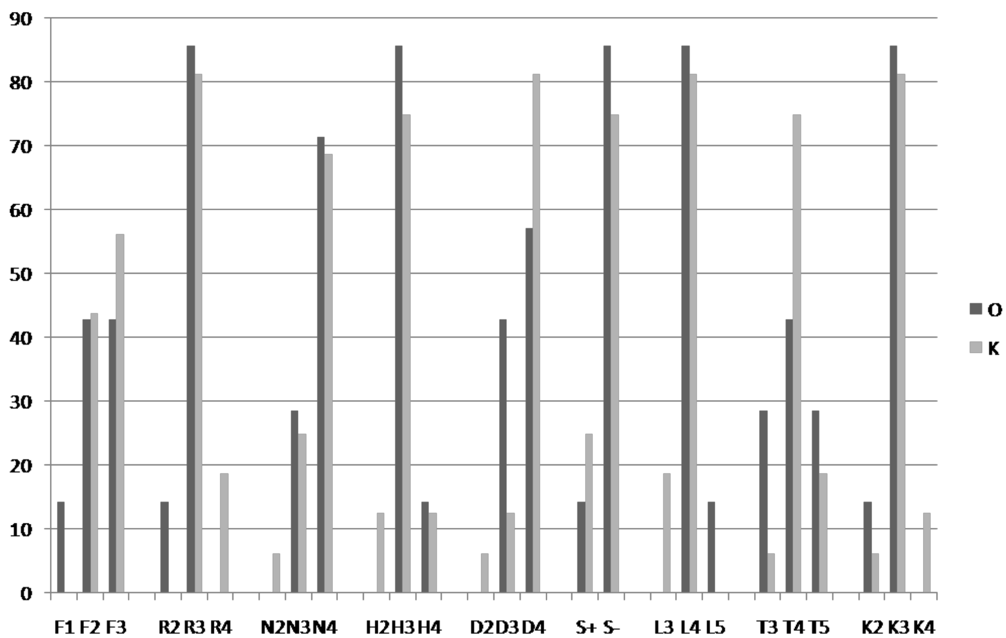


***Figure 2.*** Percentage of ecological indices of weed flora in basil crop in conventional (K) and organic (O) production

The ecological analysis of substrate chemical reaction indices showed the predominance of neutrophilic ($R_3$) plants (K-81.25%, O-85.71%). The indicators of neutral to slightly alkaline soil ($R_4$) were present in conventional production only (18.75%). Concerning organic plots, one taxon (14.28%) adapted to acid soil ($R_2$) was found. The mean values of the ecological indices indicate neutral to slightly acid reaction (3.18) on conventional and neutral to slightly alkaline reaction (2.86) on organic plots.

The analysis of ecological indices for nitrogen compounds showed the dominance of the indicators of eutrophic ($N_4$; K-68.75%, O-71.43%) and moderately productive ($N_3$; K-25.00%, O-28.57%) ecosystems. One indicator of low amount of soil nitrogen compounds was present in conventional production. The mean values of the indices (K-3.62, O-3.71) characterize the agro ecosystems as eu-mesotrophic, with somewhat higher nitrogen content in plots maintained organically.

The indices concerning organomineralcompoundsindicated medium soil humus content ($H_3$) in both production systems (K-75.00%, O-14.28%). The indicators of soil with high ($H_4$; K-12.50%, O-14.28%) and low ($H_2$; K-12.50%) humus content were less abundant. Slightly higher humus content was estimated for organic production (3.14) when compared to conventional (3.00).

Regardingdispersion (aeration) of soil, dominate the indicators of moderately aerated substrate ($D_4$; K-81.25%, O-57.14%). The indicators of well aerated substrate are less abundant ($D_3$; K-12.50%, O-42.86%). One indicator of well aerated sites ($D_2$) was present on conventional plots. All analyzes plots were well aerated, with a slightly more favorable situation in organic system (K-3.75, O-3.57).

The weed species that are the indicators of non-saline soils ($S_-$) were dominated on both conventionally (75.00%) and organically (85.71%) maintained plots. However, taxa adapted to higher $Na^+$ ion content ($S_+$) were more frequent on conventional (25.00%) than on organic (14.28%) plots.

The site was characterized by high light intensity ($L_4$; K-81.25%, O-85.71%). Semi-sciophytes ($L_3$) were found in conventional (18.75%), andheliophytes ($L_5$) in organic (14.28%) system. The mean values of the ecological indices for light confirm favorable light regime (K-3.81, O-4.14).

Concerning temperature, the most abundant were the indicators of warm sites ($T_4$; K-75.00%, O-42.86%). Less numerous were the indicators of moderately warm ($T_3$; K-6.25%, O-28.57%) and very warm sites ($T_5$; K-18.75%, O-28.57%). Temperature regime was favorable, with mean values of the ecological indices of 4.12 (K) and 4.00 (O).

The analyzed site was characterized by moderately continental conditions ($K_3$; K-81.25%, O-85.71%). The mean values of the ecological indices were 3.06 (K) and 2.86 (O).

## CONCLUSION

Weed flora in conventional basil production system consisted of 16 taxa. Differential plant species were: *Ambrosia artemisifolia*, *Anagallis arvensis*, *Cirsium arvense*, *Convolvulus arvensis*, *Hibiscum trionum*, *Portulaca oleracea*, *Setaria glauca*, *Sonchus arvensis*, *Stachys annua*, *Veronica hederifolia* and *V. persica*, with *Setaria glauca* as the dominant one. Weed infestation was 5% and 80% between and inside rows, respectively.

Only seven taxa were found in organic production system. Differential species were: *Polygonum lapathifolium* and *Sorghum halepense*, with *Sorghum halepense* dominating. Weed infestation was less than 1% and 5% between and inside rows, respectively.

The analysis of weed flowering showed that the flora found in conventional growing system had longer vegetation period.

The weed flora was of therophyte-geophyte character in both production systems. Therophyte *Setaria glauca* dominates on conventional and geophyte *Sorghum halepense* on organic plots.

The ecological indices of the weed flora were similar for the two growing systems.

The relatively small differences concerning weed flora are related to the agro technical procedures specific for growing medicinal and spice plants that are similar for conventional and organic plots. Manual weeding was not performed any of the conventional or the organic plots, providing similar conditions for weed development. The higher floristic diversity recorded for the conventional plots was related to mineral fertilizer applied during the previous year, in contrast to organic plots which remained unfertilized for three consecutive years. In addition, the reduction in weed diversity on organic plots may be partially explained by still not fully balanced ecological conditions, as well as their partial space isolation.

Invasive plant species in weed flora are important from the ecological and agronomical aspect, as well as because their possible undesirable effects on autochthonous flora, therefore *Amaranthus retroflexus*, *Ambrosia artemisiifolia*, *Portulaca oleracea* and *Sorghum halepense* should be monitored and controlled.

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## KOROVI U KONVENCIONALNOJ I ORGANSKOJ PROIZVODNJI BOSILJKA (*OCIMUM BASILICUM*, LAMIACEAE MARTYNOV 1820, LAMIALES)

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**Izvod:** Cilj rada bio je da se ukaže na razlike u korovskoj flori bosiljka u konvencionalnom i organskom sistemu gajenja. Floru korova pri konvencionalnoj proizvodnji čini 16 taksona, a dominiraju *Setaria glauca* i *Portulaca oleracea*. U organskoj proizvodnji zabeleženo je svega sedam taksona, a dominiraju *Sorghum halepense* i *Amaranthus retroflexus*. Neočekivano manji floristički diverzitet u organskom sistemu gajenja uzrokovan je izostankom đubrenja u poslednje tri godine, još sasvim neuravnoteženim ekološkim uslovima, delimičnom izolovanošću parcela i prisustvom čak četiri invazivne vrste.

**Key words:** *Ocimum basilicum*, organska i konvencionalna proizvodnja, korovi, ekološka analiza.

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