BIOLOGICA NYSSANA
4 (1-2) • December 2013: 9-14
11th SFSES • 13-16 June 2013, Vlasina lake

Original Article

Analysis of weed flora in conventional and organic potato production

Ljiljana Nikolić, Olivera Ilić, Dejana Džigurski, Branka Ljevnaić-Mašić

Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21 000 Novi Sad, Serbia

** E-mail: ljnik@polj.uns.ac.rs*

***Abstract*:**
Nikolić, Lj., Ilić, O., Džigurski, D., Ljevnaić-Mašić, B.: ***Analysis of weed flora in conventional and organic potato production. Biologica Nyssana, 4 (1-2), December 2013: 9-14.***

Composition of weed flora is highly dynamic and depends upon great number of factors, of which cultural practices that are applied by humans in certain crops are the most important. One of the most frequently grown plants in the world and in our country is potato (*Solanum tuberosum* L., Solanaceae), due to its high biological and nutritive value. Therefore, in the paper was presented taxonomic analysis of weed flora in potato grown conventionally and according to the principles of organic agricultural production, with the intention to point out to eventual differences between present weeds. Of the total number of identified species, from phylum Equisetophyta and class Equisetopsida, in organic potato crop, was determined only one, *Equisetum arvense.* Of remaining 38 weeds from phylum Magnoliophyta., classified into two classes, Magnoliopsida and Liliopsida. On both of potato growing systems, 39 weed species were found, classified into 16 families and 32 genus. Of the total number, 31 species was identified in conventional potato crop, and only 23 species in potato crop grown according to organic principles, which is for about quarter less. Biological spectrum of weed flora in both potato growing systems is pronouncedly of terrophytic – geophytic type. In the spectrum of area types were recorded differences, i.e. in the conventional potato crop represented are only widely distributed species, while in the organic crop, beside species of wide distribution are also present elements of Pontic group.

Key words: taxonomic analysis, weeds, potato

Introduction

Floristic diversity, as well as overall biodiversity of natural and anthropogenic ecosystems, is a subject of numerous studies. Fundamental research comprising of direct verification and systematization of biodiversity forms the foundations for biodiversity conservation in general. Biodiversity changes due to anthropogenic factors pose numerous risks, while yielding paucity of immediate benefits (Stevanović & Vasić 1995). Hence, research focusing on studying and preserving the biodiversity of agroecosystems that are under direct human influence is of particular importance, as reflected in the development of a European-level action plan (The 2001 Biodiversity Action Plan for Agriculture /COM/2001/0162).

Since the early nineties, interest in organic farming has significantly increased in Europe, with particular attention to agroecosystems and their biodiversity, emphasizing the differences between conventional crops and those grown according to organic principles (Roschewitz et al., 2005; Weibull et al., 2003; Hyvönen et al., 2003; Hyvönen, 2007).

The main difference between conventional and organic farming principles is reflected in the fact that the latter completely exclude the use of chemicals and fertilizers. It is this specificity that, on one hand, raises the question of whether organic farming could contribute to the restoration and preservation of biodiversity (H y v ö n e n , 2007). However, on the other hand, control of weed proliferation—which, as a regular crop companion, has a significant negative impact on the quality and quantity of agricultural products—is a major problem in organic production, as it almost completely excludes chemical weed control measures (B à r b e r , 2002; K r i s t i a n s e n , 2003).

To address these issues, this paper presents the analysis of the weed flora accompanying potato (*Solanum tuberosum* L.), one of the most widely cultivated plants in the world and in our country, grown both conventionally and according to the organic farming principles, in order to identify potential differences between the outcomes of the two systems.

The reported results provide a foundation for long-term monitoring and study of weed flora as an important component of agroecosystem biodiversity.

Material and methods

Floristic weed analysis in conventional potato production was carried out during the 2008-2010 vegetative period at the experimental plots in the vicinity of Bečej. The two-factor experiment was carried out, whereby conventional potato production with and without herbicide application was conducted in the varying cultivation conditions (number of inter-row potato earthing repetitions). This paper reports only on the weed flora found in the control part of the experiment, which included cultivation and planting, with no other crop care or weed protection measures.

Floristic weed analysis in organic potato production was carried out during 2012, on the localities registered for organic farming—family "Biofarm" in Kelebija and biofarm "Mamudžić" in Ljutovo—where weed proliferation is suppressed by mechanical means only.

Determination of plant material was performed according to Josifović (1970-1977), whereas taxonomy conformed to Takhtajan (2009), life-form categorization followed Ujvárosi (1973), and floral elements were determined according to Gajić (1980).

Results and discussion

The following sections present the analysis of weed flora in potato crops grown conventionally and according to organic principles.

In both potato cultivation systems, 39 weed species were identified, grouped into 32 genera, 16 families, 12 orders, 5 subclasses, 3 classes and 2 divisions. More specifically, the control variant of conventional potato crops showed the presence of 31 weed species, classified into 25 genera, 11 families, 7 orders, 5 subclasses, 2 classes and 1 division. On the other hand, in the organic potato crops, only 23 weed species were recorded, which were classified in 22 genera, 15 families, 12 orders, 5 subclasses, 3 classes and 2 divisions (Table 1 and 2).

Of the total number of identified species, *Equisetum arvense* L. (2.56%) from the Equisetophyta division and Equisetopsida class was found in organic potato crops only. The remaining 38 weeds from the Magnoliophyta division were noted in varying numbers in both conventional and organic potato crops. These were divided into two classes, whereby the Magnoliopsida (82.05%) class was represented by four subclasses (Caryophyllidae, Dillenidae, Lamiidae and Asteridae) and the Liliopsida class (15.38%) was represented by the Commelinidae subclass only (Table 1, 2).

As noted above, greater floristic diversity (31 species) and more significant weed proliferation was found in the control variant of the conventionally grown potatoes, while nearly 25% (23 species) reduction in floristic diversity is evident in organically grown potato crops. The analysis revealed presence of 15 common species, as well as 8 specific to organic and 16 to conventional potato crops. In the conventionally grown crops, the following were found in significant numbers: *Panicum crus-galli* L., *Cirsium arvense* (L.) Scop., *Amaranthus retroflexus* L., *Sorghum halepense* L. and *Polygonum lapathifolium* L., while only individual weeds were generally recorded in organic potato crops, except for *Equisetum arvense* L. and *Polygonum convolvulus* L. in Ljutovo, both of which were more abundant.

Although the findings reported by some authors (Hald, 1999; Menalled et al., 2001; Boguzas et al., 2004) indicate greater species wealth in organic crops compared to conventional cultivars, data obtained in this work point to the greater weed floristic diversity in conventional potato crops. This discrepancy can be explained by the fact that our analyses were conducted on the control variant of the experiment, which did not permit any herbicide application. However, it should be noted that, as the soil on which the experiment was conducted had been previously used for conventional agricultural production, the previously applied agrotechnical practices certainly affected the obtained results.

Table 1. Taxonomic review of weed flora in potato crops

Phylum	Class	Subclass	Order	Family	Genus	Plant species	Life form	Floristic elements	C	O
Equisetophyta	Equisetopsida		Equisetales	Equisetaceae	Equisetum	*E. arvense* L.	G_1	Cirk.	-	+
Magnoliophyta	Magnoliopsida	Caryophyllidae	Caryophyllales	Portulacaceae	Portulaca	*P. oleracea* L.	T_4	Cosm..	+	+
				Caryophyllaceae	Stellaria	*S. media* L.	T_1	Cosm..	+	-
				Amaranthaceae	Amaranthus	*A. retroflexus* L.	T_4	Adv.	+	+
				Chenopodiaceae	Chenopodium	*C. album* L.	T_4	Cosm..	+	+
						C. hybridum L.	T_4	Subcirk.	+	+
			Polygonales	Polygonaceae	Polygonum	*P. convolvulus* L.	T_4	SubEur.	+	+
						P. lapathifolium L.	T_4	Subcirk.	+	-
						P. persicaria L.	T_4	Eur.	+	-
						P. aviculare L.	T_4	Cosm..	+	-
		Dillenidae	Capparales	Brassicaceae	Capsella	*C. bursa-pastoris* (L.) Med.	T_1	Cosm..	+	+
					Sinapis	*S. arvensis* L.	T_3	SubEur.	+	-
			Malvales	Malvaceae	Hibiscus	*H. trionum* L.	T_4	Pont.ea.-subm.	-	+
					Malva	*M. silvestris* L.	HT-H_4	Eur.	-	+
			Euphorbiales	Euphorbiaceae	Euphorbia	*E. helioscopia* L.	T_4	SubEur.	-	+
		Lamiidae	Solanales	Solanaceae	Datura	*D. stramonium* L.	T_4	Cosm..	+	+
					Solanum	*S. nigrum* L.	T_4	Cosm..	+	+
			Convolvulales	Convolvulaceae	Convolvulus	*C. arvensis* L.	G_3	Cosm..	+	+
				Cuscutaceae	Cuscuta	*C. epithymum* L.	T_4	SubEur.	+	-
						C. europea L.	T_4	Eur.	-	+
			Boraginales	Boraginaceae	Heliotropium	*H. europaeum* L.	T_4	Pont.-subm.	-	+
			Lamiales	Lamiaceae	Stachys	*S. annua* L.	T_4	Subpont.-Subm.	-	+
					Lamium	*L. amplexicaule* L.	T_1	SubEur.	-	+
		Asteridae	Asterales	Asteraceae	Ambrosia	*A. artemisiifolia* L.	T_4	Adv.	+	+
					Cirsium	*C. arvense* (L.) Scop.	G_3	SubEur.	+	+
					Galinsoga	*G. parviflora* Cav.	T_4	Adv.	+	-
					Erigeron	*E. canadensis* L	T_4	Adv.	+	-
					Matricaria	*M. chamomilla* L.	T_2	Eur.	+	-
						M. inodora L.	T_4	Eur.	+	-
					Senecio	*S. vulgaris* L.	T_1	Eur.	+	-
					Sonchus	*S. arvensis* L.	G_3	Eur.	+	+
						S. oleraceus L.	T_4	SubEur.	+	-
					Xanthium	*X. strumarium* L.	T_4	Adv.	+	-
	Liliopsida	Commelinidae	Poales	Poaceae	Agropyrum	*A. repens* Beauv.	G_1	Eur.	+	-
					Cynodon	*C. dactylon* Pers.	G_1	Cosm..	+	-
					Digitaria	*D. sanguinalis* Scop.	T_4	Cosm..	+	-
					Panicum	*P. crus-galli* L.	T_4-T_4(H)	Cosm..	+	+
					Setaria	*S. glauca* P.B.	T_4	Cosm..	+	+
					Sorghum	*S. halepense* L.	G1	Cosm..	+	+
2	**3**	**5**	**12**	**16**	**32**	**39**			**31**	**23**

Table 2. The number of weed species of the higher taxonomic categories in potato crop

	Division	Class	Subclass	Family	Genus	Species	
						No	%
	Equisetophyta	Equisetopsida		1	1	1	2,56
	Magnoliophyta	*Magnoliopsida*	4	14	25	32	82,05
		Liliopsida	1	1	6	6	15,38
Ukupno	**2**	**3**	**5**	**16**	**32**	**39**	**100**

The 25% reduction in weed variety in the organic potato crops, when compared to the conventional production, could be potentially explained by the still not fully balanced ecological conditions in these plots, their partial isolation, as well as regular mechanical weed control. Still, some authors (Weibull et al., 2003) maintain that the cultivation (farming) system is yet to be established as a factor affecting the floristic diversity, while Roschewitz et al. (2005) reported that the floristic diversity of conventional crops, especially their peripheral parts, is significantly influenced by dissemination of various species from the surrounding area.

As can be seen in **Table 3**, the total floristic spectrum of weed flora found in potato crops is dominated by the Asteraceae family with 10 species (25.65%), and Poaceae family with 6 species (15.39%). This relationship is not surprising, given that these vascular plant families are already very rich in species, among which the representatives from the weed category are very numerous.

Table 3. Floristic range of families according to species number

Familija	Broj vrsta	%
Asteraceae	10	25,65
Poaceae	6	15,39
Polygonaceae	4	10,26
Chenopodiaceae	2	5,13
Brassicaceae	2	5,13
Malvaceae	2	5,13
Solanaceae	2	5,13
Cuscutaceae	2	5,13
Lamiaceae	2	5,13
Equisetaceae	1	2,56
Portulacaceae	1	2,56
Caryophyllaceae	1	2,56
Amaranthaceae	1	2,56
Euphorbiaceae	1	2,56
Convolvulaceae	1	2,56
Boraginaceae	1	2,56
Ukupno	**39**	**100**

Polygonaceae family is represented by 4 species (10.26%), whereas Chenopodiaceae, Brassicaceae, Malvaceae, Solanaceae, Cuscutaceae and Lamiaceae families are represented by 2 species (each with 5.13% participation). Finally, only one species (2.56%) each was found for Equisetaceae, Portulacaceae, Caryophyllaceae, Amaranthaceae, Euphorbiaceae, Convolvulaceae and Boraginaceae families.

Life-form analysis of the identified potato crop weed flora indicated its terophytic-geophytic character (Fig. 1). In conventional potato crops, terophytes comprised 80.64% (25 species), and were dominated by T_4 terophytes—annual weeds whose seeds germinate in spring and bear fruit in summer—with 64.52% (20 species). The remaining 19.36% (6 species) were of geophytic character, of which three species (9.68%) belonged to the G_1 category, with developed rhizomes, and the remaining three (9.68%) to the G_3 category, characterized by adventitious root buds. In the organic potato crops, the ratio is similar, as the terophytes predominate with 73.91% (17 species), albeit with a slightly lower share compared to the conventional crops. The participation of geophytes is also similar, with 21.74% (5 species), of which three (13.05%) are in G_3 and two (8.69%) in the G_1 category. Only one species (*Malva silvestris*) belongs to the hemiterophyte-hemicryptophyte category (Fig. 1). This life-form ratio is characteristic of agroecosystems, where due to intensive agricultural practices, the conditions are most favorable for development of terophytes (Kojić et al., 1998; Knežević & Baketa, 1990; Gabriel & Tscharntke, 2007).

The spectrum of areal types, as is characteristic of agroecosystems, is dominated by species capable of wide spatial distribution, due to their wide ecological valence, and adaptation to intense anthropogenic impacts (Kojić et al., 1998). Although they cover relatively small surface and comprise only a few species, we note a few differences. Namely, in the conventional potato crops, only highly proliferative species are present, among which, the cosmopolitan floral elements predominate with 41.94% (13 species). In contrast, in the organic crops, in addition to proliferative species, the conditions are favorable for the development of markedly continental representatives of pontic groups (Pontic-Submediterranean – *Heliotropium europaeum* L., Pontic-Eastern Submediterranean – *Hibiscus trionum* L., and Subpontic-Submediterranean – *Stachys annua* L.) (Fig. 2).

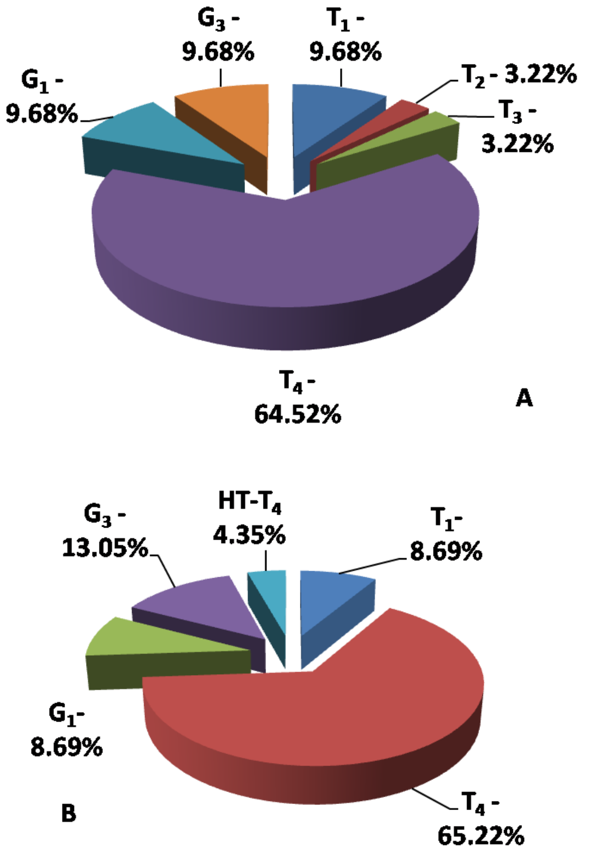

Fig. 1. Biological spectrum of weed flora in potato crop, A – conventional, and B - organic

These results point to slight differences in the structure of the weed flora found in potato crops grown conventionally and according to organic principles, probably due to differences in applied agrotechnical practices.

It should be noted that, although the weed flora plays a significant role in the overall biodiversity and the functioning of these anthropogenic ecosystems, their optimal operation still requires maintaining a correct balance between cultivated and wild plants, as weeds contribute to better regulation of environmental conditions (Bound & Grundy, 2001; Boguzas et al., 2004).

Protection and conservation of sensitive weed species can be achieved by different means, and given their increasing endangerment, the focus should be on the intensification of organic agriculture, with reduced use of herbicides and fertilizers. However, conservation of these species in botanical gardens is also one of the possible measures (Znaor, 1996; Moss et al., 2004; Hulina, 2005).

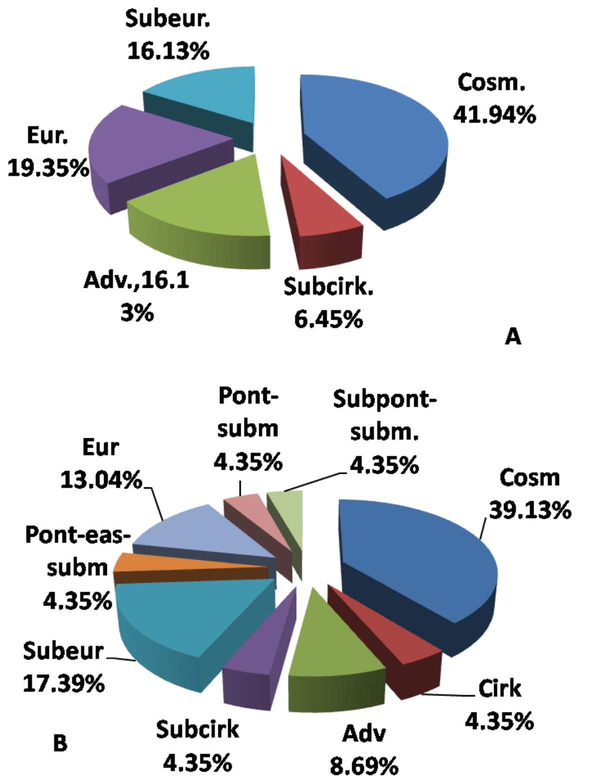

Fig. 2. Area type spectrum of weed flora in potato crop, A – conventional, and B – organic

Conclusion

In both organic and conventional potato crops, the presence of 39 weed species was noted, which were grouped into 16 families and 32 genera. Greater floristic diversity (31 species) and greater weed infestation was found in the control plots of conventionally grown potatoes, while nearly 25% (23 species) reduction in floristic diversity was established in organically grown crops. The two cultivation methods had 15 species in common, while 8 were specific to organic and 16 to conventional potato crops.

In the total floristic spectrum of potato crops weed flora, Asteraceae family predominates with 10 species, followed by Poaceae family with 6 species.

Biological spectrum of weed flora in both potato production systems is of predominantly terophytic-geophytic character, with a slightly lower participation of terophytes in organic potato crops.

In terms of the spectrum of areal types, only species capable of wide distribution are present in conventional potato crops, while in organic crops, elements of pontic group are also found.

The results reveal small differences in the weed flora structure between conventionally and organically grown potato crops, most likely due to agrotechnical practices.

Acknowledgements. This study is part of the project TR – 31027 «Organic agriculture: Improvement of production by use of fertilizers, biopreparations and biological measures« funded by subsidized by the Ministry for Science and Technological Development of the Republic of Serbia.

References

Bàrberi, P. 2002: Weed management in organic agriculture: are we addressing the right issues? *Weed Research,* 42(3): 177-193.

Boguzas, V., Marcinkeviciene, A., Kairyte, A. 2004: Quantitative and qualitative evaluation of weed seed bank in organic farming. *Agronomy Research*, 2(1): 13-22.

Bound, W., Grundy, A.C. 2001: Non-chemical weed management in organic farming systems. *Agronomy Research,* 41: 383-405.

Gabriel, D., Tscharntke,T. 2007: Insect pollinated plants benefit from organic farming. *Agriculture, Ecosystems and Environment*, 118: 43-48.

Gajić. M. 1980: Pregled vrsta flore SR Srbije sa biljnogeografskim oznakama. *Glasnik Šumarskog fakulteta*, 54(A): 111-141.

Hald, A.B. 1999: Weed vegetation (wild flora) of long estabilished organic versus conventional cereal fields in Denmark. *Annals of Applied Biology*, 134: 307-314.

http://europa.eu/legislation_summaries/agriculture/environment/l28024_en.htm The 2001 Biodiversity Action Plan for Agriculture /COM/2001/0162).

Hulina, N. 2005: List of threatened Weeds in Continental Part of Croatia and their Possible Conservation. *Agriculturae Conspectus Scientificus*, 70 (2): 37-42.

Hyvönen, T., Ketoja, E., Salonen, J., Jalli, H., Tiainen, J. 2003: Weed species diversity and community composition in organic and conventional cropping of spring cereals. *Agriculture, Ecosystems and Environment*, 97: 131-149.

Hyvönen, T. 2007: Can conversion to organic farming restorethe species composition of arable weed communities? *Biological conservation*, 137: 382-390.

Josifović, M. (ed.), 1970-1977: Flora SR Srbije, I-IX, SANU, Beograd.

Kojić, M., Popović, R., Karadžić, B. 1998: Sintaksonomski pregled vegetacije Srbije. Institut za biološka istraživanja »Siniša Stanković«, Beograd, 1-218.

Knežević, M., Baketa, E. 1990: Phytocenological characteristics of the buckwheat weed community in north-eastern Croatia. *Fagopyrum*, 11: 15-18

Kristiansen, P. E. 2003: Sustainable Weed Management in Organic Herb and Vegetable Production. Monash, New England, Australia, University of New England, PhD thesis, Archived at http://orgprints.org/4829

Menalled, F.D., Gross, K.L., Hammond, M. 2001: Weed aboveground and seedbank community response to agricultural management systems. *Ecological Applications*, 9: 634-641.

Moss, R.S., Storkey, J., Cussans, W.J., Perryman, A.M.S., Hewitt, V.M. (2004): Simposium The Broadbalk long-term experiment at Rothamsted: what has it told us about weeds? *Weed Science,* 52: 864-873.

Roschewitz, I., Gabriel, D., Tscharntke, T., this C. 2005: The effects of landscape complexity on arable weed species diversity in organic and conventional farming. *Journal of Applied Ecology*, 42: 873-882.

Stevanović, V. , Vasić, V. 1995. O biodiverzitetu. In: Stevanović, V. & Vasić, V. (eds.). Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja, 1-9, Ecolibri, Beograd, Biološki fakultet, Beograd.

Weibull, A.C., Östman, Ö., Granqvist, A. 2003: Species richnes in agroecosystems; the effect of landscape, habitat and farm management. *Biodiversity and Conservation*, 12: 1335-1355.

Takhtajan, A. 2009: Flowering Plants. Second Edition. Springer.

Ujvárosi, M. 1973: Gymnövények. Mezőgazdasági Kiado, Budapest.

Znaor, D. 1996: Ekološka poljoprivreda. Nakladni zavod Globus, Zagreb, 469pp.