The Arable Weeds of Plešivica Hills (NW Croatia)

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Summary

The arable weeds (segetal flora) were explored on Plešivica hills (NW Croatia) during vegetational seasons 2002 and 2003 at 10 locations. The common methods of plant recording, collecting and identification were applied in the research of the arable weeds. The nomenclature of plants was according to Tutin et al. (1964-1980, 1993). The total of 107 taxa of arable weeds that classified to 32 families was noted. The most represented families were *Poaceae*, *Asteraceae* and *Fabaceae*. Therophytes were dominant in the fields that were the subject of this research. Most of the species were the cosmopolites and the Euroasian origin.

78 weed species were noted in dense crop fields (wheat, barley). Some of them (*Chamomilla recutita* (L.) Rausch., *Cirsium arvense* (L.)Scop., *Galium aparine* L., *Papaver rhoeas* L., *Stellaria media*(L.)Vill. and *Veronica persica* Poir.) are the most harmful weeds of dense crops. 62 weeds were noted in maize fields. Some of them were typically row crop weeds, as for instance: *Amaranthus retroflexus* L., *Chenopodium album* L., *Ch. polyspermum* L., *Cirsium arvense*, *Convolvulus arvensis* L., *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.) PB., *Polygonum lapathifolium* L. and *Sorghum halepense* (L.) Pers. Very invasive species *Abutilon theophrasti* Med. was found on the row crop fields. Very dangerous aeroallergenic species *Ambrosia artemisiifolia* L. was dispersed in many of the researched fields.

Key words

arable, weed, weed flora, segetal flora, Plešivica hills

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Introduction

The history of plant cultivation is the history of confrontation with weeds. The arable weeds (segetal flora) adapted to all methods of crop production.

Floristic composition of arable weeds and their agricultural characteristics are object of numerous researches (Pujadas Salvį and Hernįndez Bermejo, 1988; Saavedra et al., 1989; Hidalgo et al., 1990; Saavedra et al., 1990; Adžgauskiene, 1995; Albrecht 1995; Qasem, 1995; Topić, 1998; Čušin and Šilc, 2002).

Plešivica hills is a suitable area for agricultural production in the north-west part of Croatia due to hydrological and soil characteristics as well as meteorological circumstances.

Two cropping rotation system of dense crops and row crops (for economic reason) is usual for this area. The crop rotation and intensified cultivation of fields are two main possibilities for weed control. The crop rotation in the same field can solve three important problems that have got to do with diseases, pests or weeds. In addition, it has influence on the composition of arable weeds and their "seed banks". The positive influence of crop rotation can be supplemented by herbicide application. However, the chemical control with herbicide is not cheap and has negative influence on environment (resistance, residue, depressive influence on culture, etc.). For that reason it is seldom practiced for field cultivation.

The list of arable weeds in the area of Plešivica hills can point out significance of weeds for biodiversity of researched area. The biodiversity depends on human activities in many ways. At the same time it is most endangered by these very actions. Abandoning or intensifying anthropogenic activities can both cause changes of ecological circumstances. That is why the optimal husbandry with agricultural resources is extremely important.

Area of investigation

Plešivica hills are placed in the north-west part of Croatia (Fig. 1). In the geological structure dolomites are predominant, and limestone is much less in evidence. Rendzinas, which developed on the dolomite bedrock, are a dominant pedotaxon (Mayer and Vrbek, 1995). The macroclimate on Plešivica hills is continental, middle European type, with average annual amount of precipitation 924 mm and an average annual temperature was of between 9.4 and 10.9^{0}C (Dujmović Purgar, 2006).

Almost 4000 ha in the area of Plešivica hills are covered with the arable lands. The fields at 10 locations (1 - Beter, 2 - Črnilovec, 3 - Desinec, 4 - Donja Reka, 5 - Krašić, 6 - Miladini, 7 - Petrovina, 8 - Pribić, 9 - Slavetić and 10 - Volavje) were chosen in the region of Plešivica hills (Fig. 1).

Figure 1. Map of localities in the area of Plešivica hills (north-west part of Croatia)

Methods

The field observations of arable weeds were carried out every two weeks during growing seasons 2002 and 2003 (Dujmović Purgar, 2006).

The usual identification keys and iconography were used for identification (Hegi, 1906-1931; Javorka and Csapody, 1934; Bonnier, 1962; Tutin et al., 1964 - 1993; Domac, 1994; Knežević, 2006). The nomenclature of plants is according to Tutin et al. (1964 - 1993). The list of weed species was presented in alphabetic order of families. The division of arable weeds on *Dicotyledons* and *Monocotyledons,* which are in practice well known as "broad leafed" and "narrow leafed" weeds was included in our taxonomic survey (Tab. 1).

The spectrum of life forms (T – therophytes, H – hemicryptophytes, G – geophytes, P – phanerophytes and Ch – chamephytes) and life cycle duration (1 – annual, 2 – biannial, peren – perennial and w. peren – woody perennial) for each species are based on Garcke (1972) and Hulina (1991a). Floral elements (cosmop - cosmopolites, euras - Euroasian origin, adv – adventive, eur - European origin, sue - South-European origin, circ - Circumholarctic origin, med – Mediterranean, submed - submediteranian origin, mie - Middle- European origin, cult – cultivated and subatl - subatlantian) are based mainly on Garcke (1972), but the absent floral elements of the local flora are taken from Kovačević (1976), Šegulja (1977), Hulina (1989, 1991a) and Vrbek (2000).

Results and discussion

The total of 107 taxa (105 species and two subspecies) of arable weeds that classified to 32 families was noted in the area of Plešivica hills during two years' research (Tab. 1)

Table 1. The list of arable weeds in the area of Plešivica hills

No.	Taxa	Life form	Duration of life	Floral element	Location
	PTERIDOPHYTA				
	SPHENOPSIDA				
	EQUISETACEAE				
1	*Equisetum arvense* L.	G	peren	cosmop	5, 9
	SPERMATOPHYTA				
	MAGNOLIOPSIDA = DICOTYLEDONS				
	AMARANTHACEAE				
2	*Amaranthus retroflexus* L.	T	1	cosmop	3, 8, 9, 10
	ASTERACEAE				
3	*Achillea millefolium L.*	H	peren	cosmop	1
4	*Ambrosia artemisiifolia* L.	T	1	adv (N.Am.)	3, 5, 7, 8, 10
5	*Anthemis cotula* L.	T	1	cosmop	2
6	*Arctium lappa* L.	H	peren	euras	10
7	*Artemisia vulgaris* L.	H	peren	cosmop	8
8	*Bidens tripartita* L.	T	1	euras	9
9	*Chamomilla recutita* (L.) Rausch.	T	1	cosmop	2, 3
10	*Cirsium arvense* (L.) Scop.	G	peren	cosmop	1, 3, 5, 7, 8, 10
11	*Conyza canadensis* (L.) Cronq	T	1	adv (N.Am.)	3
12	*Erigeron annuus* (L.) Pers.	H	peren	adv (N.Am.)	2, 9, 10
13	*Galinsoga parviflora* Cav.	T	1	adv (S.Am.)	8, 9
14	*Matricaria perforata* Merat	T	1	euras	2
	BORAGINACEAE				
15	*Anchusa officinalis* L.	H	2	mie	7, 1
16	*Cerinthe minor* L.	H	2	sue	7, 1
17	*Myosotis arvensis* (L.) Hill	H	peren	euras	1, 3, 4, 7, 9
	BRASSICACEAE (=Cruciferae)				
18	*Brassica rapa* L.	T	1	cult	3, 6, 8, 10
19	*Capsella bursa-pastoris* (L.)Med.	T	1	cosmop	2
20	*Cardamine hirsuta* L.	H	peren	cosmop	6, 7, 10
21	*Diplotaxis muralis* (L.) DC	T	1	cosmop	9
22	*Thlaspi alliaceum* L.	T	1	submed	3, 6, 9
	CARYOPHYLLACEAE				
23	*Cerastium brachypetalum* Pers.	T	1	sue	3
24	*Silene alba* (Miller)E.H.L.	H	peren	euras	7
25	*Stellaria media* (L.) Vill.	T	1	cosmop	2, 6, 7, 9, 10
	CHENOPODIACEAE				
26	*Atriplex patula* L.	T	1	euras	2, 3, 8
27	*Chenopodium album* L.	T	1	cosmop	2, 5, 9, 10
28	*Chenopodium polyspermum* L.	T	1	euras	9
29	*Chenopodium urbicum* L.	T	1	euras	7, 8
	CICHORIACEAE				
30	*Picris hieracioides* L.	H	peren	euras	9
31	*Sonchus asper* (L.)Hill	T	1	med	2, 8
32	*Taraxacum officinale* Wiggers	H	peren	cosmop	1
	CONVOLVULACEAE				
33	*Calystegia sepium* (L.) R.Br.	H	peren	cosmop	1, 2, 3, 7, 8, 9
34	*Convolvulus arvensis* L.	H	peren	cosmop	3, 4, 5, 7, 8, 9, 10
	EUPHORBIACEAE				
35	*Euphorbia esula* L.	H	peren	eur	6, 1
36	*Euphorbia helioscopia* L.	T	1	cosmop	5, 9
	FABACEAE (=Leguminosae)				
37	*Lathyrus aphaca* L.	T	1	sue	4
38	*Lathyrus tuberosus* L.	H	peren	euras	5, 8
39	*Lotus corniculatus* L.	H	peren	cosmop	3, 8
40	*Lotus tenuis* W & K	H	peren	eur	8
41	*Medicago lupulina* L.	T	1	euras	8
42	*Trifolium pratense* L.	H	peren	euras	7, 9
43	*Trifolium repens* L.	H	peren	cosmop	4, 7, 8
44	*Vicia cracca* L.	H	peren	euras	3
45	*Vicia pannonica* Cr.	T	1	med	4
	GENTIANACEAE				
46	*Centaurium erythraea* Rafn.	T	1	cosmop	7
47	*Centaurium pulchellum* (Sw) Druce	T	1	euras	1, 3
	GERANIACEAE				
48	*Geranium molle* L.	T	1	cosmop	4, 7, 9
	LAMIACEAE (=Labiatae)				
49	*Glechoma hederacea* L.	H	peren	circ	3
50	*Lamium maculatum* L.	H	peren	euras	9
51	*Lamium purpureum* L.	T	1	euras	4, 7, 9, 10
52	*Mentha arvensis* L.	H	peren	circ	1, 3, 8
53	*Stachys annua* L.	T	1	eur	10
54	*Stachys palustris* L.	H	peren	circ	3, 7, 8, 10
	LYTHRACEAE				
55	*Lythrum salicaria* L.	H	peren	circ	3
	MALVACEAE				
56	*Abutilon theophrasti* Med.	T	1	sue	2
	ONAGRACEAE				
57	*Epilobium hirsutum* L.	H	peren	euras	2
58	*Epilobium tetragonum* L. ssp. *lamyi* (Schultz) Nyman	H	peren	eur	1
	OXALIDACEAE				
59	*Oxalis stricta* L.	H	peren	adv (N.Am.)	1, 3

	PAPAVERACEAE				
60	*Fumaria officinalis* L.	T	1	euras	7
61	*Papaver rhoeas* L.	T	1	cosmop	1, 3, 4, 7, 8, 10
	PLANTAGINACEAE				
62	*Plantago major* L.	H	peren	cosmop	9
63	*Plantago media* L.	H	peren	euras	1
	POLYGONACEAE				
64	*Biderdykia convolvulus* (L.) Dumort.	T	1	euras	7, 9, 10
65	*Polygonum aviculare* L.	T	1	cosmop	1, 7
66	*Polygonum lapathifolium* L.	T	1	cosmop	5, 9
67	*Polygonum persicaria* L.	T	1	cosmop	8, 1
68	*Rumex acetosa* L.	H	peren	cosmop	4
69	*Rumex crispus* L.	H	peren	cosmop	8
70	*Rumex obtusifolius* L.	H	peren	euras	3
	PRIMULACEAE				
71	*Anagalis arvensis* L.	T	1	cosmop	1, 3, 7, 10
72	*Lysimachia nummularia L.*	Ch	peren	euras	1
	RANUNCULACEAE				
73	*Consolida regalis* S.F. Gray	T	1	euras	7
74	*Ranunculus arvensis* L.	T	1	cosmop	3, 6, 8
75	*Ranunculus repens* L.	H	peren	mie	1, 2, 3, 4, 9, 10
	ROSACEAE				
76	*Potentilla reptans* L.	H	peren	cosmop	1, 3
77	*Rubus caesius* L.	P	w. peren	euras	3, 1
78	*Rubus fruticosus* L.	P	w. peren	euras	10
	RUBIACEAE				
79	*Galium aparine* L.	T	1	cosmop	5, 6, 7, 9, 10
80	*Galium laevipes* Opiz	H	peren	euras	2
	SCROPHULARIACEAE				
81	*Kickxia elatine* (L.) Dum.	T	1	sue	3
82	*Melampyrum nemorosum* L.	T	1	eur	2
83	*Veronica hederifolia* L.	T	1	cosmop	7, 9, 10
84	*Veronica persica* Poir.	T	1	cosmop	3, 4, 5, 7, 9, 10
	SOLANACEAE				
85	*Solanum nigrum* L.	T	1	cosmop	9
	URTICACEAE				
86	*Urtica dioica* L.	H	peren	cosmop	2, 1
	VALERIANACEAE				
87	*Valerianella dentata* (L.) Poll.	T	1	sue	3
	VERBENACEAE				
88	*Verbena officinalis* L.	T	1	cosmop	3, 8
	VIOLACEAE				
89	*Viola arvensis* Murr.	T	1	eur	3, 7
	LILIOPSIDA = MONOCOTYLEDONS				
	POACEAE (=Gramineae)				
90	*Arrhenatherum elatius* (L.) Pre.	H	peren	eur	2, 4
91	*Bromus racemosus* L.	H	peren	subatl	4
92	*Dactylis glomerata* L.	H	peren	euras	8
93	*Digitaria sanguinalis* (L.) Scop.	T	1	cosmop	2, 3, 7, 10
94	*Echinochloa crus-galli* (L.) PB.	T	1	cosmop	3, 7, 9
95	*Elymus repens* (L.) Gould	G	peren	euras	8
96	*Festuca arundinacea* Schreb.	H	peren	euras	3
97	*Holcus lanatus* L.	H	peren	euras	1, 2, 3, 4
98	*Lolium multiflorum* Lam.	T	1	med	3, 4
99	*Panicum capillare* L.	T	1	adv (N.Am.)	3, 9
100	*Panicum dichotomiflorum* Mich.	T	1	adv (N.Am.)	2
101	*Phleum pratense* L.	H	peren	circ	4
102	*Poa pratensis* L.	H	peren	circ	2, 3
103	*Poa trivialis* L.	H	peren	euras	1, 4, 8
104	*Setaria italica* (L.) Beauv.	T	1	submed	10
105	*Setaria pumila* (Poiret) Schultes	T	1	cosmop	3, 8, 9
106	*Setaria verticillata* (L.) Beauv.	T	1	cosmop	2
107	*Sorghum halepense* (L.) Pers.	G	peren	cosmop	8, 1

Our taxonomic survey shows that arable weeds were predominantly composed of dicotyledons ("broad leafed") with 82.24%. The rest were monocotyledons ("narrow leafed") with 16.82%, and only one species (*Equisetum arvense* L.) classified to the class Pteridophyta.

Poaceae (18 species), *Asteraceae* (12 species) and *Fabaceae* (nine species) are the most dominant families. The reasons for their domination are the influence of the indigenous flora and biological – ecological characteristics of these three families. The most represented genera were *Chenopodium* (three species), *Polygonum* (three species) and *Rumex* (three species).

An analysis of life forms (Fig. 2) showed that the most numerous were therophytes (55 species – 51.40%). That is in accordance with application of high level of agricultural engineering (Božić, 1980; Hidalgo et al., 1990; Hulina, 1991b; Poldini et al., 1998). The following were hemicryptophytes (43 species – 40.19%), geophytes (six species – 5.61%), phanerophytes (two species – 1.87%) and chamephytes (one species – 0.93%).

The spectrum of life cycle duration shows that the annual plants (55 species – 51.40%) were dominant in the fields that were the subject of this research (Fig. 3). The following were perennial herbaceous plants (48 species – 44,86%), biennial plants and woody plants with two species (1.87%).

The predomination of annual plants in arable weeds is in line with literature data (Hulina, 1998). It is usually consequence of intensive agriculture.

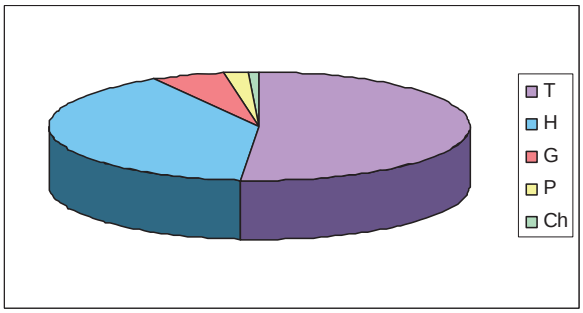

Figure 2. The spectrum of life form for arable weeds

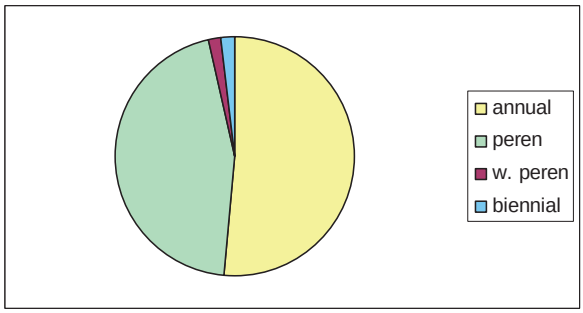

Figure 3. The spectrum of duration of life cycle for arable weeds

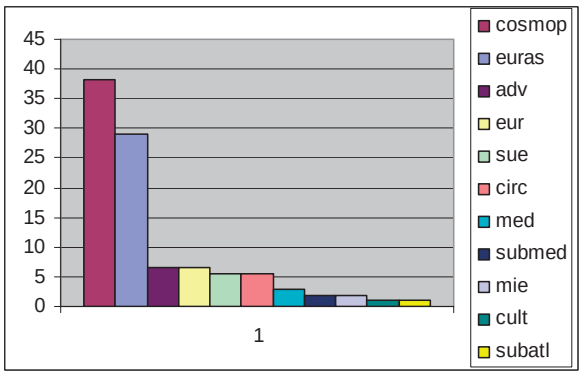

Figure 4. The spectrum of floral elements for arable weeds

The total of 11 floral elements exists in the researched area and shows transfer characteristics of it (Fig. 4.). Most of the species were the cosmopolites (41 species – 38.32%) and the species of Euroasian origin (31 species – 28.97%). The majority of adventive species (seven species) were American origin (six species).

78 weed species were noted in dense crop fields (wheat and barley). Some of them (*Chamomilla recutita*, *Cirsium arvense*, *Galium aparine*, *Papaver rhoeas*, *Stellaria media* and *Veronica persica*) are the most harmful weeds of dense crops. The water competition between *Cirsium arvense* and winter wheat has a strong influence on yield. It can be reduced to 49% (McLennan et al., 1991). The species *Galium aparine* can make the harvest more difficult causing the culture dumping off (Hulina, 1998).

It is interesting to point out we find the traditional grain crops weed *Papaver rhoeas* in the researched wheat fields. Most of the time, this species was expelled from the fields to the ruderal habitats by herbicides and intensive tillage.

62 weeds were noted in the maize fields. Some of them were typically row crop weeds, as for instance: *Amaranthus retroflexus*, *Chenopodium album*, *Ch. polyspermum*, *Cirsium arvense*, *Convolvulus arvensis*, *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Polygonum lapathifolium* and *Sorghum halepense*.

The wide sowing distance and the slow initial growth make the maize very sensitive on weed competition. The competition of *Echinochloa crus-galli* and maize has strong influence on yield, which is reduced to 80% (Rola, 1984). Furthermore, the competition of *Sorghum halepense* and maize can destroy the whole crop because this species is much faster in growth than maize (Hulina, 1998). In addition, the presence of species *Digitaria sanguinalis*, *Echinochloa crus-galli* and *Sorghum halepense* can reduce the yield of maize, because these species are host for the maize virus (Hulina, 1998).

It is interesting to point out the presence of a few new invasive and very noxious species like *Abutilon theophrasti* Med., *Ambrosia artemisiifola* L., *Panicum dichotomiflorum* Mich. and *P. capillare* L. in some researched maize fields.

A very dangerous species *Abutilon theophrasti*, commonly known as "velvetleaf", was expanded through maize fields (from east to west side of Croatia) since 1980 (Hulina, 1995). Velvetleaf is able to produce a "persistent seed bank" and for that reason it has influence on high level of weediness in maize fields (Zanin and Sattin, 1988; Hulina, 1995; 2000). Once *Abutilon theophrasti* becomes established in the field, even intensive efforts cannot eradicate it (Zanin and Sattin, 1988). Competition for light is a primary cause of yield loss (Lindquist and Mortensen, 1999). Namely, growth habit of this species surpasses maize crop in height.

Ragweed - *Ambrosia artemisiifolia* is the most dangerous American species that is dispersed in many of the researched fields on Plešivica hills. It spreads very quickly from ruderal habitats to cultivated habitats like vineyards, gardens and maize fields. In addition, this species can cover stubble fields and abandoned fields completely (Hulina, 2002). Ragweed, with its presence on arable land, makes damages to agricultural production. It is also aeroallergenic species which causes pollenosis and contact dermatitis. Namely, it has harmful effects on human health (Hulina, 2002).

The species *Panicum dichotomiflorum* and *P. capillare* are potentially dangerous weeds, thus requiring atten-

tion especially in maize fields (Hulina, 1985; 1995) as for instance *Panicum dichotomiflorum* (smooth witchgrass) with its short life cycle and massive production of seeds. Furthermore, smooth witchgrass is resistant on herbicides and mowing (Hulina, 1985).

Continuous and profound monitoring of those and similar species is extremely important.

Two cropping rotation system with dense crops and row crops are usual in the researched area. There was a number of common species capable for growing in the dense crops as well as in the row crops, for example: *Ambrosia artemisiifolia*, *Calystegia sepium*, *Chenopodium album*, *Cirsium arvense*, *Convolvulus arvensis*, *Echinochloa crus-galli*, *Panicum capillare*, *Ranunculus repens*, *Sorghum halepense, Stachys palustris*, *Stellaria media* and *Veronica persica*. These make the difference in flora between the two types of crops less obvious (Hidalgo et al., 1990). However, the same weed species in row crops can be better developed than in dense crops (Hulina, 1998).

The climbing species such as *Calystegia sepium* and *Convolvulus arvensis* compete with crops for light. In addition, these species can complicate the harvest, because they can cause dumping off culture. The species *Chenopodium album* is the inhibitor for wheat seedling growth and maize growth (Hulina, 1998).

The numbers of weed species in all researched fields depend on intensity of husbandry. When the tillage increases the number of weed species decrease. Namely, extensive tillage makes better biodiversity of fields possible. Intensive tillage and chemical weed control were minimized in researched fields of Plešivica hills. That is why the luxuriant weed flora was developed in them.

Conclusions

It may be concluded as follows:

1. The total of 107 taxa of arable weeds that belonged to 32 families was noted.
2. Therophytes were dominant which is typical for arable lands.
3. Most of the species were of the cosmopolites (41 species – 38.32%) and the Euroasian origin (31 species – 28.97%).
4. 78 weed species were noted in dense crop fields (wheat and barley). Some of them are the most harmful weeds of dense crops. 62 weeds were noted in maize fields. Some of them were typically row crop weeds. There was a number of common species capable for growing in the dense crops as well as in the row crops, but, the same weed species in row crops can be better developed than in dense crops.
5. The finding of the species such as *Abutilon theophrasti* Med., *Ambrosia artemisiifola* L., *Panicum dichotomiflorum* Mich. and *P. capillare* L. are very important because they are invasive and noxious species.

The number of weed species in all researched field depend on intensity of husbandry.

With tillage increasing the number of weed species decrease. Furthermore, extensive tillage makes possible biggest biodiversity of fields.

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