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FLORISTIC AND PHYTOCOENOLOGICAL RESEARCH OF SEGETAL PLANT COMMUNITIES IN CULTIVATED AREAS OF SOUTHERN SREM

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Abstract: Segetal vegetation was studied in the cultivated areas of southern Srem with the aim of analyzing its taxonomy, phytocoenology, syntaxonomy and phytogeography, as well as determining to what extent ecological factors influenced the differentiation of segetal plant communities among row crops, small grain crops and in alfalfa fields. Segetal flora was comprised of 124 plant species, classified into 38 families, of which *Asteraceae* (28), *Fabaceae* (10) and *Poaceae* (10) contained the greatest number of species. Three associations were selected based on phytocoenological analysis: *Polygonetum convolvulo-avicularis*, *Consolido-Polygonetum avicularis* and *Lolio-Plantaginetum majoris*, as well as five lower syntaxa (subassociations and facies). Crop type, moisture, habitat acidity (pH), temperature and anthropogenic factors had the greatest impact on the ecological differentiation of the studied vegetation. The significant presence of non-native species (18) was another consequence of the anthropogenic effects and geographic position of southern Srem, and these, as coenobionts of segetal plant communities and undesirable species, had a significant impact on crop yield.

Key words: segetal plant communities; row crops; small grains; alfalfa crop, anthropogenic factors.

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INTRODUCTION

The formation and survival of segetal plant communities (agrophytocoenoses) is the result of the systematic and intensive effects of anthropogenic factors – the introduction of new ediphicatory species, the removal of matter created by organic production (harvesting and cutting), and the introduction of matter into soil which is not the result of natural cycling (the adding of organic and mineral fertilizers), as well as appropriate interventions such as the use of a variety of agrotechnical measures, the use of chemicals, etc. (Kojić and Šinžar, 1985). In agrophytocoenoses comprising two components – cultivated plants and weeds – it is a common occurrence for the yield to be reduced as a result of various interactions between the crops and the weeds (Radoshevic et al., 1997). Weeds, as undesirable members of an agroecosystem, compete with cultivated plants for the finite resources available (light, water, and mineral nutrients) and reduce crop yield; their presence necessitates the employment of human labor and technologies to control and eradicate them (Liebman, 2001). Plant competition intensity depends on crop yield on the one hand, and the abundance, cover and degree of presence of weeds on the other.

Besides the anthropogenic factors, the floristic composition of segetal vegetation is also greatly affected by the spectrum of climatic and edaphic factors with certain variations in their seasonal dynamics (Lososová, 2004). However, a more current view is that weeds are capable of rapid genetic change, thereby making analysis of their evolutionary ecology potentially valuable for the development of sustainable weed management systems. In particular, further analysis of ongoing evolutionary change in cropland weeds is important because (i) most cropland weed species exhibit considerable adaptability, (ii) cropland agriculture is continuously changing, and (iii) further research on weed adaptability is needed to design cropping systems to address evolutionary change (Clements et al., 2004). Segetal plant communities are relatively labile formations, which, when anthropogenic factors cease, pass through a series of transitional communities before returning to *climax* communities, which as a rule are zonal in character (Clements, 1916).

In the last few decades, important changes have been noted in the composition of weed flora in cultivated areas because of global climatic and other changes. In this sense, non-native invasive species are of particular importance. Although for now their frequency is not high, they have great biological potential and competitive abilities, marked adaptability, a genetic variability that enables them to adapt successfully to their new environment, and are extremely aggressive, all of which means that the frequency and abundance of these species in cultivated areas is bound to be high in the near future (Jarić, 2009).

Weed vegetation became the subject of geobotanical studies as early as the beginning of the 20th century. Segetal (as well as ruderal) communities were first studied phytosociologically and soon became an integral part of the Braun-Blanquet hierarchical system (one of the first contributions to this topic was made by Braun-Blanquet in 1931), which was later named the Zürich-Montpellier school by its followers (Westhoff and van der Maarel, 1978). This type of vegetation in northwestern areas of Balkan peninsula, i.e. on the territory of the former Yugoslavia, was studied by using the Braun-Blanquet method (Kojić, 1975). However, in 2006-2008 a database with 4258 relevés analyzed by using up-to-date methods of multivariate analyses (classification, direct and indirect ordination, and use of indicator values – Pignatti, Raunkiaer forms) in different statistical programs such as JUICE, CANOCO, PS-ORD, has been formed (Šilc and Vrbničanin, 2008).

This type of vegetation is the subject of study from different aspects by numerous researchers even today, both abroad (Mirkin et al., 1988; Lososová, 2004; Clements, 2004; Kropáč, 2006; Chytrý, 2007a, 2009; Yarci et al., 2007; Lososová and Grulich, 2009; Šilc and Čarni, 2012; Šilc et al., 2014), and at home (Gajić, 1955; Kojić, 1975; Stepić, 1984; Vrbničanin, 2002, Vrbničanin and Aćić (2004); Vrbničanin et al., 2008; Stefanović, 2006; Perišić, 2004; Nestorović, 2005; Jarić, 2009).

In this research we analyzed segetal plant communities in the cultivated areas of southern Srem (in row crops, small grain crops and

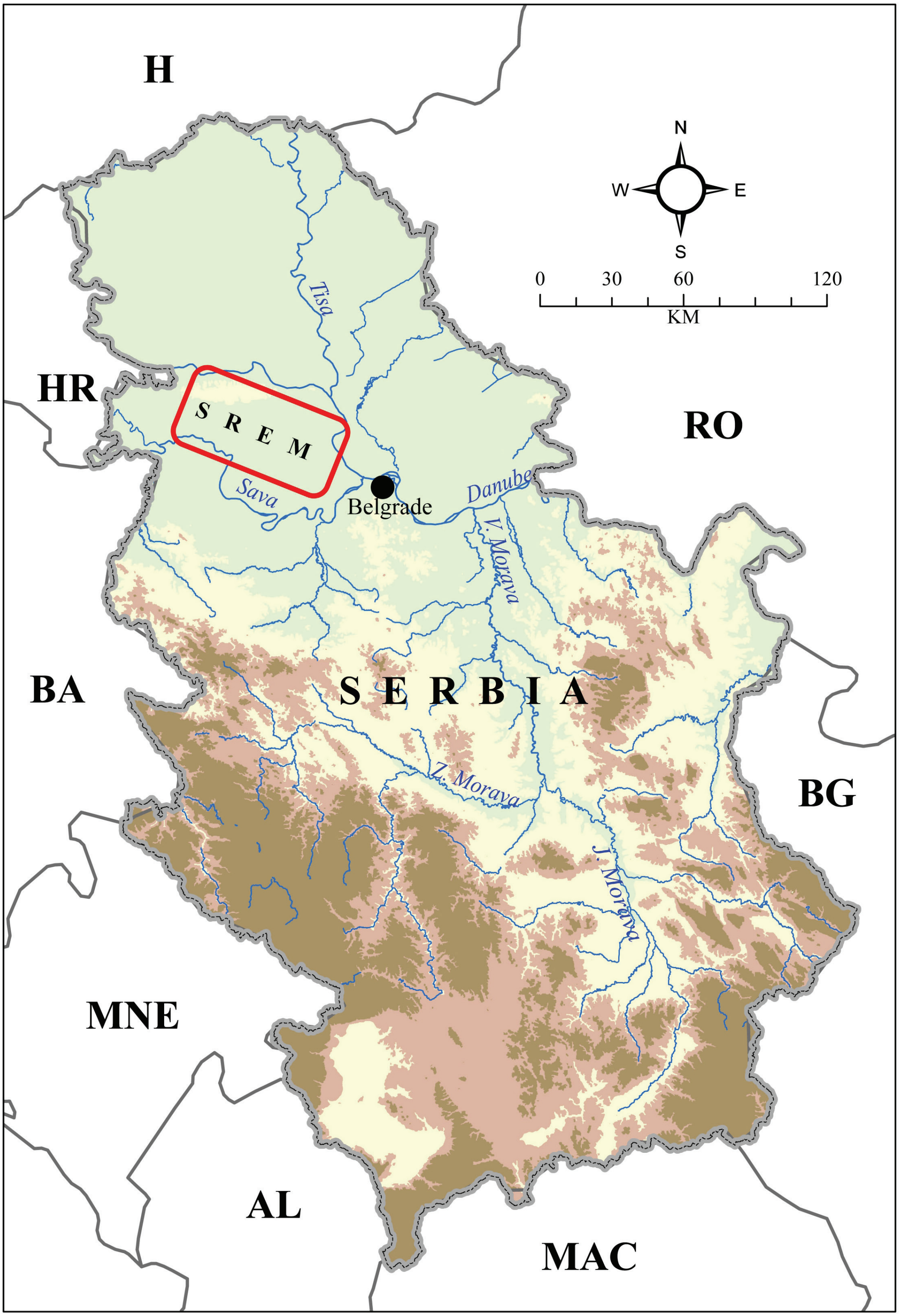

Fig. 1. Geographical position of the investigated area.

alfalfa fields) in terms of taxonomy, phytocoenology, syntaxonomy and phytogeography. The ecological differentiation of the vegetation was also analyzed, and one of the aims was to detect the presence of non-native plant species and establish their abundance, origin, method of seed dispersal, status and time of introduction to the cultivated areas being researched.

MATERIALS AND METHODS

Floristic and phytocoenological research of segetal vegetation was made in cultivated areas of southern Srem (northwestern Serbia), in small grain crops, row crops and fields of alfalfa (Fig. 1.).

The plant species recorded were determined on the basis of several sources (Josifović, 1970-1980; Javorka and Chapody, 1975; Tutin, 1964-1980). Their abundance in the analyzed relevés was determined by the Westhoff-van der Maarel combined abundance/cover scale, which has an entirely numerical character and, as such, is completely applicable in the mathematical processing of data (Westhoff and van der Maarel, 1973). The 'FLORA' software package was used for rearranging the phytocoenological tables, on the basis of which suitable communities were selected (Karadžić et al., 1998). Stand ordination was carried out using correspondence analysis (Hill, 1974; Greenacre, 1984), which arranges those relevés that were most similar floristically closest together, while relevés least similar in terms of floristic composition were furthest apart, i.e. distributed towards the ends of the axes. The degree of presence of plant species was determined according to the Braun-Blanquet scale (Braun-Blanquet, 1964). Nomenclature of detected plant communities was done in accordance to "International Code of Phytosociological Nomenclature" (Weber et al., 2000). Literary sources were used to establish life forms (Raunkiaer, 1934) and floral elements (Gajić, 1984) of all recorded species. The correlation between environmental factors and the segetal communities described was established by using canonical correlation analysis – CCA (ter Braak, 1994). Sörensen's similarity index (1948) was used to calculate similarities in the floristic composition of the segetal plant communities. Ecological indicators such as moisture, soil pH, soil nitrogen content, light and temperature were used (Ellenberg, 1974; Kojić et al., 1998). Soil characteristics were analyzed in collected soil samples. Ten-gram soil samples were collected randomly throughout the three sampling areas covered with different types of segetal vegetation as units. Five well-mixed cultivated land surface soil subsamples at each site were taken, 10 g per sample, from depths of 0-10 and 10-20 cm in the root zone. A composite soil sample was formed and subjected to chemical analysis, in five replicates. Soil pH and levels of N, C, P and K were analyzed using standard chemical methods (Bogdanović et al., 1966). The soil type has been determined.

RESULTS AND DISCUSSION

Floristic and phytogeographic analysis

Biological spectrum.

Floristic analysis of the segetal vegetation of the study area recorded 124 plant species, classified into 38 families, of which *Asteraceae* (28), *Fabaceae* (10), *Poaceae* (10), *Brassicaceae* (8), *Polygonaceae* (8), *Lamiaceae* (7) contained the greatest number of species (Table 1).

Phytogeographic analysis established the presence of 19 floral elements, among which geoelements of wide distribution dominate: Eurasian (24), sub-Eurasian (23), sub-Central European (19),

Table 1. Floristic, phytogeographical and phytocoenological characteristics of plant species in the cultivated areas of southern Srem.

Species	Family	Life form	Floral element	Polygonetum convolvulo avicularis	Consolido Polygonetum avicularis	Lolio-Plantaginetum majoris
				degree of presence (%)		
1	2	3	4	5	6	7
Cirsium arvense (L.) Scop.	Asteraceae	g	sub-Eurasian	100	100	85.7
Polygonum aviculare L.	Polygonaceae	t	cosmopolitan	100	63.6	42.9
Sinapis arvensis L.	Brassicaceae	t	sub-Eurasian	100	100	28.6
Polygonum lapathifolium L.	Polygonaceae	t	sub-circumpolar	100	27.3	28.6
Xantium strumarium L.	Asteraceae	t	adventive	100	45.4	28.6
Chenopodium album L.	Chenopodiaceae	t	cosmopolitan	90.9	45.4	57.1
Convolvulus arvensis L.	Convolvulaceae	g	cosmopolitan	90.9	90.9	28.6
Setaria viridis (L.) P. B.	Poaceae	t	sub-Eurasian	81.8	36.4	42.9
Ambrosia artemisiifolia L.	Asteraceae	t	adventive	90.9	63.6	57.1
Sorghum halepense (L.) Pers.	Poaceae	g	adventive	90.9	45.4	57.1
Polygonum convolvulus L.	Polygonaceae	t h	sub-Eurasian	81.8	81.8	42.9
Agropyrum repens (L.) P. B.	Poaceae	g	Eurasian	81.8	45.4	42.9
Cichorium intybus L.	Asteraceae	h	sub-Eurasian	81.8	45.4	28.6
Setaria glauca (L.) P. B.	Poaceae	t	cosmopolitan	81.8	45.4	71.4
Amaranthus retroflexus L.	Amaranthaceae	t	adventive	90.9	.	14.3
Datura stramonium L.	Solanaceae	t	cosmopolitan	81.8	.	.
Plantago major L.	Plantaginaceae	h	Eurasian	72.7	36.4	100
Solanum nigrum L.	Solanaceae	t	cosmopolitan	72.7	27.3	14.3
Panicum crus-galli L.	Poaceae	t	cosmopolitan	72.7	45.4	71.4
Artemisia vulgaris L.	Asteraceae	h	circumpolar	72.7	27.3	28.6
Stenactis annua (L.) Nees.	Asteraceae	th	adventive	63.6	54.5	71.4
Veronica persica Poir.	Scrophulariaceae	th	adventive	63.6	63.6	71.4
Daucus carota L.	Apiaceae	th	sub-Eurasian	63.6	63.6	.
Anthemis arvensis L.	Asteraceae	t	sub-Central-European	54.5	45.4	28.6
Poa pratensis L.	Poaceae	h	sub-circumpolar	36.4	18.2	42.9
Pastinaca sativa L.	Apiaceae	th	Eurasian	54.5	45.4	57.1
Lolium perenne L.	Poaceae	h	sub-Central-European	45.4	18.2	71.4
Rumex crispus L.	Polygonaceae	h	Eurasian	45.4	27.3	42.9
Erigeron canadensis L.	Asteraceae	th	adventive	54.5	45.4	28.6

Table 1 continued

1	2	3	4	5	6	7
Sonchus asper (L.) Mill.	Asteraceae	th	sub-Eurasian	54.5	63.6	57.1
Polygonum persicaria L.	Polygonaceae	t	Eurasian	54.5	54.5	14.3
Galega officinalis L.	Fabaceae	h	sub-Mediterranean	45.4	54.5	.
Asclepias syriaca L.	Asclepiadaceae	g	adventive	45.4	36.4	.
Hibiscus trionum L.	Malvaceae	t	Pontic-east-sub-Mediterranean	45.4	.	28.6
Chenopodium polyspermum L.	Chenopodiaceae	t	Eurasian	45.4	.	.
Lythrum salicaria L.	Lythraceae	h	Pontic-Central-Asian-sub- Mediterranean	27.3	45.4	14.3
Sonchus oleraceus L.	Asteraceae	th	sub-Eurasian	36.4	9.1	14.3
Euphorbia salicifolia Host.	Euphorbiaceae	h	Pontic-Pannonian	27.3	45.4	42.9
Anagallis arvensis L.	Primulaceae	t	cosmopolitan	27.3	81.8	28.6
Roripa prolifera (Heuff.) Neilr.	Brassicaceae	th	sub-Moesian	36.4	27.3	14.3
Verbena officinalis L.	Verbenaceae	th	cosmopolitan	36.4	72.7	85.7
Helminthia echioides (L.) Gaertn.	Asteraceae	t	sub-Mediterranean	36.4	54.5	57.1
Stachys annua L.	Lamiaceae	t	sub-Pontic-sub- Mediterranean	27.3	63.6	14.3
Consolida regalis S. F. Gray	Ranunculaceae	t	sub-Central-European	36.4	81.8	.
Bidens tripartitus L.	Asteraceae	t	sub-Central-European	36.4	54.5	.
Kickxia elatine (L.) Dumort.	Scrophulariaceae	t	sub-Atlantic-sub- Mediterranean	27.3	9.1	.
Lathyrus tuberosus L.	Fabaceae	g	sub-south-Siberian	27.3	45.4	.
Medicago lupulina L.	Fabaceae	th	sub-Eurasian	27.3	9.1	.
Taraxacum officinale Web.	Asteraceae	h	Eurasian	27.3	.	85.7
Digitaria sanguinalis (L.) Scop.	Poaceae	t	cosmopolitan	27.3	.	14.3
Atriplex patula L.	Chenopodiaceae	t	sub-circumpolar	27.3	.	14.3
Cynodon dactylon (L.) Pers.	Poaceae	g	cosmopolitan	27.3	.	.
Abutilon teophrasti Med.	Malvaceae	t	adventive	27.3	.	.
Chenopodium hybridum L.	Chenopodiaceae	t	sub-circumpolar	36.4		.
Xantium italicum Mor.	Asteraceae	t	adventive	36.4	.	.
Oxalis stricta L.	Oxalidaceae	h	adventive	27.3	.	.
Melilotus albus Med.	Fabaceae	th	sub-Central-European	36.4	.	.
Capsella bursa-pastoris (L.) Med.	Brassicaceae	th	cosmopolitan	18.2	36.4	57.1
Trifolium pratense L.	Fabaceae	h	sub-Eurasian	18.2	27.3	28.6
Lactuca serriola L.	Asteraceae	th	sub-Pontic-sub-Central-Asian-sub- Mediterranean	18.2	45.4	42.9
Rorippa sylvestris (L.) Bes.	Brassicaceae	h	sub-Eurasian	18.2	27.3	28.6
Epilobium parviflorum Schreb.	Oenotheraceae	h	sub-Eurasian	18.2	45.4	14.3
Lycopus europaeus L.	Lamiaceae	g	sub-Eurasian	18.2	63.6	14.3
Sonchus arvensis L	Asteraceae	h	Eurasian	18.2	36.4	28.6
Ranunculus repens L.	Ranunculaceae	h	Eurasian	9.1	36.4	28.6
Galium aparine L.	Rubiaceae	t	Eurasian	9.1	54.5	14.3
Rubus caesius L.	Rosaceae	p	sub-south-Siberian	9.1	54.5	57.1
Veronica chamaedrys L.	Scrophulariaceae	g	sub-Central-European	9.1	72.7	28.6

Table 1 continued

1	2	3	4	5	6	7
Calystegia sepium (L.) Br.	Convolvulaceae	h	Eurasian	9.1	9.1	14.3
Dipsacus laciniatus L.	Dipsacaceae	th	Pontic-Central-Asian-sub- Mediterranean	9.1	18.2	14.3
Helianthus tuberosus L.	Asteraceae	g	adventive	9.1	18.2	14.3
Eupatorium cannabinum L.	Asteraceae	h	sub-Central-European	18.2	27.3	.
Centaurium umbelatum Gilib.	Gentianaceae	th	sub-Central-European	18.2	36.4	.
Medicago sativa L.	Fabaceae	h	adventive	9.1	18.2	100
Scutellaria galericulata L.	Lamiaceae	g	circumpolar	9.1	36.4	.
Lythrum hyssopifolia L.	Lythraceae	t	cosmopolitan	9.1	27.3	.
Euphorbia stricta L.	Euphorbiaceae	th	sub-Atlantic-sub- Mediterranean	9.1	9.1	.
Rumex palustris Sm.	Polygonaceae	th	sub-Central-European	9.1	45.4	.
Adonis flammea Jacq.	Asteraceae	t	sub-Pontic-sub- Mediterranean	9.1	18.2	.
Plantago lanceolata L.	Plantaginaceae	h	Eurasian	18.2	.	42.9
Bromus arvensis L.	Poaceae	t	Eurasian	18.2	.	14.3
Urtica dioica L.	Urticaceae	h	Eurasian	9.1	.	14.3
Humulus lupulus L.	Cannabaceae	h	sub-south-Siberian	9.1	.	14.3
Rumex obtusifolius L.	Polygonaceae	h	sub-Central-European	9.1	.	71.4
Prunella vulgaris L.	Lamiaceae	h	sub-Eurasian	9.1	.	14.3
Crepis setosa Hall.	Asteraceae	t	sub-Mediterranean	9.1	.	85.7
Silene vulgaris (Mnch.) Gar.	Caryophyllaceae	h	sub-Eurasian	9.1	.	.
Verbascum sp.	Scrophulariaceae			9.1	.	.
Hypericum perforatum L.	Hypericaceae	h	sub-Eurasian	9.1	.	.
Rumex conglomeratus Murr.	Polygonaceae	h	sub-Eurasian	9.1	.	.
Epilobium hirsuta L.	Oenotheraceae	h	sub-Eurasian	9.1	.	.
Malva sylvestris L.	Malvaceae	th	Eurasian	9.1	.	.
Melilotus officinalis (L.) Pall.	Fabaceae	th	Eurasian	9.1	.	.
Sambucus ebulus L.	Sambucaceae	g	sub-Pontic-sub- Mediterranean	9.1	.	.
Brassica nigra (L.) Koch	Brassicaceae	t	east-Central-European	9.1	.	.
Arctium lappa L.	Asteraceae	h	Eurasian	9.1	.	.
Vitis sylvestris Gmel.	Vitaceae	Slig	sub-Euxine	9.1	.	.
Raphanus raphanistrum L.	Brassicaceae	t	sub-Central-European	9.1	.	.
Sonchus palustris L.	Asteraceae	h	Central-European	.	54.5	.
Lotus corniculatus L.	Fabaceae	h	sub-Eurasian	.	27.3	14.3
Symphytum officinale	Boraginaceae	h	sub-Central-European	.	36.4	14.3
Cyperus fuscus L.	Cyperaceae	t	sub-Eurasian	.	27.3	14.3
Mentha aquatica L.	Lamiaceae	g	Eurasian	.	27.3	.
Galeopsis speciosa Mill.	Lamiaceae	t	sub-Central-European	.	27.3	.
Lamium purpureum L.	Lamiaceae	th	sub-Central-European	.	18.2	14.3
Stellaria media (L.)Vill.	Caryophyllaceae	th	cosmopolitan	.	36.4	14.3
Lepidium draba L.	Brassicaceae	h	Pontic-Central-Asian-sub- Mediterranean	.	45.4	14.3

Table 1 continued

Leucanthemum vulgare Lam.	Asteraceae	h	Eurasian	.	27.3	14.3
Glycyrrhiza echinata L.	Fabaceae	h	Pontic-east-sub-Mediterranean	.	9.1	.
Trifolium repens L.	Fabaceae	h	sub-Eurasian	.	.	57.1
1	2	3	4	5	6	7
Erodium cicutarium (L.)L'Hér.	Geraniaceae	th	Eurasian	.	.	42.9
Cuscuta epithymum L.	Cuscutaceae	st	sub-Eurasian	.	.	28.6
Gypsophyla muralis L.	Caryophyllaceae	t	Eurasian	.	.	28.6
Lactuca saligna L.	Asteraceae	th	sub-Pontic-sub- Mediterranean	.	.	28.6
Ranunculus ficaria L.	Ranunculaceae	g	sub-Central-European	.	.	14.3
Alliaria officinalis Andr.	Brassicaceae	h	sub-Central-European	.	.	14.3
Chelidonium majus L.	Papaveraceae	h	Eurasian	.	.	14.3
Viola sylvestris Lam.	Violaceae	h	Central-European	.	.	14.3
Carduus acanthoides L.	Asteraceae	h	sub-central-European	.	.	14.3
Matricaria chamomilla L.	Asteraceae	t	Eurasian	.	.	14.3
Tussilago farfara L.	Asteraceae	g	sub-Eurasian	.	.	14.3
Lapsana communis L.	Asteraceae	th	sub-central-European	.	.	14.3
Silene alba (L.) Kr.	Caryophyllaceae	th	sub-Eurasian	.	.	14.3
Galium mollugo L.	Rubiaceae	h	sub-Central-European	.	.	14.3

Cosmopolitan (14) and Adventive (13), which is a result of the fairly uniform ecological conditions at the habitat and the ecological plasticity of the recorded species (Fig. 2.).

The biological spectra of the selected agrophytocoenoses reveal the domination of hemicryptophytes and therophytes (Fig 3.).

The presence of life forms is a direct result of the use of agrotechnical measures in cultivated areas and the level of their impact: the greater the impact, the higher the percentage of therophytes in relation to perennial species. The high proportion of hemicryptophytes is in accordance with the domination of this life form in the flora of Serbia (Diklić, 1984), and also with the instability of habitats where man hinders the development of plants (mainly perennials) through his activities. As a rule, the greater the impact of anthropogenic factors on a habitat, the greater the percentage of therophytes and the lower the proportion of biennial and perennial plant species in the composition of the biological spectrum. In the segetal vegetation of the study area, the most frequent and abundant therophytes are the following species: *Setaria* spp., *Polygonum aviculare, Ambrosia artemisiifolia, Sinapis arvensis* and *Bilderdykia convolvulus*. With regard to dominant species, the geophytes *Cirsium arvense* and *Convolvulus arvensis* are also significant and are among the most aggressive weeds in cultivated areas.

Phytocoenological analysis, syntaxonomic affiliation and numerical ordination of plant communities

Syntaxonomic affiliation of ass. *Polygonetum convolvulo–avicularis*

Class: *Stellarietea mediae* Tx., Lohm. et Prsg.1950.

Order: *Chenopodietalia albi* Tx., Lohm. et Prsg. 1950.

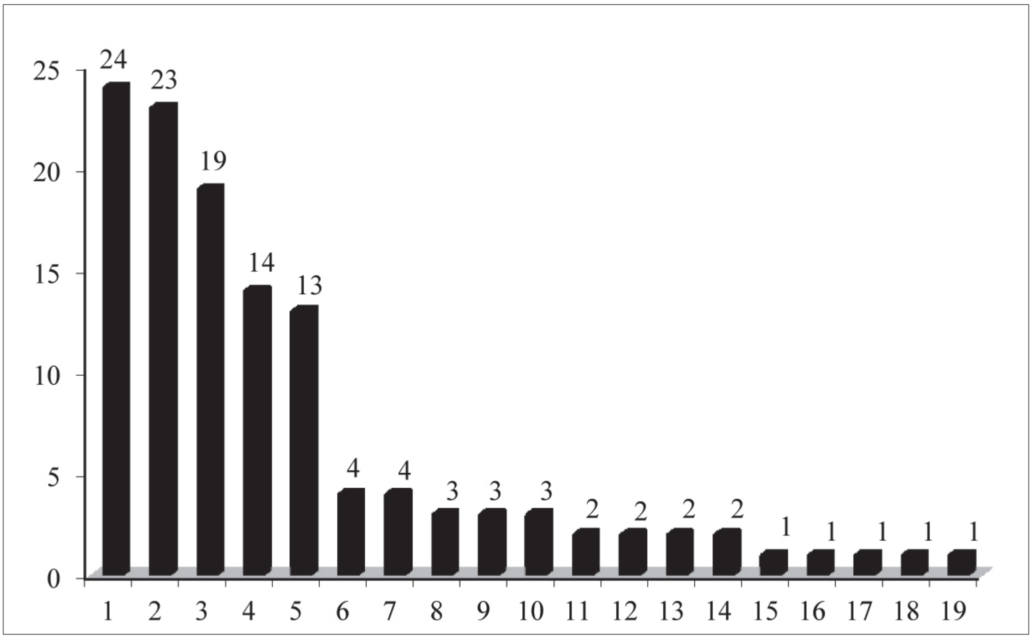

Fig. 2. Spectrum of floral elements (1. sub-Eurasian; 2. Eurasian; 3. sub-Central European; 4. Cosmopolitan 5. Adventive 6. sub-Circumpolar; 7. sub-Pontic-sub-Mediterranean; 8. Pontic-Central Asia-sub-Mediterranean; 9. sub-South Siberian; 10. sub-Mediterranean 11. Circumpolar; 12. Pontic-east-sub-Mediterranean 13. Central European 14. sub-Atlantic-sub-Mediterranean 15. Pontic-Pannonian 16. sub-Euxine 17. sub-Mesian; 18. sub-Pontic-sub-Central Asia-sub-Mediterranean; 19. east sub-Mediterranean).

Alliance: *Polygono-Chenopodion* Koch 1926. em. Sissing 1946.

Association: *Polygonetum convolvulo-avicularis* Kojić et al. 1984.

facies: *anthosum arvensae*

facies: *polygonosum persicariae*

The *Polygonetum convolvulo-avicularis* association was recorded in corn and soya crops. It is extremely rich floristically, containing 100 plant species with the basic ediphicators being *Polygonum aviculare* and *Convolvulus arvensis* (Table 1). A typical set comprises 20 species (with a degree of presence of V and IV), which are of great diagnostic importance and give the association a specific appearance through their habitus. The high levels of abundance and cover indicate that coenotic relations are stable and that the *Polygonetum convolvulo-avicularis* association is fully formed.

Numerical ordination

The ordination diagram (Fig. 4.) shows that the association can be clearly differentiated into the *anthosum arvensae* (relevés 1-5) and *polygonosum persicariae* (relevés 6-10) facies. The relevés are grouped into two homogenous groups on the basis of floristic similarities. The isolation of relevé stand 1 is the result of floristic poverty, while that of stand 11 is due to the presence of species specific solely to it: *Melilotus officinalis, Helianthus tuberosus, Urtica dioica, Arctium lappa, Rumex palustris, Adonis flammea,* etc.

The spring aspect of the *Polygonetum convolvulo-avicularis* association develops after the planting of maize, during the spring and early summer, up until the formation of crop rows characteristic for maize. Conditions for the sprouting and development of segetal species are favorable due to the limited growth of the crops and the favorable temperature, moisture and illumination of the soil. During the spring and early summer, inter-row tilling and the mechanical eradication of weeds takes place, which then allows for the most effective use of herbicides. After each tilling, new plant species emerge, which renew the stands, and in some instances, their life cycle ends in between two successive tillings. The spring aspect comprises several species: *Veronica persica, Sinapis arvensis, Erigeron canadensis, Capsella bursa-pastoris* and *Taraxacum officinale*. As the maize grows and the characteristic crop cover is formed, phytoclimatic conditions deteriorate, leading to a temporary reduction in the association in terms of quality and quantity. When the use of agrotechnical protection measures ceases, the summer aspect of the association develops, formed by a large number of species with optimal growth and development. If conditions are favorable, some species from the spring aspect can sprout once again (even if they have finished their life cycle) and thus be a constituent of the association's summer aspect. At the end of summer and beginning of autumn, the maize enters its leaf decay phase. This causes an increase in light intensity on the soil's surface, which is warm and moist, and hence conditions are favorable for the sprouting of segetal species. Most of the frequent species that sprout are from the spring aspect. Thus, the association changes both qualitatively and quantitatively as the autumn aspect forms, which lasts until harvest and autumn ploughing.

Syntaxonomic affiliation of ass.
Consolido-Polygonetum avicularis

Class: *Stellarietea mediae* Tx., Lohm. et Prsg. 1950.

Order: *Centauretalia cyani* Tx., Lohm. et Prsg. 1950.

Alliance: *Caucalion lappulae* Tx. 1950.

Association: *Consolido-Polygonetum avicularis* Kojić et al. 1973.

Subassociation: *sonchetosum palustrae*

Subassociation: *galietosum aparinae*

facies: *stellariosum mediae*

The *Consolido-Polygonetum avicularis* association was recorded among the small grains, i.e. in the wheat and barley crops. Its floristic composition comprises 78 species with *Cirsium arvense* as the most abundant. In addition, diagnostic combination includes 14 more species (with a degree of presence of V and IV) (Table 1).

Numerical ordination

The ordination diagram (Fig. 5.) shows the differentiation of this association into corresponding subassociations: *sonchetosum palustrae* and *galietosum aparinae*. The relevés of the subass. *sonchetosum palustrae* form a relatively homogenous group as a result of the fairly uniform presence of species in relevés 1-6. This is a consequence of the habitat's openness, relatively similar levels of ecological factors (apart from moisture, which exhibits certain oscillations) and anthropogenic factors. The relatively low homogeneity of the group comprising relevés 7-11 is a result of the low level of floristic similarity. The greatest deviation in the ordination diagram is exhibited by stand 11, which is why it is differentiated as the facies *stellariosum mediae*.

Small grains are dense crops among which a plant community forms parallel to crops sprouting. The structure and floristic composition of the association are conditioned by the time of sowing and the agroecological conditions that the crops create during the vegetation period with their abundance and cover. As crops sprout, so do segetal species. Due to the marked anthropogenic impact, the ass. *Consolido-Polygonetum avicularis* is quite species-poor, with the diversity of ediphicators significantly lower. However, there is a clear invasion of some species: *Cirsium arvense*, *Convolvulus arvensis*, *Ambrosia artemisiifolia*, *Sorghum halepense*, *Xantium strumarium*, *Setaria glauca*, etc.

Syntaxonomic affiliation of ass.
Lolio-Plantaginetum majoris

Class: *Plantaginetea majoris* Tx.et Prsg.

Order: *Plantaginetalia majoris* Tx. et Prsg.

Alliance: *Polygonion avicularis* Br.-Bl. 1931.

Association: *Lolio-Plantaginetum majoris* Beger 1930.

The association *Lolio-Plantaginetum majoris* was recorded and studied among the alfalfa crops (*Medicago sativa*). Alfalfa is a perennial forage plant with dense cover and is harvested several times during the vegetation period. The floristic composition of this association consists of 84 species and the basic ediphicators are *Plantago major* and *Lolium perenne*, while a typical set, in addition to these species, also contains *Cirsium arvense, Verbena officinalis, Crepis setosa*, *Rumex obtusifolius* and *Taraxacum officinale* (Tab 1).

Numerical ordination

The ordination diagram of the ass. *Lolio-Plantaginetum majoris* shows the heterogeneous arrangement of the relevés (Fig. 6.), which is a result of the location of the alfalfa fields as they are situated in the immediate vicinity of a drainage channel, an oak forest (*Quercus robur*), small grain crops and row crops.

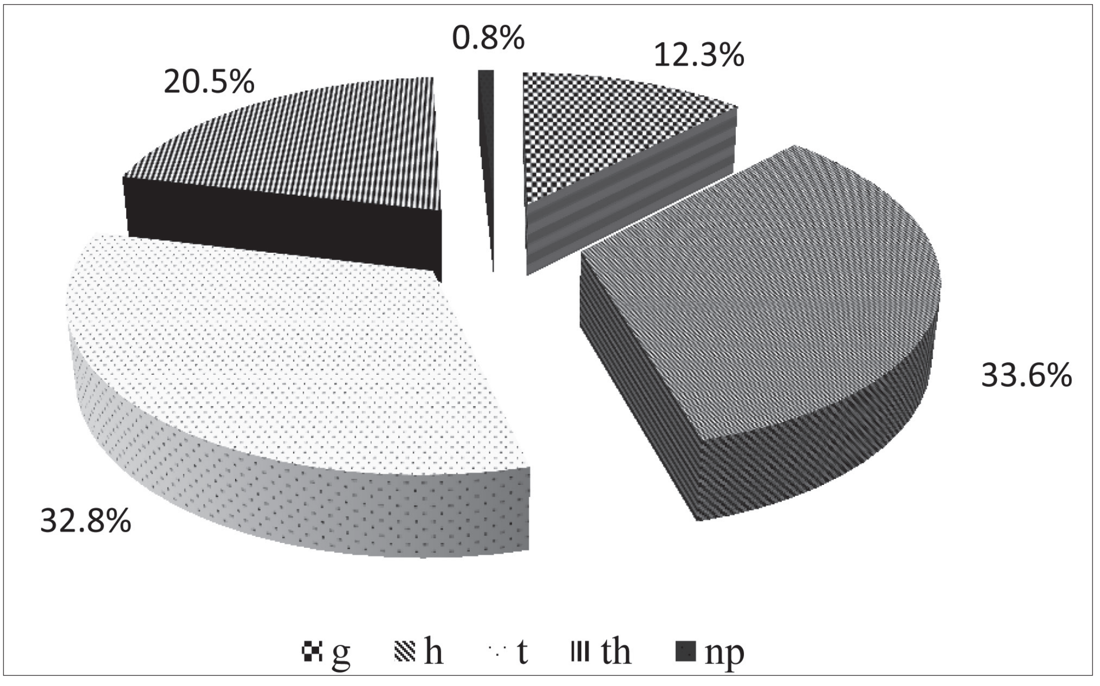

Fig. 3. Biological spectrum (**g** – geophytes; **h** – hemicryptophytes; **t** – therophytes; **th** – thero-hemicryptophytes; **np** – nanophanerophytes).

A comparison of the floristic composition of the row crops and small grains with the floristic composition of the alfalfa crop reveals certain differences arising from the method of cultivation, density and cover, as well as the repeated harvesting of alfalfa during the vegetation period. The floristic composition of ass. *Lolio-Plantaginetum majoris* exhibits characteristics of segetal, ruderal and meadow phytocoenoses, which is confirmed by the species present. It could be said to be segetal as it is an anthropogenic phytocoenosis that lives for 5 to 6 years until crop rotation is applied. The most frequent segetal species in the association were *Cirsium arvense, Veronica persica*, *Sonchus asper*, *Setaria glauca, Panicum crus-galli* and *Sorghum halepense*. The alfalfa fields gain the characteristics of ruderal and meadow phytocoenoses as time passes with hemicryptophytes appearing, and while alfalfa is present the soil surface is not tilled, but is partially trampled and regularly mown. Typical ruderal species among the alfalfa crops are *Verbena officinalis* and *Artemisia vulgaris*, while *Trifolium repens*, *Euphorbia salicifolia* and *Trifolium pratense* are typical meadow plants. Representatives of ruderal-meadow species are *Crepis setosa, Rumex obtusifolius, Veronica chamaedrys* and *Poa pratensis*. Of the ruderal-segetal species in the ass. *Lolio-Plantaginetum majoris,* the following are prominent in terms of frequency: *Stenactis annua, Rubus caesius, Capsella bursa-pastoris, Ambrosia artemisiifolia* and *Pastinaca sativa*. Jovanović (1994), Kojić et al. (1998) and Chytrý (2007b) said that this association is one of the most important and widespread ruderal communities in Belgrade, appearing in dry, porous, warm, open and sunny habitats with unfavorable physical characteristics of the soil exposed to intense trampling, as well as in damp places in the shade of walls or in forest clearings and on paths on well-developed, but compact (moderately trampled) soil. The amount of water in this kind of soil often varies and in some cases, the earth is almost completely saturated, but because of the unfavorable structure it dries very quickly (Kojić et al., 1998).

Ecological differentiation of segetal vegetation

Soil analysis revealed that the basic soil type in the study area is meadow-black-soil (Table 2). These are fertile soils in which it is possible to grow almost all types of crops once minimal limitations have been overcome (Antić, 1982). The impact of anthropogenic factors is highly pronounced, as there is virtually no decomposition of organic material because the crops are harvested and taken away and the land is then ploughed. Artificial mineral fertilizers are applied to the soil in order to achieve higher yields.

The impact of ecological factors on the differentiation of segetal vegetation into the appropriate syntaxa was estimated using canonical correspondence analysis (CCA) (Fig. 7.).

The results of CCA revealed that the type of crop (whether row crops, small grain crops, or perennial alfalfa), moisture, habitat acidity (pH) and temperature have the greatest impact on the ecological differentiation of the researched segetal vegetation into appropriate syntaxa. The *Consolido-Polygonetum avicularis* association found among the small grain crops exists in the moistest habitats (in the immediate vicinity of the drainage channel) (shown by black squares), while the habitats of the ass. *Lolio-Plantaginetum majoris* growing among alfalfa crops (shown by red squares) are the most xerophilous. Soil pH and temperature most often affect associations that develop among small grain crops and row crops (ass. *Polygonetum convolvulo-avicularis* – shown by blue squares).

The effects of type of crop on floristic composition were proved by cluster analyses of 2456 relevés obtained from arable areas, which is in line with the syntaxonomic and ecological pattern already detected for southeast Europe and in conflict with the Central European classification that has appeared in recent years (Šilc et al., 2008a). Beside crop type, Šilc et al. (2009) pointed out the importance of spatial (phytogeography) and

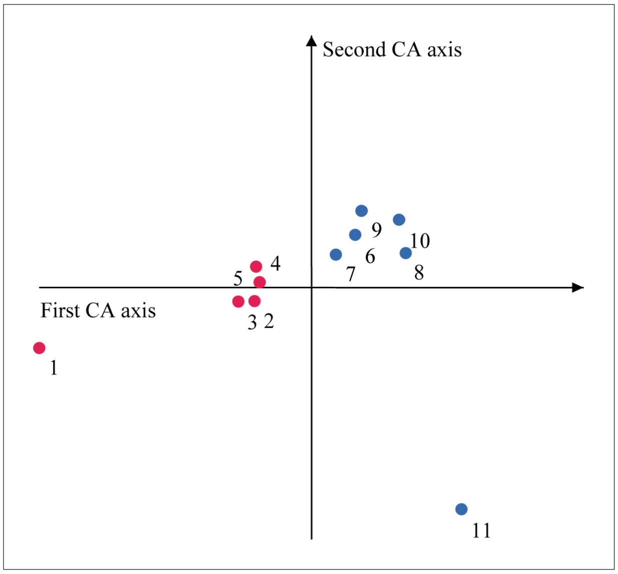

Fig. 4. *Ordination diagram ass. Polygonetum convolvulo-avicularis Kojić et al. 1984.*

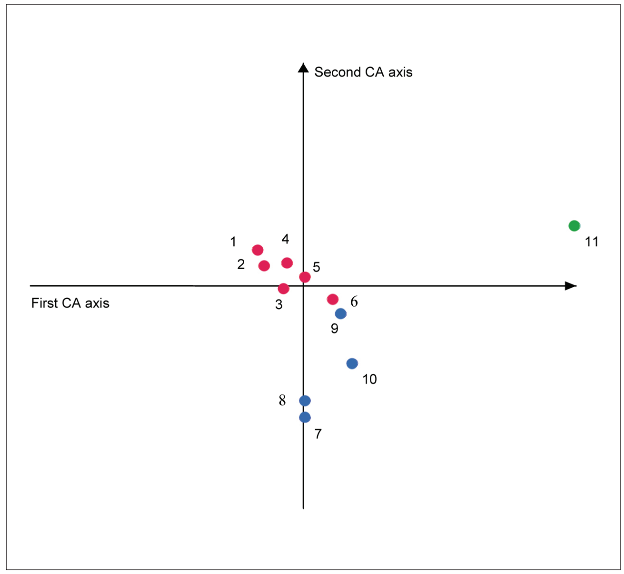

Fig. 5. *Ordination diagram ass. Consolido-Polygonetum avicularis Kojić et al. 1973.*

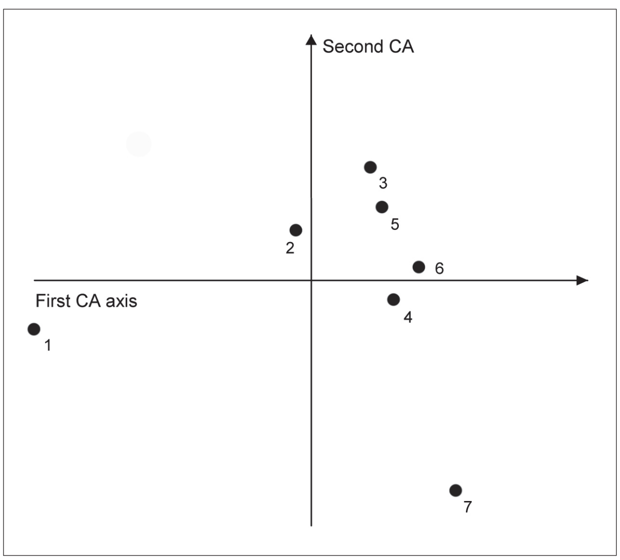

Fig. 6. *Ordination diagram ass. Lolio-Plantaginetum majoris Berger 1930.*

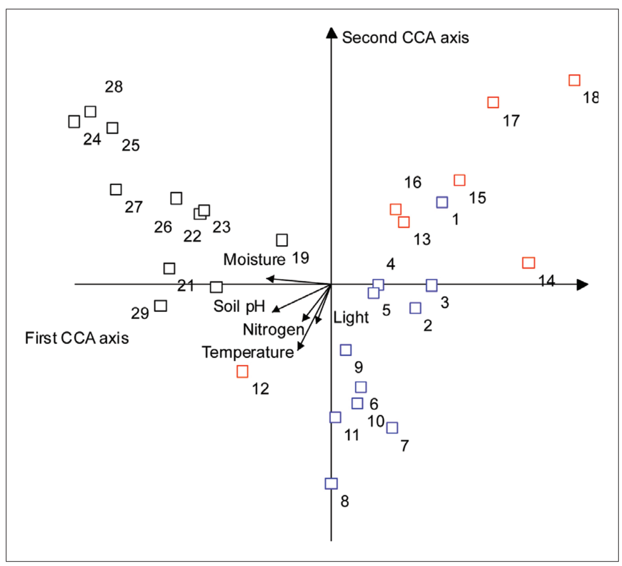

Fig. 7. Ecological differentiation of segetal vegetation.

environmental factors on species composition in the northwestern Balkans. Comparing rank of importance of environmental variables on species composition shows a decrease of influence of crop type. Fried et al. (2008) also confirmed that crop has the most significant impact on species composition in Western Europe, with Atlantic and Mediterranean climates. They advocated adopting the broad crop categories used by Lososová et al. (2004) because, when applying these groupings to their data set, the significance of gross and net effects dropped.

The most frequent and abundant species in all the recorded associations in the cultivated areas are *Ambrosia artemisiifolia*, *Cirsium arvense* and *Veronica persica*. In addition to these, *Polygonum convolvulus, Chenopodium album, Convolvulus arvensis, Daucus carota, Panicum crus-galli, Plantago major, Polygonum aviculare, Setaria glauca, Sinapis arvensis, Sonchus asper, Sorghum halepense, Stenactis annua* and *Verbena officinalis* contribute greatly to the physiognomy of the agrophytocoenoses.

In the small grain fields, only a few agrotechnical interventions are undertaken (with none carried out during certain periods of the year), which allows for the existence of relatively clear coenotic relations and structural and seasonal dynamics of the ass. *Consolido-Polygonetum avicularis*. The fields with row crops are exposed to more frequent agrotechnical interventions (tilling, fertilizing and the use of pesticides and herbicides, hilling, etc.), which most often leads to a reduction in the diversity of the weed community, i.e. of the ass. *Polygonetum convolvulo-avicularis*. In the main, well-adapted species survive, while the floristic composition is reduced considerably and seasonal dynamics of the plant community are not clearly marked.

A comparison of segetal vegetation growing in the corn crops in southern Srem with those in northeastern Serbia (Stefanović, 1987) reveals similarities in the floristic composition, as well as in the domination of therophytes, which increase in number from spring to autumn. In vegetation among the small grain crops, the ass. *Consolido-Polygonetum avicularis* is most similar floristically (ISs=40%) to the same associations in northwestern Serbia (Stepić, 1984) and Kraljevo and the surrounding region (ISs=39.3%) (Ajder, 1996). The biological spectrum of the association in southern Srem is hemicryptophytic-therophytic in character, while in the small grain crops in the vicinity of Kraljevo and in northwestern Serbia it is therophytic. Geoelements of wide

Table 2. Chemical properties of arable land in the studied areas.

Crops and plant communities	Soil type	Depth	pH_{H2O}	C	Humus	N	Physiologically active P and K (mg/100g earth)	
					(%)		P_2O_5	K_2O
Alfalfa (ass. *Lolio-Plantaginetum majoris*)	meadow-black-soil	0-10 cm	8.44	1.22	2.10	0.01	2.91	16.00
		10-20 cm	8.47	0.88	1.51	0.00	1.68	12.00
Corn (ass. *Polygonetum convolvulo-avicularis)*	meadow-black-soil	0-10 cm	8.66	0.83	1.43	0.05	3.63	9.00
		10-20 cm	8.65	0.52	0.89	0.03	2.93	8.20
Soya (ass. *Polygonetum convolvulo-avicularis)*	meadow-black-soil	0-10 cm	8.57	0.90	1.56	0.06	3.16	11.40
		10-20 cm	8.63	0.65	1.11	0.04	3.30	12.60
Wheat (ass. *Consolido-Polygonetum avicularis*)	meadow-black-soil	0-10 cm	8.63	0.92	1.58	0.11	2.10	12.60
		10-20 cm	8.63	1.05	1.82	0.08	2.16	9.80

distribution dominate the spectrum of floral elements. In terms of its floristic composition, the ass. *Lolio-Plantaginetum majoris* among the alfalfa crops of southern Srem has characteristics of segetal, ruderal and meadow phytocoenoses. According to the index of floristic similarity, this association is most similar (ISs=59%) to the corresponding association from the ruderal habitats of the Pančevački rit wetlands (Stanković-Kalezić, 2006) and Belgrade (ISs=42%) (Jovanović, 1994).

Weed species can greatly reduce crop yield through the process of competition. The intensity of this process, particularly with wide-rowed crops such as maize and soya, is determined mainly by their density (the number of crop plants per ha) and the spatial arrangement of plants (the distance between rows and between plants in the row) (Murphy et al., 1996; Simić and Stefanović, 2007). In the areas analyzed, the impact of weed species on yield is negligible and their abundance is controlled by the use of appropriate herbicides.

Alien species

Sixteen non-native species were identified in the segetal vegetation: *Asclepias syriaca, Sorghum halepense, Abutilon theophrasti, Ambrosia artemisiifolia, Erigeron canadensis, Medicago sativa,*

Table 3. Non-native plant species in the segetal vegetation of Southern Srem.

Allochthonous plant species	Dispersal	Origin	Status	Time of introduction	Plant community
Abutilon theophrasti Medic.	anthropoch., zooch.	Adventive (East Asian)	nat	neo	1
Amaranthus retroflexus L.	anthropoch., zooch.	Adventive (North American)	inv	neo	1,3
Amorpha fruticosa L	hydroch., anemoch.,	Adventive (North American)	nat	neo	1,2
Ambrosia artemisiifolia L.	anthropoch., anemoch., hydroch.	Adventive (North American)	inv	neot	1,2,3
Asclepias syriaca L.	anemoch., zooch.	Adventive (North American)	inv	neo	1,2
Erigeron canadensis L.	anthropoch., ornithoch.	Adventive (North American)	inv	neot	1,2,3
Helianthus tuberosus L.	anthropoch., parts of the tubers	Adventive (North American)	nat	neo	1,2,3
Medicago sativa L.	anthropoch.	Adv (Central Asian, cultivated)	nat	arch	1,2,3
Oxalis stricta L.	autoch.	Adventive (North American)	inv	neo	1
Panicum crus-galli L.	anthropoch., zooch. (birds and insects), hydroch.	Cosmopolitan (subtropical-tropical)	nat	neo	1,2,3
Polygonum aviculare L.	anthropoch.	Cosmopolitan (tropical)	inv	neo	1,2,3
Stenactis annua (L.) Nees.	anemoch., anthropoch.	Adventive (North American)	inv	neo	1,2,3
Sorghum halepense (L.) Pers.	anemoch. hydroch., zooch. (endozooch.), anthropoch.	Adventive (paleotropical-Eurasian)	inv	neo	1,2,3
Xantium italicum Mor.	anthropoch., hydroch., ornithoch.	Adventive (North American)	inv	neo	1
Xantium strumarium L.	anthropoch., hydroch., ornithoch.	Adventive (North American)	inv	neo	1,2,3
Veronica persica Poir.	anthropoch., anemoch., ornithoch.	Adventive (Asian)	nat	neo	1,2,3

1. *Polygonetum convolvulo-avicularis* Kojić et al., 1984; **2.** *Consolido-Polygonetum avicularis* Kojić et al., 1973; **3.** *Lolio-Plantaginetum majoris*, Berger, 1930. **Modes of dispersal: zooch.**-zoochory, **anemoch.**-anemochory, **ornithoch.**-ornithochory, **anthropoch.**-anthropochory, **autoch.**-autochory, **hydroch.**-hydrochory, **endozooch.**-endozoochory. **Status**: **inv**-invasive; **nat**-naturalized. **Time of introduction: arch**- archaeophytes; **neo**-neophytes; **neot**-neotophytes.

Xantium italicum, Xantium strumarium, Panicum crus-galli, Polygonum aviculare, Amaranthus retroflexus, Helianthus tuberosus, Oxalis stricta, Portulaca oleracea, Stenactis annua and *Veronica persica* (Table 3). In terms of their status following introduction, 10 non-native species can be classified as invasive and 6 as naturalized. Species of North American origin (10) dominate, while in relation to the time of introduction, neophytes are the most numerous (13). *Ambrosia artemisiifolia* dominates among the small grains and row crops, but is considerably less abundant among alfalfa. Apart from common ragweed, there is also a high presence of *Amaranthus retroflexus*, *Polygonum aviculare*, *Veronica persica*, *Sorghum halepense* and *Panicum crus-galli.* Most of the species recorded are from the *Asteraceae* family, which can be attributed to the wide diversity of life forms, their adaptability to anemochorous, anthropochorous and zoochorous seed dispersal, and their high plasticity in relation to various natural habitats (Maillet and Lopez-Garcia, 2000). The most invasive species from this family are *Ambrosia artemisiifolia*, *Erigeron canadensis*, *Stenactis annua*, *Xantium italicum* and *Xantium strumarium,* and they are strong competitors for natural resources such as light, water and mineral matter. The more limited natural resources are and the more similar the ecological characteristics of species are, the greater the competitive intensity. Therophytes dominate because they finish their vegetative and reproductive cycle in a very short period of time in accordance with the existing conditions.

The dominant vectors of alien plants spread in the study area are through direct or indirect anthropogenic activities, which are manifested in different ways: a) the use of manure containing seeds which, having passed through an animal's digestive tract, maintain their germinability; b) cultivation of the soil (cutting of underground organs (rhizomes, bulbs, roots) into smaller parts which then root and develop); c) the use of agricultural machinery; and d) covering the terrain with soil containing the seeds of weed species. The direct influence of anthropogenic factors on widening the distribution range of non-native species comes in their being planted or sown for a whole range of reasons (Jarić, 2009).

Šilc et al., (2012) studied anthropogenically induced vegetation of the western Balkans in order to establish the degree of their liability to invasion of alien species. Detailed analysis of 3089 relevés sampled over a long period, between 1939 and 2009, showed that every relevé contains approximately 12.7% allochthonous species with the lowest share of archaeophytes (4.3%) and neophytes (8.4%). Therefore, they concluded that local habitat conditions proved to have the greatest effect, rather than climatic variables or propagule pressure on the distribution of allochthonous species, which is confirmed by our study. Lososová and Cimalova (2009) studied the effects of different cultivation types on native and alien weed species richness and diversity in Moravia (Czech Republic). Their results confirmed the importance of climatic factors and management practices for changes in weed species composition. They also showed a distinct pattern of species richness and beta diversity of native and alien weed species.

The influence of anthropogenic factors (agrotechnical measures)

The most pronounced effect of anthropogenic factors on segetal vegetation in the study area is from the use of agrotechnical measures and pesticides. This causes major changes in the qualitative and quantitative relations of plant species in segetal associations and changes their floristic composition. The application of suitable agrotechnical measures should be aimed at increasing the biodiversity of agrophytocoenoses, reducing empty ecological niches that weed species fill, and decreasing the availability of resources necessary for their development. Greater crop biodiversity entails including a larger number of species in the rotation, which leads directly to a reduction in the use of herbicides and a change in the way the soil is cultivated, and indirectly to better temporal and spatial exploitation of available resources (Kovačević and Momirović, 2004). This strategy aims to reduce the diversity of weeds, i.e. to change the weed-crop ratio in favor of crops (Dekker, 1997). Because of the impact of anthropogenic factors (harvest and picking) manifested by the removal of organic matter arising from crop production and the introduction of mineral and organic fertilizers into the soil, the processes of organic matter cycling and energy flow have a different pattern in agrophytocoenoses than in other phytocoenoses. Thus, segetal plant associations, due to their synmorphological, synecological, particular biological, and ecophysiological characteristics, are the basis for the structure and functioning of agroecosystems as a whole.

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