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QUALITATIVE AND QUANTITATIVE CONTENT OF SOIL WEED SEED BANK IN SUNFLOWER CROP

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Abstract

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Soil contains great amount of seeds of different weed species. The term "seed bank" refers to the reservoir of seed capable of germinating in favorable conditions in the soil or on the surface. Determination of the seed bank is of great significance for study of population dynamics, as well as for planned weed control. Data on seed quantity in certain area enable better choice of crops and cultural practices, as well as more rational herbicide use. During 2008-2009 studies of the seed bank in sunflower crop were performed in two different localities with the aim of determination of quantitative and qualitative properties of the seed bank and viability of seeds from arable soil layers of 0-10; 10-20 and 20-30 cm. Samples of the soil were taken before the end of vegetation, from each plot in four replications. The samples were rinsed in the water through copper sieves of specific diameters, and weed seeds were separated. Seed was germinated in controlled conditions of climatic chamber. Germination capability and hypocotyls and epicotyls lengths of seedlings were evaluated after 14 days. Seeds determined from the studied samples showed a great diversity but only a few of them were dominant, i.e. were more abundant in seed, such as: *Amaranthus retroflexus, Sinapis arvensis, Polygonum lapathifolium* and *Datura stramonium*. The species *Sinapis arvensis, Polygonum lapathifolium, Hibiscus trionum, Amaranthus retroflexus, Echinocloa crus-galli* and *Datura stramonium,* which were the species whose seed proved to be dominant in all of the examined soil samples had the greatest percentage of viable seeds. The highest level of germination viability was found in seed of *Polygonum lapathifolium*, *Datura stramonium* and *Sinapis arvensis*.

Key words: germination, soil layers, sunflower, weed seed bank

Introduction

In order to obtain efficient and quality weed protection of crop, it is necessary to apply various methods of their control. A precondition for their efficient control represents knowledge related to ecological and biological properties of weeds, which are formed over time under the strong influence of anthropogenic factors. Basic biological properties of weeds that enable them survival are production of large quantities of viable seeds, a high potential of vegetative reproduction, ability of fast spreading, and adaptation to unfavorable environmental conditions (Wijdeven and KuZee, 2000; Konstantinović, 2008).

The term "seed bank" refers to the reservoir of seed capable of germinating in favorable conditions in the soil or on the surface (Simpson et al., 1989; Fernandez-Quintanilla and Saavedra, 1991; Boutsalis and Powles, 1998). The content of the seed bank shows remarkable differences, being composed of variable and persistent part. Variable part of it consists of seeds of weeds of short vegetation cycle, while persistent part consists of seeds that maintain viability for many years, causing regular germination throughout the year, enabling their

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further distribution and survival. Seed longevity and occurrence of dormancy are the main characteristics of weed species that enable their further distribution and survival. Purpose of the study of dynamics of weed seed population in the soil is to determine changes in its size in the course of time and variation, as well as the factors that influence them. In agrophytocenozis with frequent soil tillage, seed banks tend to be more stable and provide survival to weed species (Roberts, 1981 and Konstantinović, 2008). There are different ways that enable occurrence of weed seeds in soil. They can be disseminated mechanically by wind, water, animals or by agricultural machinery, thus contributing to the regular recharging of the seed reservoirs. The most significant seed inflow periods depend upon the time of dissemination and dominant weed species within the local population (Konstantinović et al., 2008).

Soil tillage and crop rotation are the primary agricultural activities that influence the reduction of the volume of seed bank in soil. However, soil tillage disposes great number of weed seeds to the soil surface, where dormancy brakes and they begin to germinate and shoot. Concurrently, the seeds from the surface are brought to deeper soil layers, where they enter into the phase of dormancy and represent a potential source of weeds in the future (Konstantinović, 2008). Most weed species show a higher degree of sustainability in undisturbed soils than in cultivated soils. The presence of seeds in the top layer and frequent tillage are the factors that influence the reduction of weed seed bank in the soil, since seeds are exposed to conditions of larger variations of temperature and soil moisture that cause breaking of their dormancy. In deeper soil layers, with more uniform conditions, seeds longevity depends only upon their characteristics. Qualitative and quantitative properties of seed bank also depend on the soil type. Seed density is lower in heavy clay than in the lighter types of soil (Swanton, 2001). Herbicide use can also affect the composition of seed banks in soil. Most studies have shown that the absence of herbicides has resulted in increased weed seed bank (Hyvönen and Salonen, 2002). The interaction between the methods of cultivation, herbicide use and crop choice determines the size and composition of the weed seed bank (Roberts, 1981). In agro-ecosystems, knowledge of weed seed bank in a certain area allows better choice of crops and cultural practices, as well as more rational application of herbicides (Voll et al., 1996).

Materials and Methods

During 2008-2009 study on distribution of weed seeds on different depths of arable soil layers in sunflower crop in localities of Žabalj (45°21'N, 20°12'E) and Zmajevo (45°28'N, 19°40'E) was performed. In the first decade of May, in both localities sowing of the hybrid Dolby was done. After sowing and before germination crops were treated by acetochlor and then by prometryn. During vegetation period followed the additional treatment by fluazifop-P-butyl. Sampling of the soil was carried out before the end of the vegetation period diagonally in four replications and separately from the depths of 0-10 cm, 10-20 cm and 20-30 cm (Smutný and Křen, 2002). The samples, which contained in average about 1.5 kg of the soil, were rinsed with water through copper sieves of 0.25 mm in diameter. After drying of the obtained samples, and separation of weed seeds followed their determination (Kronaveter and Boža, 1994). After data processing by the method of Conn (1987) and Sharratt (1998), germination of weed seed species was performed in Petri dishes that were kept for 14 days in a climate chamber, in favorable conditions for seed germination. After evaluation of germination, hypocotyls and epicotyls length of seedlings were measured. Statistical data processing was performed using the software Statistica 7. Life forms of weeds species were given according to Soó -in (1980) and Šinžar et al. (1995). The main objective of the study was to determine quantitative and qualitative characteristics of seed bank and viability of weed seeds in the arable soil layer of 0-30 cm under sunflower.

Results

From the soil samples taken in the locality Žabalj, seeds of eight following weed species were separated and determined: *Amaranthus retroflexus* L., *Calistegia sepium* (L.) R. Br., *Echinocloa crus-galli* (L.) R. et Sch., *Hibiscus trionum* L., *Polygonum lapathifolium* L., *P.aviculare* L., *P. persicaria* L and *Sinapis arvensis* L. (Table 1). According to the number of seeds, the species *Polygonum lapathifolium* proved to be dominant with 175 seeds m^{-2} at depth of 20-30 cm. LSD test showed statistically highly significant differences in number of seeds of this species in relation to all species present in each of the studied soil layers. At a depth of 0-10 cm, slightly higher quantities of weed seed species *Sinapis arvensis* and *Amaranthus retroflexus* were found numbering 81 seeds m^{-2}, i.e. 75 seeds m^{-2}, respectively. Generally, slightly larger quantities of seeds were determined in soil layers of 0-10 and 10-20 cm in comparison to the layer of 20-30 cm depth, but no statistically significant differences were found. In majority of trials, acetochlor showed high efficiency in control of annual weeds and in combination with prometryn, it proved to have good efficiency on sunflower weed flora. Fluazifop-P-butyl showed high efficiency to the herbal species *Sorghum halepense*. Despite of the applied herbicides, large quantities of *Polygonum lapathifolium, Amaranthus retroflexus* and *Sinapis arvensis* seeds were found.

Table 1
The number of weed species seeds in locality Žabalj (the average no. of seeds m^{-2})

Weed species	Depth of the arable soil layer, cm			Average
	0-10	10-20	20-30	
Amaranthus retroflexus	75	62.5	0	45.83
Calistega sepium	6.25	0	0	2.08
Echinocloa crus-galli	0	6.25	12.5	6.25
Hibiscus trionum	6.25	0	12.5	6.25
Polygonum aviculare	12.5	6.25	6.25	8.33
Polygonum lapathifolium	87.5	81.25	175	114.58**
Polygonum persicaria	0	0	6.25	2.08
Sinapis arvensis	81.25	12.5	37.5	43.75
Average:	33.59	31.25	21.09	
%	39.1	36.4	24.5	

LSD – weed species: $P<0.01 = 67.11$
$P<0.05 = 48.35$
LSD- depth of the arable soil layer: $P<0.01 = 41.10$
$P<0.05 = 29.61$

From the soil samples, taken in the locality Zmajevo, seeds of 15 weed species were determined (Table 2). In the surface soil layer of 0-10 cm weed species *Amaranthus retroflexus* had the largest number of seeds (268 seeds m^{-2}). In the same soil layer, a larger quantity of *Datura stramonium* seeds (175 seeds m^{-2}) was established. LSD test found statistically highly significant

Table 2
The number of weed species seeds in locality Zmajevo (the average no. of seeds m^{-2})

Weed species	Depth of the arable soil layer, cm			Average
	0-10	10-20	20-30	
Amaranthus retroflexus	268.75	150	139.06	185.93**
Ambrosia artemisifolia	6.25	14.56	9.38	10.06
Calistega sepium	6.25	0	0	2.08
Chenopodium album	21.87	9.38	14.06	15.1
Datura stramonium	173.44	140.63	104.69	139.59**
Euphorbia cyparissias	8.31	6.25	0	4.85
Echinochloa crus-galli	50	66.63	64.56	60.4
Onopordum acanthium	0	6.25	0	2.08
Polygonum aviculare	9.38	18.75	6.25	11.48
Polygonum persicaria	12.5	0	6.25	6.25
Sinapis arvensis	15.63	6.25	0	7.28
Solanum nigrum	9.38	8.31	9.38	9.02
Sorghum halepense	31.25	18.75	12.5	20.8
Stachys annua	0	0	6.25	2.08
Veronica hederifolia	6.25	12.5	0	6.25
Average:	41.28	30.54	24.22	
%	43	31.8	25.2	

LSD – weed species: $P<0.01 = 45.84$
$P<0.05 = 33.98$
LSD- depth of the arable soil layer: $P<0.01 = 21.16$
$P<0.05 = 15.68$

differences in the number of seeds of these two species in relation to all other determined types.

Weed community of sunflower consists mainly of therophytes (annual weeds), mostly due to deep presowing cultivation and inter-row tillage and hoeing, which reduce occurrence of perennial weed life forms of geophytes and **hemicryptophytes** (Table 1). The obtained results suggest that dominant were the seeds of weed species having identical or similar needs for light, water and heat as well as the studied crop. Results of germination of seeds segregated from samples (locality Žabalj, 2008.) showed high germination capability of seeds of weed species *S. arvensis*, which ranged from 45% in seeds from arable soil layer, up to 67% in seeds from the deepest soil layer (Figure 1).

Epicotyls and hypocotyls growth of the germinated seeds was measured on daily basis. Results are presented in Figures 2 and 3. Results obtained by measuring of epicotyls length of seedlings, showed that the longest average epicotyls length in locality Žabalj was attributed to the seeds of weed species *Polygonum lapathifolium* L. (9.42 mm) and *Sinapis arvensis* L. (4.66 mm), while in the locality Zmajevo seeds of weed species *Datura stramonium* L. and *Echinochloa crus-galli* L. had the longest average epicotyls length, i.e. (16.67 mm) and (2.92 mm), respectively.

Results of measurement of hypocotyls length were similar to previous results (Figure 3).

Seedlings of weed species *Datura stramonium* L. from locality Zmajevo and species *Polygonum lapathifolium* L. from locality Žabalj had the longest hypocotyls length.

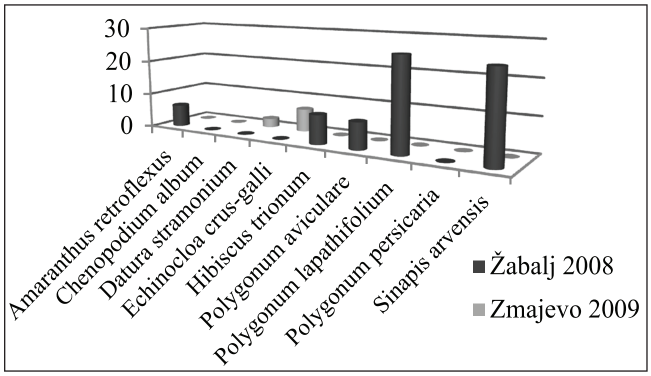

Fig. 1. Percentage of germination capability of weed seeds in both of the studied localities

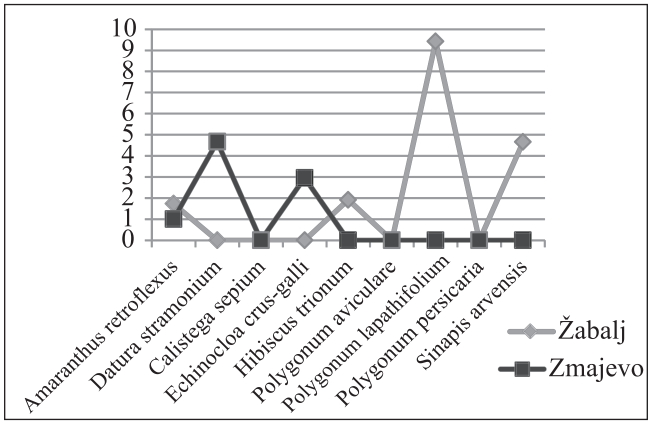

Fig. 2 . The average epicotyls length of weed species from both localities

Table 3
Dominant weed species in seed bank and their ecological characteristics (Soó, 1980; Šinžar et al., 1995)

Weed species	Light regime of plants	Thermal regime of plants	Water regime of habitats	Life form*
Amaranthus retroflexus L.	heliophytic	thermophilic	mezophytic	Th
Chenopodium album L.	heliophytic	-	mezophytic	Th
Datura stramonium L.	heliophytic	thermophilic	mezophytic	Th
Polygonum aviculare L.	heliophytic	-	mezophytic	Th
Polygonum lapathifolium L.	heliophytic	-	mezophytic	Th
Sinapis arvensis L.	heliophytic	thermophilic	mezophytic	Th
Sorghum halepense (L.) Pers.	heliophytic	thermophilic	xerophytic	G

* Th – thermophiles; G – geophytes

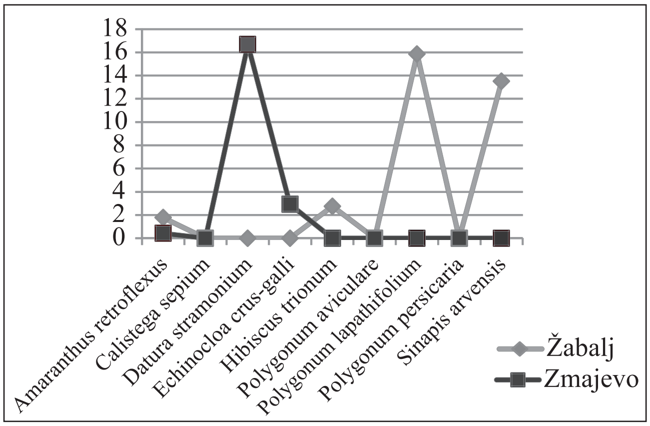

Fig. 3. The average hypocotyls length of weed species from localities Žabalj and Zmajevo

Discussion

During 2008-2009, in two localities in the northern part of Serbia (Žabalj and Zmajevo) distribution of weed seeds at different depths of the arable soil layer in sunflower crop was studied.

In locality Žabalj, of eight (8) dominant weed species, species *Sinapis arvensis* with 81 seeds m^{-2} and *Amaranthus retroflexus* with 75 seeds m^{-2} had the highest distribution in the surface soil layer of 0-10 cm. Živanović - Katic et al. (2004) also found a high level of *Sinapis arvensis* seeds germinating under wheat crops and concluded that this weed reduces wheat yield by as much as 70% since it germinates within the crop, being even more competitive. The species *Polygonum lapathifolium* having 175 seeds m^{-2} proved dominant at the depth of 20-30 cm. Higher percentage of seeds was found in soil layers of 0-10 and 10-20 cm in relation to the layer of 20-30 cm of depth. However, there were no statistically significant differences. In locality Zmajevo, from the soil samples taken under sunflower crop fifteen (15) seeds of weed species were determined, of which the most abundant was seed of *Amaranthus retroflexus* in the top soil layer of 0-10 cm (268 seeds m^{-2}). In the same soil layer, higher number of *Datura stramonium* seeds was also found, amounting 175 seeds m^{-2}. Similar results were also obtained by Demirci and Kaa (2009) in Turkey. The highest germination percentage was established in seeds of weed species *Sinapis arvensis, Polygonum sp., Amaranthus retroflexus, Datura stramonium* and *Echinochloa crus-galli*. Species *Sinapis arvensis* had the highest germination viability, ranging from 45% in seeds from arable surface layer, up to 67% in seeds from the deepest layer. Seeds of weed species *Polygonum lapathifolium* also had higher germination viability ranging from 15-35%, regardless of the arable soil layer depth. Increased germination ability was determined also for seeds of the species *Amaranthus retroflexus* amonting 37%, in the soil layer of 10-20 cm and 50% for the species *Hibiscus trionum* in the soil layer of 10-20%. Due to seed longevity and increased shooting energy *Amaranthus retroflexus* is known as significant competitor in the field, especially in the first phases of weed and crop development (Johnson, 1971; Omami et al., 2002). In locality Zmajevo, seeds of *Echinocloa crus-galli* and *Datura stramonium* showed higher percentage of germination ranging from 16.7% to 2.5%, respectively. Similar results in the study of *Echnochloa crus-galli* germination were obtained by Honek and Honek (2002).

Conclusions

Seeds of other weeds species showed weak or negative ability to germinate. By measuring of the average epicotyls and hypocotyls lengths of the segregated seed, it was concluded that those having the highest germination potential also had the longest epicotyls and hypocotyls length, and those were seeds of weed species *Sinapis arvensis* and *Polygonum lapathifolium*.

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