Population variability of weedy sunflower as invasive species

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Abstract

Three populations of weedy sunflower were investigated with the aim to assess its population variability. The following parameters were evaluated: vegetative parameters - plant height (cm), leaf lenght (cm), leaf width (cm), number of ray flowers, number of bract; generative parameters - head diametar (cm), mass of achene per head (g), number of achene per head; and achene parameters - achene lenght (µm), achene width (µm), mass of 100 achenes (g). Except that, achene morphology as indicator of population variability was studied. The studied populations significantly differed regarding to most measured parameters, while only plant height and number of ray flowers were similar in all three populations.

Keywords: Invasive species, population variability, weedy sunflower.

Introduction

Sunflower (*Helianthus annuus* L.) belongs to the genus *Helianthus* with 49 species native to North America (NOORYAZDAN *et al.* 2010). It was introduced into Europe, probably through Spain, in the sixteenth century, first as an ornamental plant. Breeding of oilproducing varieties started in Russia in the nineteenth century, and from there, sunflower expanded as an oilseed crop in other European countries and all over the world (MULLER *et al.* 2009). The genus *Helianthus* displays substantial phenotypic and genetic diversity and habitat variation and is composed of wild, weedy and domesticated species (RİBEİRO *et al.* 2010). *H. annuus* species include

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several forms („normal" crop plants, atypical plants known as "off type" crop plants, volunteer plants, wild and weedy plants) which are clearly phenotypic and genetic different. Wild *H. annuus* is considered ancestor of the cultivated sunflower (*H. annuus var.macrocarpus*) and despite many phenotypic differences between them, they are interfertile (URETA *et al.* 2008). Weedy forms are morphologically clearly different from the volunteers that arising from the segregation of hybrid-F1 varieties (MULLER *et al.* 2009). Weedy populations are characterized by a high morphological diversity with plants combining in different proportions cultivated and wild traits, from typical F2 plants to typical wild-like phenotypes (POVERENE *et al.* 2006). Those plants have adapted to different environment in an undesired way, becoming of harmful and invasive weeds (MULLER *et al.* 2009). PRESOTTO *et al.* (2011) consider that the main features that make sunflower invasive species are its invasiveness, potential herbicide tolerance and competitiveness.

Weedy sunflower populations are made of a wide diversity of phenotypes, constituting a continuum between wild and cultivated morphotypes (MULLER *et al.* 2010). In Europe, where *H. annuus* is not native, weedy plants showing typical wild phenotypic traits: strong branching, presence of anthocyanin pigmentation in various organs, reduced size of head and achenes, seed dormancy, seed shattering and sporophytic self-incompatibility (MULLER *et al.* 2009). URETA *et al.* (2008) in their studies obtained that hybridization reaches 42% and alleles from cultivated sunflower persist in frequencies up to 38% in wild sympatric populations.It is confirmed that wild plants flower longer (20–40 days) and that it affects the hybridization (URETA *et al.* 2008). The invasive process has probably been concomitant with the occurrence of new mutations, gene flow and recombination, which is enough to maintain high infraspecific variability (PRESOTTO *et. al.* 2011).

Distribution of weedy sunflower in Europe and Serbia are presented in Fig. 1 and Fig. 2, respectivelly. According to survey the weedy sunflower composed the biggest population on southern Srem (around 1 000 ha of crop and non-crop fields) and southern Banat (around 7-8 000 ha of crop and non-crop fields) in Vojvodina Province (north part of Serbia). This invasive form of sunflower grows along with other weed species in row crops, where its coverage varies, but tends to increase over the years. Analysis and monitoring of invasive species in a wider area of the Vojvodina Province in row crops (maize, sugar beet, soybean, *etc.*) have indicated a significant presence of this weed in regional weed vegetation suggesting a need to take a closer look at these populations in order to develop a strategy for suppressing further spread of this species (STANKOVİC-KALEZİC *et al.* 2008). Therefore, the aim of our study was to determine the populatuion variablity in fitness parameters of three weedy sunflower populations from Serbia.

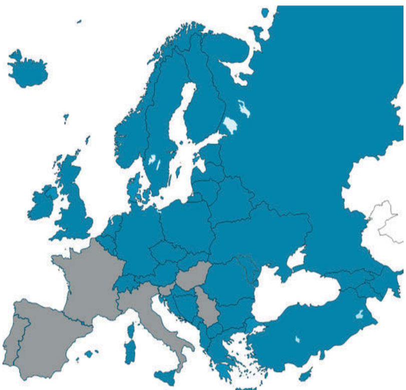

Fig. 1. Distribution of weedy sunflower in Europe (gray color).

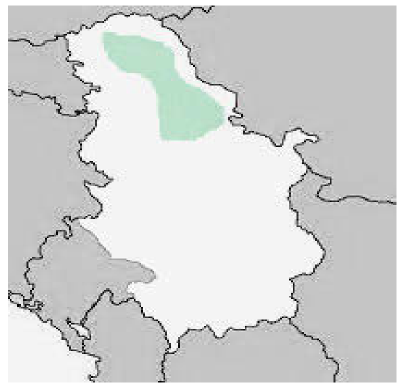

Fig. 2. Distribution of weedy sunflower in Serbia (green colour).

Material and Methods

During 2012 three weedy sunflower populations (P1, P2 and P3) were observed on three different locations in the southern Srem (around 1 000 ha of crop and non-crop fields) and southern Banat (around 7-8 000 ha of crop and non-crop fields) area in the Province of Vojvodina (northern Serbia). Populations were examined at the stage of plant maturity. Twenty plants were chosen from every location and three heads were taken from each plant for the analysis. Heads were packed in paper bags and were kept in laboratory conditions until the further analysis. The following parameters were evaluated and described: vegetative parameters (plant height (cm), leaf lenght (cm), leaf width (cm), number of ray flowers, number of bract), generative parameters (head diametar (cm), mass of achene per head (g), number of achene per head) and achene parameters (achene lenght (μm), achene width (μm), mass of 100 achenes (g)). We believe that these parameters determine the level of fitness of a plant and that they can be used to determine plant productivity in the following year, as well as their dispersal in the ecosystem. Achene samples were examined under binocular Leica XTL 3400D, photographed with a digital camera LEICA DC 300 and length and width of achene were measured using the LEICA IM 1000 software.

The results were processed using software Statistica 5.0 by the descriptive statistics and student´s t-test to determine the significance of differences between means.

Results and Discussion

Variability of the weedy sunflower populations was evaluated based on vegetative, generative and achene parameters. Analysis of the results showed that the studied populations significantly differed regarding to most measured parameters ($P<0.01$), except regarding plant height and number of ray flowers (Table 1-4). At the stage of maturity plant leaf length (20.55 cm) and width (19.50 cm) of population P2 differed highly significant in comparison to the same parameters of populations P1(length: 16.94 cm; width: 15.08 cm) and P3 (length: 16.05 cm; width: 13.75 cm). Number of bract were similar (about 35) in populations P1 and P2, while it was significantly smaller in population P3 (31.36).

Table 1. Vegetative parameters (mean±sd) of weedy sunflower populations.

Parameters	P1	P2	P3
Plant height (cm)	204.00±31.97	202.00±42.29	197.00±30.18
Leaf length (cm)	16.94±2.81	20.55±3.68	16.05±2.61
Leaf width (cm)	15.08±3.79	19.50±3.00	13.75±2.66
Number of ray flowers	26.03±3.66	38.55±4.49	25.22±5.63
Number of bract	35.16±5.69	34.91±6.31	31.36±5.38

Studied weedy sunflower populations showed very pronounced variability in all generative parameters (Table 2, 4). Head diameter was between 3.37 and 5.18 cm and very significant differed between populations ($P<0.01$; Tab. 4). Also, it was higher then head diameter of wild form of sunflower (2.75-3.79 cm) studied by NOORYAZDAN *et al.* (2010) and *Helianthus petiolaris* Nutt (1.98 to 2.5 cm) studied by PEREZ *et al.* (2007). The highest mass and number of achenes per head was obtained in population P2 (mass: 3.54 g; number: 216), while the lowest was obtained in population P3 (mass: 1.66 g; number: 159). Using t-test to compare between populations we found that both parameters differed significantly ($p<0.05$) between all three populations (Table 4).

Table 2. Generative parameters (mean±sd) of weedy sunflower.

Population	Head diameter (cm)	Mass of achenes per head (g)	Number of achenes per head
P 1	4.51±1.23.23	2.16 ± 2.26	181 ± 86.26
P 2	5.18 ± 0.67	3.54 ± 1.44	216 ± 82.64
P 3	3.37 ± 0.86	1.66 ± 0.86	159 ± 68.76

Achene morphology, including colour, hair presence , stripes and dots, was very variable between the studied populations (Fig.3).High level of intrapopulation variability was observed. Percentage of achene surface covered by hairs and hair length was a highly variable parameter in the studied populations (data not shown). Similarly, PEREZ *et al.* (2007) showed that the surface of the achenes of *H. petiolaris* has abundant straight hairs which can serve as a defence mechanism against diseases.

Fig. 3. Achene morphology of weedy sunflower.

Data in Table 3 represent some achene parameters of studied weedy sunflower populations. Those results indicate that achene length of population P2 (6.1mm) is significantly higher then achene lenght of other two populations (P1: 5.8 mm; P3: 5.5 mm), while achene width is similar in populations P1 (2.7 mm) and P2 (2.8 mm) and considerably smaller in population P3 (2.5 mm). NOORYAZDAN *et al.* (2010) and PEREZ *et al.* (2007) measured achene length and width of wild form of sunflower and *H. petiolaris*. The achene length in their studies was generally smaller in comparison with weedy form, while achene width in our study is similar like in their studies. In contrast, cultivated sunflower achenes had higher length (9.52 mm) and width (5.12 mm) (GUPTA & DAS 1997). Mass of 100 achenes (between 1.09 and 1.78 g) was greater then for population of *H. petiolaris* (about 0,7 g) from Argentina (PEREZ *et al.* 2007) and USA (DORRELL & WHELAN 1978).

Table 3. Achene parameters (mean±sd) of weedy sunflower.

Population	Achene length (μm)	Achene width (μm)	Mass of 100 achenes (g)
P 1	5774.91 ± 479.86	2722.43 ± 208.19	1.20 ± 0.08
P 2	6096.67 ± 386.37	2763.41 ± 332.90	1.78 ± 0.64
P 3	5509.92 ± 594.25	2489.64 ± 147.88	1.09 ± 0.10

Table 4. Level of the differences between populations for nvestigated parameters (t-test).

Parameters	P1:P2	P1:P3	P2:P3
Plant height	*ns*	*ns*	*ns*
Leaf length	**	*ns*	**
Leaf width	**	*ns*	**
Number of ray flowers	*ns*	*ns*	*ns*
Number of bract	*ns*	**	**
Head diameter	**	**	**
Mass of achenes per head	**	**	**
Number of achenes per head	**	*	**
Seed length	**	*ns*	**
Seed width	*ns*	**	**
Mass of 100 achenes	**	*ns*	**

Conclusions

In conclusion, high level of populations' variability was observed for three weedy sunflower populations from northern Serbia. The most variable were generative parameters (head diametar, mass of achene per head, number of achene per head).For many vegetative (except plant height and number of ray flowers) and achene parameters was confirmed level of variability between populations.

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Allelochemical explanation of *Heracleum sosnovskyi* invasiveness

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Among the reasons of species invasiveness success in new environment is its chemical interaction with the recipient community determined by the absence of tolerance of resident flora to new chemicals produced by the invader, in this particular case by Heracleum sosnovskyi Manden. The allelopathy is expected to be an important mechanism in the plant invasion and may encourage the development of general research models of invasive susceptibility in the ecosystems. H. sosnovskyi is native to the Caucasus region and is a dangerous invader which successfully spread worldwide, as well as has naturalized in Lithuanian habitats and plant communities. *H. sosnowskyi* exhibited high biochemical activity due to the accumulation of phenolics. The assessment of the total phenolics content (TPC) and biochemical impact of *H. sosnovskyi* on perennial ryegrass (monocots) and winter rapeseed (dicots) seed germination was done *ex situ*. The aqueous exudates of 2-year old *H. sosnovskyi* exhibited higher phytotoxicity than 1-year old plant exudates. The phytotoxic effects of *H. sosnovskyi* aqueous exudates on the germination depended on the extract concentration (0.02-0.2%), plant age (1-year, 2-year), plant parts (shoot: stem, leaf, blossom, seed, root) and growth stage (rosette-ripening). The phytotoxicity of *H. sosnovskyi* determined extract was most strong at flowering stage due to highest TPC (30.42 mg ml^{-1}). All parts of *H. sosnovskyi* produced phenolics, which inhibited the acceptor-species seed germination. The exudates inhibited the seed germination. The level of inhibition was concentration depended. The phenolics content varied throughout the plant age (0.22-81.03 mg ml^{-1}), growth stage (0.17-81.03 mg ml^{-1}) and across different plant parts (2.97-92.61 mg ml^{-1}) inhibiting the germination of acceptor plants. The results suggested that the invasive plant species may acquire spreading advantage in new territories through

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