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Short research contribution

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REPRODUCTIVE POTENTIAL OF THE ALIEN SPECIES *ASCLEPIAS SYRIACA* (ASCLEPIADACEAE) IN THE RURAL LANDSCAPE

ABSTRACT: In the beginning of its introduction Common milkweed, *Asclepias syriaca* L. was used in Hungary as ornamental plant. After escaping from cultivation it has become wide spread during last decades of the 20th century. Nowadays, it covers large areas especially on sandy soils, and its further appearance is expected on dry, deforested and degraded areas.

Two neglected fields and one abandoned vineyard were selected. For sampling two quadrates of size 4 m^2 were used at each stand. The stands were characterized by the following variables: density of stems, percentage of reproductive stems, average number of inflorescences, average number of fruits, fruits per all inflorescences on a stem, pods per fruited inflorescences on a stem, average number of seeds per fruit.

In the same quadrates the soil seed bank was studied at two depths (0–5 cm and 5–10 cm).

The results showed that the density of stand, percentage of reproductive specimens and average number of fruits were significantly higher on the neglected fields than on the abandoned vineyard. In the neglected fields large number of seeds were detected in the upper soil-layer (2.7–18.6 × 10^3 seeds m^{-2}), but in the lower soil-layer much fewer seeds were found and only in one of the fields. Common milkweed seeds were almost completely missing from both soil layers of the abandoned vineyard. However, the seeds recovered from the soils practically did not germinated, indicating that seeds of earlier years sets have lost viability, *i.e.* the studied stands of *A. syriaca* did not form a persistent soil seed bank. Nevertheless, the fresh seed production of the neglected field populations, that can reach 7–10 thousands seeds m^{-2}, may cause a very strong propagulum load not only in the site but also on the surrounding areas.

KEY WORDS: *Asclepias syriaca,* reproductive capacity, soil seed bank, seed production, stand density, weed control

Common milkweed (*Asclepias syriaca* L.) is a widespread weed on its native land (the United States and Canada). It is mainly found is soya, maize, wheat, oat and broomcorn plantations, and often appears also in road-side vegetation (Cramer and Burnside 1982, Yenish *et al.* 1997b, Hartzler and Buhler 2000).

It was brought to Hungary as an ornamental plant in the 19th century, therefore its exact date of naturalization is difficulty to determine. After the naturalization it was a sporadically occurring member in the native vegetation for long time, which is a relatively frequent phenomena in case of alien species (Kowarik 1995, Tamás 2000). Following the latency period Common milkweed increasingly spread and in 1997 it was recorded as the 76th of most dangerous weed species in Hungary (Csontos 2001).

Common milkweed has several attributes typical for ideal weed species (*sensu* Newsome and Noble 1986): it is perennial, able to reproduce by vegetative organs (Bhowmik and Bandeen 1976), successful competitor (Yenish *et al.* 1997a), and it expresses allelopathic potential (Kazinczi *et al.* 2004), thus its further invasion is expected. The most threatened areas in Hungary are the grasslands on sandy or other coarse-textured soils, especially if the habitats are degraded or at least the upper soil layers are disturbed (Bhowmik 1978). However, Tobisch *et al.* (2003) reported *A. syriaca* from the herb layer of sandy-soiled *Robinia pseudoacacia* L. stands in Central Hungary, and its existence was also observed in pine plantations of the same region. This refer to the fact, that Common milkweed may emerge in some new, yet unoccupied habitats of Hungary. Its spreading towards the new habitats can be mostly realized by the wind dispersed seeds. Several experiments demonstrated that seeds of *A. syriaca*, especially after cold treatment, express high rate of germination (Oegema and Fletcher 1972, Baskin and Baskin 1977, Horváth 1984), and plants developed from seeds are often stronger and more prolific than new shoots developed from the running roots (Gaertner 1979). In an artificial seed burial experiment its seeds showed considerable longevity as well, 90% of the seeds germinated after six years (Csontos 2001). However, natural soil seed bank of *A. syriaca* was never reported. Therefore, in this study particular attention was paid: 1) to examine quantitative characteristics connected with generative reproduction of *Asclepias syriaca*, and 2) to investigate its natural seed bank in the soil of established stands.

In the surroundings of Budapest extent stands of Common milkweed are found on disused agricultural lands, and some smaller stands occur in abandoned vineyards. Considering this pattern of distribution of Common milkweed, three sampling areas were selected in the vicinity of the settlements: Mogyoród, Ecser and Szada (hereafter site-A, -B and -C, respectively). Sampling site-A was an abandoned vineyard on a south-slope of 20° covered with *Festuca valesiaca* Schleich. type grassland in which *Salvia nemorosa* L., *Seseli varium* Trev. and *Eryngium campestre* L. were the major accompanying species. Here *A. syriaca* colonized an area of 0.2 ha with stand height 70–90 cm. Site-B and -C were neglected fields on plain ground forming relatively large milkweed stand areas (B: 20–30 ha; C: 8–10 ha) with stand height of 90–110 cm and 70–110 cm, respectively. On these latter areas the latest crop plant was maize, and the major accompanying species in the *A. syriaca* stands were *Conyza canadensis* (L.) Cronqu. and *Oenothera biennis* L. Field sampling on the three sites was carried out in September 2003, at the full ripened stage of the stands.

For each sampling area two 4 m^2 quadrates were marked in the centre of the stands. Within the quadrats *A. syriaca* stems were counted and removed. Then the number of inflorescences and the number of fruits developed from them, if any, were determined in the field. Later on the following variables were calculated from the field data: percentage of the reproductive stems, average number of inflorescences per reproductive stem, average number of pods per reproductive stem, number of pods per number of inflorescences on a stem, number of pods per number of fruited inflorescences on a stem, average number of seeds per fruit (see Table 1).

We emphasize that density data in this study reflects stems (not individuals) per square metre since we did not recover the underground clonal structure of *A. syriaca* in the field. A stem was considered as 'reproductive stem' if it bore at least one inflorescence (regardless if it produced pods or not). For determining the average number of inflorescences, the sum of the fruited and non-fruited inflorescences were considered. The number of seeds per pod was calculated at each site from twenty randomly collected, non-opened pods.

Soil seed bank of Common milkweed was sampled in the same quadrates. Soil cores of 80 cm^2 surface area and 10 cm depth were cut, then they were divided to upper and lower layers 0–5 cm and 5–10 cm, respectively. Prior to sampling, seeds originated from recent seed rain, it present, were removed from the soil surface, thus ensuring that the samples contain only seeds from previous years seed sets. This sampling procedure was repeated two times in the abandoned vineyard (site-A) and four times in each of the neglected fields (sites B and C). Pairs of soil cores originated from the same vertical layers were bulked thus forming 800 cm^3 soil samples (1 replicate per soil layer of the vineyard site and 2 replicates per soil layers of each field). The 800 cm^3 soil volume exceeds the required minimal volume that is 500–600 cm^3 in case of pioneer vegetation (Roberts 1981, Csontos 2007). Samples were transported to the laboratory, and washed through a sieve with mesh size of 2 mm. After drying, seeds of *A. syriaca* were removed from the debris, counted and packed in paper bags according to habitats, layers and replicates. After 7–10 days seeds were sown into flower pots filled with 1:1 mixture of sand and potting soil. Sowing depth was 5 mm in order to achieve the highest germination percentage (Bhowmik 1978). Pots were exposed to natural daylight regime at room temperature and watered regularly. First period of germination test lasted 40 days, then flower pots were exposed to cold treatment (+7 C°, 4 weeks) to break possible dormancy of ungerminated seeds, then repositioned to natural daylight and room temperature conditions for an additional 40 days period.

In statistical analyses ANOVA was used to compare means of reproductive variables among the three study sites (InStat 1998). Raw data showed normal distribution in all cases, however, standard deviations proved to be different (in Bartlett test) in case of some variables. In these latter cases Kruskal-Wallis test was used for evaluation. As post tests Tukey-Kramer test was applied following ANOVA and Dunn test in the other cases. Significant differences were accepted at $P < 0.05$.

Common milkweed density varied between 7.4 and 18.1 stems m^{-2} (Table 1a). These values are somewhat higher than the density reported from North America (ranging from 1.2 to 8.8 stems m^{-2}, Bhowmik and Bandeen 1976), but much lower than observed in West Slovakian populations (45 stems m^{-2}, Valachovič 1989).

Rate of reproductive stems in our study ranged between 90 and 99 percent (Table 1b) that is somewhat higher than the Slovakian values, 77–96%. However stand height of the Hungarian populations were smaller than the Slovakian ones (150–170 cm, Valachovič 1989).

Average number of inflorescences on an average stem was 5.1 in the population of site-B, which was significantly higher ($P < 0.001$)

Table 1. Variables of the generative reproduction of *Asclepias syriaca* in three study sites Mogyoród (A), Ecser (B) and Szada (C) near Budapest. Letters in superscript indicate groups defined by variance analyses. Values in parentheses show standard deviation.

		A (abandoned vineyard)	B (neglected field)	C (neglected field)
(a)	Density (stems m^{-2})	7.4	14.0	18.1
(b)	Percentage of reproductive stems (%)	89	98	98
(c)	Number of inflorescences per reproductive stem	3.1^a (1.2)	5.1^b (1.5)	3.3^a (1.2)
(d)	Number of pods per reproductive stem	1.8^a (1.4)	2.7^b (2.1)	2.9^b (1.7)
(e)	Number of pods per number of inflorescences on a stem	0.6^a (0.4)	0.5^a (0.4)	0.9^b (0.4)
(f)	Number of pods per number of fruited inflorescences on a stem	1.4^a (0.5)	1.3^a (0.4)	1.5^a (0.9)
(g)	Number of seeds per pod	206.4^a (30.9)	206.9^a (31.9)	201.9^a (22.9)

Table 2. Soil seed bank in three stands of *Asclepias syriaca* near Budapest. Each sample consisted of 800 cm^3 soil, seeds were washed out then sown in flower pots filled with 1:1 mixture of sand and potting soil. Upper soil layer means 0–5 cm, lower layer means 5–10 cm (see the methods section for further details).

Study site	Soil layer	Number of seeds: found in soil sample	per m^2	sown for germ. test	germinated
Site-A (abandoned vineyard)	upper	1	62.5	1	0
	lower	0	0	-	-
Site-B (neglected field)	upper	244	15150	244	1
	lower	57	3563	57	0
Site-C (neglected field)	upper	51	3201	51	0
	lower	0	0	-	-

than the values for site-C and site-A populations (Table 1c). In the Slovakian sampling site fewer inflorescences were detected (2.5 per stem), but in this case both reproductive and vegetative stems were considered in the calculations. In the course of a North American survey 2.2 inflorescences per stems were found in average (Franson and Wilson 1983).

Number of pods were significantly lower (P <0.001) on the abandoned vineyard than on the two neglected fields (Table 1d). According to literature data more pods (4.1–6.3 per stem) were found in most of the cases (Evetts and Burnside 1973, Sauer and Feir 1974, Horváth 1984, Caruso *et al.* 2005).

In case of pods per all inflorescences on a stem the value for the site-C (field) was significantly higher than for site-B (field) and the abandoned vineyard (site-A), (Table 1e). Valachovič (1989) reported 0.5 pod per stem, that is similar to the Hungarian values, but it is notable that much higher fruit production was observed for cultivated and wild populations in North America.

Average number of pods per fruited inflorescences of the three sampling sites were statistically indistinguishable (Table 1f).

Average numbers of seeds per pod in the three sites again formed a single group in ANOVA (Table 1g). The seed numbers of our study fit well to other results measured within native range of the species and it somewhat exceeds the reported values of previous Hungarian studies (Horváth 1984, Varga 2003). Much lower seed per pod values were reported from SW Slovakia (Valachovič 1991).

Finally, on the basis of the measured data, we calculated the annual seed production per square metre (SP) for each study site, based on the following formula (letters refer to the reproductive characteristics in Table 1):

$$SP = a \times b/100 \times d \times g$$

where a = density (stems m^{-2}), b = percentage of reproductive stems, d = number of pods per reproductive stem and g = number of seeds per pod.

According to the results annual seed production was: 2.4×10^3 seeds m^{-2} in the abandoned vineyard (site-A), 7.7×10^3 seeds m^{-2} in the neglected field at site-B and 10.4×10^3 seeds m^{-2} in the neglected field at site-C.

Soil seed banks were found in the upper soil layer (0–5 cm) in each sampling site (Table 2). In case of the abandoned vineyard (site-A) the seed bank was negligible, whereas the highest seed content was found in site-B (244 seeds per sample).

In the lower soil layer (5–10 cm) seeds were only detected in the neglected field of site-B, and it was about 23% of the seed content of the upper soil layer of the same site.

Burial of seeds from upper soil layers to deeper ones can be caused either by soil cultivation or by natural burying processes (Roberts 1981, Benvenuti 2007). If the latter case prevails, viable seeds found in deeper soil layers may prove the species ability to form persistent seed bank, because natural burial is a slow process, and therefore, deeply buried seeds are much older than shallow ones (Fenner and Thompson 2005).

In this study practically no germination occurred from sown old seeds originated from any of the soil layers (Table 2), thus the buried seeds of previous years seed sets of *A.*

syriaca can be considered non-viable, *i.e.* the species does not maintain a persistent seed bank in the soil. Since we found seeds in the 5–10 cm soil layer in one of the neglected fields only, the deep burial of seeds was most probably caused by soil cultivation. Yenish *et al.* (1996) also pronounced that more than 90% of Common milkweed seeds remained within the top two cm of soil surface with no-tillage.

The rate of reproductive stems and average number of pods per stem were higher in both neglected fields than in the abandoned vineyard. The abandoned vineyard site showed the lowest stem density, stem height and pods per stem ratio, and none of the studied reproductive variables were top ranked here. However, abandoned vineyards do not form barrier in the distribution of Common milkweed, but instead they are 'stepping-stone' habitats helping the species to colonize further plain ground fields in nearby valleys of the hilly landscape.

When the studied populations of Common milkweed are compared to populations from other countries, higher values for both stem density and stem height were reported from some places of foreign ones. However, the studied populations overcame foreign ones regarding rate of generative stems and average number of inflorescences per stem. Regarding seed production, the latter variables would partly compensate the loss originating from the characteristics mentioned before. However, the definitely lower values of number of pods per stem and pods per inflorescences in the studied populations, if compared to stands studied within the native range of the species, underline an ultimately lower reproductive potential of Common milkweed populations in the surroundings of Budapest. Nevertheless, the actual seed numbers on neglected field that may reach 7–10 thousands seeds per square metre are still considerable, and make *A. syriaca* a successful invader.

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