EVALUATION OF MECHANICAL REGULATION OF INVASIVE HELIANTHUS TUBEROSUS POPULATIONS IN AGRICULTURAL LANDSCAPE

HODNOTENIE MECHANICKEJ REGULÁCIE INVÁZNYCH POPULÁCIÍ HELIANTHUS TUBEROSUS V POĽNOHOSPODÁRSKEJ KRAJINE

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Manuscript received: March 12, 2008; Reviewed: September 22, 2009; Accepted for publication: October 6, 2009

ABSTRACT

In our research the effect of cutting of H. tuberosus stands have been studied by comparison of both mown (2-4 times) and not mown populations during four years. The repeated mowings reduced the number and viability of ramets (during the growing season the decrease of shoots on not-mown plots was not as rapid as on mown plots). On mown plots there was a higher initiate density in spring in comparison with the not mown populations (the high number of shoots could be induced by the stress generated by cutting during the previous year). During our research no generative organs have been observed on mown plants. Changes in species composition have been also studied. We were not able to confirm the high effectiveness of mechanical control of H. tuberosus, however we observed highly effective mowings in natural (not experimental) conditions.

Key words: agricultural landscape, Helianthus tuberosus, invasive plants, management of biological invasions, mechanical regulation.

DETAILNÝ ABSTRAKT

H. tuberosus patrí k najvýznamnejším inváznym druhom rastlín v poľnohospodárskej krajine Strednej Európy. Splanelé populácie tohto druhu rastú v rôznych typoch biotopov a ich regulácia doteraz nebola dostatočne vyriešená. V našom výskume sme na výskumných políčkach experimentálnej bázy SPU (Malanta) skúmali efektívnosť mechanickej regulácie umelo vysadených porastov pomocou opakovanej kosby. Porovnávali sa kosené (2x až 4x ročne podľa klimatických podmienok) a kontrolné porasty bez mechanického zásahu, a to počas 4 rokov (2002-2005). Zistili sme, že opakovaná kosba znížila počet a vitalitu výhonkov (ramiet), pričom pokles populačnej hustoty nepokoseného porastu nebol taký rýchly ako pri pokosených rastlinách (až 44 %). Kosba počas vegetačného obdobia redukovala aj hmotnosť podzemnej biomasy. V nasledujúcom roku počiatočná hustota pokoseného porastu bola väčšia v porovnaní s kontrolným porastom, pravdepodobne v dôsledku stresu spôsobeného kosbou v predchádzajúcom roku. Do konca vegetačného obdobia sa obe hustoty približne vyrovnali. Počas výskumu na rastlinách regulovaných kosbou neboli zistené generatívne orgány. V rámci výskumu sme hodnotili aj zmeny v druhovom zložení porastov (H. tuberosus rastie spolu s inými spontánnymi druhmi), pričom bol zaznamenaný výrazný rozdiel v biodiverzite medzi mechanicky regulovaným a kontrolným porastom (hodnotených bolo 18 druhov). Na základe zistených poznatkov nebolo možné potvrdiť vysokú efektívnosť kosby, ako regulačného opatrenia v potláčaní porastu H. tuberosus, hoci pri pozorovaní spontánnych pobrežných populácií pri rieke Nitra sme zaznamenali úspešnú likvidáciu jeho porastov pomocou opakovanej kosby.

INTRODUCTION

Helianthus tuberosus (Jerusalem Artichoke) is an invasive perennial native to North America, escaped from cultivation and distributed to many countries of the world (biology and ecology of the species, see [20]). It is one of the most expanded invasive plant species in Central Europe and prefers certain habitat types [6]. The earlier taxonomical problems of non-native species of Helianthus genus in Central Europe (H. tuberosus, H. decapetalus etc.) have been analysed by Řehořek [16]. The population and growth dynamics of European H. tuberosus populations have not been studied in detail, except for some short-time research [7, 10]. The invasive plant ecology and management oriented papers and books are sometimes very general in offering information about mechanical regulation of invasive plants ("Invasive plants can be cut, hand-pulled or removed by specific tools … Larger plants can be uprooted, with the aid of tools, such as winches, if necessary. The effectiveness of this technique will vary considerably depending on the response of the weed" [26]) and do not deal with control of this species [e.g. 3, 4, 14, 17, 23, 26].

In the environmental conditions of Slovakia H. tuberosus is propagated mainly by vegetative organs – rhizomes and tubers (under-ground system of rhizomes and tubers) [2, 12 etc.]. Swanton and Cavers [19] reported a higher allocation of carbohydrates to clonal growth than to sexual reproduction. Compounds are initially stored in the above-ground plant organs and later reallocated into the tubers [13]. New tubers production starts in July and August (it is a short-day plant from point of tuberisation), the decomposition of old tubers is initiated in April and ends in June [e.g. 8, 11, 14]. The populations of H. tuberosus reach their maximum density in May and June and then the number of shoots decline [7].

In this paper the effects of mechanical regulation (cutting) of shoots of H. tuberosus have been studied and evaluated. Our research hypothesis was based on observation of a successfully suppressed H. tuberosus stand in a twice-mown alluvial meadow at the Nitra River (unpublished, 1998).

MATERIALS AND METHODS

The mown and not mown permanent research plots have been established in the Malanta Experimantal Centre at the Slovak Agricultural University in Nitra (planted area: 25 m^2, with removed herb layer, plots established in the zero research year – in 2001, the initiative shoot/ramet densities: 240-250 i.m^{-2}, observations done on 3+3 plots, one plot`s area was 1 m^2). The geological ground of the research site consists of loess covered by luvisol. The locality belongs to the European continental climate area of the mild zone. The average annual temperature is about 9.7°C, the average annual rainfall is 560 mm.

The impact (effect) of mechanical regulation of H. tuberosus stands has been studied by comparison of both mown and not mown populations in years 2002-2005. We expected, that in June the old tubers produced in the previous year would be exhausted by fast spring growth of shoots. After that the above-ground biomass was removed as a part of the control method (no energy and nutrients were available for new tubers production). In September, after a regeneration of above-ground shoots, the cutting was repeated (after that there would be not enough time for a new regeneration and tuberisation before winter came).

In 2002 and 2003 cuttings were done two times (once in June and once in September), in 2004 and 2005 four and three times respectively (April, June, August, September and May, July, September according to speed of growth). The different frequency of cutting in the particular seasons (depended on weather conditions) and the different starting shoot densities made the experiment inconsistent but practical in field conditions. The number of shoots, biomass weight (in the not mown stand: new sets of control plots have been established for harvesting individuals) and species composition of developing plant communities have been studied during the growing seasons. Data were evaluated using ANOVA (not included in this paper).

RESULTS

At the beginning of July (2002) the dry mass of underground organs was 110 g.m^{-2} and by September it had increased only by 12 g.m^{-2} because the assimilates were allocated primarily in the above-ground biomass (on the control plots without mowing the difference was 132 g.m^{-2}). The number of shoots had decreased on every research plot (on mown plots by 44 % from July to September).

In the growing seasons of the next 3 years the decrease of number of shoots continued as a result of mechanical regulation (Fig. 1). In 2004, the number of shoots increased between the first and the second mowing (intensive initial spring growth) but between the 2nd, 3rd and 4th cuttings the population density decreased. A similar phenomenon was observed regarding the height of the plants: the plants got taller between the 1st and 2nd mowing but their height decreased after the next cuttings (Fig. 2).

The intra-specific competition and dry environmental conditions could result in a decrease of number of shoots of H. tuberosus on not-mown plots during the growing season but this decline was not as rapid as on mown plots (Fig. 3). The between-year decrease (“winter” decrease = difference in number of shoots between the end of the growing season and the beginning of the next growing season) was relatively high (128, 84 and 45 shoots per winter) while on mown plots there was an increase (!) in population density (144, 75 and 27 shoots per winter, generated probably by cutting stress). The two main growth processes (density change during the growing season and during „winter“) are different on mown and not mown plots but in summary resulted in similar number of shoots at the end of the growing seasons (excl. 2002, very high starting density on the not mown plots). There were incomparable less viable shoots on the mown plots (thin stem, small leaves etc.).

Differences in species composition processes have been also registered (18 species). Some accompanying species occurred only on the not mown plots (4 species), other ones on the mown plots only (6 species). The not mown stands were mostly influenced by expansion of grasses from the neighbouring fields and on the “open” cut plots a remarkable abundance of Polygonum aviculare was observed. On a not mown plot infested by Elymus repens the between-year decrease in number of shoots was different (higher in the first year, lower after three years) in comparison with not infested plots (160, 66 and 9 shoots per winter).

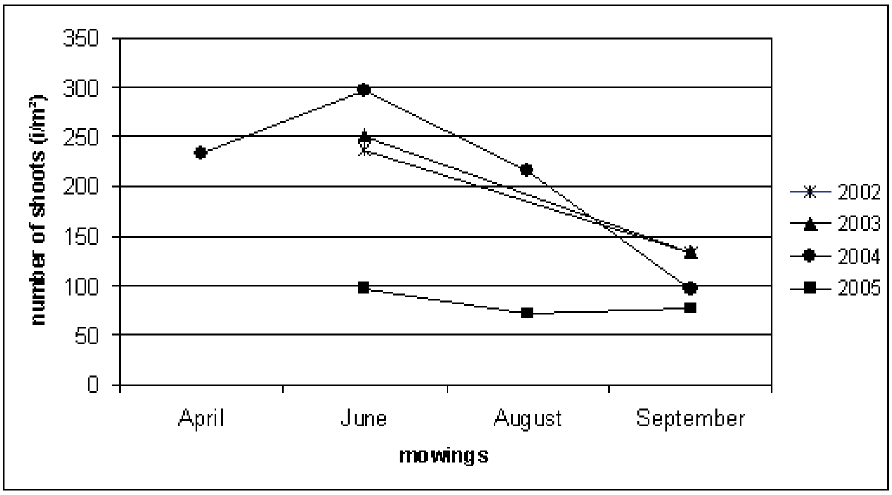

Fig. 1. Change in population density of H. tuberosus on mown research plots during the growing seasons of years 2002-2005.

Obr. 1. Zmeny populačnej hustoty H. tuberosus na kosených výskumných plôškach počas vegetačných období v rokoch 2002-2005 (number of shoots = počet výhonkov, mowings = kosby).

DISCUSSION

In Central Europe a high vegetative reproduction of H. tuberosus is reported. Konvalinková observed 1031 new tubers per 25 cultivated plants in the first year, 1176 in the second year and 1012 in the third year [10]. There is very little information on mowing/cutting affects on H. tuberosus. The repeated mowings before tuberisation reduced the abundance of H. tuberosus [27]. The reduction of population density could be up to 80 % a year [15]. Wagner and Hartmann et al. suggest two mechanical treatments per year: by the end of June and end of August [8, 25], Swanton and Cavers propose discing or rototilling during periods of minimum regeneration [18]. The above-ground biomass can be used as forage for animals. If there is only one cut in June, the plants can form new tubers that can be collected in November or December [24]. Balogh proposed repeated mowings at shoot height 0,5 m [2].

The removal of above-ground biomass can decrease the tubers` formation. Not only because of lack of assimilates but also because of chemical stimulation-inhibition processes. The stimulation metabolism of roots brakes tubers` development, and adult leaves support the tuberisation by their inhibition metabolism [e.g. 21]. The number of tubers can be influenced by assimilate availability, photoperiod, ramet density, planting depth and planting date [5, 18]. Very high density of H. tuberosus suppresses tuberisation [9]. We have very little comprehensive information about competition relations of clonal species in plant communities but it was proved that relative abundance of perennial species with annual ramets is positively correlated with shoot density and species diversity [22]. Swanton and Cavers suggested that H. tuberosus tends to maintain a relative constancy of resource and nutrient supply to clonal growth structures [19].

Some authors [1, 7, 10] reported seed germination from Central European plants (but in Germany no generative reproduction is suggested [8, 11]. During our research no generative organs have been formed on mown plots, which can be another important effect of this control method.

CONCLUSIONS

On mown research plots the number of shoots, the under-ground biomass weight and viability of shoots were reduced per area during the growing seasons but there was a higher initiate density in spring in comparison with the not mown populations. The decrease in number of shoots during the growing seasons is slower on not mown plots. In spring the high number of shoots on the mown plots could be generated by the stress of human manipulation during the previous year. We could not confirm experimentally the high effectiveness of mechanical control of H. tuberosus, however we observed highly effective mowings in riparian habitats of the Nitra river. The difference between mowing effects on experimental plots and sites in riparian habitats could be caused by different biotic and abiotic habitat conditions (different water balance, nutrient supply, disturbances, inter-specific competition etc.).

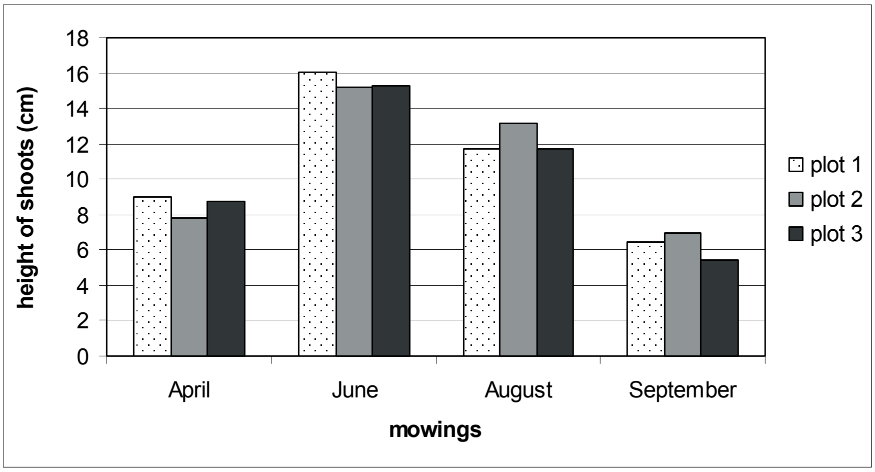

Fig. 2. Height of individuals on mown plots of H. tuberosus during the growing season in 2004 (recorded before mowings).

Obr. 2. Výška jedincov na kosených plôškach H. tuberosus v priebehu vegetačného obdobia v r. 2004 (zistené pred kosbami) (height of shoots = výška výhonkov, mowings = kosby).

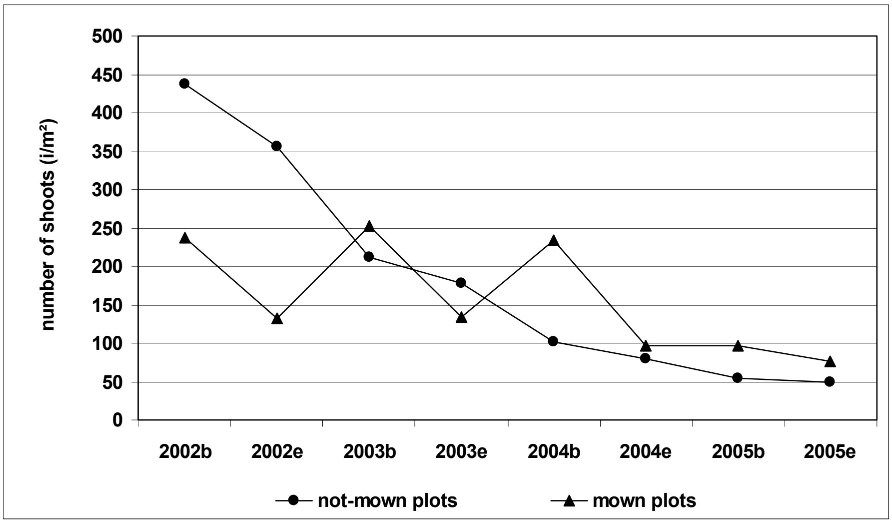

Fig. 3. Annual differences in population density of H. tuberosus on mown and not-mown research plots during the growing seasons of years 2002-2005 (b – at the beginning of the growing season, e – at the end of the growing season).

Obr. 3. Ročné rozdiely v populačnej hustote H. tuberosus na kosených a nekosených výskumných plôškach počas vegetačných období v r. 2002-2005 (b – na začiatku vegetačného obdobia, e – na konci vegetačného obdobia, number of shoots = počet výhonkov, not-mown plots = nekosené plôšky, mown plots = kosené pôšky).

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