Biochemical contribution toward spatial and temporal scale in colonization and spread of invasive species *Heracleum sosnowskyi* across river Nemunas slopes

La contribution biochimique pour l'étude de la colonisation spatiale et temporelle de la propagation de l'espèce invasive *Heracleum sosnowskyi* le long de la rivière Niémen

Baležentienė L.

Aleksandras Stulginskis University, Kaunas LT-53361, Lithuania,
ligita.balezentiene@asu.lt

RÉSUMÉ

Des études récentes suggèrent que les berges sont considérées comme étant un couloir important pour la propagation des plantes invasives. Cependant, les mécanismes selon lesquels les plantes invasives affectent les espèces végétales indigènes étaient moins bien connus. Nous avons effectué des expériences de laboratoire pour tester l'hypothèse selon laquelle l'invasive *H. sosnowskyi* que l'on trouve le long de la rivière Niémen, peut affecter la germination des plantes à travers l'exsudation des allélochimiques. Toutes les parties du *H. sosnowskyi* produisent des composés phénoliques, et inhibent ainsi la germination des graines des espèces acceptrices. Les données obtenues indiquent que le caractère de l'impact phytotoxique d'extraits aqueux *H. sosnowskyi* sur les données de germination est significativement soumis à l'âge de la plante (de 1 an, 2 ans), les différentes parties des plantes (shoot; tige, feuille, fleur, graines; racine), le stade de croissance (rosette maturation) et la concentration de l'extrait (de 0.02 à 0.2%). La plus forte phytotoxicité de *H. sosnowskyi* a été déterminé au stade de la floraison en raison de plus de PTC (30,42 mg ml^{-1}). Les résultats suggèrent une nouvelle vision et montrant que les espèces végétales envahissantes peuvent se répandre davantage dans de nouveaux territoires en utilisant des substances allélochimiques afin d'inhiber la germination des espèces indigènes. Par conséquent, ce n'est pas seulement la taille géante du *H. sosnowskyi*, la vigueur de l'absorption substance nutritives, ni la reproduction avec un rendement élevé en graines, mais aussi l'activité biochimique qui apporte une contribution substantielle au développement des plantes invasives.

ABSTRACT

Recent studies suggest that riverbanks are considered a significant corridor for invasive plants spread. However, the mechanisms by which invasive plants affect native plant species were less well known. We conducted lab experiments to test the hypothesis that the invasive *H. sosnowskyi* which established in river Nemunas slopes, may affect plants germination through exudation of allelochemicals. All the parts of *H. sosnowskyi* produce phenolics, and thus inhibit acceptor-species seed germination. The obtained data indicated that the character of phytotoxic impact of *H. sosnowskyi* aqueous extracts on the germination data significantly subjected on plant age (1-year, 2-year), different plant parts (shoot; stem, leaf, blossom, seed; root), growth stage (rosette-ripening) and extract concentration (0.02-0.2%). The strongest phytotoxicity of *H. sosnowskyi* was determined at flowering stage due to highest TPC (30.42 mg ml^{-1}). The results suggested a new insight that invasive plant species may acquire spreading advantage in new territories by using allelochemicals to inhibit germination. Therefore, it is not only *H. sosnowskyi* giant size, vigor uptake of nutrition material, and reproduction of high seed yield but also biochemical activity that makes a substantial contribution to the plant invasion invasiveness.

KEYWORDS

Allelopathy, H. sosnowskyi, Invasion, riverbank.

1 MATERIAL AND METHODS

1.1 Measure of phenolic compounds

Total phenolics content (TPC) in extract samples were determined by traditional Singleton and Rossi's method (1965) relied on a colorimetric reaction and direct measurement of photo absorption in the ultraviolet. In determining the TPC, standard curve with chlorogenic acid (C3878, Sigma, Aldrich, Germany) was introduced. 1 ml of extract solution contains was mixed with 45 ml of distilled water. One milliliter of Folin-Ciocalteu reagent (Merck, Darmstadt, Germany) was added and the content of the flask and mixed thoroughly. After 3 min 3 ml of Na2CO3 was added then the mixture was allowed to stand for 2 h. The absorbance was measured at 760 nm. Samples were analyzed in two replicates. Identification and quantification of individual target polyphenolic compounds was performed by UV-Vis spectrophotometry (Bechman DU-40, Germany). To evaluate the effects of selected chemicals as a standard equivalent on total phenolics in H. sosnowskyi, the content was calculated on the basis of the standard curve of chlorogenic acid. Equivalent value was calculated by multiplication of the absorbance of each sample by a single value of equivalent chemical weight per absorbance unit determined under the same condition. In crude extracts and each fraction TPC of H. sosnowskyi was expressed on a fresh weight basis as milligram per gram chlorogenic acid equivalent.

1.2 Germination bioassay

Allelopathic activity of *H. sosnowskyi* and plant parts was estimated on the basis of seed germination bio–screening and recalculating to conventional coumarine units (CCU) according to A. Grodzinsky's method (1990). The biochemical (allelopathic) characteristics of *H. sosnowskyi* aqueous extracts were examined at different growth stages: rosette (end of May), flowering (end of June) and seed milky maturity (end July). Noteworthy, the amount of phenols and its impact on seed germination rate were assessed across plants of different age, namely 1st (achieved only rosette growth stage) and 2nd years.

2 RESULTS AND DISCUSSION

Phytotoxicity of aqueous extracts produced from *H. sosnowskyi* tissues was studied first. The results of this study show that the all parts of *H. sosnowskyi* produce allelopathic compounds, namely phenolics. Phytotoxic impact of *H. sosnowskyi* aqueous extracts on the germination of the acceptor plant seeds significantly relied on plant age, different plant parts, growth stage and extract concentration.

Among reasons of species invasiveness success in new environment may be its chemical interaction with the recipient community determined by the absence of tolerance of resident flora to new chemicals produced by invader, in this particular case by *H. sosnowskyi*. The hypothesis, that allelopathy is expected to be an important mechanism in the plant invasion may encourage development of general research models of invasive susceptibility in ecosystems. Invasive species *H. sosnowskyi* exhibited high biochemical activity due to accumulation of phenolics (Fig. 1). The species phytotoxicity (0% germination of acceptor seed; Fig. 2) was determined the strongest of 2-year shoots at flowering stage due to highest phenolics content (30.42 mg ml^{-1}). Therefore, it is not only *H. sosnowskyi* giant size, vigor uptake of nutrition material, and reproduction of high seed yield but also biochemical activity that makes a substantial contribution to the plant invasion invasiveness. The results suggested a new insight that invasive plant species may acquire spreading advantage in new land by using 'novel weapons' to inhibit germination. Nonetheless, *H. sosnowskyi* evidence for allelopathic effects should not be restricted to analysis of the plant exudates in the lab, but also based on research in natural environment.

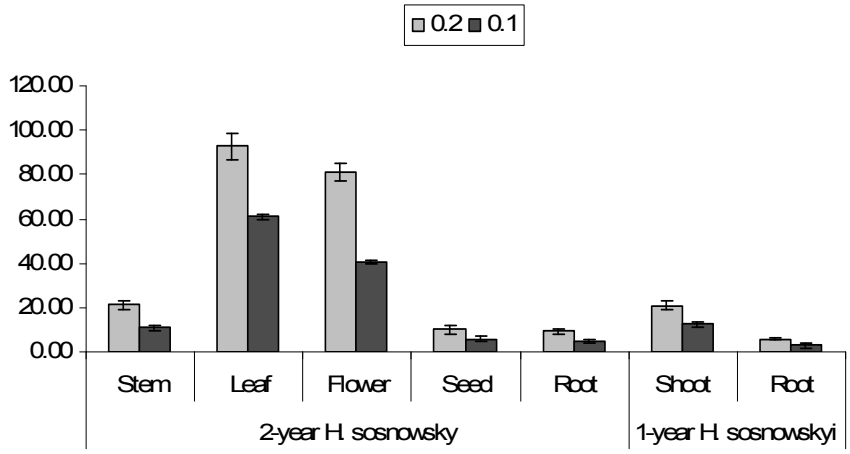

Figure 1. Comparison of phenols accumulation in different part of 1-year and 2-year *H. sosnowskyi* (mean ±SE)

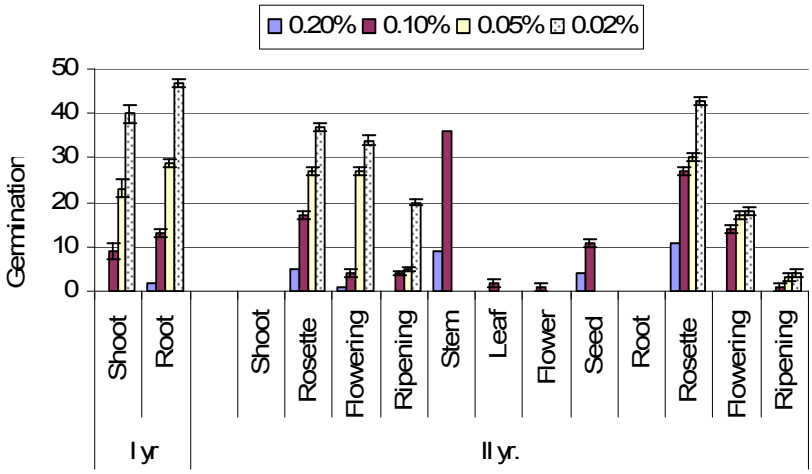

Figure 2. Inhibitory effect of *H. sosnowskyi* on acceptor germination

LIST OF REFERENCES

Grodzinsky, A.M., *Allelopathy and Productivity of Plants*. Naukova Dumka, Kijev, 1990, 125-134.

Singleton, V.L., and Rossi, J.A. (1965). *Colorimetry of total phenolics with phosphomolybdic–phosphotungstic acid reagents.* Am. J. Eno. Viticult., 16, 144–158.

Davis, M.A. (2006). Invasion biology 1958 – 2005: the pursuit of science and conservation. In Conceptual Ecology and Invasion Biology: Reciprocal Approaches to Nature (ed. M.W. Cadotte, S.M. McMahon and T. Fukami), pp. 35 – 64 . Springer, Berlin.