Ecologie

VALORISATION POSSIBILITIES OF INVASIVE INDIGOBUSH (*AMORPHA FRUTICOSA* L.) IN ROMANIA

ALEXANDRU LIVIU CIUVĂŢ, DIANA VASILE, CRISTIANA DINU, ECATERINA APOSTOL, BOGDAN APOSTOL, ANY-MARY PETRIŢAN

1. Introduction

Amorpha fruticosa L. (false indigobush, desert false indigo) is a North American bush (height of 1 to 4 m) that was first introduced in Romania as an ornamental species (Prodan 1923, Bolea et al. 2014), after which it was used in degraded land reclamation due to its adaptability in poor site conditions and the capacity to rapidly cover the soil thus providing mainly an antierosional effect (Mănescu 2002, Xiong et al. 2012).

The species ecological amplitude and its early (second-third year) and abundant fructification that caused its wide spread in the south of the country, especially in wet areas (riparian) like floodplains and river islands. In the last decade its invasive character was highlighted, due to its negative impact on protected areas ranging from the West (e.g. Mureş Floodplain Natural Park), South (e.g. Comana Natural Park), and East of the country (e.g. Danube Delta Biosphere Reserve and Small Wetland of Braila Natural Park), furthermore being encountered in all the protected islands along the Danube River and in numerous Natura 2000 sites (Fig. 1.). According to Romania's third National Report under the Biological Diversity Convention (2005), the false indigo is considered among the most important invasive terrestrial plant species (ITPS) in the country (Dumitraşcu et al. 2013).

This review paper has intended to provide sustainable solutions to value its biopotential. This is due to the fact that little research is available about the positive aspects of *Amorpha fruticosa*, the majority of the environmental scientific community (at least at European level) being focused on its negative impact in protected habitats (Anastasiu & Negrean 2006, Jongepierová et al. 2012, Bostan et al. 2014).

As Romania is part of different international agreements regarding the conservation of biodiversity, all the national environmental strategies an protected areas management plans take into consideration the need to control (in most cases to eradicate) the river locust populations (Doniță et al. 2008).

The control measures for *Amorpha fruticosa* consists mainly of mechanical removal (chemical control being forbidden in protected areas) with little effect on the local populations due to their high vegetative and generative regeneration capacity (Enache 2010).

Fig. 1. Areas where Amorpha fruticosa L. is abundant

Fig. 2. Indigobush covering the banks in Small Wetland of Braila Natural Park

2. Material and method

After consulting the available bibliography on false indigo, the published results were structured in three separate categories of possible uses: *medicinal, food and industrial*. The land reclamation use of *Amorpha fruticosa* was not taken into account as it implies increasing the spread of the species.

Data of *Amorpha fruticosa* distribution in Romania were generated in a JI Project implemented in the last

15 years by the National Forest Administration – RNP Romsilva and the World Bank in the framework of the Kyoto Protocol. *Afforestation of Degraded Agricultural Land Project* in Romania covers 6500 ha in the SW, S, SE and E of the country and it's intended to mitigate climate change through reduction of CO_2 emissions by sequestration in the ecosystem carbon pools (e.g. biomass, deadwood and soil). Within the project's 184 permanent sampling plots, false indigo has been recorded especially in those located in the Danube floodplain (which make up 1/3 of the project) where it invaded the gaps within the young plantations but also under the canopy of up to 10 year old white poplar regenerations (Ciuvat 2012).

3. Results

Medicinal uses. The indigo bush fruits (pods) are the most studied part of the plant for their medicinal uses. Effect of new rotenoid glycoside from the fruits of *Amorpha fruticosa* on the growth of human immune cells was shown by Lee et al. (2006). Besides rotenoid and flavanon compounds with antimicrobial and anticancer properties (Fang & Casida 1998, Gao et al. 2003, Sangthong et al. 2011), the volatile oil extracted from false indigo seeds manifested moderate antibacterial activity against Gram-positive bacteria (e.g. *Staphylococcus aureus, Sarcina lutea, Bacillus cereus, B. subtilis*) (Ivănescu et al. 2014). The anti-bacterial and wound healing activity of the fruits were also highlighted by Qu et al. (2013).

Further development in using the plant extracts shows antioxidant activity that could be useful in therapy of free radical pathologies and neurodegenerative disorders and also has the potential to be utilized for the mammalian cell culture media formulation by replacing the animal serum and as green alternative to existing synthetic corrosion inhibitors (Jakovljević et al. 2015).

Food uses attributed to the false indigo consist mainly of melliferous products (e.g. honey, pollen and propolis), food additives (e.g. traditional spice) and an alternative forage source for game (e.g. pheasants) and livestock (e.g. sheep and goats).

Amorpha fruticosa has a high melliferous potential (Mačukanović-Jocić & Jarić 2016), the honey being reddish in colour with mild taste and fragrance. Blooming (abundant) occurs in late May – early June with a long flowering period of 20-25 days (Panchev at al. 2014), and reported quantities range between 55 kg (age 6) and 113 kg (age 9) of honey per 1 ha (Jablonski & Koltovki 2004).

As an alternative forage source De Hann et al. (2006) shows that indigobush has a high second-year leaf concentration, averaging 660 g kg^{-1} DM. Forage quality was high, with average crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) concentrations in July of 205, 226, and 235 g kg^{-1}, respectively.

Industrial uses could be found in the chemical and pharmaceutical fields and also as a green energy resource (e.g. biomass for pellets). The resinous pustules located on the plant (fruits, leaves, root) contain chemical substances ('amorpha') that can be used for pharmaceutical industry, for insecticidal or insect repellent purposes (Brett 1946, Cao et al. 1996), or for its phytotoxic, antimicrobian, antipathogen role (Marinaș et al. 2014, Hovanet et al. 2015, Liang et al. 2015).

Krpan et al. (2011) emphasize that including indigobush biomass into alternative energy flows could bring multiple benefits and development opportunities, as it would widen the range of forestry products, would reduce the cost of regeneration of lowland forests, and offer the possibility to residents of rural and urban areas of earning an income related to harvesting of *A. fruticosa* as well as introduction of biomass power plants. *Amorpha fruticosa* dry biomass production varies from 7.28 t/ha to 12.18 t/ha, with moisture less than 35%, ash content of 1.5% (Krpan et al. 2014), and calorific value of up to 16.9 MJ kg^{-1}, making it very suitable for pellet production (Mészáros et al. 2007). As a leguminous shrub, *Amorpha* is symbiotic with nitrogen fixing bacteria, being used to enrich the poor soils and to fix the mining waste materials (Wang et al. 1999, Jelea & Jelea 2008).

Fig. 3. False indigobush spreading into and under white poplar regeneration

Species management in protected areas

In recent years in protected areas along the Danube River and other major inland rivers, control measures against the spread of the river locust were implemented. The only effective measure against this invasive species proved to be the mechanical removal of the plants followed by replanting native species (Doniță et al., 2008, Enache 2010, Pedashenko 2012).

4. Conclusions

Taking in consideration *Amorpha fruticosa* already covers significant areas (inside and outside protected habitats) in Romania and the species tendency is to naturally continuous spreading into new territories we are focusing in this paper on the opportunity to sustainably control its spread by valuing its biopontential.

The main valuing possibilities for false indigo identified based on published research, are medicinal, food and industrial. Currently in Romania the species is appreciated for its high melliferous potential, but new research is undertaken on using the plant chemical compounds that can have an important role in developing new natural remedies for various health problems (e.g. heart diseases) and other green technologies (e.g. corrosion inhibitors).

Capitalizing of the species benefits can be realized in three different stages: first stage (during spring) would be the gathering pollen for honey production, second stage consisting of fruit gathering for medicinal purposes (during autumn) and final stage being the harvesting of biomass for industrial use (during winter). This way, the false indigo covered areas can be managed as short rotation crops (SRC) for biomass, with a harvesting cycle of 1 to 3 years depending on site conditions. Harvesting technology required is similar to that used for common reed. Seeds and leaves that would result after the harvesting process represent an important alternative forage source for game (e.g. pheasants).

References

Anastasiu P., Negrean G., 2006. Alien vascular plants in Dobrogea (Romania) and their impact on different types of habitats. Plant, fungal and habitat diversity investigation and conservation. Proceedings of IV BBC – Sofia. 590-596.

Bostan C., Borlea F., Mihoc C., Beceneaga A.M., 2014. Spread of *Ailanthus altissima* species in new areal and impact on biodiversity. Research Journal of Agricultural Science, 46 (1), 104-108.

Bolea V., Chira D., Sârbu G., 2014. Reconstrucția ecologică, îngrijirea și conducerea ecosistemelor forestiere riverane. RSC 34: 53-73.

Brett C.H., 1946. Insecticidal properties of the indigobush (*Amorpha fruticosa*). *J. Agric. Res.* 73: 81–96.

Cao Y.P, Bai G.J., Wang G.Q., Lu C.Y., 1996. Extraction and isolation of toxic constituents from the leaves of *Amorpha fruticosa*. *J. Northwest Forestry College* 11: 110–112.

Ciuvăț L., 2012. Monitorizarea proiectului de împădurire a terenurilor degradate, estimarea acumulării de carbon și resimularea acumulării. Manuscris ICAS București.

Cogalniceanu D., Skolka M., Fagaras M., Anastasiu P., Preda C., Samoila C., 2007-2010. SMDRSI – Sistem de Monitorizare si Detectare Rapida a Speciilor Invazive.

DeHaan L.R., Ehlke N.J., Sheaffer C.C., Wyse D.L., DeHaan R.L., 2006. Evaluation of diversity among North American accessions of false indigo (*Amorpha fruticosa L.*) for forage and biomass. *Genetic Resources and Crop Evolution* 53(7): 1463–1476.

Doniță N., Biriş I.-A., Filat M., Roşu C., Petrila M., 2008. Ghid de bune practici pentru managementul pădurilor din Lunca Dunării. Ed. Silvică.

Dumitraşcu M., Doroftei M., Grigorescu I., Kucsicsa G., Dragotă C.-S. 2013. Key biological indicators to assess *Amorpha fruticosa* invasive terrestrial plant species in Romanian protected areas. In Kanarachos A. & Mastorakis N.E.: Recent Advances in Environmental Science, *Environmental and Structural Engineering Series* 7: 144–149.

Enache V. (coord.), 2010. Conservarea și managementul integrat al ostroavelor de pe Dunăre, România. LIFE06NAT/RO/000177 http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3111

Fang N., Casida J.E., 1998. Anticancer action of cubé insecticide: Correlation for rotenoid constituents between inhibition of NADH: ubiquinone oxidoreductase and induced ornithine decarboxylase activities. *Proc Natl Acad Sci* USA. 95, 7: 3380-3384.

Gao H.H., Li W., Yang J., Wang Y., Guo G.Q., Zheng G.C., 2003. Effect of 6-benzyladenine and casein hydrolysate on micropropagation of *Amorpha fruticosa*. *Biologia Plantarum*. 47, 1: 145-148.

Hovanet M.V., Marinas I.C., Dinu M., Oprea E., Chifiriuc M.C., Stavropoulou E., Lazar V., 2015. The phytotoxicity and antimicrobial activity of *Amorpha fruticosa* L. leaves extract. *Romanian Biotechnological Letters* 20(4): 10670-10678.

Ivănescu B., Lungu C., Șpac A., Tuchiluș C., 2014. Essential oils from *Amorpha fruticosa* L. fruits – chemical characterization and antimicrobial activity. *Analele Științifice ale Universității „Al. I. Cuza" Iași* s. II. *Biologie vegetală*, 60, 1: 33-39.

Jakovljević T., Halambek J., Radošević K., Hanousek K., Gradečki-Poštenjak M., Srček V.G., Radojčić Redovniković I., De Marco A., 2015. The Potential Use of Indigobush (*Amorpha fruticosa* L.) as Natural Resource of Biologically Active Compounds. *SEEFOR* 6(2): 171-178.

Jablonski B., Koltovki Z., 2004. Nectar secretion and honey potential of honey-plants growing under Poland's conditions – Part XIV. *Journal of Apicultural Science* 48 (1): 5-10.

Jelea M., Jelea S.G., 2008. Efectele proceselor microbiene de drenaj minier acid asupra instalării florei spontane în depozitele de sterile sulfidice. Conservarea diversității plantelor in situ și ex situ, Univ. „A.I. Cuza" Iași, 62.

Jongepierová I., Pešout P, Jongepier J.W., Prach K., 2012. Ecological restoration in the Czech Republic. Nature Conservation Agency of the Czech Republic: 102, 129.

Krpan A.P.B., Tomašić Ž., Palković P.B., 2011. Biopotential of indigobush (*Amorpha fruticosa* L.) – second year of investigation. *Šumarski List* 135(13): 103-113.

Krpan A.P.B., Tomašić Ž., Stankić I., 2014. Study of bioproductive and energy potentials of indigobush (*Amorpha fruticosa* L.). *Šumarski List* 138 (1-2): 43-54.

Lee H.J., Kang H.Y., Kim C.H., Kim H.S., Kwon M.C., Kim S.M., Shin I.S., Lee H.Y., 2006. Effect of new rotenoid glycoside from the fruits of *Amorpha fruticosa* Linne on the growth of human immune cells. *Cytotechnology* 52(3): 219–226.

Liang Y., Li X., Gu Z., Qin P., Ji M., 2015. Toxicity of Amorphigenin from the Seeds of *Amorpha fruticosa* against the Larvae of *Culex pipiens pallens* (Diptera: Culicidae). *Molecules*, 20: 3238-3254.

Marinas I.C., Maruntescu L., Bleotu C., Chifiriuc C., Oprea E., Badea I., Buleandra M., Lazar V., 2014. Flow cytometry applications in antimicrobial and antipathogenic activities investigation of *Amorpha fruticosa* essential oil. Al-X lea Congres National de Citometrie: 91-93.

Mănescu M., 2002. Cercetări privind evoluția arboretelor instalate pe terenurile degradate din Dobrogea. Analele I.C.A.S. 45: 165-170**.**

Mačukanović-Jocić M.P., Jarić S.P., 2016. The melliferous potential of apiflora of south Western Vojvodina (Serbia). *Arch. Biol. Sci.,* 68(1): 81-91.

Mészáros E., Jakab E., Várhegyi G., Tóvári P., 2007. Thermogravimetry/mass spectrometry analysis of energy crops. *Therm Anal Calorim* 88(2): 477.

Panchev H., Vasileva B., Georgiev A., 2014. Analysis of the melliferous vegetation. Focus on the cross-border region: Sofia District and Montana District. Bulgaria – Serbia IPA Cross-border Programme, CCI 2007CB16IPO006-2011-2-96.

Pedashenko H.P., Apostolova I.I., Vassilev K.I., 2012. Amorpha fruticosa invasibility of different habitats in lower Danube. *Phytologia balcanica* 18(3): 285-291.

Qu X., Diao Y., Zhang Z., Wang S., Jia Y., 2013. Evaluation of anti-bacterial and wound healing activity of the fruits of *Amorpha fruticosa* L. *Afr J Tradit Complement Altern Med.* 10(3): 458-468.

Sangthong S., Krusong K., Ngamrojanavanich N., Vilaivan T., Puthong S., Chandchawan S., Muangsin N., 2011. Synthesis of rotenoid derivatives with cytotoxic and topoisomerase II inhibitory activities. *Bioorg. Med. Chem. Lett.* 21, 16: 4813-4818.

Wang E.T., van Berkum P., Sui X.H., Beyene D., Chen W.X., Martinez-Romerol E., 1999. Diversity of rhizobia associated with Amorpha fruticosa isolated from Chinese soils and description of Mesorhizobium amorphae sp. nov. International Journal of Systematic Bacteriology, 49, 5: 1-65.

Xiong Q., Liu Z. Yao G., Li B., 2012. Antierosion effect of hedgerows in hillside croplands of Danjiangkou based on the evaluation with water erosion prediction project (WEPP) model. *Yingyong Shengtai Xuebao*; 21(9): p2383.

Abstract

Amorpha fruticosa (false indigo bush or indigobush) is one of the most important invasive terrestrial plant species (ITPS) found in Romania alongside *Ailanthus altissima, Acer negundo*, and *Fraxinus pennsylvanica*. In Romania, given its ecological requirements and initial use (degraded land reclamation), it's found especially in the floodplains of the main rivers and the Danube and most abundantly in the Danube Delta. It has a negative impact on native wetland ecosystems and control measures have been applied exclusively in protected areas.

Taking into consideration the need to diminish the aggressive spread of this ITPS, one economically viable solution would be to value its biological potential. In this respect in Romania, beekeepers have learned to take advantage of the *Amorpha fruticosa* melliferous proprieties (i.e. honey). Yet in the last decades international scientific research highlighted a number of potential uses for the indigobush, among which biomass production (i.e. pellets), and obtaining different medicinal and pharmacological products (i.e. mammalian cell culture media formulation) rank as the most important.

Through this paper the authors try to raise awareness to the valuing possibilities of *Amorpha fruticosa* as a means to control and diminish its spread in Romania and also at European level.

Keywords: indigobush, biopotential, management, economic value.

Rezumat

Posibilități de valorificare a speciei invazive *Amorpha fruticosa* L. in Romania

Amorpha fruticosa L. (amorfă, salcâm pitic) este una dintre cele mai importante specii de plante terestre invazive (ITPS) din România, alături de *Ailanthus altissima*, *Acer negundo* și *Fraxinus pennsylvanica*. În România, datorită cerințelor sale ecologice și utilizării inițiale (reconstrucția terenurilor degradate), acest arbust se întâlnește în special în luncile principalelor râuri și Dunării, dar cel mai abundent în Delta Dunării. Specia are un impact negativ îndeosebi asupra ecosistemelor din zonele umede, iar măsurile de control au fost aplicate în unele arii protejate. Având în vedere necesitatea diminuării răspândirii agresive a amorfei, o soluție viabilă din punct de vedere economic o constituie evaluarea potențialului său biologic. În acest sens, apicultorii români au învățat să profite de proprietățile melifere ale salcâmului pitic iar în ultimele decenii, cercetarea științifică internațională a dovedit o serie de utilizări potențiale pentru această specie, printre care producția de biomasă (ex. peleți) și obținerea diferitelor produse medicinale și farmacologice (ex. medii de cultură celulară la mamifere). Prin această lucrare autorii încearcă să evidențieze posibilitățile de valorificare ale amorfei, ca mijloc de a controla și diminua răspândirea ei în România și la nivel european.

Cuvinte cheie: amorfă, potențial biologic, management, valoare economică.