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ORIGINAL ARTICLE

Invasive alien plants in plant health revisited: another 10 years

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Abstract

Ten years ago, the authors gave an overview of the early history of invasive alien plants in plant health. In the last decade, the field has seen further development, which is reported here. This includes new activities at the global scale, e.g. in the International Plant Protection Convention and the Convention on Biological Diversity, on a regional scale, e.g. in the EU and the region of the European and Mediterranean Plant Protection Organization, and on a national scale. New activities include a prioritization scheme for the pest risk analysis of invasive alien plants, new Standards and regulations, and a further development of the cooperation between the environmental and plant health sectors.

Plantes exotiques envahissantes dans le domaine de la santé des végétaux: Revue dix ans plus tard

Il y a dix ans, les auteurs ont présenté une vue d'ensemble des débuts des plantes 1 envahissantes dans l'histoire de la santé des végétaux. Cette activité a connu de nouvelles évolutions au cours de la dernière décennie, lesquelles sont rapportées dans le présent article. Ces évolutions comprennent de nouvelles activités à l'échelle mondiale, par exemple dans le cadre de la Convention internationale pour la protection des végétaux (CIPV) et de la Convention sur la diversité biologique (CDB) ; à l'échelle régionale, par exemple au sein de l'UE et dans la région de l'Organisation européenne et méditerranéenne pour la protection des plantes (OEPP), ainsi qu'à l'échelle nationale. Parmi ces nouvelles activités, citons un schéma de hiérarchisation des priorités pour l'analyse du risque phytosanitaire (ARP) des plantes exotiques envahissantes, de nouvelles normes et réglementations, ainsi que le développement de la coopération entre les secteurs de l'environnement et de la santé des végétaux.

Ещё раз об инвазивныхе чужеродныхе растениях в вопросах карантина растений: еще 10 лет спустя

Десять лет назад авторы представили обзор ранней истории инвазивных чужеродных растений (ИЧР) в вопросах карантина растений. За последнее десятилетие эта область получила дальнейшее развитие, о чем и сообщается здесь. Это включает новые мероприятия на мировом уровне, например, в рамках

Dedicated to the memory of Jens Georg Unger, who fought tirelessly to ensure that plant health also deals with invasive alien plants and that the invasion biology community is more aware of the plant health sector.

Международной конвенции по карантину и защите растений (МККЗР) и Конвенции о биологическом разнообразии (КБР), на региональном уровне, например, в ЕС и регионе Европейской и Средиземноморской организации по карантину и защите растений (ЕОКЗР), а также на национальном уровне. Новые мероприятия включают схему определения приоритетов для анализа фитосанитарного риска (АФР), связанного с инвазивными чужеродными растениями, новые стандарты и регламентации, а также дальнейшее развитие сотрудничества между секторами окружающей среды и карантина растений.

1 | INTRODUCTION

Ten years ago, the authors described what we saw as the beginning of the plant health world working on invasive alien plant (IAP) species (Schrader et al., 2010). A core message of that paper was the fact that the congruence of the terms invasive alien species (IAS) and quarantine pest was becoming increasingly accepted between the sectors of nature conservation – as set out in the Convention on Biological Diversity (CBD) – and of plant health, with the International Plant Protection Convention (IPPC) as a basis.

In the meantime, numerous further activities and discussions at the IPPC level as well as at the European level, including the improvement of pest risk analysis (PRA) procedures for IAPs, and the enactment of new EU regulations on IAS and plant health, have taken place. Activities are also being promoted and carried out at the national level. It is therefore timely to follow up on the more recent history since 2010.

2 | THE GLOBAL SCALE: IPPC, CBD AND WTO

There are several global players dealing with IAPs, coming from different angles but trying to achieve the common goal to provide protection against the introduction and spread of IAPs and the damage they cause.

2.1 | International standards on phytosanitary measures

International Standards on Phytosanitary Measures (ISPMs) are adopted and provided by the IPPC to help contracting parties deal with phytosanitary issues. The Standard ISPM No. 11: Pest Risk Analysis for Quarantine Pests, in general deals with the assessment of risks posed by new organisms (pests including pathogens) to plants. In 2009, an expert working group convened by the IPPC Secretariat drafted Annex 4 to this Standard: Pest risk analysis for plants as quarantine pests. After internal discussions and country consultations, the 8th Commission on Phytosanitary Measures (CPM-8) adopted this Annex and consequential changes to the core text in 2013. Key elements of this PRA procedure and differences compared to the PRA procedure for other plant pests consist of specific guidance on the consideration of habitats, locations and endangered areas for IAPs, and the consideration of intentionally introduced plants (for planting or other intended uses); unintentional introductions are not considered. Furthermore, the manifestation of a plant as a pest is different from other pests. This occurs through competition for space and resources, through altering habitat conditions, through parasitism or allelopathy, or through hybridization with cultivated plants or wild plants, while damage caused by other pests is more direct, for example feeding on or infection of plants. IAPs can also act as pathways for other pests.

2.2 | Co-operation between plant health and the environmental sector

The World Trade Organization's (WTO) Standards and Trade Development Facility (STDF) organized a workshop in 2012 together with the IPPC and the World Organization for Animal Health (OIE) on the application of the SPS Agreement (STDF, 2012; Starfinger & Unger, 2013). It was stressed that the Sanitary and Phytosanitary (SPS) Agreement allows for measures against all kinds of noxious organisms, hence the term IAS should be used with a wide definition. Whereas although it was the CBD which coined the term IAS, it has no specific Standards on IAS acknowledged by the WTO's SPS. The major partners for the WTO in this respect are hence the 'three sisters' Codex Alimentarius, IPPC and OIE. A paper published after the workshop (Lopian & Stephen, 2013) recommends following IPPC and OIE standards in IAS-related activities such as risk analysis, monitoring and management, policy formulation and capacity building in developing countries. The authors explicitly state that the 'IPPC's risk analysis tool covers a wide range of organisms that directly or indirectly affect plants, and consequently the environment.' By this, governmental authorities have a powerful instrument at hand to regulate and manage IAPs in compatibility with the SPS Agreement. Several regional plant protection organizations [including the European and

Mediterranean Plant Protection Organisation (EPPO) and the North American Plant Protection Organisation (NAPPO)] regularly assess the risks by IAPs in compliance with the IPPC standards on risk analysis.

The United Nations declared the period 2011–2020 as the UN Decade for Biodiversity with a view to contributing to the implementation of the Strategic Plan for Biodiversity 2011–2020. At its 10th Conference of the Parties in Nagoya in 2010 the CBD declared targets for saving biodiversity that have become known as the Aichi Targets. Target 9 specifically addresses the threat by IAS, including IAPs, and demands that by 2020 IAS and their pathways are identified and prioritized. To achieve this, the CBD has set up an Inter-Agency Liaison Group on Invasive Alien Species, which includes the IPPC Secretariat and other agencies. The main focus of this group is to identify gaps and inconsistencies in existing policies and regulations related to IAS and to promote inter-sectoral cooperation and capacity development.

The United Nations declared 2020 as the International Year of Plant Health (IYPH) with the aim to raise global awareness. In this context, protecting plant health is meant as a way not only to combat hunger and poverty but also to secure the protection of the environment (FAO, 2020). The IYPH has been used as an occasion to advocate cooperation between invasion science and other concerned bodies [e.g. Jactel et al., (2020) for forest pests]. The IYPH was also used as a chance to draw attention to the need for better incorporation of IAPs into the plant health sector (Starfinger, 2020).

3 | ACTVITIES ON THE REGIONAL LEVEL

On the regional level, the example of the EPPO and the European Union (EU) shows that an interdisciplinary approach is possible to address the challenge posed by IAPs to new environments. The European and Mediterranean Plant Protection Organization, since starting work on IAPs, has organized and reviewed data on alien plants for an early warning system. For this purpose, a panel of experts from EPPO member countries was established in 2002, the Panel on Invasive Alien Plants, which has met a total of 25 times (IAP Panel; EPPO, 2021). In an article by Brunel et al. (2010a), particular attention was drawn to the Mediterranean Basin, since this is specifically vulnerable to invasion by alien plant species. This is due to the climatic conditions allowing the establishment of subtropical and sometimes even tropical species. A series of species were identified in that study with priority for action, including *Alternanthera philoxeroides* (Amaranthaceae), *Ambrosia artemisiifolia* (Asteraceae), *Baccharis halimifolia* (Asteraceae), *Cortaderia selloana* (Poaceae), *Pontederia* (*Eichhornia*) *crassipes* (Pontederiaceae), *Fallopia baldschuanica* (Polygonaceae), *Hakea sericea* (Proteaceae), *Humulus japonicus* (Cannabaceae), *Ludwigia grandiflora* and *L. peploides* (Onagraceae), *Hydrilla verticillata* (Hydrocharitaceae), *Microstegium vimineum* (Poaceae), *Myriophyllum heterophyllum* (Haloragaceae), *Pennisetum setaceum* (Poaceae), *Pistia stratiotes* (Araceae), *Salvinia molesta* (Salviniaceae) and *Solanum elaeagnifolium* (Solanaceae). In the following years, for most of these species, PRAs have been conducted (Table 1).

Since PRAs are strongly resource limited [an EPPO PRA is normally drafted by an expert, discussed in a week-long expert working group and later reviewed by EPPO core members and (for IAPs) the EPPO IAP Panel], a prioritization process was developed to help experts decide on a consistent basis which plant species should have priority for PRA (Brunel et al., 2010b). This prioritization process is regularly applied during the work of the IAP panel to select species for new PRAs (Table 2).

IAPs are treated by NAPPO in a very similar way: terrestrial and aquatic plants that meet the IPPC definition of pest are included in NAPPO's scope of pests and regional cooperation between competent authorities is recommended (NAPPO, 2011).

On the EU level, the project PRATIQUE within the 7th framework programme, mentioned in Schrader et al. (2010), dealt with the revision of the EPPO Decision-support scheme (DSS) for PRA, including its adaption and better applicability for IAPs. Steffen et al. (2012) describe the testing of the new scheme on *Polygonum perfoliatum* (mile-a-minute weed) and *Pontederia crassipes* (formerly *Eichhornia crassipes*, water hyacinth), focusing on the improvements that have been made by the revision of the scheme. It was found that the new version with its clearer rating guidance has increased transparency, is more user-friendly and more consistent, as well as allowing individual risk elements to be documented and summarized for a comparable and conclusive result. Consequently, it was applied to upcoming pest risk analyses for the above-mentioned plants.

A more specific project at the EU level was HALT Ambrosia, which conducted complex research on methods to stop the ragweed invasion in Europe (Sölter et al., 2012). The international research consortium consisted of partners from the fields of plant health, herbology and agroecology. Common ragweed, *Ambrosia artemisiifolia*, has strong impacts on human health and on agriculture, and has therefore united researchers from various fields, including plant health, in several international activities that aim to reduce these impacts, e.g. the COST Action SMARTER (Müller-Schärer & Lommen, 2014) or the International Ragweed Society (Thibaudon et al., 2020).

As reported in Schrader et al. (2010), several IAPs were also assessed by the European Food Safety Authority (EFSA), including the assessment of the PRAs on *Ambrosia* spp. This triggered the EFSA's Plant Health

TABLE 1 Invasive alien plant species recommended for listing as quarantine pests by EPPO and listed as IAS of union concern in EU Regulation 1134/2014

Species	Listed by EPPO[a]	PRA in IAP-RISK project	IAS of union concern
Acacia saligna			2019
Ailanthus altissima	IAS in 2004		2019
Alternanthera philoxeroides	A2 in 2015		2017
Amaranthus palmeri	A2 in 2020		
Amaranthus tuberculatus	A2 in 2020		
Ambrosia confertiflora	A2 in 2018	+	
Ambrosia trifida	A2 in 2019		
Andropogon virginicus	A2 in 2018	+	2019
Asclepias syriaca			2017
Baccharis halimifolia	A2 in 2013		2016
Cabomba caroliniana	IAS in 2006		2016
Cardiospermum grandiflorum	A2 in 2017	+	2019
Cortaderia jubata	A1 in 2018	+	2019
Crassula helmsii	A2 in 2006		
Ehrharta calycina	A2 in 2018	+	2019
Elodea nuttallii	IAS in 2004		2016
Gunnera tinctoria	IAS in 2014		2017
Gymnocoronis spilanthoides	A2 in 2017	+	2019
Hakea sericea	A2 in 2018	+	
Heracleum mantegazzianum	IAS in 2004		2017
Heracleum persicum	A2 in 2009		
Heracleum sosnowskyi	A2 in 2009		
Humulus scandens	A2 in 2018	+	2019
Hydrocotyle ranunculoides	A2 in 2005		2016
Impatiens glandulifera	IAS in 2004		2017
Lagarosiphon major	IAS in 2004		2016
Lespedeza cuneata	A1 in 2018	+	2019
Ludwigia grandiflora	A2 in 2011		2016
Ludwigia peploides	A2 in 2011		2016
Lygodium japonicum	A1 in 2018	+	2019
Lysichiton americanus	Obs in 2012[b]		2016
Microstegium vimineum	A2 in 2015		2017
Myriophyllum aquaticum	IAS in 2004		2016
Myriophyllum heterophyllum	A2 in 2015		2017
Parthenium hysterophorus	A2 in 2014		2016
Pennisetum setaceum	IAS in 2012		2017
Pistia stratiotes	A2 in 2017	+	
Polygonum perfoliatum	A2 in 2008		2016
Pontederia crassipes	A2 in 2008		2016
Prosopis juliflora	A2 in 2018	+	2019
Pueraria montana var. *lobata*	A2 in 2006		2016
Salvinia molesta	A2 in 2017	+	2019
Solanum elaeagnifolium	A2 in 2006		
Triadica sebifera	A1 in 2018	+	2019

[a]IAS, EPPO List of Invasive Alien Plants; Obs, EPPO Observation List of invasive alien plants; A1/A2, lists of pests recommended for regulation as quarantine pests (A1 absent, A2 present in the EPPO region).

[b]Listed as A2 in 2005 but de-listed in 2009.

TABLE 2 Summary of actions regarding invasive alien species on the global, regional and European level from 2010 to 2020

Year	Global level	Regional level	European level
2010	First meeting of the Inter-Agency Liaison Group on IAS	EPPO PM9 *Sicyos angulatus* approved	EFSA opinion on Ambrosia seeds in feed
2011		New illustrated version of the EPPO/Council of Europe Code of conduct on horticulture and invasive alien plants	
2012	STDF/WTO workshop stresses role of IPPC		
2013	ISPM 11, annex 4, adopted		
2014		EPPO PM9 Invasive alien aquatic plants	EU Regulation 1143/2014 published
2015		EPPO PM9 *Parthenium hysterophorus*	
2016		Life project IAP-RISK launched, coordinated by EPPO; EPPO PM9 *Baccharis halimifolia*	EU Reg. 2016/2031 published
2017		IAP-RISK training workshops run by EPPO; EPPO PM9 *Microstegium vimineum*	
2018		IAP-RISK: communication kits published	
2019			
2020	International Year of Plant Health	Strategy against IAS for the Maghreb 2020–2030 EPPO PM9 *Ailanthus altissima*; EPPO PM9 *Ambrosia confertiflora*	

Panel and other panels in 2010 to publish an opinion on the risk of spreading seeds of *Ambrosia* spp. in animal feed, causing human or animal health impacts (EFSA, 2010).

3.1 | New EU regulations

Discussions at the EU level on how to address IAPs legally led to the adoption of a regulation under the Directorate-General for Environment of the European Commission (DG ENV). In 2014, Regulation (EU) No 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of IAS (IAS Regulation) was adopted and it entered into force on 1 January 2015 (EU, 2014). A core element of this regulation is the list of IAS of union concern, i.e. species that have particularly strong impacts on biodiversity and ecosystem services. For these species certain restrictions apply, such as prohibition of import, breeding, selling etc. The basic requirements for risk assessment as set out in Article 5 of the regulation were met to a large extent by already existing risk assessment procedures from the plant health sector, such as the EPPO standard PM 5 (EPPO, 2011; Roy et al., 2018). EPPO's expertise in PRA was acknowledged by the DG ENV in awarding a LIFE project to EPPO and partners (IAP RISK, EPPO, 2019a). In this project, 39 plant species were prioritized for PRA using a version of the EPPO prioritization process modified to be compliant with the needs of the EU Regulation (Tanner et al., 2017). PRAs were subsequently conducted on 16 alien plant species. Of these, only two species were found to present a low risk, the other 14 were recommended for regulation as A1 or A2 quarantine pests. Eleven of these species are listed as IAS of union concern (EU, 2019, see also Table 1).

The IAS Regulation explicitly acknowledges that the Plant Health Directive 2000/29 (predecessor of the EU Regulation 2016/2031) also covers harmful organisms and that these regulations should be aligned and not overlap [EU, 2014, preamble (8)]. In consequence, this regulation is not applied to harmful organisms listed in the plant health regulation, not even to those that would fit the definition of IAS.

The new plant health regulation (EU, 2016/2031) was launched and came into force in 2019 (EU, 2016). In the course of the discussions for this new regime, it was strongly advocated by some EU member states to follow IPPC definitions and generally include invasive plants as potential quarantine pests. In the final version it is indeed stated that plants, including non-parasitic plants, can be treated as pests for the purpose of the regulation [EU, 2016, Article 1 (2)]. In preamble (8), however, it is made clear that the status of quarantine pests in relation to plants should preferentially be given to plants that are parasitic to other plants. In consequence, the European Commission, GD SANTE, has so far not listed any non-parasitic plant species as quarantine pest.

In the North African Maghreb, an adjacent (and partly overlapping) region to the EPPO, a strategy to combat IAS in the decade 2020 to 2030 was published (OSS, 2020). It has a focus on IAPs and recommends national and international cooperation between the sectors.

4 | EXAMPLE OF ACTVITIES ON THE NATIONAL LEVEL: GERMANY

From the global to the national level, the example of Germany dealing with IAPs shows that international and regional activities can be translated to national actions. In Germany, a technical meeting took place in February 2012 to discuss biological diversity in agricultural landscapes. In this framework, the threat of IAPs to biodiversity was also discussed and it was emphasized that for the implementation of prevention, national and international regulations, voluntary self-restraints and public relations play an important role. It was found that a crucial point is the differentiation of safe and risky activities in the trade and use of plant species. To address this, PRA procedures have been developed and adapted further (Starfinger & Schrader, 2012). In this context, it was also emphasized that, in particular due to the predicted climate change, changes in the invasion potential of plant species are to be expected. Therefore, scientific work on the risks of introduction, establishment and spread as well as information from specialized authorities and the public on risks and possible measures will continue to be necessary or need to be intensified. Regardless of the design of new national and international legal regulations, an interdisciplinary approach is required. Generally, developments related to IAP/IAS regulation are discussed on a case-by-case basis between the agencies involved, i.e. the Federal Agency for Nature Conservation (BfN) and the Institute for National and International Plant Health of the Julius Kühn-Institute (JKI). BfN projects are usually supervised by a team of external experts, which may include a member of the JKI, e.g. in the project to prioritise pathways of IAS (Rabitsch, 2018). In a similar way, phytosanitary expertise is incorporated in an expert team supervising a project on the control of Japanese knotweed along roads that is funded by the Federal Highway Research Institute (BASt, 2020).

The fact that it is not always easy to draw a line between the competencies of the sectors but that there are common goals is illustrated by the example of the local eradication of the invasive primrose willow *Ludwigia grandiflora* in North-West Germany: as funding was not available within the environmental sector, the activity was successfully conducted using JKI funds (Hussner et al., 2016).

5 | DISCUSSION

The need to integrate the sectors concerned with IAPs is increasingly acknowledged. Synergies between the academic fields of invasion biology and plant protection science can help improve the understanding of invasion processes and the assessment of their impacts (Ireland et al., 2020). Prevention and mitigation of these impacts is sought through regulations which should consequently be designed to incorporate the sectors (Meyerson & Reaser, 2002). A well-known example of a comprehensive biosecurity system is that of New Zealand (Hulme, 2020). In contrast, the fragmented regulatory landscape in Europe makes the alignment of different regulations necessary (Baquero et al., 2021).

The new EU regulations discussed above permit better protection against IAS than the previous regulations. They also allow for synergies between the plant health and the environmental sectors: the application of phytosanitary risk analysis by EPPO has led to the listing under the EU Regulation on IAS as IAPs of union concern for a number of plant species. In these cases the plant health sector supports the environmental sector with its expertise in PRA. At the same time, the IAS regulation serves the needs of the phytosanitary sector by regulating pests that are currently not regulated by that sector itself. For those plants, however, that cause solely economic impacts without damaging the biological diversity, a gap exists in the European legislation as long as they are not subjected to plant health regulation. Several EPPO PRAs have recently demonstrated the ability of IAPs to severely threaten agricultural production without having marked effects on biodiversity, e.g. *Ambrosia trifida*, *Amaranthus tuberculatus* and *A. palmeri* (EPPO, 2019b; EPPO, 2020a,b). As with other pests, EPPO recommends that its member countries regulate these species as quarantine pests. In addition, EPPO may recommend specific management plans in its PM9 Standards, for example the one being developed for *Ambrosia trifida* (EPPO, in preparation). Compared to EU regulations or other subregional or national acts, however, these recommendations have lower weight as they are not mandatory. In conclusion, while the role of plant health in dealing with IAPs has become evident in many respects in the last decade, work has still to be done to consistently achieve better protection against their impacts.

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