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PLANT PROPAGATIVE MATERIAL AS A PATHWAY FOR THE MOVEMENT OF EXOTIC PLANT PESTS INTO AND WITHIN THE GREATER CARIBBEAN REGION

A. Lemay, H. Meissner, and A. Koop, United States Department of Agriculture, Animal and Plant Health Inspection Service, 1730 Varsity Drive, Suite 300, Raleigh, North Carolina, USA

ABSTRACT: Imports of plant propagative material (PM) may present a phytosanitary risk in two ways: 1) by introducing exotic plant pests associated with the PM, and 2) by introducing plants that themselves may become invasive. We found a high likelihood that pests, especially plant pathogens, are being spread between countries of the Greater Caribbean Region (GCR) through both legal and illegal movement of PM. Because of the relative ineffectiveness of visual inspection and the scarcity of diagnostic tests for pathogens, there is no easy solution to this problem. The PM pathway also leads to the spread of invasive plants in the GCR, where they cause considerable economic and environmental damage. Most invasive exotic plant species in the GCR were introduced on purpose. There are few safeguards in place to prevent this invasion from happening. Weed risk assessments and predictive weed screening tools may help mitigate this risk. This work was carried out in the framework of the CISWG Caribbean Pathway Analysis. The complete report can be accessed at: http://carribean-doc.ncsu.edu/index.htm.

Keywords: Propagative material, invasive plants, invasive species, pest risk

INTRODUCTION

Plant propagative material (PM), also referred to as nursery stock, is any plant material capable of and intended for propagation, including buds, bulbs, corms, cuttings, layers, rhizomes, root clumps, scions, stolons, seeds, tubers, or whole plants. Propagative material is mainly imported for commercial nursery and horticulture uses, and uses in agriculture and forestry. Smaller quantities are imported for "plant exploration" by botanical gardens or researchers, or for planting by private collectors or homeowners.

In the Greater Caribbean Region (GCR)[5] the demand for PM is strongly linked to tourism development, and there can be great economic and political pressure to allow needed imports. Spikes in demand also tend to occur during renovation and reforestation efforts after hurricanes and other extreme weather events (Klassen et al., 2004).

The trade of PM is a multi-billion dollar industry. The United States, Canada, Israel, and the Netherlands, are the major exporters of nursery products to the GCR (UNComtrade, 2008). Available data on the commercial trade of PM are categorized by harmonized tariff codes and do not contain the taxonomic identity of the imported commodities. Compounding the difficulties in understanding PM trade is that not all countries report their trade data (UNComtrade, 2008), and there is no way of quantifying the unofficial, unregistered trade that occurs among Caribbean nations.

The United States maintains a database of plant genera it imports. Unfortunately, the data is not reported in consistent units of measurement, thus making quantitative comparisons impossible. In 2007, nearly 800 different plant genera were imported into the United States from 21 countries of the GCR (USDA, 2008), mainly from Costa Rica, Guatemala, and Colombia.

[5] The GCR includes all countries bordering the Caribbean Sea, plus the Bahamas, Turks and Caicos, El Salvador, Suriname, Guyana, and the U.S. Gulf States (Florida, Alabama, Mississippi, Louisiana, and Texas)

Because the database lists only the genera and not the species of PM imported, a discussion of the potential risk posed by these imports is difficult.

The purpose of this discussion is to highlight some concerns regarding the sale and planting of PM in the GCR and to provide recommendations towards the improvement of plant health and ecosystem safeguarding.

RESULTS AND CONCLUSIONS

Plant Propagative Material as a Pathway for Plant Pests

Infested or infected plant propagative material (PM) may be one of the primary and highest risk pathways through which plant pests and pathogens invade new areas (Palm and Rossman, 2003). Large numbers of pests move in association with PM. During 2007, 1,541 pests of quarantine significance were intercepted at U.S. ports of entry in commercial shipments of PM from the GCR (Table 1) (USDA, 2008). Childers and Rodriguez (2005) found that most mites are not detected during port-of-entry inspections of PM, and presumably most other types of minute organisms are also missed. Mites can vector plant viruses, such as citrus leprosis virus, coffee ringspot virus, passion fruit green spot virus, ligustrum ringspot virus, and orchid fleck virus (Miranda et al., 2007). There are numerous viruses not yet present throughout the GCR that could cause significant economic damage if introduced and spread within the GCR by mites occurring there (CABI 2007). Most pathogens are extremely likely to escape detection. Out of the 1,285 pest interceptions on PM entering Miami from the GCR in 2007, fungi were intercepted only 39 times (≤17 species), and no interceptions of viruses, bacteria, or phytoplasmas were recorded. Kairo et al. (2003) noted that the number of microorganisms reported introduced in the insular Caribbean is negligible, thus indicating a knowledge gap in species inventory.

Why do port-of-entry inspections miss pests? The reasons are numerous and diverse: overwhelming workload; pressure to perform quick inspections; inadequate working conditions (*e.g.*, lighting, space); difficulty of detecting minute and hidden pests, especially pathogens (Schaad et al., 2003); lack of appropriate diagnostic tools for pathogens (Schaad et al., 2003); difficulty of knowing which pathogens to screen for; and the huge number of yet undescribed plant pests. For example, some 10,000 known species of fungi cause plant diseases worldwide (Agrios 2005) and perhaps only 10 percent of all existing fungi have been described (Palm and Rossman, 2003).

Smuggling of propagative material bypasses established phytosanitary safeguards. For example, in 2004, citrus budwood cuttings were intercepted in mail packages arriving in the United States. The packages, destined for a citrus growing area in California, were labeled on the shipment manifest as “books and chocolates.” One of the shipments tested positive for *Xanthomonas axonopodis* pv. *citri*, the causal agent of citrus canker (CBP, 2005). Even though this smuggling event is not related to the GCR, there is no reason to believe that similar events would not be occurring in the Caribbean countries.

Plant Propagative Material as Invasive Species

Numerous studies have shown that the majority of invasive exotic plant species in regional floras were intentionally introduced (Niemiera and Von Holle, 2009). Commercial trade not only helps to introduce plants, but also distribute them throughout entire regions, thereby increasing the opportunity for invasive plants to establish (Mack, 1991). Economic losses due to introduced plants surpass those caused by any other class of invasive species. For example, the annual economic impact of invasive weeds is estimated to be approximately $39 billion in India, $34 billion in the United States, $17 billion in Brazil, $1.4 billion in the United Kingdom

(Pimentel et al., 2001), $12 billion in South Africa (van Wilgen *et al.* 2001), $3 billion in Australia (Sinden et al., 2004), and $1 billion in New Zealand (Williams and Timmins, 2002).

Novel plant species are introduced for ornamental, research, and educational purposes, as well as for environmental stabilization. For the insular Caribbean, Waugh (2008) reviewed the published literature for invasive species and estimated that of the 191 invasive plants examined, 66 percent were introduced deliberately through the horticultural pathway. In Barbados, sweet lime, *Triphasia trifolia* (Rutaceae), and mother-in-law's tongue, *Sansevieria hyacinthoides* (Agavaceae), are both garden escapes that have replaced shrub layers in forested gullies (Waugh 2008). Mock orange, *Pittosporum undulatum* (Pittosporaceae), spread from the Cinchona Botanic Gardens in Jamaica and from other areas where it is planted as an ornamental tree species; whereas, wild ginger, *Hedychium gardneranum* (Zingiberaceae), and redbush, *Polygonum chinense* (Polygonaceae), were also introduced through the botanic garden (Waugh 2008). Among the worst weeds of Florida are the punk tree, *Melaleuca quinquenervia* (Myrtaceae), introduced to drain wetlands (Frank and McCoy, 1995). The neem tree, *Azadirachta indica* (Meliaceae), introduced for the purpose of reforestation, has become an invasive species throughout the Dominican Republic, as well as Puerto Rico and Antigua and Barbuda (IABIN 2008). Kairo et al. (2003) list the following tree species as naturalized and/or invasive; they consider them major invasive threats to the GCR: the red beadtree, *Adenanthera pavonina* (Fabaceae); woman's tongue, *Albizia lebbeck* (Fabaceae); Australian pine, *Casuarina equisetifolia* (Casuarinaceae); white cedar, *Tabebuia heterophylla* (Bignoniaceae); and Indian jujube, *Ziziphus mauritiana* (Rhamnaceae).

A review of the phytosanitary laws of the GCR countries showed that most regulations regarding PM aim to prevent the introduction of pests associated with plants but are not concerned with the invasiveness or weed potential of the imported plants themselves. Although many countries require phytosanitary certificates, inspections, and freedom from soil, weed risk assessments are typically not a requirement for import. The regulated pest list of most GCR countries either contains no weeds at all or lists only a small number of plants, which tend to be agricultural weeds not likely to be imported as PM (IPPC, 2008).

Factors Making Propagative Material a High Risk Pathway

There are environmental, economic, and phytosanitary operational factors which dispose PM to be a high risk pathway. The following data describe a few of these factors.

Propagative material (PM) is usually planted in a climate conducive to its growth, and the same climate is also likely to be suitable for its associated pests. Pests introduced on PM have the advantage of being moved together with a suitable host plant. Furthermore, because plants are often planted in groups, we inadvertently provide pests with an oasis of resources that they may use to establish a new population.

It may not be immediately apparent when a plant species is an invasive. A lag period between introduction and invasion is commonly observed with invasive plant species (Reichard and White, 2001). In addition, changes in environmental conditions may alter the invasive potential of a plant. In Florida, over 60 *Ficus* (fig) species have been introduced. Because *Ficus* are pollinated by species-specific agaonid wasps, it is generally assumed that *Ficus* are not able to set fruit outside of their native range. However, the pollinators of three *Ficus* species in Florida have been accidentally introduced, leading to the spread of these *Ficus* species in two Florida counties (Frank and McCoy, 1995). The desirable characteristics in a plant can also be the very characteristics that make a plant invasive. In agroforestry operations, tree species with rapid growth, high fecundity, small seeds, and the ability to fix nitrogen are desirable; however, these very characteristics contribute to a tree's invasive potential (Richardson et al., 2004).

Volumes of PM imports as well as the diversity of PM imported add strain to a country's phytosanitary system. In the United States, the volume of PM imports has increased; between 1996 and 2005, the volume of plant cuttings increased by 242%, followed by nursery plants (28%), and bulbs (19%); seed volume decreased by 3% (U.S. Department of Commerce) (80% of PM imports enter the U.S. through Miami, FL) (Griffin, 2007). The diversity of taxa imported has also increased. Effective safeguarding is hindered by the difficulty of identifying PM to the species level. If shipment manifests or phytosanitary certificates provide incorrect information, phytosanitary officers may often be unable to detect the error; thus prohibited species may be allowed to enter.

Suggestions for Improved Safeguarding

In summary, pests, and especially plant pathogens, are spreading between countries through both legal and illegal movement of propagative materials. This is occurring on a global scale. About 50 new disease locations or disease-host associations were reported during 2008 in the journal *New Disease Reports* alone. Apart from severe restrictions on the importation of propagative materials, there is no easy solution to this problem. The propagative material pathway also allows invasive plants to continuously enter countries of the GCR, where they often cause considerable economic and environmental damage. There are essentially no safeguards in place to prevent this invasion from happening. Below are some specific safeguards that may help to reduce the risk associated with the PM pathway.

- Require phytosanitary certificates for all imports of propagative materials, indicating species and variety of the imported plants and also certifying freedom from pests based on clearly specified inspection protocols.
- Require weed risk assessments for the importation of plants, and prohibit the importation of any plant species that is likely to become invasive. A variety of assessment and screening tools have been developed, including the Australian Weed Risk Assessment system, which is the most widely known and tested system of its kind (Gordon et al., 2008; Jefferson et al., 2004; Reichard and Hamilton, 1997).
- Assess the invasiveness of plant species retrospectively (Fox et al., 2005; Heffernan et al., 2001; Randall et al., 2008). This is important because a lag time may exist between species introduction and onset of invasiveness; invasiveness may change because of environmental changes (Reichard and White, 2001).
- Adopt voluntary codes of conduct for nurseries and landscaping businesses to promote the sale and use of native and non-invasive plants (*e.g.*, The Saint Louis Declaration (Baskin, 2002).
- Draft a voluntary code of conduct for botanical gardens and arboreta stipulating that they conduct weed risk assessments prior to introducing new plant species; re-evaluate current plant collections for invasiveness; educate the public about the importance of choosing non-invasive plants; and contribute to research related to invasive plant species (BGCI, 2000).
- Maintain records of PM imports by plant species, with information on variety, type of material (roots, cuttings, etc.), country of origin, growing and inspection practices followed, date of importation, and amount imported in consistent units.
- Develop a list of pathogens of economic importance for which plant material should be tested on a regular basis. Use early warning and bio-surveillance systems as input for decision-making.

Table 1. Interception of plant pests on plant propagative material exported from Caribbean countries into the United States, 2007. Pests are grouped by taxonomic order followed by the number of interception records (this is not synonymous to the number of specimens intercepted)

Pest type	Pest family, class, or order (depending on the level of identification)	No. of Interception records
Disease	Coelomycetes	24
	Didymosphaeriaceae	1
	Hyphomycetes	3
	Leptoshpaeriaceae	1
	Mycosphaerellaceae	7
	Phaeosphaeriaceae	1
	Pucciniaceae	1
	Valsaceae	1
Insect	Agromyzidae	5
	Aleyrodidae	24
	Aphididae	41
	Bruchidae	1
	Cecidomyiidae	3
	Chrysomelidae	1
	Cicadellidae	411
	Coccidae	93
	Coccoidea	61
	Coreidae	2
	Curculionidae	9
	Diaspididae	6
	Diptera	1
	Elachistidae	1
	Formicidae	1
	Gryllidae	4
	Hesperiidae	1
	Heteroptera	4
	Hymenoptera	2
	Insecta	7
	Lepidoptera	1
	Limacodidae	1
Insect	Lygaeoidea	1
	Miridae	3
	Noctuidae	36
	Ortheziidae	1
	Pentatomidae	14
	Pentatomoidea	18
	Phlaeothripidae	2
	Plutellidae	1
	Pseudococcidae	107
	Pyralidae	1

Pest type	Pest family, class, or order (depending on the level of identification)	No. of Interception records
	Pyraloidea	1
	Rhyparochromidae	1
	Scarabaeidae	5
	Scolytidae	2
	Syrphidae	1
	Tenebrionidae	2
	Tettigoniidae	110
	Thripidae	292
	Tineidae	2
	Tortricidae	5
Mite	Acari	1
	Tetranychidae	48
Mollusk	Agriolimacidae	1
	Helicarionidae	4
	Philomycidae	1
	Succineidae	156
	Veronicellidae	5
Nematode	Longidoridae	1

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