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Air Potato Vine Management Guide: Combining management strategies to achieve eradication of the noxious weed *Dioscorea bulbifera* (air potato vine).

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INTRODUCTION

The air potato vine *(Dioscorea bulbifera* L.), native to much of Asia, tropical Africa and northern Australia (Burkill 1960; Coursey 1967), was first introduced to the US in the late 1700s (Alabama) (Morton 1976). In the early 1900s, it was introduced to southern Florida and has since spread to all 67 Florida counties, as well as Alabama, Georgia, Hawaii, Louisiana, Mississippi, South Carolina and Texas.

Air potato is listed as a noxious weed by the Florida Department of Agriculture and Consumer Services (FDACS) and by the Florida Exotic Pest Plant Council as a Category I invasive plant: "species which are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives." In central and southern Florida, it is one of the more common natural area weeds.

The vine is considered one of the most aggressive weeds ever introduced into Florida; it grows rapidly, crowding out native plant species, climbing tree canopies and forming dense blankets that smother native trees and understory plant species. It can persist in poor soil types and generates large numbers of bulbils, or "air potatoes," from which new vines sprout and are the primary source of reproduction and dispersal. Bulbils are spread most often by humans, flowing water and rolling along topographical gradients, and are the reason this vine is such a successful invader. Most natural and disturbed habitats are susceptible to air potato infestation, including floodplain forests, marshes, scrub forest, sinkholes, tropical and subtropical hammocks, waterways and urban lots (Schultz 1993).

BIOLOGICAL CONTROL

After the discovery of the air potato beetle *Lilioceris cheni* Gressitt and Kimoto (Coleoptera: Chrysomelidae), biological control was determined to be a strong addition to the management strategy for this invasive plant (Wheeler et al. 2007). The air potato beetle is a leaf-eating beetle that feeds exclusively on the air potato vine. They aggressively consume vine tissue, preventing the vine from climbing high into the canopy and disrupting photosynthesis (Rayamajhi et al. 2016). This results in the vines producing fewer and smaller bulbils, their primary source of reproduction and dispersal. Laboratory production and release of tens of thousands of beetles is more cost-effective than mechanical and chemical control methods. Beetles representing two different biotypes were collected from locations in Nepal and China and imported into a U.S. Department of Agriculture (USDA) containment facility. Host specificity testing was performed on 41 non-target plant species— including numerous other *Dioscorea* species— and *L. cheni* was found to be highly host-specific. Due to the mass-rearing efforts of the FDACS Division of Plant Industry (FDACS-DPI), USDA Agricultural Research Service and the University of Florida Institute of Food and Agricultural Sciences, beetles have been released in nearly every county in the state of Florida. Release and establishment of the beetle in Florida has resulted in a massive reduction in vine biomass, bulbil production and spread of the vine. This program can be considered one of the major successes in the field of biological control (Rayamajhi et al. 2019).

Adult air potato beetles are red and black, and newly hatched larvae are yellowish, becoming grey to red with black legs as they progress through the four larval instars (Fig. 1). The life cycle of the air potato beetle spans 28 days. Adult females can lay more than 1,200 eggs in their lifetime (Manrique et al. 2017). Adults bite the leaf veins of new leaves, resulting in cupping of plant leaves; eggs are most often laid in these cups. The pale white eggs will become yellowish if fertilized and larvae will hatch in approximately four days. The larval stage lasts approximately eight days. After this time, larvae will drop off the plant and cluster

in the soil to pupate. They secrete a substance that solidifies into a hard puparium. The pupal stage lasts approximately 14 days. Mating begins approximately 10 days after adult emergence and the cycle continues. Adults can live over five months. During winter, the air potato beetle goes into a state of hibernation known as diapause (Smith et al. 2018).

Figure 1: *Liliocerис cheni* adults (above) and larvae (below) on an air potato leaf.
Photos by Rosemary Murray and Emily Kraus, FDACS-DPI

Beetles may return to a property year after year on their own. While often hiding and hard to spot, you can tell if beetles have started feeding based on the unique damage they cause. Adult feeding exhibits a hole-punch-like appearance, while leaves fed on by larvae will be 'skeletonized' and have a 'lacy' appearance after excessive feeding (Fig. 2) (Pemberton and Witkus 2010). If beetles are released before enough vegetation is present, they may leave the initial release area in search of a larger infestation. For this reason, it is recommended to wait four to six weeks after the start of vine growth to see if natural populations will return to an area before reporting an infestation.

Figure 2: Adult feeding damage (top). Larval feeding damage (bottom).
Photos by Rosemary Murray, FDACS-DPI

Although air potato beetles appear well-established and widespread in Florida, and they have made an impact on vine biomass in many release areas (some showing significant vine and bulbil reduction), vines continue to regrow from underground tubers each spring (Rayamajhi et al. 2019). Additional releases are needed to address patches of the vine where beetles do not naturally return. This can be done by reporting the vine to FDACS-DPI (https://www.fdacs.gov/Divisions-Offices/Plant-Industry/Bureaus-and-Services/Methods-Development-Biological-Control/Biological-Control/Air-Potato-Vine-Biological-Control), which ships a limited number of beetles to residents each year, or by relocating adult beetles from areas where the beetles are abundant to areas where they are needed. In this case, it is only necessary to move 15-25 adult beetles to establish a population at a new air potato vine location.

MECHANICAL MANAGEMENT

Tubers: The most effective method for complete eradication is to dig up and destroy the tubers. It is very important to remove the entire tuber because even a small section left behind can regrow and sprout new vines. The tubers of well-established vines can be large and make removal difficult, so it is best to remove them when the vines are young. Tubers can be dug up year-round, but they are easiest to locate in the spring when they are sending up new sprouts and before the vine has started twining around other plants. Tubers will sprout throughout the growing season. Tubers will send up one or more sprouts every year until they are removed or otherwise killed.

Tuber removal is best for small infestations and can completely eradicate an infestation before it gets out of control. However, if the labor is available, this is recommended for infestations of any size as it is extremely effective and will reduce additional bulbil production. Collected tubes should be burned or frozen for 48 hours and placed in a landfill trash bag (Langeland & Burkes 1998).

Figure 3: Bulbils can be light tan or dark brown, smooth or bumpy, perfectly round or asymmetrical and range in size from less than 1 cm to greater than 10 cm with the majority of bulbils in between (Schultz 1993) Wheeler et al. 2007).
Photos by Rosemary Murray, FDACS-DPI

Bulbils: Collecting the aerial bulbils that form in between the vine nodes above ground is also important (Fig. 3). They usually form in mid- to late summer and grow larger during the fall, and can sprout without soil, sunlight or water; these new vines begin forming underground tubers. Collecting bulbils will reduce the subsequent season's new air potato sprouts and will reduce the potential of air potato vine spreading into other areas. Freeze or burn bulbils to prevent sprouting.

Vines: Mowing and cutting the air potato vine is a temporary method of management, as the vine will always grow back. However, if done frequently enough, this method can allow the native plants to compete for the resources they need and make it easier to locate underground tubers as vines sprout again. If vines are cut back prior to bulbil formation the risk of spreading bulbils and therefore the infestation are greatly reduced. Even a cut section of bulbil can form a new sprout and, eventually, a tuber. Avoid emptying lawn clippings containing bulbil fragments into a compost pile. Bulbil fragments should be burned or frozen.

HERBICIDE MANAGEMENT

Herbicide use should be a last resort as the application will kill any vegetation it contacts, including native plants. There is limited research covering herbicide management for air potato vine. The most effective herbicides are those with main ingredients triclopyr or glyphosate (Langeland & Burkes 1998, Wheeler et al. 2007). The best time to apply herbicide is in late fall when the plant begins to move sugars back into its tubers. Repeated and well-timed applications may kill the tubers. Applying an herbicide to aerial bulbils may delay sprouting in the next spring by as much as five months, but they will still sprout (Langeland & Burkes 1998). It is a better management practice to burn or freeze bulbils.

IPM Solution

While the air potato beetle is an effective biological control agent, it is important to remember **the beetles will not eradicate the vine**. Due to the subterranean tubers, the vine will re-grow each spring using the nutrients stored from the previous year (Center et al. 2013). The recommended solution for complete eradication of the air potato vine is through an integrated pest management (IPM) system. The IPM solution for air potato vine combines mechanical management, biological control and herbicidal management, and can be tailored to each person's unique situation. You may need to make alterations depending on your area and the infestation severity. The timeline below is a general guide to addressing an air potato infestation:

February – May

Mechanical management: Dig up sprouting tubers while they are still manageable and collect bulbils you may have missed during the winter. Vines can and will sprout from bulbils as small as a pea, so it is important to be as thorough as possible.

May – September

Biological control: Wild beetle populations will start to build in late spring but will typically not be noticeable until mid- to late summer.

September – November

Herbicidal management: Around this time, the vines will begin to show yellowing and then browning of their leaves. They will die back in the winter (Schultz 1993) and beetles will no longer feed on the vine. Beetle populations preparing for the upcoming winter may leave the vine infestation. **This is the recommended time to apply an herbicide if the infestation warrants such an extreme measure.** This will kill some of the tubers, reducing the number of vines that sprout the following year. If using an herbicide in conjunction with air potato beetles, apply the herbicide to only the lower leaves of the plant during the fall season. The beetles and larvae prefer the new growth and upper leaves, and are not negatively affected by the herbicide itself. Leaving upper leaves untreated will provide food for remaining beetles, possibly improving their ability to overwinter.

November – February

Mechanical management: Collect any bulbils that have fallen to the ground or are still attached to the vine. This can and should be done any time you notice bulbils. Any bulbils you can collect and dispose of will be bulbils you do not have to pull out of the ground in the future.

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