REDUCTION OF DAMAGE TO MAHOGANY BY MAHOGANY SHOOT BORER AND MAHOGANY LEAF MINER BY USE OF AZADIRACHTIN

F. W. Howard

University of Florida, Fort Lauderdale Research & Education Center, 3205 College Avenue, Fort Lauderdale, Florida 33314, United States of Ameria

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HOWARD, F. W. 1995. Reduction of damage to mahogany by mahogany shoot borer and mahogany leaf miner by use of azadirachtin. In a study conducted in Florida in the spring of 1993, after initial attack of West Indies mahogany [*Swietenia mahagoni* (Meliaceae)] by mahogany shoot borer [*Hypsipyla grandella* (Pyralidae)], frass production, used as an indicator of larval development with accompanying internal damage to shoots, did not progress on 22 trees treated with azadirachtin, but did progress in shoots in 49.9% and 22.9%, of 22 untreated trees on two different observation dates, May 26 and June 18 respectively. On these untreated trees, 73.9% and 88.2% of the attack sites observed on May 20 and June 10 respectively, showed significant frass development within about a week. Damage by mahogany leaf miner [*Phyllocnistis meliacella* (Gracillariidae)] was observed in samples from 5 of 22 trees treated with azadirachtin and from 17 of 22 trees in the controls. There were more than 4 times as many mines in the controls than in the trees treated with azadirachtin ($p < 0.01$). Because in Florida the period of mahogany shoot borer and mahogany webworm (*Macalla thyrsisalis*) attack coincides with the spring flush of West Indies mahogany, azadirachtin applications timed with spring flush could reduce damage of both pests, plus the spring populations of mahogany leaf miners. The potential of this method for situations outside of Florida is discussed.

Key words: *Swietenia* - *Cedrela* - *Hypsipyla* - *Phyllocnistis* - mahogany shoot borer - mahogany leaf miner - neen - azadirachtin

HOWARD, F.W. 1995. Pengurangan kerosakan oleh pengorek pucuk mahogani dan ulat inti daun mahogani pada pokok mahogani dengan menggunakan azadiraktin. Satu kajian telah dijalankan di Florida pada musim bunga 1993 setelah serangan pertama pengorek pucuk mahogani [*Hypsipyla grandella* (Zeller) (Pyralidae)] terhadap mahogani India Barat [*Swietenia mahogani* (Meliaceae)]. Penghasilan fras yang digunakan sebagai penunjuk perkembangan lava, beserta dengan kerosakan dalaman pada pucuk tidak bertambah pada 22 pokok yang dirawat dengan azadirachtin tetapi bertambah dalam pucuk 22 pokok yang tidak dirawat sebanyak 49.9% dan 22.9% masing-masing pada dua tarikh pemerhatian yang berbeza, 26 Mei dan 18 June masing-masing. Bagi pokok-pokok yang tidak dirawat ini, 73.9% dan 88.2% dari kawasan yang diserang, masing-masing diperhatikan pada 20 Mei dan 10 Jun, menunjukkan perkembangan fras yang ketara dalam masa lebih kurang seminggu. Kerosakan oleh ulat inti daun mahogani [*Phyllocnistis meliacella* (Gracillariidae)] diperhatikan dalam sampel-sampel yang diambil pada 5 dari 22 pokok yang dirawat dengan azadiraktin dan pada 17 dari 22 pokok dalam kawalan. Terdapat lebih dari 4 kali ganda kerosakan dalam kawalan daripada pokok yang dirawat dengan azadiraktin ($p< 0.01$). Di Florida, penerapan azadiraktin serentak dengan kemuncak musim bunga mungkin boleh mengurangkan kedua-dua perosak iaitu pengorek pucuk mahogani dan 'webworm' mahogani (*Macalla thyrsisalis*) serta

ulat inti daun mahogani. Perkara ini berkemungkinan kerana tempoh serangan pengorek pucuk mahogani dan 'webworm' mahogani berkebetulan dengan kemuncak musim bunga mahogani India Barat. Potensi untuk kaedah ini di luar lokasi Florida dibincangkan.

Introduction

West Indies mahogany, *Swietenia mahagoni* Jacquin, is native to Florida and parts of the West Indies. Excessive cutting has long eliminated it as a source of one of the most important of tropical timbers, but it is desirable for reforestation in the Caribbean because of its adaptability to a wide range of growing conditions as well as its potential value for timber. It remains abundant in urban areas of Florida and the Caribbean region as one of the most important ornamental/ shade trees.

Three species of Lepidoptera are pests of West Indies mahogany in Florida. The mahogany shoot borer, *Hypsipyla grandella* (Zeller) (Pyralidae), is considered the major pest of mahogany (*Swietenia* spp.) and cedros (*Cedrela* spp.) at the nursery and young plantation stage in the American tropics. The principal damage is when borers kill the apical shoot. A secondary shoot is produced, resulting in a crooked stem. The interruption of apical dominance may result in excessive side branches, thus poorly formed trees. Failures of many nurseries and young plantations have been attributed to mahogany shoot borer damage (Lamb 1966, Grijpma 1974, Yamazaki *et al.* 1990). Research on the biology and control of mahogany shoot borer was recently reviewed by Newton *et al.* (1993).

The mahogany webworm, *Macalla thyrsisalis* (Walker) (Pyralidae), causes highly conspicuous aesthetic damage (Morton 1987, Howard 1989, Howard & Solis 1989).

The mahogany leaf miner, *Phyllocnistis meliacella* Becker (Gracillariidae), was described from specimens collected on *Swietenia* spp. and *Cedrela* spp. in Costa Rica (Becker 1976) and attacks the same species in Florida. Although reported only from the above two localities, it is probably distributed elsewhere within the range of mahoganies [e. g. an unidentified mine that appears to be typical of *P. meliacella* is visible in a leaflet of *Cedrela mexicana* in Figure 5 of Ramirez' (1964) study of *H. grandella* in Venezuela]. West Indies mahogany leaves have 5 - 7 leaflets; mines are usually on the lower leaf surface, and usually not more than one occurs per leaflet. The effects of the mahogany leaf miner on tree growth are not known.

Because a method which used an azadirachtin product was found to be successful in controlling mahogany webworm in Florida (Howard 1989, 1990), I was interested in potential control of the additional lepidopterous pests of these trees. Azadirachtin, a natural product extracted from the seed of the neem tree, *Azadirachta indica* A. Juss., acts as an antifeedant or insect growth regulator against many species of insects (Warthen 1989, Subrahmanyam 1990). It is essentially nontoxic to mammals, effective against a broad spectrum of pest species (Warthen 1989), and appears to be less damaging to non-target invertebrates than synthetic insecticides that have been compared with it (Stark 1992).

In Florida, larval activity of both mahogany webworm (Howard & Solis 1989) and mahogany shoot borer (Howard 1991) is mostly limited to spring, coinciding with the spring flush. Thus, treatments applied during the spring could possibly be effective for both these species.

The eggs of the mahogany shoot borer are laid external to the plant and the tiny first instar larvae consume external shoot and sometimes leaf tissue before boring into the shoot (Roovers 1971). Thus, this insect is a good candidate for control with azadirachtin applied to the external plant parts.

Mahogany leaf miners also attack mahogany foliage in the spring, but unlike the above two species, this activity continues throughout much of the year, apparently coinciding with secondary flushes in foliage production (F. W. Howard, unpublished data). It was of interest whether azadirachtin applied in the spring for the other two pest species might be effective against spring populations of mahogany leaf miner.

This paper reports the results of a field test of azadirachtin applied to West Indies mahoganies to control mahogany shoot borer and mahogany leaf miner.

Materials and methods

West Indies mahoganies were propagated from seed collected on the Fort Lauderdale Research and Education Center (FLREC) in May 1988 and grown in containers (final size of container, 32 cm dia.) in equal parts of sedge peat, sharp sand and cypress shavings. All mahoganies were fertilized equally with a 3N-5P-9K + microelements formulation about every two months, the rate increasing from 2.5 g per plant during the first year to 36 g per plant during the season of this study. The mean height of the trees at the beginning of the experiment was 1.25 m (SD = 0.16). The containerized trees were kept outdoors at the FLREC during the experiment. They were all free of shoot borer attack prior to the experiment.

Twenty-two trees were assigned at random to each of two treatments:
(1) 2 ml/1 H_2O Azatin (Agridyne Technologies, Inc., Salt Lake City, Utah 84108, U.S.A.) (corresponding to 60 ppm azadirachtin) + 0.5 ml/1 Triton B-1956 [Rohm and Haas Company, Philadelphia, Pennsylvania 19105, U.S.A. (a spreader-sticker)], and (2) 0.05 ml/1 H_2O Triton B - 1956 (i. e. the experimental control for the test of the effect of azadirachtin).

The material was applied with a 2-litre hand-held sprayer. The sprayer was elevated so that the general direction of the cone-shaped spray was horizontal or slightly downward, and each tree was sprayed from two sides, so as to obtain thorough coverage of the green shoot and upper surfaces of leaves. Applications were made weekly during the period April 6 - June 22 (a total of 11 applications). For each weekly spraying, the containerized trees were briefly moved into separate treatment groups. The rest of the time, they remained in a randomized block within a few meters of five West Indies mahogany trees about 8 m tall which during the experiment became infested with mahogany shoot borers and mahogany leaf miners. This tree species was common on the grounds of and in the general area of the FLREC, and those observed were attacked by both insects.

The trees were examined weekly for mahogany shoot borer damage. These insects eject frass from the galleries which accumulates in a compact mass at the gallery entrance. The frass initially has a pale wood colour which darkens to reddish brown after exposure for an undetermined period. In dissecting several hundred attacked shoots in previous years, I observed that a tiny hole with small mass of up to about 3 mm was indicative that an early instar larva was present in the shoot. The size of the frass aggregation increases to a maximum of about 15 to 20 mm as the larva grows and completes its gallery. Although the duration of larval activity has been reported to be about 30 days (Ramirez 1964, Roovers 1971), a frass aggregation reaches a large volume at least approaching the maximum within a week. A darkened, dissipated frass aggregation, which may be present for many weeks, indicates that boring has ceased, in which case the insect has died, pupated in the gallery, or vacated it. To measure the effect of the azadirachtin treatment, damage was characterized as initial (frass aggregation < about 3 mm dia.), or advanced (frass aggregation > 10 mm, usually 15-20 mm, the color and texture indicating it was freshly produced).

To facilitate observations, all borer damage was pruned from the trees on June 3 and again on June 19. The numbers of trees attacked and mean numbers of initial borer attacks per tree in both treatments were compared for the following observation dates: April 15 (the first observation date when borer attacks were observed), May 20 (the second observation date when new attacks were observed), and June 8 (the first observation date following the June 3 pruning of damage). Mean advanced borer attacks per tree were compared for May 26, at which time initial borer attacks observed on May 20 had time to develop and for June 18, at which time initial borer attacks following the June 3 pruning had time to develop to near maximum. The effect of this method was to compare initial attacks on three different dates as indicated, and the development of borer attacks for the periods May 20 - 26 and June 3 - 18.

Counts to compare mahogany leaf miner damage in treatments #1 and #2 were made following the 11th spraying (June 23). A shoot with fresh leaves was chosen at random on each tree and the number of leaflets with mines in the youngest ten leaves determined.

Mean numbers of initial and advanced borings per tree (as indicated by frass aggregations) and mean numbers of mines per sample shoot were compared and the significance of the means tested by t-tests (SAS Institute 1985), after $(x + 0.5)^{0.5}$ transformation of the data.

Results

Higher percentages of trees were attacked in the control group than in the azadirachtin-treated group on the three observation dates when trees were examined for initial attacks (Table 1). Trees that were attacked had 1-5 frass aggregations. The differences in the mean initial attacks per tree on these dates were not statistically significant, however.

After initial attack, there was no progress in damage on trees treated with azadirachtin, based on frass development observed on dates when the trees were examined for advanced attacks. In contrast, advanced attacks were observed on 49.9% of the control trees on May 26 and 22.9% of the control trees on June 18. The mean numbers of advanced attacks per tree in the control on the two observation dates were 1.1 (transformed data: x = 1.1, SD = 0.6) (May 26) and 0.7 (transformed data: x 1.0, SD = 0.5) (June 18) compared to 0 advanced attacks in the controls on both dates ($p < 0.05$). In the control, 73.9% of the initial attacks observed on trees on May 20 were advanced attacks on May 26, and 88.2% of those observed on June 10 were advanced attacks on June 18; none of the initial attacks on the azadirachtin-treated trees had advanced on these observation dates (Table 2).

Table 1. Initial shoot borer attack as determined from frass development on mahogany trees treated and untreated with azadirachtin, Fort Lauderdale, Florida, 1993

Observation date	% trees attacked		Mean initial attacks per tree			
	azadirachtin	control	azadirachtin		control	
			x	SD	x	SD
April 15	0.0	13.4	0.0	0.0	0.2	0.5
May 20	31.8	40.9	0.5	0.9	0.8	1.2
June 10	18.2	40.9	0.6	1.5	1.3	1.2

Table 2. Advanced shoot borer attack as determined from frass development on mahogany trees treated and untreated with azadirachtin, Fort Lauderdale, Florida, 1993

Observation date	% trees with advanced attacks		Mean advanced attacks per tree			
	azadirachtin	control	azadirachtin		control	
			x	SD	x	SD
May 26	0	49.9	0*	0	1.1*	0.6
June 18	0	22.9	0*	0	0.7*	0.5

* Means of transformed data for azadirachtin treatment and control are significantly different [$p < 0.01$, t-test (SAS 1985)].

There were no further shoot borer attacks during the period July 18 - August 15 on the trees in the experiment or on numerous other trees examined on the research center. This corroborates previous observations that in Florida mahogany shoot borer attacks are confined to a short period in spring (Howard 1991). The infestation levels of the untreated trees were similar to what I have generally observed for trees of their size under nursery conditions.

On the observation date for mahogany leaf miner (June 23), leaf miner damage was present in samples from 5 trees treated with azadirachtin and from 17 trees in the controls. There were 1.4 mines per sample (transformed data: x = 1.1, SD = 0.88) from the trees treated with azadirachtin compared to 6.2 mines per sample (transformed data: x = 2.15, SD = 1.5) from the trees in the control, i. e. more than four times as many mines in the controls compared to the trees treated with azadirachtin ($p < 0.01$).

No symptoms of phytotoxicity due to the azadirachtin treatments were observed.

Discussion

In Florida, control methods for mahogany webworm using azadirachtin (Howard 1990) can be implemented to obtain the additional benefit of reducing damage by mahogany shoot borer and mahogany leaf miner by timing applications to the spring flush. Because the period during which mahogany leaf miners attack is more extended than that of the other two species, additional applications or other methods would be necessary for managing this insect.

There is evidence that in countries where the period of mahogany shoot borer larval activity is prolonged, borer attacks peak in spring or in the rainy season, during which time leaf flush is most pronounced (Bauer 1987, Roovers 1971, Yamazaki *et al.* 1990, 1992). Azadirachtin treatments applied during this period could significantly reduce damage by mahogany shoot borers, and thus play a role in integrated pest management (IPM) of this pest. IPM of this pest has been proposed as a research goal (Grijpma 1974, Newton *et al.* 1993).

That there were consistently smaller percentages of trees attacked by mahogany shoot borers in the azadirachtin treatment compared to the control suggests that azadirachtin may prevent some early stage shoot borer larvae from making an initial penetration. Small holes made by larvae that did penetrate but failed to develop further due to the azadirachtin treatment would probably become plugged quickly by resins and eventually repaired. They probably would not result in significant growth loss or collapse of the shoot. I have observed some mahogany shoot borer attacks stopped by resin flow (similar to pitch tubes of pines). These attacks apparently did not damage the shoots significantly, but the effect of initial damage by early instar borers needs to be studied further.

The mahogany leaf miner has generally been ignored as a potential pest. However, mahoganies are often so highly infested with miners that these insects may be assumed to affect vigor and growth. In the untreated trees in this study, mines were present in 62% of young leaves sampled. Since West Indies mahogany leaves consists of 5 - 7 leaflets, it can be calculated that about 8.8-12.4% of the leaflets were infested. Azadirachtin could be used to control the leaf miners to study their potential affect on growth of mahogany trees.

Methods involving fewer applications of azadirachtin than used in this study are needed. I began the series of applications in early April to insure exposure of the first instar larvae to azadirachtin. However, in 1993, spring flush came relatively

late, towards the end of May, and thus the first several applications were superfluous. Future research should be conducted involving applications timed precisely with the spring flush and possibly with longer intervals between treatments. More attention to coverage of lower leaf surfaces could result in better control of the mahogany leaf miner. Additionally, more precise information is needed concerning the effects of various dosages of azadirachtin on larval development, on the effect of this substance on the rate and extent of gallery construction, the persistence under tropical conditions of azadirachtin + various spreader-stickers, and possible effects on beneficial insects, including indirect effects on parasitoid populations due to population reductions of their phytophagous hosts.

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