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Relative susceptibility of four species of African mahogany to the shoot borer *Hypsipyla robusta* (Lepidoptera: Pyralidae) in the moist semideciduous forest of Ghana

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Abstract

We examined the relative susceptibility of four mahogany species, *Khaya ivorensis*, *Khaya anthotheca*, *Entandrophragma angolense*, and *E. utile*, to *Hypsipyla robusta* attack. Seeds were obtained from one to three parent trees for each species. The research was conducted in the moist semideciduous forest zone in Ghana and used a randomized complete block design. Tree height and diameter and height to first branch were measured until 24 months after out-planting in the field. *H. robusta* damage was assessed by counting the numbers of shoots attacked, branches, and dead shoots. *Khaya* spp. grew better but experienced more attack than *Entandrophragma* spp. The relative susceptibility to *H. robusta* attack, from most to least, of the four species was: *K. anthotheca* > *K. ivorensis* > *E. angolense* > *E. utile*. At 24 months, the mean number of shoots attacked per tree ranged from 1.0 for an *E. utile* seed source to 3.6 on for a *K. anthotheca* seed source. At 15 months, *K. anthotheca* and *K. ivorensis* started branching at about 1.5 m, but height of clear trunk increased over time due to self-pruning. As *K. anthotheca* grew taller, the number of *H. robusta* attacks per tree declined. This suggested that selection of genotypes and species that are tolerant of *H. robusta* attack based on infestation of young plants may not be appropriate. Genetic factors more completely reflecting the response of different species and genotypes to *H. robusta* attack may manifest themselves at later growth stages.

Keywords: Meliaceae; *Khaya*; *Entandrophragma*; African mahogany; *Hypsipyla*; Susceptibility; Tolerance

1. Introduction

The African mahoganies *Khaya*, *Entandrophragma*, *Guarea*, and *Lovoa* spp. (Meliaceae), are considered to be among the most valuable tropical timber species worldwide. These species are found naturally throughout the moist semideciduous and dry forest zones of West Africa (Hall and Swain, 1981; Hawthorne, 1995). Timber from native mahoganies, especially *Khaya* and *Entandrophragma* spp., contribute on average 15–30% of the timber exports of the West African nation of Ghana (Atuahene, 2001). Unfortunately, this has led to the overexploitation of these species in the native forests of Ghana.

Despite the decline of mahoganies in West Africa, demand for African mahogany is anticipated to increase further as a result of reduced supply of native mahogany timber from Southeast Asia and South America (Elliot and Pleydell, 1992; Atuahene, 2001). An increase in demand will threaten the viability and sustainability of mahoganies in areas where significant volumes of these species are still found. By the end of this decade they may become commercially extinct if harvested at the rate of the late 1980s (Alder, 1989). Measures to ensure sustainable production of the mahoganies into the future include their successful establishment in plantations, and more stringent regulation of timber volume removal so that it reflects the rate of replacement by natural or managed regeneration.

As in Latin America, most mahogany plantations established in West Africa have failed due to attack by the larvae of the shoot borer moth, *Hypsipyla* spp. (Lepidoptera: Pyralidae) (Roberts, 1966; Entwistle, 1967; Atuahene, 1972, 2001; Grijpma, 1976). The mahogany shoot borers are among the most economically significant insect pests in tropical forestry, with the most

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important species in Africa being *Hypsipyla robusta* (Entwistle, 1967). *H. robusta* has been recorded in West Africa on *Khaya* spp., *Entandrophragma* spp., *Carapa procera*, *C. grandiflora*, *Lovoa trichiniodes*, and *Swietenia macrophylla* (Roberts, 1968; Wagner et al., 1991; Newton et al., 1993). The principal damage caused by these species is from larval feeding in apical shoots. Repeated attack of the main leader results in numerous secondary shoots and stunted growth, both of which affect the quality of timber produced (Wagner et al., 1991; Dupuy, 1995). Despite significant research and management efforts, previous attempts to manage *Hypsipyla* spp. have largely been unsuccessful (e.g. Wagner et al., 1991; Newton et al., 1993; Mayhew and Newton, 1998; Hauxwell et al., 2001). However, prospects for reducing the impact of *Hypsipyla* spp. have increased with the identification within *S. macrophylla* and *Cedrela odorata* of partial resistance to attack by *H. grandella* in Central America (Newton et al., 1993, 1998; Watt et al., 2001).

The objective of this study was to compare the extent of shoot borer damage in four species of African mahogany with a view to determining plant characteristics that are associated with tolerance of shoot borer attack, and to search for resistant or tolerant germplasm.

2. Materials and methods

2.1. Study species

Four species of Meliaceae (African mahogany) were used for this study: *Khaya ivorensis*, *Khaya anthotheca*, *Entandrophragma utile*, and *Entandrophragma angolense*. All are non-pioneer light demanders with wing-dispersed seeds (Hawthorne, 1995). *K. ivorensis* is found mainly in the moist evergreen forest zone, *K. anthotheca* mainly in the moist semideciduous zone, *E. angolense* mainly in the moist evergreen and moist semideciduous zones, and *E. utile* mainly in the moist semideciduous zone of Ghana (Hall and Swain, 1981). The *Entandrophragma* species used are slower growing than the *Khaya* used, and need some shade for the first few years after germination (Hawthorne, 1995).

2.2. Experimental design

An extensive search was carried out for seed trees of *K. anthotheca*, *K. ivorensis*, *E. angolense*, and *E. utile*, but the number sampled was limited by cutting and a season of reduced reproduction. Therefore these species were represented by from one to three seed sources each. We report on findings from this limited collection because the difficulty of procuring seed from native forests will only increase at the current rate of logging.

The study site was located in the moist semideciduous forest type (Hall and Swain, 1981) of Ghana's Upper Guinean tropical forest (Fig. 1). This forest type is favorable for the growth of all the native West African mahogany species. The annual precipitation ranges between 1200 and 1750 mm per annum in this region, and there is a dry season between December and March, with rainfall of less than 100 mm per month (Table 1).

Seedlings were grown and maintained at the Forestry Research Institute of Ghana (FORIG) central nursery at Mesewam. Ten days after germination, seedlings were transplanted into polyethylene bags (17.5 cm × 2.5 cm) filled with topsoil. Weeds were removed by hand throughout the nursery stage. Eighty seedlings from each seed source were established at the trial site when they were 35–40 cm tall. The trial was laid out in a randomized complete block design, with four blocks in an open field. Each block was divided into eight plots, and within each plot, 20 seedlings from one of the seed sources were planted in four rows and five columns at 0.5 m spacing. Hence each block had 20 seedlings from each of the eight seed sources, assigned to plots within blocks at random.

2.3. Measurements

Data were collected at 15, 18, 21, and 24 months after planting in the field. At each date, 10 trees randomly selected from each seed source in each block were measured for growth and assessed for damage by *H. robusta*. The growth measurements taken were total tree height, diameter at breast height (dbh; measured at a standard height of 1.3 m), and height of clear trunk (height to first fork in response to *H. robusta* attack; Cornelius, 2001). Damage by *H. robusta* was assessed by recording the total number of shoots attacked, the total number of dead shoots, and total number of shoots sprouted in response to *H. robusta* attack on the sampled trees. Sprouted shoots were counted and attributed to *Hypsipyla* attack when there was evidence of attack and dieback with new shoots sprouting for recovery. Percentage of trees attacked by *H. robusta* was also determined.

2.4. Data analysis

Analysis of variance (ANOVA) for a randomized complete block design was used to test the significance ($P < 0.05$) of differences between seed sources for each of the parameters measured. If overall effect of seed source was significant, *a priori* user-defined contrasts were performed to make the following six orthogonal comparisons between seed sources: (1) all *Khaya* seed sources compared to all *Entandrophragma* seed, (2) the two *K. anthotheca* seed sources compared to the two *K. ivorensis* seed sources, (3) the three *E. angolense* seed

Table 1
Sources of seeds from four African mahogany species used in tests of tolerance of damage by the shoot borer *Hypsipyla robusta*

Code name	Species	Seed source	Forest type
Ka1	*Khaya anthotheca*	Abofour	Dry forest
Ka2	*K. anthotheca*	Afram Headwaters	Dry forest
Ki1	*K. ivorensis*	Bobiri	Moist forest
Ki2	*K. ivorensis*	Pra Anum	Moist forest
Ea1	*Entandrophragma angolense*	Abofour	Dry forest
Ea2	*E. angolense*	South Fomanso	Moist forest
Ea3	*E. angolense*	Jimira	Moist forest
Eu1	*E. utile*	Abofour	Dry forest