RESISTANCE TO THE MAHOGANY SHOOT BORER: RESULTS OF RESEARCH AT CATIE, 1990-1995

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Summary: The shoot borer *Hypsipyla* prevents successful plantation silviculture of mahogany and other commercially important Meliaceae. The present article describes the results to date of a programme of research on genetic variation in resistance to attack, initiated by CATIE and the Institute for Terrestrial Ecology, Scotland, in 1990. The three genetic tests described demonstrated the existence of provenance-level and family-level variation in resistance to attack. It is concluded that deployment of selectd germplasm has potential as one element of a pest management system for *Hypsipyla*.

Introduction

The attack of the shoot-borer *Hypsipyla* (Lepidoptera: Pyralidae) has long been recognized as a critically limiting factor in the successful plantation silviculture of mahogany (*Swietenia* spp), African mahogany (*Khaya* spp) and Spanish cedar (*Cedrela* spp.) (1,3,4). Although the insect has been closely studied (7), until recently, with the exception of work at the species level (2), there had been no efforts at approaching the problem through germplasm selection and breeding for resistance (5). For this reason, in 1990, CATIE, in collaboration with the Institute for Terrestrial Ecology, began a pilot programme of research into resistance breeding in *Cedrela* and *Swietenia*. In the present document we report results of three genetic field tests.

Materials and methods

In February 1991, provenance trials of *Cedrela odorata* and *Swietenia macrophylla* were established in Turrialba, Costa Rica. Each trial had five provenances. The mahogany provenances (Guajataca, Puerto Rico; Juan Díaz, Puerto Rico; Honduras; Trinidad; Haití) were represented by bulked lots. Experimental design was randomized complete blocks, with 25-tree square plots and five blocks. Each of the *Cedrela* provenances (Cañas, Carmona, Hojancha, San Carlos (all Costa Rica); Trinidad) was represented by progeny of five trees. Experimental design was randomized complete blocks, with five-tree family line plots and nine blocks. The trials were assessed fortnightly for shoot borer attack and phenology from 22 April 1991 until early December 1992. Tree height was measured after 26, 56 and 88 weeks, and form evaluations (height to first branch and number of forks) made at 141 weeks (*Cedrela*) and 177 weeks (*Swietenia*). Analyses of variance of block and provenance effects was carried out. Further details on these two experiments are given elsewhere (6). In September 1994, a second *Cedrela* trial was established in San Carlos, Costa Rica. Six Costa Rican provenances were included (Cañas, Cóbano, Guápiles, Hojancha, San Carlos, Talamanca), each represented by five families. Design was randomized complete blocks, with three tree line plots and ten bloques. Tree height and presence of *Hypsipyla* attack was assessed in March, July, September and October 1995. In addition, in October 1995 the presence or absence of a dominant leader was assessed. Trees were also scored 1 (present) or 0 (absent) for tolerance, where a tolerant tree was defined as one that had been attacked at least once and had retained a dominant leading shoot, whereas an intolerant tree was defined as one that had been attacked and had no dominant leader. Trees that had never been attacked were considered to be missing values for tolerance. In addition, a score for degree of tolerance was derived; tolerance degree for those trees that scored 1 for tolerance was set equal to the total number of attacks. Tolerance degree of trees with zero tolerance was also zero. Analyses of variance of block, provenance and family effects were made for all variables

Results

In all three trials, strong temporal trends were noted. The 1991 *Cedrela* trial evinced peaks in attack in May 1991 and, particularly, May-June 1992. The mahogany trial was virtually unattacked during the first year of growth, but experienced a sharp peak of attack from May to June 1992. The second Cedrela trial was unattacked at the time of the first evaluation in March 1994. By May, 14% of the trees were being attacked, rising to 56% in July, thereafter declining to 27% and 29% respectively in September and October. There is thus evidence that, at least in the Atlantic zone of Costa Rica, attacks tend to be concentrated in the May-July period, although the tail-off in attack has not been as marked in San Carlos as in the Turrialba trials.

Genetic variation in attack and tolerance

Swietenia macrophylla.

At the time of peak attack, there were significant differences between the provenances in mean number of attacks per tree (p=.01), number of forks (p=.001), proportion attacked (p=.001) and height to the first fork (p=.01). The Juan Díaz (Puerto Rico) provenance was markedly superior in the first three characteristics, although its height at 68 weeks was 16.7% less than the best source.

Cedrela odorata.

In the 1991 trial, at the time of the second peak there were significant differences in number of attacks per tree (p=.001), number of forks (p=.001), height to the first fork (p=.001), and the proportion of trees attacked (p=.001). The Costa Rican dry-zone provenances were attacked least (e.g. means of 0.94 and 2.3 attacks per tree in Hojancha and San Carlos respectively). However, the San Carlos provenance was much faster growing (3.1m (San Carlos) v. 1.5m (Hojancha)) and had the best form.

In the 1994 trial, in October 1995 there was highly significant variation between the provenances in mean number of attacks per tree (p=.0001) (e.g. Hojancha 1.5±0.8, San Carlos 3.6±0.8), mean number of trees attacked (p=.0001) (e.g. Hojancha 0.6±0.2, San Carlos 0.9±0.05) and mean height (p=.0001) (e.g. Hojancha 0.8m±0.2m, San Carlos 1.3m±0.25m). The mean number of attacks per tree and mean number of trees attacked was significantly (p=.0001) lower for the dry zone provenances than the wet zone provenances. The mean height of the wet zone provenances was significantly (p=.0001) greater than that of the dry zone provenances. There were no significant differences in dominance between the provenances, and no significant differences in tolerance. However, degree of tolerance showed highly significant (p=.0001) provenance effects (e.g. Hojancha 1.3±0.5, San Carlos 2.9±0.7) and, in addition, the wet zone provenances showed significantly superior tolerance degree and tolerance (p=.0001, p=.07, respectively) to the dry zone provenances.

Because of the evidently strong zonal provenance effect, the dry-zone provenances were eliminated from the family-level analysis, in order to avoid undue confounding of family and provenance effects. The analysis therefore included five families from each of Guápiles, San Carlos and Talamanca, plus three families from Upala, which were excluded from the provenance analysis on grounds of inadequately representing the Upala source. The analysis of the October 1995 data revealed significant family effects on total height (p=.0004) (e.g. best family 1.7± 0.6m, worst 0.9m±0.4m) and total number of attacks (p=.0007) (e.g. most severely attacked family 5.7±1.9 attacks per tree, least severely attacked family 2.1±0.7 attacks per tree). There were no significant family effects of proportion of trees attacked, tolerance, or tolerance degree.

Discussion and conclusions

The trials clearly demonstrate the existence of genetic variation in resistance to the attack of *Hypsipyla*, both in the case of *Swietenia* and *Cedrela*. However, both for purposes of application of the results and design of future research directions, it is important to appreciate the scope of the research to date and the nature, particularly with regard to genetic structure, of the variation identified. The *Cedrela* trials provide very clear evidence for major

genetic differences between the provenances from the seasonally-dry Pacific watershed and those from the Atlantic zone. The magnitude of the growth differences are such that Pacific provenances would be unlikely to be selected for planting in the Atlantic zone, whilst their relative freedom from attack may in any case be a function of their size and consequent lower number of oviposition and feeding sites. There are, however, clear indications in the data of more practically useful forms of genetic variation. The continuing fast growth and good form of the San Carlos provenance and particularly the existence of genetic variation in attack severity within the broadly similar Atlantic zone provenances, are highly encouraging. At the same time, the failure to detect variation in tolerance within the Atlantic zone material is disappointing. Future research will concentrate on clonal testing of Atlantic-derived material and the development of an integrated pest management systemof which superior germplasm will be one element.

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