TECHNICAL REPORT FINAL PROJECT

Management of *Hypsipyla grandella* in *Swietenia macrophylla* King plantations in Pará and São Paulo States, Brazil

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ABSTRACT

Mahogany, *Swietenia macrophylla* King is one of the most valuable tropical timber species in the world. In the Brazilian Amazon, particularly in the state of Para, it has been logged in a disorderly manner in natural forests, so that it was considered as endangered species and therefore included in CITES Appendix II. Thus, mahogany reforestation is an alternative to reduce logging pressure on natural forests. For that reason, several mahogany reforestation projects were implemented in Latin America, but they were unsuccessful due to the attack by mahogany shoot borer *Hypsipyla grandella*.

Therefore, this project aims at selecting *Hypsipyla grandella* management/control systems to stimulate mahogany reforestation in the states of Pará and São Paulo in Brazil. Several research activities were developed, whose main results were as follows: 1) two mahogany shoot borer management systems in the state of Para - mahogany plantation intercropped with *Toona ciliata* + Colacid application and plantantion system mahogany intercropped with *T. ciliata* + fertilization with calcium and boron + Colacid application, because they were the most efficient on *Hypsipyla grandella* control, with efficiencies of up to 94.02% and 100%, respectively; 2) a shoot borer management system in the state of São Paulo- mahogany plantation intercropped with *T. ciliata* + Colacid application presenting 99.4% control of the borer; 3) Selecting a Colacid spray formulation that was used in the experiments in Aurora do Pará and São José do Rio Preto, because of the practicality of its application, and due to an efficiency presented similar to Colacid solution in drops application; 4) Building of lifting platforms and a pantograph type platform has facilitated silvicultural practices (pruning and application of treatments) of mahogany with 3m to 9m of height.

With the results achieved in this research, mahogany plantation owners will have more trust and confidence in the success of its mahogany reforestation projects, and this will be an incentive for future reforestation projects in this sector.

1. INTRODUCTION

The Amazon region holds the largest biodiversity of the world. Its forest plays a vital role in carbon cycling, as well as for the environmental stability of the planet. However, logging activities, cattle ranching and shifting cultivation have had extensive negative impact to the environment. Currently, 17% of the Amazon region has been deforested. Deforestation and uncontrolled logging are the main causes to reduce the habitats of animal and plants in the region. As a consequence, many species have been considered as threatened of extinction, such as mahogany (*Swietenia macrophylla*).

Due to its high commercial value, mahogany is also called "green gold" that has been exploited in a selective and uncontrolled manner (Castro et al, 2002). This resulted in its inclusion in CITES Appendix II, so that in Brazil mahogany exploitation in natural forests through Sustainable Forest Management Plans (SFMP).

Due to this situation, reforestation with *S. macrophylla* is a viable alternative for commercial mahogany production. However, the establishment of commercial mahogany plantations has as a limiting factor that is the attack of *Hypsipyla grandella* Zeller, commonly known as "mahogany shoot borer". 835,000 plants of *S. macrophylla* and 1,000,000 of *Cedrela* sp. were affected and abandoned in the period 1935 to 1943 in Puerto Rico (Newton et al., 1993). The high infestation of the pest was the main reason for the failure of the establishment of mahogany plantations in southern Pará (Grogan et al., 2002).

Berti Filho (1973), Rodan et al. (1992), Veríssimo et al. (1992), Newton et al. (1993), Costa (2000), Gallo et al. (2002) and Ohashi et al. (2002), argue that mahogany shoot borer *H. grandella* is the major pest of *S. macrophylla* and is responsible for successive failures of reforestation projects in North, Central and South America. According to Hilje and Cornelius (2001), this insect is considered a major forest pest in Latin America and the Caribbean for the following characteristics: low level of tolerance, since only one caterpillar per tree results in severe damage, specificity to attack the members of subfamily Swietenoideae of Meliaceae; wide geographical distribution; the insect can attack several structures of the plant (leaves, stem and fruits), however the greatest damage is the drilling of new shoot sprouts, and especially the main sprouts that causes the ramification of the stem. Considering that the first three years of plantation are the critical period for the following reasons: a) lower part of log (basal area) is the most valuable; b) a tree with low bifurcation will not produce wood of commercial value; c) the attack of *H. grandella* retards the growth, increasing the maintenance costs, which are very high in the first years; d) the evidences indicate that when the trees reach about 6 m in height, the damage is less because the plants presents high regenerative capacity.

Due to high commercial value of mahogany, the level of the economic damage of shoot borer is only one plant per hectare, and therefore preventive measures to control the shoot borer attack should be taken (Ohashi et al. 2002). Thus, Allan et al. (1976), Yamazaki and Vasques (1991) and Newton et al. (1993), cite several efficient

insecticides for controlling mahogany shoot borer, but call attention to the high cost, as well as for environmental contamination by repeated applications of the products, and the product is washed away by rains.

The use of shading and natural barriers has presented contradictory results as Campbell (1966) reported that 50% of shade can reduce the shoot borer attack. However, Newton et al. (1993) pointed out that shaded seedlings were attacked by the shoot borer.

Ohashi et al. (2002) recommend for the management of *H. grandella*, the use of resistant plants and the application of Colacid. The authors suggest that planting mahogany with *Toona ciliata*, reduced by 50% the shoot borer attack, because this exotic Meliaceae plant acts as a trap, attracting the moths that lay around 85% of eggs in *T. ciliata* and after two hours that caterpilar *H. grandella* eat the leaves of this plant die by the antibiosis effect. According to Agostinho et al (1994), the dry limonoids A-B are the basis of resistance of *T. ciliata* to *H. grandella*. Based on the behavior of newly hatched caterpillar egg, the use of Colacid only on new mahogany sprouts reduced from 80 to 100% the shoot borer attack during the two years of study.

Ohashi et al. (2005) reported that the combination of mahogany with *T. ciliata* and *Khaya ivorensis* presented the efficiencies of the shoot borer control of 48% and 46%, respectively, and the egg parasitism of *H. grandella* by *Trichogrammatomyia tortricis* was up to 45%. The authors also point out that fertilization by calcium and boron, induced the resistance of mahogany to the shoot borer attack for three months. Silva et al. (2009) concluded that the application of doses of calcium in nutrient solution reduced the length of gallery bored into the tree stem, as well as it has been effective on pests control of mahogany plants.

The information above, mainly cited by Ohashi et al. (2002 and 2005), is the scientific basis for the development of research and is directly related to the project objective.

2. MATERIALS AND METHODS

This section outlines the experiments with respective treatments, evaluation methods and places where the respective experiments were conducted. In order to achieve the objectives, the following research was carried out:

2.1. Comparison of mahogany shoot borer control systems in the state of Pará

This experiment was established in the municipality of Aurora do Pará at the Tramontina farm, about 220 km from Belém (sate of Pará), which consisted of the following treatments (T):

T1 – Mahogany plantation intercropped with *T. ciliata* - this intercropping plantation was considered as standard treatment for the following reasons: it was considered the most efficient (Ohashi et al 2002 = 52%; Ohashi et al 2005 = 48%) among the alternatives, which presented the highest rate of parasitism of eggs of *H. grandella* by *T. tortricis* (Ohashi et al 2005 = 45%), attracting 80% of *H. grandella eggs*, that is, for every 10 eggs laid by this moth 8 are placed on *T. ciliata* and only 2 are placed on mahogany (Ohashi et al 2002). Caterpillars originating from eggs laid on *T. ciliata* eats the leaves of *T. ciliata* and die moments later (Alves 2002), *T. ciliata* is a tree species of rapid growth, with wood quality similar to *Cedrela* gender and so far no pest problems limiting its cultivation has been presented (Ohashi et al 2005);

T2 – Intercropping plantation of mahogany x *T. ciliata* + fertilizer with calcium and boron (Ohashi et al, 2004 = fertilization controlled the shoot borer attack for the first three months);

T3 – Intercropping plantation mahogany x *T. ciliata* + Colacid (Ohashi et al 2002 = 83% control efficiency);

T4 – Intercropping plantation mahogany x *T. ciliata* + fertilization + Colacid

T5 – Control: only mahogany plantations.

It is worth noting that the biological control in the region was not evaluated because it is not possible to isolate portions of the parasitoid action, and therefore, it was considered that parasitism occurred evenly across the experimental area.

The design was randomized blocks with five treatments and five repetitions. Each experimental parcel consisted of 52 plants (24 mahogany + 28 *T. ciliata*) planted at 3 m x 3 m spacing, interspersed cultivation in an area of about 1.5 ha of experimental area at the Tramontina farm in Aurora do Pará

Before planting in these experimental parcels, the following activities were carried out: soil fertility analysis, soil preparation, including plowing and harrowing, preparation of seedlings of mahogany and *T. ciliata*.

The seedling's planting of these species was carried out respectively in March and April 2009. In July 2009, due to low levels of nutrients in the soil, soil correction

was carried out at a dosage of 650 kg of dolomite limestone with 100% PRNT, as well as application of super phosphate fertilizer 75g per plant, 45g of potassium chloride, 40g of urea, 5g of zinc sulfate and 10g of borax.

Due to the first attacks of the shoot borer that started from January 2010, an analysis of this initial attack was conducted to show this pest occurrence in the experimental area, and soon after that, all the attacked/damaged shoots were pruned to start on the same conditions in all experimental parcels.

From that moment, the application of Colacid began in T2 and T4, which were conducted monthly in new mahogany sprouts. Colacid was applied in two formulations and in two distinct periods:

a- From January to June 2010, Colacid in drops was used, applying two drops using a plastic tube (Figure 1), placing a drop in the new sprout and another drop in the middle of new sprout;

b- Due to the height of some mahogany plants reaching more than 3 m of height, from July 2010 to January 2011 Colacid spray was used, whose spraying was carried out through manual backpack sprayer with flat fan spray nozzle (110 SF white) (Figure 2).

From February 2010, monthly assessments of various treatments began, taking notes of mahogany plants attacked and not attacked by the shoot borer in the useful parcel, that is, eight central plants of mahogany of each parcel. The measurement of height and diameter of these eight mahogany plants were also made.

In order to carry out statistical analysis, the number of attacked plants were transformed into attack percentage, which in turn was transformed into Arcsen $\sqrt{x + C}$, whose values were analyzed by randomized block design with parcels subdivided in time. Two analyses were carried out for the two study periods (February to June 2010 and July 2010 to January 2011).

The average of treatments was compared using the Tukey test. The heights were also examined by the same experimental design without transforming the values noted in centimeters.

Statistical analysis was carried out using the software Assistat 7.5 beta (2010) (INPI registration 0004051-2) from the Federal University of Campo Grande in the state of Paraiba, Brazil.

The control efficiency was calculated by the Abbot´s formula cited by Nakano et al. (1981).

2.2. Evaluation of Colacid formulation for application to mahogany 3 m high

Due to the difficulty and the time consumed in the application of two drops of Colacid (it is difficult to see and place the drops on top of the plant since the wind shakes the plant) in the mahogany shoots over 3 m in height. This study was carried out to select a more practical formulation to achieve the biological target. Thus, this

experiment was established at the UFRA farm in the municipality of Igarapé-Açu, located about 130 km from Belém in an area of mahogany (*S. macrophylla*) plantation intercropped with African mahogany (*Khaya ivorensis)*, which were planted on 30 March 2006 in a 3 m x 3 m spacing. Therefore, it was a three years old plantation that was attacked by the mahogany shoot borer. Thus, in April 2009, it was necessary to prune all branches and twigs attacked by shoot borer to start the treatments in mahogany plants already about 4 m high.

Due to this height, the use of equipment to help in the application of treatments was necessary. Initially (from June 2009 to May 2010), an adapted tractor (3 m in height) with lifting platform (Figure 3) was used for the application of Colacid treatment in new shoot sprouts of mahogany until the arrival (June 2010) of pantograph type lifting platform (Figure 4), which was custom made in Minas Gerais by the MVR industry specifically for this project. This platform allowed raising up to 7 m high, as well as rotating platform 45 degrees on both sides. The operations with this new platform facilitated pruning activities and application of treatment in mahogany plants up to 9 m high (Figure 5).

With these new equipments, the following treatments were tested on mahogany with more than 4 m in height:

T1 – Polyisobutylene 10% spray: spray 35ml / new sprout;

T2 – Polyisobutylene 10% spray + insecticide to 0.00375% i.a./35ml / sprout;

T3 – Colacid spray (Polybutene 3.2% + insecticide 0.005% i.a.) / 35ml / sprout;

T4 – Colacid drops (Polybutene 80% + insecticide 1.25% i.a.) / 2 drops / sprout;

T5 – Control (mahogany without shoot borer control)

The products polybutene and polyisobutylene are liquid oligomers, colorless, nontoxic, sticky and widely used in plastic manufacturing.

The Colacid drops formulation and the three spray formulation were prepared during the implementation of research and remain secret until the filing of the patent, which is the right of UFRA, ITTO and the researcher who invented the formulations.

The experiment was in randomized blocks with five treatments and four repetitions with parcels divided in months. Each parcel consisted of four mahogany plants that were treated and evaluated monthly from June 2009 to November 2010. In the evaluations, the number of plants attacked by the shoot borer *H. grandella* was considered, as well as the height and DBH (diameter at 1.30 m high) were measured.

Statistical analysis was carried out similar to that described in Section 2.1. Two analyses were carried out for the two periods: i) June 2009 to May 2010 when the tractor was used for the Colacid application; and ii) June 2010 to November 2010 when the pantograph type lifting platform was used.

2.3. Comparison of mahogany shoot borer control systems in São Paulo

Due to high demand from mahogany plantation owners for the control of mahogany shoot borer in the states of São Paulo and Minas Gerais, it was decided to select a control system where mahogany plantation is developing well. Mr. Nelcindo Gonsalez was selected and agreed to participate as one of the contributors to this project. He has dedicated to the cultivation of 12,000 mahogany intercropped with *T. ciliata*, in São José do Rio Preto in the state of Sao Paulo, where he also has been using the Colacid drops with great success. Other advantages seen in this plantation in the beginning of the treatments were: i) mahogany plantation with 22 months of age without the attack of the shoot borer due to the use of Colacid; ii) mahogany with 3.35 m high, thus presenting difficulties to apply 2 drops of Colacid without the use of a platform. Mr. Gonsalez had ordered to manufacture a pantograph type platform that was adapted to a tractor, in which a worker could make the treatment application on a tree 5 m high.

Thus, this experiment was conducted at the farm of Mr. Gonsalez, located on km 5 of the road for Talhado and about 12 km from São José do Rio Preto.

The experiment was conducted in randomized blocks with four treatments and five repetitions with parcels in months (months of observation). Each parcel consisted of 24 mahogany and 28 *T. Ciliata*, planted in four rows with 3 m x 2 m spacing, a total of 20 parcels in an area of about 1ha.

The main treatments were:

T1 – Intercropping mahogany x *T. ciliata*;

T2 – Intercropping mahogany x *T. ciliata* + fertilization with calcium and boron;

T3 – Intercropping mahogany x *T. ciliata* + Colacid;

T4 – Intercropping mahogany X *T. ciliata* + Colacid + fertilization with Ca and Bo.

This experiment did not have treatment control (only Mahogany), because all mahogany plantation was intercropped with *T. ciliata*.

The treatments started in September 2009, applying 8 kg of limestone per parcel and 10 g Boron per plant in the T2 and T4 treatments. This last treatment was reapplied in November 2009.

In the treatments T3 and T4, the Colacid was applied in two formulations and two distinct periods, using the pantograph type platform (Figure 6):

a- From September 2009 to April 2010, mahogany was treated with two drops of Colacid;

b- Due to good mahogany growth in May 2010, mahogany plantation reached a height of 8 m, which were treated with Colacid spray, that was carried out through manual backpack sprayer with flat fan spray nozzle (110 SF white)

(Figure .7).

Data evaluations and analysis were conducted similarly to those described in Section 2.1.

2.4. Effects of applying different levels of calcium and boron on the resistance of mahogany cultivated in soil and hydropony to the caterpillar *Hypsipyla grandella*

2.4.1. Effects of different levels of calcium and boron applied in the soil for the resistance to mahogany shoot borer

The purpose of this experiment was to evaluate the growth, dry matter production, nutrient content and control of *Hypsipyla grandella* (Zeller) (Lepidoptera: Pyralidae) in mahogany (*Swietenia macrophylla* King, Meliaceae) seedlings grown in Yellow latosol under increasing doses of limestone and boron.

The experiment was conducted from June 2009 to November 2010 in the greenhouse at the Department of Soil Science, Institute of Agricultural Sciences (ICA) of the Federal Rural University of Amazonia (UFRA), whose geographic coordinates in UTM are 22M 784552.92 and 9839229.18 (6.37 m high). The soil used as a substrate was collected in the layer 0-0.2 m depth in dystrophic yellow latosol (EMBRAPA, 2006), medium texture, located in an area of commercial mahogany plantation at the Fazenda Tramontina S.A. in the municipality of Aurora do Pará, whose geographic coordinates in UTM are 38M 722460.636 and 221196.538. The soil was transported to UFRA, where 7 kg of soil was placed per pot, planting a sapling of mahogany in a greenhouse.

The experiment was in randomized blocks (DIC) with different numbers of replications in a factorial arrangement (4x4+1), with additional treatment (absolute control), and factors are: a) four corrective doses (0.5, 1.0, 1.5 and 2.0 t.ha-1); and b) four doses of boron (1, 2, 3, and 4 mg.kg-1 of substrate). To evaluate the percentage of *H. grandella´*s attack, DIC was used with three replications per treatment. To evaluate the length of the gallery DIC was utilized with four replications. The remaining variables were evaluated using DIC with five replications.

The soil corrective used was dolomitic limestone (Total Relative Neutralizing Power -96%), and the doses were calculated based on the results of soil analysis, using the base saturation method (Raij, 1991), to increase to 44, 53, 62, and 71% base saturation. The doses of boron were applied in a solution form, using boric acid reagent p.a. (H3BO3). The calculation of doses was carried out by taking the recommendation 1.0 mg of boron per kg of substrate (Novais et al., 1991) as the smallest dose and it was increased by one unit the remaining doses to check the responses of plants in relation to this element.

H. grandella eggs inoculations were made on seedlings of 255-day-old plants with new sprouts between 16:30 h and 17:00 h, which is the period under natural conditions that the moths prefer for oviposition (Ramirez-Sanchez, 1964). Eggs

produced at the UFRA Laboratory of Entomology following the methodology used by Almeida (2005) were placed in the region near the apical meristem (two eggs/plant), using an entomological pin, thereby trying to simulate the natural condition of oviposition of the moth. After 24 hours that the eggs hatched from three to ten days, damages were observed in apical meristem, characterized by gum exudation and dust release, indicating the effective attack by the shoot borer. Nine plants were inoculated per treatment and the percentage was calculated from the arithmetic mean of three plants, remaining three percentage replications in each of 17 treatments. After 20 days of inoculation, harvesting of the plants and measurement of other variables were carried out.

For measuring the length of gallery (comprimento da galleria - CG), the cross-section of the stem was made, with a pocket knife for measuring using graduated ruler. It was considered as a gallery a part inside the stem near the top which was hollow due to the caterpillar attack. Since there were different numbers of attacked plants in different treatments and the lowest number was four plants per treatment, a selection of data was done based on arithmetic average of each treatment.

The data were submitted to an analysis of variance (ANOVA) with differentiated factor, considering the additional treatment, and the significance level determined by F test and the averages compared by Tukey test at 5% probability. The Dunnet test ($p < 0.05$) was applied when the interaction factor x witness was significant.

When there was a significance by F test of the factorial ANOVA, the variables were evaluated by ANOVA of regressions to adjust a model (linear or quadratic), considering the growth, biomass and nutrient content data as dependent variables of corrective doses of Boron applied.

For the procedure of statistical analysis, the Assistat program, version 7.5 beta (SILVA, 2008) and Microsoft Office Excel 2007 were used. For the normalization of the variable dry matter of root, the values were transformed by square root function. The other variables were not transformed.

2.4.2. Effects of different levels of calcium and boron on the resistance of mahogany in hydroponic cultivation to *Hypsipyla grandella*

The experiment was conducted in the greenhouse of Soil Science Department of the Institute of Agricultural Sciences at the Federal Rural University of Amazonia, in Belém. Mahogany seedlings (three months old) purchased from a certified producer were used. The seedlings were transplanted to plastic pots with a capacity of four liters of thick silica-type zero.

The experiment was conducted in randomized blocks (BIC) with 13 replications in a factorial arrangement (4x4), and factors are: a) four doses of calcium (0, 100, 200 and 400 mg / L of nutrient solution); b) four doses of boron (0, 0.5, 2.0 and 4.0 mg / L of nutrient solution). The nutrient solution used is Hoagland & Arnon (1954).

The experiment used the following treatments:

Treatment	Ca (mg/L)	B (mg/L)
Treat 1 -	0	0,0
Treat 2 -	0	0,5
Treat 3 -	0	2,0
Treat 4 -	0	4,0
Treat 5 -	100	0,0
Treat 6 -	100	0,5
Treat 7 -	100	2,0
Treat 8 -	100	4,0
Treat 9 -	200	0,0
Treat 10 -	200	0,5
Treat 11 -	200	2,0
Treat 12 -	200	4,0
Treat 13 -	400	0,0
Treat 14 -	400	0,5
Treat 15 -	400	2,0
Treat 16 -	400	4,0

The nutrient solution was supplied by percolation in pots and renewed at intervals of 14 days and kept at pH 6.0 ± 0.5, and the solution level was daily checked in glass collectors, completing the volume to a liter by adding distilled water.

The monitoring of symptoms was done by photos and will be described from the beginning to the complete definition after collecting the plants. These will be divided into leaves, stems and roots, washed with distilled water and placed in a greenhouse with proper air circulation at 70ºC until a constant weight is obtained.

As response variables, it will be held biometric measurements of plant height, its circumference and number of leaves, besides the production of dry matter and percentage of attack and gallery's length.

The data will be analyzed statistically by variance analysis and applied the Tukey test at 5% probability for the comparison of the average treatments in the variables studied.

3. PROJECT RESULTS

3.1. Comparison of mahogany shoot borer control systems in the state of Pará

3.1.1. Effects of the management systems in mahogany shoot borer control

Figure 8 shows the mahogany shoot borer attack in Aurora do Pará experiment started in January 2010, that is, 10 months after mahogany planting, a period foreseen for the beginning of attack when mahogany plants reach 72 cm in height and starting to launch new sprouts. The pest was present in 92% of experimental parcels on average attack in 30.40% of the plants in the parcels. This demonstrated that the pest was attacking almost all the experimental area, and that the treatments were supposed to be initiated to evaluate their effects on the shoot borer attack. However, before starting the treatments all the attacked branches and shoots were pruned to place the parcels under the same conditions, that is, without the shoot borer attack. Figure 8 also shows that in February, only the control parcel faced the shoot borer attack, while there was no attack in other parcels, probably due to the treatments on the pest.

The analyzes of these results shown in Tables 1 and 2 show that there was significant and highly significant effect of these treatments on the attack of the shoot borer, respectively, when the Colacid drops were used from February to July 2010 and when the Colacid spray was used from August 2010 to January 2011.

Figure 8 - Percentage of H. grandella attack comparing mahogany shoot borer management systems in Aurora do Pará

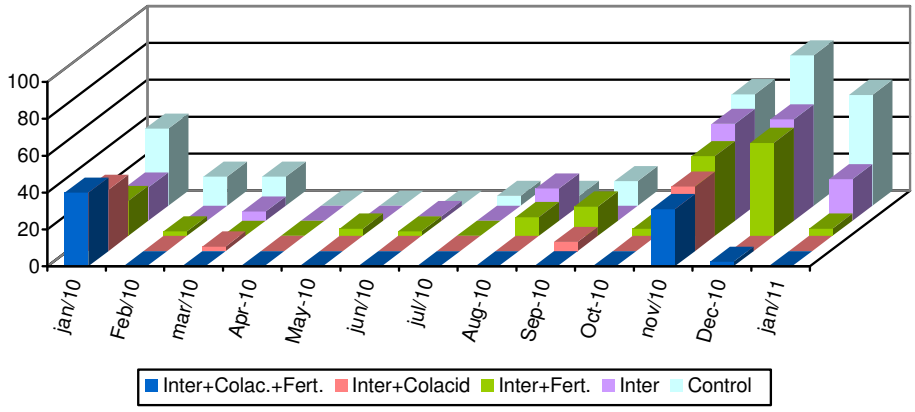


Table 1 - Analysis of shoot borer attack in Aurora do Pará in the period February - July 2010 with data transformed to Arcsen √ x +0.5, applying Colacid drops

F. V.	G.L.	S.Q.	Q.M.	F
Blocks	4	82,77	20,69	0,4902
Treat- (Ta)	4	777,07	194,26	4,6019*
Residue-a	16	675,43	42,21	
Parcelas	24	1535,28		
Trat-b (Tb)	5	519,65	103,93	3,0139*
Int. TaxTb	20	1380,26	69,01	2,0013*
Residue-b	100	3448,38	34,48	
Total	149	6883,60		

*** Significant at 5% probability (.01= < p < 0.5)**

Table 2 - Analysis of mahogany shoot borer attack in Aurora do Pará in the period August 2010 - January 2011 with data transformed to Arcsen √ x +0.5, applying Colacid spray

F. V.	G.L.	S.Q.	Q.M.	F
Blocks	4	1499,66	374,91	1,9967ns
Treat-a (Ta)	4	15369,44	3842,36	20,4638**
Residue-a	16	3004,21	187,76	
Parcelas	24	19873,32		
Treat-b (Tb)	5	26637,06	5327,41	46,73**
Int. TaxTb	20	14172,31	708,61	6,2157**
Residue-b	100	11400,41	114,00	
Total	149	72083,11		

**** Significant at 1% probability (p < .01)**

Figure 9 - Comparison of average (Tukey 5%) shoot borer attack in four management systems in Aurora do Para in the two periods of Colacid application: drops and spray

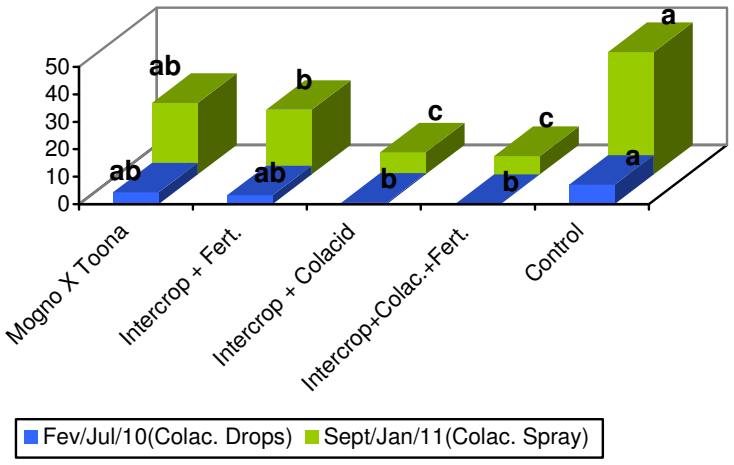
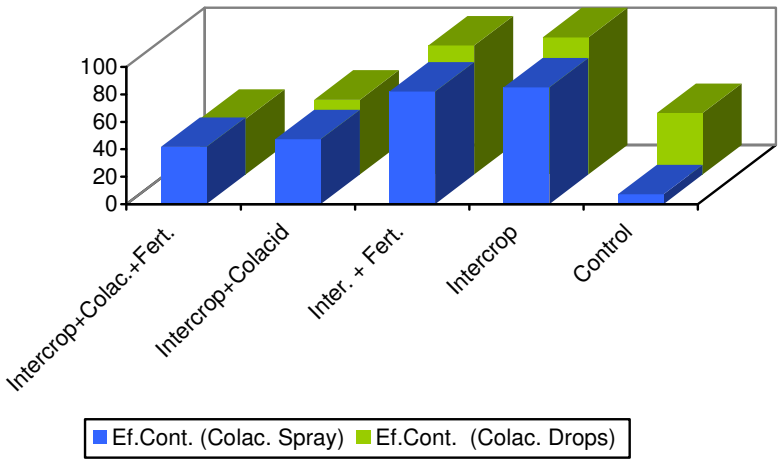


Figure 10 - Comparison of average shoot borer efficiency control in four management systems in Aurora do Para in the two periods of Colacid application: drops and spray.



Comparing the five treatments, Figure 9 shows that two control systems (a- mahogany x *T. ciliata* + Colacid; b- mahogany x *T. ciliata* + Colacid + Calcium and boron fertilization) differed statistically from the other treatments because it presented greater impact on the pest in terms of control percentage, as well as efficiency control (Figure 10).

Table 3 presents these results, which stand out those related to systems intercropping mahogany x *T. ciliata* + Colacid and mahogany x *T. ciliata* + Colacid + calcium and boron fertilization.

The efficiencies of the shoot borer control system for the intercropping of mahogany x *T. ciliata* of 40.59% and 41.75%, respectively for the periods from February to July 2010 and August 2010 to January 2011, are considered low, but the results is close to the percentage found by Ohashi et al (2005) which was 48% efficiency. It is assumed that a reason of these differences may be the application of Colacid in parcels treated with this product containing an insecticide, which may have an effect not only on the pest, but also on *Trichogrammatomya torticis*, a parasitoid cited by Ohashi et al. (2005), controlling 45% of eggs of *H. grandella*, in the same farm and in 2005 an insecticide was not used.

Table 3 - Percentage of shoot borer attack and control efficiency in the four control systems in Aurora do Pará in two periods related to the use of Colacid, Colacid drops and spray

TREATMENTS	ATTACK (%)		CONTROL EFFICIENCY (%)	
	Feb/Jul 2010 (Cola. drops)	Aug/Jan 2011 (Cola. spray)	Feb/Jul 2010 (Cola. drops)	Aug/Jan 2011 (Cola. spray)
T1 – Intercropping mahogany. x *T. ciliata*	1,25	24,58	40,59	41,75
T2 – Intercropping. + Fertilization	1,50	21,33	54,41	47,22
T3 – Intercropping. + Colacid	0,42	6,67	94,02	82,08
T4 – Intercropping + Colacid +Fertilization	0,0	5,59	100,0	84,96
T5 – Control parcel	6,13	38,09	_	_

Table 3 shows that the intercropping mahogany x *T. ciliata* combined with calcium and boron fertilization presented positive effects, the efficiencies of control increased to 54.41% and 47.22%, respectively for the period February to July 2010 and August 2010 to January 2011. It is worth noting that boron and calcium fertilizer at dosage 650 kg/ha and 10g Borogran 10G should be further investigated with a view that affected the growth, as well as it caused the death of some mahogany plants. However, it is also important to mention that Ohashi et al. (2005) reported that in the same farm 20g and 40g of boric acid induced mahogany resistance to the shoot borer *H. grandella* for 3 months without symptoms of intoxication.

The system combined with Colacid presented low percentage of the shoot borer attack and with good percentage of control efficiency as shown in Figure 9, Figure 10 and Table 3. The control system intercropping mahogany x *T. ciliata* + Colacid and the intercropping system mahogany x *T. ciliata* + Colacid + fertilization, present efficiencies varying from 82.08% to 100% (Table 3) that can be considered very good and coincide with the results cited by Ohashi et al (2002) who recommend planting mahogany x *T. ciliata* + Colacid because it controls the mahogany shoot borer attack between 80% and 100%,

Table 3 also shows the importance of adding Colacid in the management systems of the mahogany shoot borer control, because the efficiency has almost doubled in relation to intercropping systems of mahogany x *T. ciliata* + fertilization. In the period from February to July 2010 when Colacid drops were used, the efficiencies were slightly higher than in the period August 2010 to January 2011 when Colacid spray was

used. That is probably because insecticide is much more concentrated in Colacid drops than in Colacid spray. However, these two formulations could not be compared statistically because they were used in different periods, but the analysis showed no statistical differences at the experiment in Igarapé-Açu.

3.1.2. Effects of management systems in the mahogany growth in height

Figure 11 - Mahogany growth in height (cm) under four mahogany shoot borer control systems in Aurora do Pará from 10th to 22nd month-old

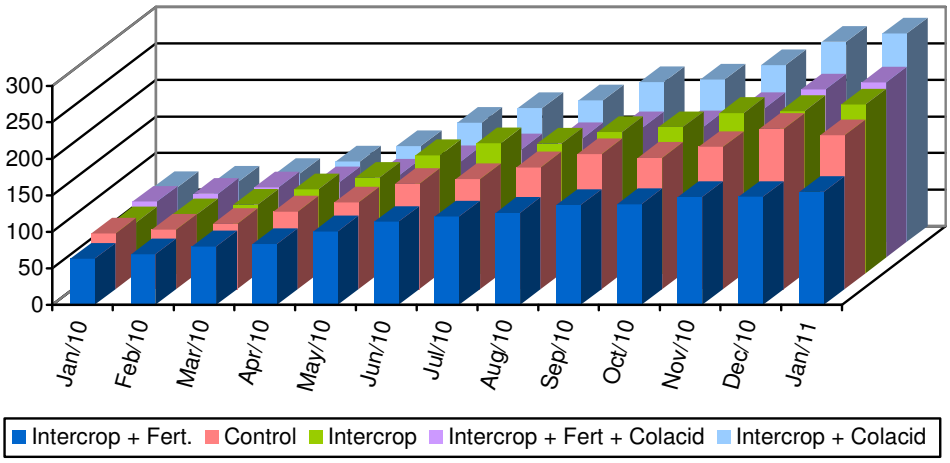


Figure 11 shows that some treatments of this experiment influenced the mahogany growth (in height). The results suggest that mahogany x *T. ciliata* + Calcium and Boron fertilization is a system that hinders mahogany growth in height. On the other hand, the intercropping system mahogany x *T. ciliata* + Colacid is the treatment that helped the growth (average height of 352cm), while other systems presented a growth similar to control parcel (146.25 cm).

The average height of the experiment in January 2011 was 224,14 cm, therefore, with an average annual growth of 122,48 cm and 10,18 cm monthly growth, which is less than the growth observed in São Jose do Rio Preto.

The analysis of the growth or variation of height growth (Table 4) between the beginning and the end of this study showed a highly significant effect of treatments on mahogany growth, that is, the treatments influenced the growth of this Meliaceae species.

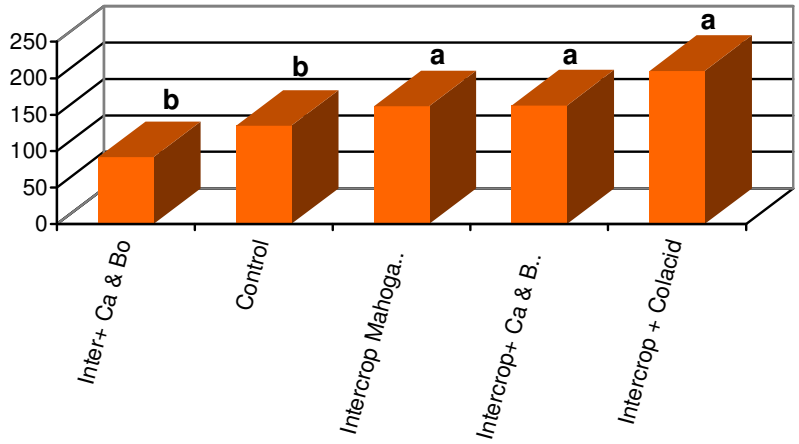
Table 4 - Analysis of mahogany height growth at Ttramontina farm from January 2010 to January 2011

F.V.	G.L.	S.Q.	Q.M.	F
Treatments	**4**	**37605.87108**	**9401.46777**	**4.7172 ****
Residue	**20**	**39860.73532**	**1993.03677**	
Total	**24**	**77466.60640**		

**** Significant at 1% probability (p <.01)**

Although Figure 11 and Figure 12 show that the plants grew more on the mahogany intercropping system + Colacid, the comparison of the average increase in height by Tukey test (Figure 12) showed that this system was not statistically different from the management systems mahogany x *T. ciliata* and the intercropping mahogany x *T. ciliata* + Colacid + Calcium and boron fertilization. On the other hand, these three systems differed statistically from the Control parcel and the system mahogany x *T. ciliata* + Calcium and Boron fertilization, which did not differ statistically among them. Despite the increase in this management system does not differ from the control parcel, mahogany plant mortality rate was 10%, while the intercropping system with fertilization, mahogany mortality rate was 20%. This indicates that the dosage of Calcium and Boron applied may have been toxic to mahogany, according to Malavolta (2006), the excess of Boron (in citrus and coffee) can cause chlorosis and burning of leaf margins, whose symptoms were observed in mahogany plants treated with Calcium and Boron.

Figure 12 – Mahogany height growth under 4 control system from 10th to 20th months old in Aurora do Pará



3.1.3. Weather effects (rain) in mahogany shoot borer control

Although Table 1 and Table 2 (item 3.1.1) present, respectively, significant effects and highly significant effect for the months of monitoring (secondary treatment), and for the interaction main treatment x secondary treatment, comparison of percentages of the shoot borer attack for the month monitored, did not follow a logical response as shown in Table 5 and Table 6. This type of response was also observed for the experiments in Igarapé-Açu and São Jose do Rio Preto.

As rainfall data was recorded monthly, the analysis was carried out with a simple correlation between the percentage of attack in the sample control parcel and the rainfall, the result was not significant, that is, there is also no correlation between rainfall and shoot borer attack, as shown in Table 7.

Table 5 – Comparison of mahogany shoot borer average attack per month under 4 control management systems in Aurora do Para from February to August 2010 (Colacid Drops)

Months - Year 2010	Attack (%)	Tukey 5%
February	**3,6**	**abc**
March	**4,6**	**ab**
April	**0,0**	**c**
May	**0,8**	**bc**
June	**1,0**	**bc**
July	**1,0**	**bc**
August	**6,6**	**a**

Table 6 – Comparison of mahogany shoot borer average attack per month under 4 control management systems in Aurora do Para from September 2010 to January 2011 (Colacid Spray)

Months Year 2010-2011	Attack (%)	Tukey 1%
September/10	**6,8**	**cd**
October/10	**2,4**	**d**
November/10	**44,4**	**a**
December/10	**37,9**	**b**
January/11	**17,3**	**c**

Table 7 – Correlation between rainfall and mahogany shoot borer attack in the treatment of control parcel in Aurora do Pará

	Jan./10	Feb./10	Mar./10	Apr/10	May/10	Jun./10	Jul./10	Aug./10	Sept/10	Oct./10	Nov./10	Dec./10	Jan./11
Rain (mm)	190,7	169,8	171,4	311,8	235,0	120,6	73,6	69,2	3,2	56,2	192,5	109,6	494,5
Attack Test.	41,7	15,7	15,7	0	0	0	5,35	5,35	13,2	8,2	60,35	81,4	60,0

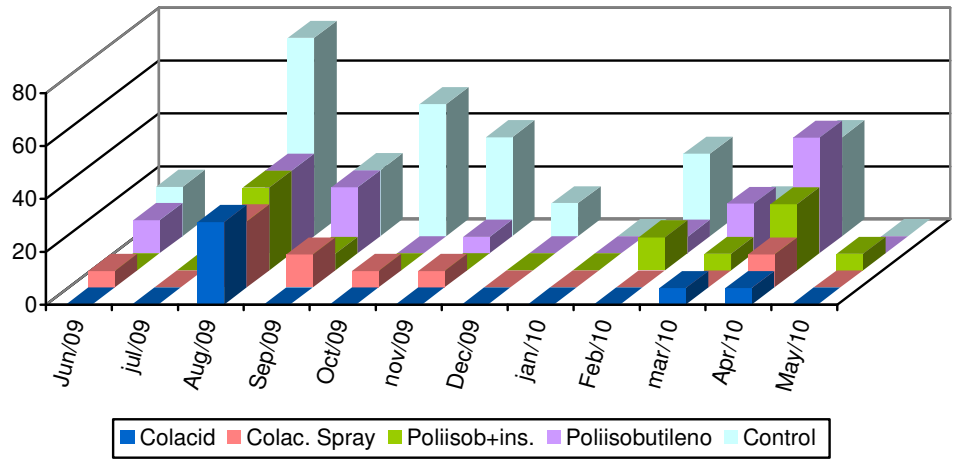
3.2. Colacid formula evaluation for the application in mahogany over 3 m high

3.2.1. Mahogany shoot borer control using tractor as support in the period June 2009 to May 2010

In selecting a more practical formulation to apply Colacid drops in mahogany plants with more than 3 m high in the municipality of Igarapé-Açu, an alternative was the use of tractor to help to raise the worker at 3 m high and increase the spray application pole to reach new shoots of mahogany, whose average height at the beginning of this work was 4.31 m. The tractor was used as support from June 2009 to May 2010, then pantograph type lifting platform started to be used from June to November 2010.

The results of mahogany shoot borer control when the tractor was used are shown in Figure 13, where parcels treated with Colacid and Polyisobutylene showed the same level of infestation, and they were attacked less than in control sample parcel.

Figure 13 - Control of mahogany shoot borer in Igarapé-Açu with various Colacid formulations using tractor for application of the treatment in mahogany plants over 3m high



The analysis of these results showed a significant effect of these treatments on the shoot borer attack, that is, there was a reduction of attack due to the application of treatments (Table 8).

Table 8 – Analysis of mahogany shoot borer attack in Igarapé-Acú from June 2009 to May 2010 with data transformed P/arcsenvx+0.5, using tractor as platform

F. V.	G.L.	S.Q.	Q.M.	F
Blocks	**3**	**794,61**	**264,87**	**0,8681ns**
Treat-a	**4**	**9561,86**	**2390,46**	**7,8348****
Residue-a	**12**	**3661,31**	**305,10**	
Parcelas	**19**	**14017,78**		
Treat-b	**11**	**19458,97**	**1768,99**	**10,44****
Int. TaxTb	**44**	**10497,74**	**238,58**	**1,4081ns**
Residue-b	**165**	**27957,95**	**169,44**	
Total	**239**	**71932,46**		

**** Significant at 1% probability**

By comparing average by Tukey test at 5% (Table 9), the 4 treatments did not differ statistically among themselves, but differed from the sample control parcel, except for Polyisobutylene spray that did not differ from this treatment.

Table 9 - Average percentage of mahogany shoot borer attack in Igarapé-Açú from June 2009 to May 2010, Tukey at 5% and control efficiency of 4 Colacid formulations using tractor as platform

Treatments	Attack (%) / Tukey 5%	Efficiency Control (%)
Poliisobutileno Spray	**15,97 ab**	**52,08**
(Poliisob.+ Ins.)Spray	**09,03 b**	**72,90**
Colacid Spray	**07,64 b**	**77,07**
Colacid Drops	**05,55 b**	**83,34**
Control Parcel	**33,33 a**	**-**

However, by the percentage of control efficiency (Table 9), Colacid drops treatment showed a good efficiency with an average 83.34%, followed by Colacid spray and Polyisobutylene + insecticide with efficiencies of 77.07% and 72.90%, respectively. On the other hand, Polyisobutylene spray presented a low efficiency of 52.08%.

3.2.2. Shoot borer control using a pantograph type lifting platform as platform from June to November 2010

Figure 14 – Percentage of shoot borer H. grandella treated with 4 Colacid formulations using pantograph type lifting platform in Igarapé Açú from June to November 2010

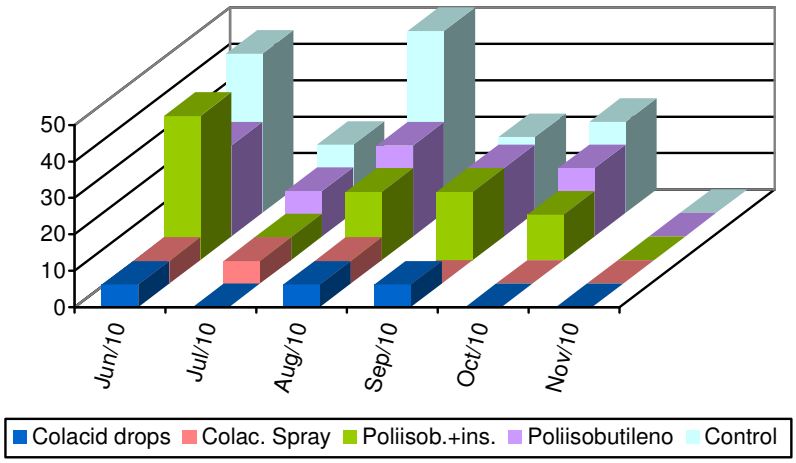


Figure 14 show the results of shoot borer control during June-November 2010 that the treaments Colacid drops and Colacid spray presented the low level of shoot borer attack, while the treatments with Polyisobutylene spray and Polyisobutylene spray + insecticide showed similar result of the control parcel. This was confirmed by variance analysis (Table 10), where there was a significant effect of treatments on the shoot borer attack.

Table 10 - Analysis of mahogany shoot borer attack in Igarapé-Açu during June-November 2010 with data transformed to P/Arcsen√ x+0.5 using lifting type platform

F. V.	G.L.	S.Q.	Q.M.	F
Blocks	**3**	**199,99**	**66,63**	**0,1567ns**
Treat-a (Ta)	**4**	**7232,75**	**1808,18**	**4,2518***
Residue-a	**12**	**5103,32**	**425,27**	
Parcels	**19**	**12535,96**		
Treat-b (Tb)	**5**	**5666,01**	**1133,20**	**6,1161****
Int. TaxTb	**20**	**3516,48**	**175,82**	**0,9489ns**
Residue-b	**75**	**13896,26**	**185,28**	
Total	**119**	**35614,73**		

**** Significant at 1% probability (p < 0.1)**

*** Significant at 5% probability (.01 =< p < .05)**

The comparison of average attack in these treatments by Tukey test at 5% showed that the best treatments were Colacid drops and Colacid spray, but they did not differ from treatments Polyisobutylene spray and Polyisobutylene spray + insecticide, which in turn did not differ from the control sample parcel (Table 11). However, by the percentage of control efficiency, the treatments with Colacid drops and Colacid spray presented a good control efficiency of 88.15%, the results are similar to percentage presented in section 3.1.1 (Table 3) and it was slightly higher using tractor (Item 3.2.1, Table 9). This shows that the treatments applied using the pantograph type lifting platform was better than using tractor.

Table 11 - Average percentage of mahogany shoot borer attack in Igarapé-Açu during June-November 2010, Tukey at 5% and control efficiency of four Colacid formulations using lifting type platform

Treatments	Attack (%) /Tukey (5%)	Efficiency Control (%)
Poliisobutileno Spray	**16,6 ab**	**36,82**
(Poliisob.+Ins.) Spray	**15,9 ab**	**39,45**
Colacid Spray	**3,1 b**	**88,15**
Colacid	**3,1 b**	**88,15**
Control	**26,3 a**	**-**

3.2.3. Effects of 4 Colacid formulations on mahogany height growth

Figure 15 shows that Colacid drops helped mahogany growth, while the other treatments showed a similar growth.

The analysis of these results showed a significant effect of the treatments on the mahogany growth, the difference can be seen by comparing the mean increment of

treatments in Figure 16, where it is evidenced by the Tukey test that Colacid drops showed better increment.

Figure 15 - Effect of treatments on the mahogany growth in height (cm) during May 2009 - November 2010 in Igarapé-Açu

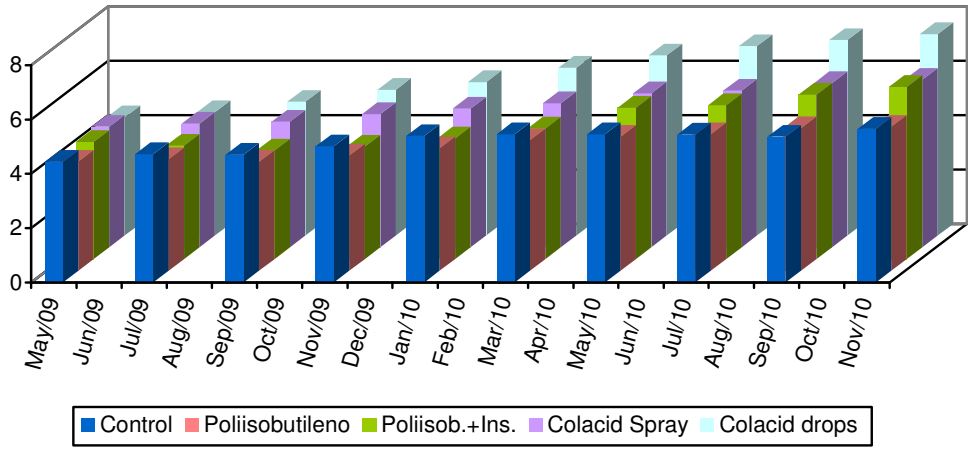
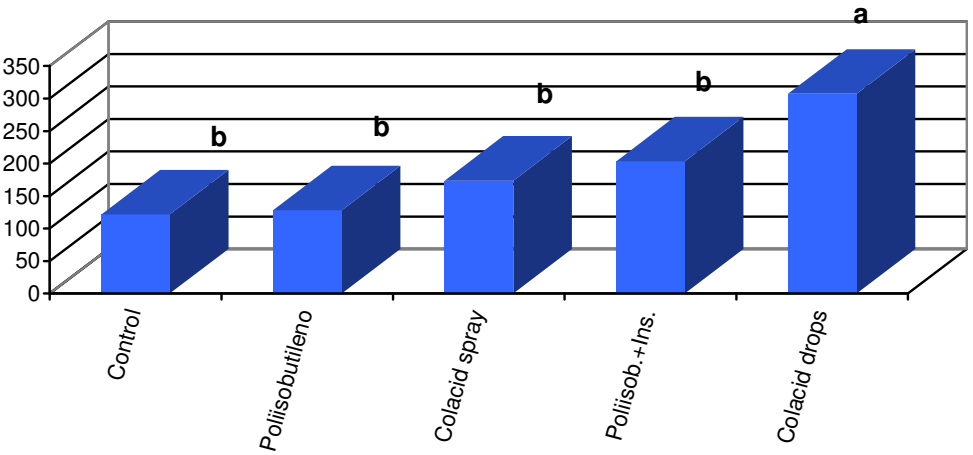


Figure 16 - Effect of treatments on the mahogany growth in height (cm) in Igarapé-Açu during May 2009 - November 2010



3.3. Comparison of mahogany shoot borer control system in São Paulo

3.3.1. Effects of management systems in the control of mahogany shoot borer

Although this experiment had started in September 2009, the shoot borer attack in this area only began in May 2010 (Figure 17). Therefore, during the period from September 2009 to April 2010 there was no attack in the experimental area, probably due to the edge effect by the control using Colacid drops across commercial planting on

the experiment located in the middle of the commercial planting, where this control was ended only in April 2010 when mahogany height ha reached 7.5 m high and hampered the application of Colacid drops even with the use of pantograph type lifting platform. Due also to this difficulty in the experimental area, the treatment was replaced by Colacid spray that showed good results in Igarapé-Acu.

From May 2010, the first shoot borer attacks were detected as shown in Figure 17, which shows that the combination system mahogany x Colacid presented the lowest percentage of shoot borer attack and is followed by other systems.

The variance analysis in Table 12 shows statistically highly significant effect of treatments on the attack of the shoot borer, and Tukey test at 5% (Table 13), the intercropping system mahogany x *T. ciliata* + Colacid spray was the system less attacked by the shoot borer (0.62%), while the intercropping system mahogany x *T. ciliata* + Calcium and Boron fertilization was the most attacked (8.43%), and the other two systems presented intermediate values, that is, there was not difference with the system less attacked or the most attacked by the pest. If we consider only the crescent order of percentage of the shoot borer attack, the two systems less attacked the intercropping mahogany x *T. ciliata* + Colacid spray (0.62%) and Intercropping mahogany X *T. ciliata* + Calcium and Boron Fertilization + Colacid spray (3.43%) were the best systems in the shoot borer control, matching with the results observed in Aurora do Pará, described in item 3.1.1.

The control efficiency was not calculated because in this experiment there was no sample control parcel.

Figure 17 – H. grandella´s attack comparing mahogany shoot borer control systems in São José do Rio Preto, São Paulo

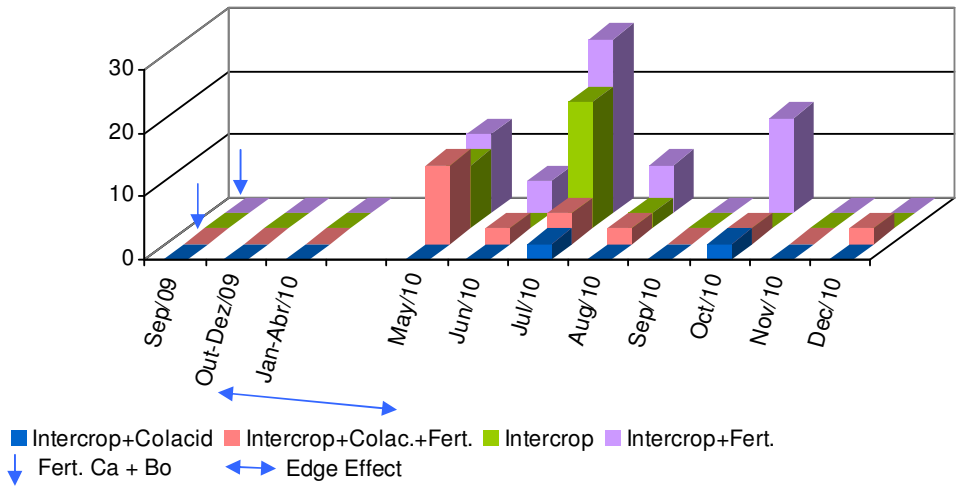


Table 12 - Analysis of mahogany shoot borer attack in São José do Rio Preto using pantograph type lifting platform during May–December 2010 with data transformed to arsen√x+0.5

F. V.	G.L.	S.Q.	Q.M.	F
Blocks	**4**	**172,55**	**43,13**	**0,4379ns**
Treat-a (Ta)	**3**	**2020,81**	**673,60**	**6,8375****
Residue-a	**12**	**1182,19**	**98,51**	
Parcels	**19**	**3375,56**		
Treat-b (Tb)	**7**	**3771,88**	**538,84**	**11,9597****
Int. TaxTb	**21**	**2613,46**	**124,45**	**2,7622****
Residue-b	**112**	**5046,11**	**45,05**	
Total	**159**	**14807,02**		

**** Significant at 1% probability (p < .01)**

Table 13 - Comparison of the average attack of mahogany shoot borer under 4 management systems in São José do Rio Preto during May-December 2010

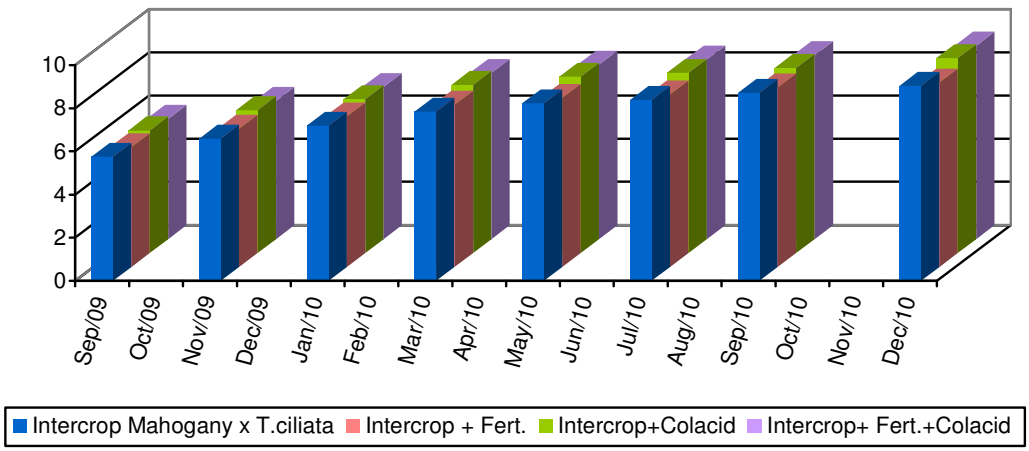
Treatments	Attack (%)/ Tukey (5%)	Efficiency Control (%)
Intercropping mahogany x *T. ciliata*	**4,06 ab**	**-**
Intercropping + Ca & Bo Fertilization	**8,43 a**	**-**
Intercropping + Colacid spray	**0,62 b**	**-**
Intercropping + Fertilization + Colacid spray	**3,43 ab**	**-**

3.3.2. Effects of management systems in mahogany growth in height in São Jose do Rio Preto

Figure 18 shows that mahogany height in the São Jose do Rio Preto experiment, grew uniformly in all mahogany shoot borer control management systems, so that the variance analysis determined no significant effect for treatments. The growth was good and similar for all treatments, considering that at 36 months, the average height was 8.95 m; therefore, with an annual growth of 2.98 m.

The increment in the period was 3.35 m or 0.24 m per month, it is above the increment observed at the Tramontina farm in Aurora do Pará, which was 152.15 cm per year x 12.68 cm per month, probably because in São José do Rio Preto, the conditions were better in terms of nutrition and by silvicultural treatments.

Figure 18 - Uniform growth of mahogany under 4 shoot borer control systems in São José do Rio Preto from 22th to 36th months of age

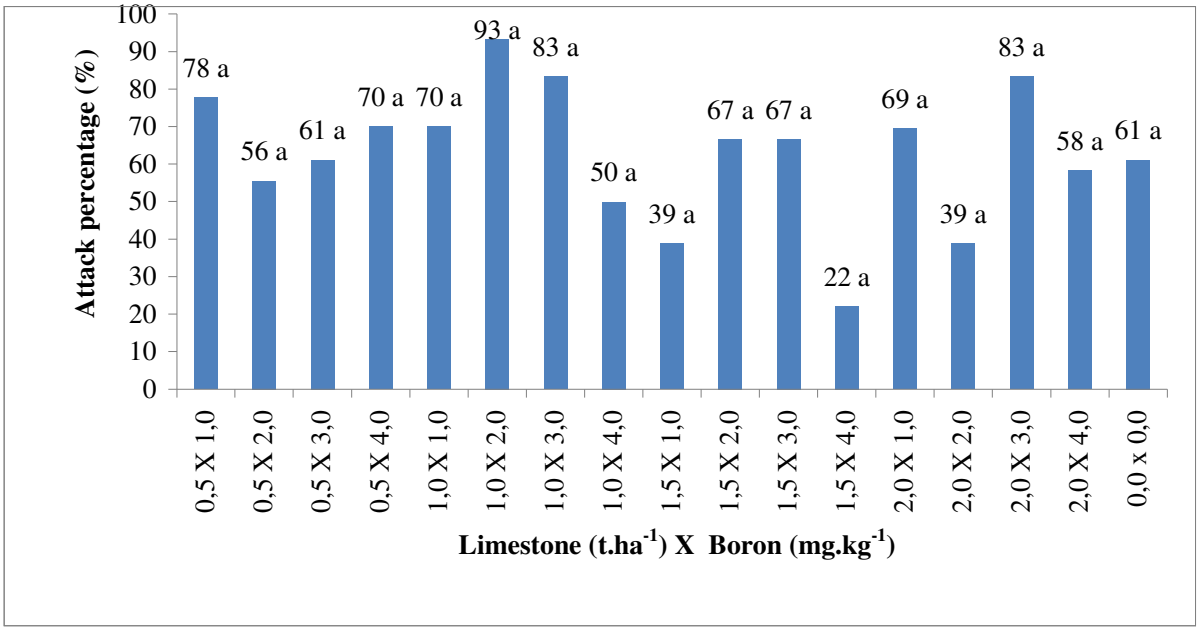


3.4. Effects of different levels of calcium and boron on the resistance of mahogany cultivated in soil and hydropony to caterpillar *Hypsipyla grandella*

3.4.1. Effects of different levels of calcium and boron applied to the soil in resistance to mahogany shoot borer

The two factors evaluated (calcium and boron) showed no significance ($p < 0.05$) for the percentage of *H. grandella* attack on mahogany seedlings. The absolute control sample parcel did not differ from the factorial treatment for this variable; its percentage of average attack was 61%. The small percentage of attack (22%) was obtained in the treatment of mixture of doses between 1.5 $kg.ha^{-1}$ of limestone and 4.0 $mg.kg^{-1}$ of boron (Figure 19). Silva et al. (2009) evaluated the effect of calcium in the control of *H. grandella* in mahogany seedlings in a hydroponic system, noting that plants with 189 and 211 days of age presented increased resistance to the shoot borer, with doses of 160, 240 and 320 mg.L of calcium in the nutrient solution, the percentages of attack were 20%, 60%, and 80%, respectively.

Figure 19 - Percentage of H. grandella attack on mahogany seedlings under increasing doses of limestone and boron in Belém in 2010



The length of the gallery showed significance ($p < 0.05$) with doses of boron. However, there was no significant difference between the lowest (1.0 $mg.kg^{-1}$) and higher dose (4.0 $mg.kg^{-1}$) (Figure 20).

Figure 20 - Average length of gallery made by the shoot borer H. grandella in mahogany seedlings under increasing doses of boron in Belém, in 2010

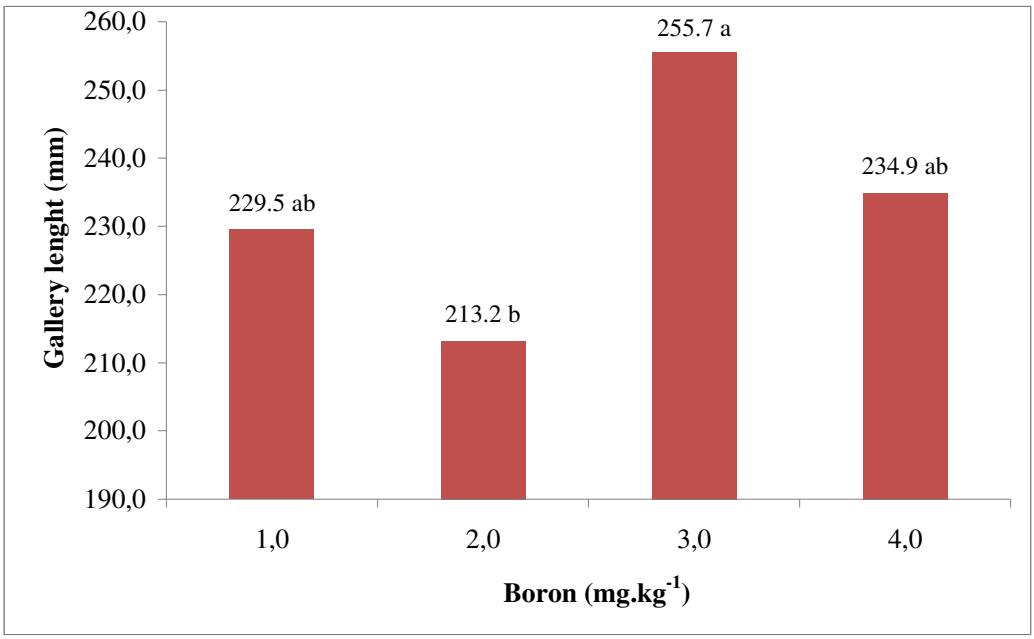
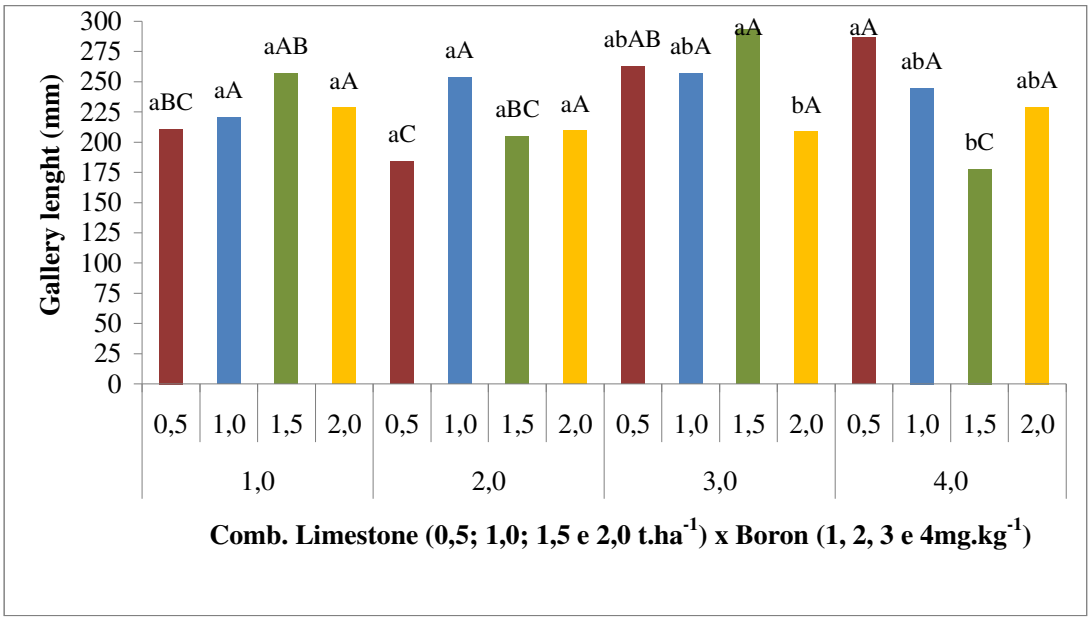


Figure 21 - Breakdown of interaction and comparison of the average gallery length of H. grandella in mahogany seedlings under increasing doses of limestone and boron



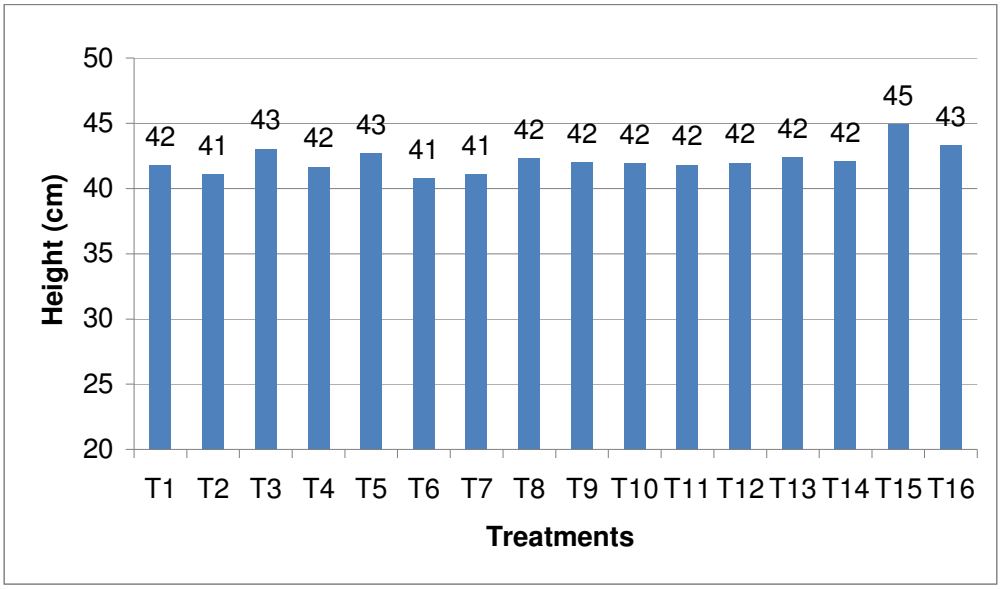
Note: Lowercase letters compare the effect of soil corrective within each dose of boron; capital letters compare the effect of boron within each dose of soil corrective by the Tukey test at 5% probability. Belém, PA. 2010.

3.4.2. Effects of different levels of calcium and boron on resistance of mahogany cultivated in hydropony to *Hypsipyla grandella* caterpillar

Partial results of mahogany growth in hydropony:

Figure 22 shows the results of mahogany plant's height 30 days after the treatments.

Figure 22 - Average height of mahogany seedlings cultivated in nutrient solution under different levels of calcium and boron 30 days after the application of treatments



3.5 - Dissemination of results

In spite of not having been scheduled them during the project design some extra activities were carried out to disseminate the results due to the importance of the products obtained in this project, as shown in Table 23.

Table 23 – Extra activities for the dissemination of results

OBJECTIVE	ACTIVITIES	PRODUCTS
Main Objective: • Select the shoot borer *Hypsipyla grandella* management systems to stimulate mahogany reforestation in the states of Pará and São Paulo	• Presentation of papers at the XXIII Brazilian Congress of Entomology • Presentation of the results in the III Taller Latino Americano ITTO-CITES • 2 field training: Aurora do Pará and São José do Rio Preto • 2 workshops: ESALQ / USP and UFRA	• Dissemination of project results to students, teachers, technicians, researchers, timber industries and politicians interested in mahogany plantations and the Brazilian Forest Code

During the III Latin American Workshop on the ITTO-CITES Program held on 15 - 17 February 2011 in Brasilia, the coordination of this project talked with ITTO to suggest that the fourth installment and the remaining amount be used to the dissemination of project results through seminars and Field trainings. As a result, 2 field trainings and 2 seminars were included as project activities.

The first field training was held on 03 February 2011 at the Tramontina farm, in Aurora of Pará, where about 50 people, including technicians, academics, agronomists and students, visited the field and learned how the treatments and evaluations of the experiment comparing management systems of mahogany shoot borer were carried out in the state of Pará. After the field visit, the participants attended a presentation of the results of all experiments of the project given by Dr. Orlando Shigueo Ohashi, the coordinator of the project.

The second field training was held on 07 April 2011 in the mahogany plantation area of Mr. Nelcindo Gonsalez in São Jose do Rio Preto, where three ESALQ/USP professors, an EMBRAPA researcher and two agronomists, visited, learned, and participated in the discussions in the field along with Dr. Orlando Shigueo Ohashi.

On 08 April 2011, a seminar was held at the IPEF building on the campus of ESALQ/USP in Piracicaba. The target audience were teachers, graduate and undergraduate students (40 people), where Dr. Orlando Shigueo Ohashi presented the results of this research project.

On 25 and May 26, 2011, the first UFRA seminar on Mahogany was carried out under the coordination of Dr. Paulo Luiz Contente de Barros and Dr. Ohashi Shigueo Orlando, at UFRA in Belém. Over 420 people participated in the seminar, including an ITTO Representative, representatives of Batisflor, the Tramontina Compamy, a representative for Mr. Nelcindo Gonsalez, politicians, loggers, farmers, researchers, professors, heads of state and federal government agencies, technicians, graudate and undergraduate students. The topics discussed were the New Forest Code, legislation and its implications for reforestation and exploitation of natural and planted mahogany in the Brazilian Amazon. The results of research projects funded by ITTO were presented by Dr. Paulo Contente de Barros, Dr. Orlando Shigueo Ohashi and Dr. Mario Lopes da Silva Junior.

4. CONCLUSIONS

4.1. Comparison of management systems of mahogany shoot borer control in the state of Pará

The most efficient systems for the shoot borer control in the state of Para were the following systems:

a- Intercropping mahogany x *T. ciliata* + Colacid;

b- Intercropping mahogany x *T. ciliata* + Colacid + fertilization with calcium and boron

The intercropping system mahogany x *T. ciliata* + fertilization with Calcium and Boron influenced negatively on mahogany height growth.

4.2. Evaluation of Colacid formulation for the application to mahogany plants over 3 m high

Colacid spray formulation was the most efficient and more practical for the application in mahogany plants over 3 m in height, but the growth in height was less than the formulation Colacid drops.

The pantograph type lifting platform is important equipment for the application of treatments in mahogany plants with more than 3 m in height.

4.3. Comparison of mahogany shoot borer management systems in São Paulo

The intercropping system mahogany x *T. ciliata* + Colacid spray is the best indicated for the state of São Paulo because it presented the lowest level of pest infestation.

4.3.1. Effects of different levels of calcium and boron applied in the soil in the resistance of mahogany to the shoot borer *H. grandella*

The interaction between doses of 1.5 $t.ha^{-1}$ of limestone and 4 $mg.kg^{-1}$ of boron is more useful in reducing the length of the shoot borer gallery of mahogany seedlings.

5. BIBLIOGRAPHY

ALLAN, C. G.; CHOPRA, C. S., FRIEDHOFF, J. F., GARA. R. I., MAGGI, M. W., NEOGI,A. N., POWELL, J. C., ROBERTS, S. C. and WILKINS, R. M. The concept of controlled release insecticides and the problem of shoot borer of the Meliaceae. In: J. L. WHITMORE (Editor) Studies on the shoot borer *Hypsipyla grandella* (Zeller). Lep. Pyralidae, IICA – CATIE, Costa Rica, Vol. II. 1976, p. 110-115.

ALMEIDA, G.B. Criação contínua de *Hypsipyla grandella* (Zeller, 1848) (Lepidoptera: Pyralidae) com dieta artificial. 2005. 63 p. Dissertação (Mestrado em Agronomia) – Universidade Federal Rural da Amazônia. Belém. 2005.

BERTI FILHO, E. Observações sobre a biologia de *Hypsipyla grandella* (Zeller, 1848) (Lepidóptera: Phycitidae). ESALQ/USP, Dissertação de Mestrado, 1973, 108 p.

CAMPBELL, K. G. Aspects of insect-tree relationships in forests of Eastern Australia. In: H. D. GEROLD et al. Breeding Pest Resistant trees. Pergamon, Lonodon, 1966, pp. 239- 250.

CASTRO, E. R., MONTEIRO, R.,CASTRO, C. P. Estudo sobre dinâmicas sociais na fronteira, desmatamento e expansão da pecuária na Amazônia: Atores e relações sociais em novas fronteiras na Amazônia. Belém. Relatório de consultoria prestado ao Banco Mundial, 145 p., 2002.

COSTA, M. S. S. Controle de *Hypsipyla grandella* Zeller (Broca do mogno) utilizando a planta resistente *Toona ciliata* Roem (Cedro australiano) e os métodos mecânico e cultural no plantio de *Swietenia macrophylla* King (mogno). Dissertação de Mestrado, FCAP, 2000, 55 p.

GALLO, D., NAKANO, O., SILVEIRA NETO, S., CARVALHO, R. P. L., BATISTA, G. C., BERTI FILHO, E., PARRA, J. R. P., ZUCCHI, R. A., ALVES, S. B. e VENDRAMIM, J. D. , MARCHINI, L. C., LOPES, J. R. S. e OMOTO, C. Entomologia Agrícola, Ed. FEALQ, Piracicaba, 2002, 920 p.

GOLDBACH, H.E.; WIMMER, M.A. Boron in plants and animals: Is there a role beyond cell-wall structure? **Journal of Plant Nutrition Soil Science.** v.170, pp.39–48. 2007.

GROGAN, J., BARRETO, P. e VERÍSSIMO, A.. Mogno na Amazônia Brasileira: Ecologia e Perspectivas de Manejo. Ed. Imazon, Belém, 2002, 56 p.

HILJE, L. and CORNELIUS, J. Es inmanejable *Hypsipyla grandella* como plaga forestal. Turrialba, Hoja Técnica del CATIE, 2001, nº 18: 1-4.

MALAVOLTA, E. Manual de Nutrição Mineral de Plantas. Ed.Agronômica Ceres, São Paulo, 2006, 631 p.

NAKANO, O., SILVEIRA NETO, S. e ZUCCHI, R. A. Entomologia Econômica. Ed. Livroceres, Piracicaba, 1981, 314 p.

NEWTON, A. C.; BAKER, P.; RAMNARINE, S.; MESÉN, J. F.; LEAKEY, R. R. B. The mahogany shoot-borer: prospects for control. Forest Ecology and Management, 1993, 57, 301-328p.

OHASHI, O. S., J.N. M. SILVA, M. F. G. F. SILVA, M. S. S. COSTA, R. G. SARMENTO JUNIOR, E. B. SANTOS, M. Z. N. ALVES, A. M. C. PESSOA, T.C. O. SILVA, P. R. G. BITTENCOURT, T. C. BARBOSA, T.M. SANTOS. Manejo Integrado

da Broca do Mogno *Hypsipyla grandella* Zeller (Lep. Pyralidae). In: POLTRONIERI, L.S., D. R. TRINDADE. Manejo Integrado das Principais Pragas e Doenças de Cultivos Amazônicos. Belém, Embrapa Amazônia Oriental, 2002, 304 p.

OHASHI, O.S., SILVA JUNIOR, M.L., LAMEIRA, O.A.,SILVA,J.N.M.,LEÃO,N.V.M.,TEREZO,E.F., BATISTA, T.F.C., HIDAKA,D.Z.L.,ALMEIDA, G.B., BITTENCOURT, P.R.G., GOMES, F.S., NEVES,G.A.M. Danos e controle da broca de *Hypsipyla grandella* em plantio de mogno no estado do Pará. In: POLTRONIERI, L.S., TRINDADE, D.R., SANTOS, I.P. Pragas e doenças de cultivos Amazônicos. Belém, Embrapa Amazônia Oriental, 483p.,2005.

RAIJ, B. Van. **Fertilidade do solo e adubação**. São Paulo: Ceres; Piracicaba: Potafós, 1991. 343 p.

RAMÍREZ-SÁNCHEZ, J. Investigación preliminar sobre biología, ecología y control de Hypsipyla grandella (Zeller). **Boletín del Instituto Forestal Latino-Americano**, Mèrida, v.16, p. 54-77. 1964

RODAN, B. D., NEWTON, C. & VERÍSSSIMO, A. 1992. Conservação de Mahogany: Condição e Iniciativa de Política. Conservação Ambiental, 1992 19 (4): 331-338.

SILVA, S. A. S.; SANTOS, M.M. L.; SILVA, G.R.; SILVA JUNIOR, M.L.; OHASHI, O.S.; RUIVO, M.L.P. Efeito do Cálcio no controle da *Hypsipila grandella* em mudas de mogno cultivadas em hidroponía. Acta Amazônica, 2009, 39 (2):273-278.

VERÍSSIMO, A. P.; BARRETO, R.; UHL, C. Mahogany extraction in the Easter amazon: Mahogany workshop, p 3-4, 1992.

YAMAZAKI, S., and VASQUEZ, C. Studies on *Hypsipyla grandella* Zeller. In: Report on joint study project of performance trials for reforestation in the Amazon area in the Peru Republic. JICA/INIAA, 1991, monog. IV, 163-173 pp.

WHITE P. J. Calcium channels in the plasma membrane of root cells. **Annals of Botany**, v. 81, p. 173-183. 1998.

ANNEX 1 PHOTOS OF APPLICATION OF COLACID FORMULATIONS ON MAHOGANY SHOOTS

Photo 1: ***Application of 2 drops of Colacid on mahogany shoots using a plastic tube applicator.***

Photo by: O. S. Ohashi, Aurora do Pará, Brazil, February 2010.

Photo 2: ***Application of Colacid spray formulation on mahogany shoots 5 m high using a back pack sprayer at the Tramontina farm.***

Photo by: O. S. Ohashi, Aurora do Pará, Brazil, January 2011.

Photo 3: Application of Colacid spray with the worker sitting on the adapted tractor, using a backpack sprayer with an elongated pole to treat mahogany shoots more than 4 m high.

Photo by: O.S. Ohashi, Igarapé-Açú, Para, Brazil, December 2009.

Photo 4: Lifting type platform to help the application of Colacid formulations on mahogany plants more than 3 m high, at the experimental area of UFRA in Igarapé-Açú

Photo by: O. S. Ohashi, Igarapé-Açu, Para, Brasil. June 2010.

Photo 5: Application of Colacid drops on mahogany shoots 9 m high in Igarapé-Acu, using lifting type platform and elongated applicator to place two drops on new shoots to protect them from the shoot borer attack.

Photo by: O. S. Ohashi, Igarapé-Acu, Para, Brazil. October 2010.

Photo 6: Pantograph type platform used for the application of Colacid spray on mahogany shoots more than 8 m high at the plantation in Sao Jose do Rio Preto, São Paulo, Brazil.

Photo by: O. S. Ohashi, São José do Rio Preto, São Paulo, Brazil, May 2010.

Photo 7: ***Application of Colacid spray with jet sprinkler in the vertical range to place the droplets along the mahogany shoots.***

Photo by: O. S. Ohashi, Sao Jose do Rio Preto, São Paulo, Brazil, May 2010.