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Building the models of Intergrated Pest Management (IPM) for *Cinnamomum cassia* in Van Yen district, Yen Bai province

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Cinnamomum cassia Blume is planted in 27/27 communes and towns of Van Yen district with an area of over 15,000 ha. Recently, Synanthedon sp. and Phalera flavescens have strongly developed, harming large areas of cinnamon plantations and influencing productivity and quality of the cinnamon trees in Van Yen. We determined four main insect species (Synanthedon sp., Zeuzera sp., Arbela baibarana, Phalera flavescens) and one main disease species (Pestalotiopsis funerae) on cinnamon trees, and built three effective models of Intergrated Pest Management (IPM) for age classes and main pest species of cinnamon. Cleaning bushes, thinning trees, prunning dead branches, maintaining proper densities (age 1 to 3 years: 3,300 trees/ha, 4 to 6: 1,100 trees/ha, and 7 to 9: 800 trees/ha) and adding microorganism organic fertilizer (2kg/tree) in combination with using the Oncol 25 WP and the Kasuran 47 WP have effectively prevented and controlled the main insect and disease pests on cinnamon trees in Van Yen district.

Keywords: *Cinnamomum cassia*, Intergrated Pest Management, Van Yen

Introduction

Cinnamomum cassia Blume is planted in 27/27 communes and towns of Van Yen district with an area of over 15,000 ha in which above 50% of the area has been available for bark harvest (VYDPC, 2013). Van Yen has become a large-scale cinnamon production area supplying for the market from 4,000 to 5,000 tons of cinnamon bark per year, and also gathering all leaves and branches for essential oil distinllation (Pham Xuan Hoan, 2001). The origin name of Van Yen cinnamon product has been legally protected and geographically targeted for eights communes: Chau Que Ha, Xuan Tam, Phong Du Ha, Phong Du Thuong, Tan Hop, Dai Son, Mo Vang, Vien Son, with a total area of 12,327.38 ha (VYDPC, 2012). Recently, *Synanthedon sp.* and *Phalera flavescens* have

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strongly developed, harming large areas of cinnamon plantations and influencing productivity and quality of the cinnamon trees in Van Yen. There were some authors conducting researches and determining insect and disease pest species on cinnamon trees in Van Yen such as *Attacus alla*, *Dasychira mendosa*, *Pestalotia cinamoni*, and *Phyllosticta cinamoni* (Tran Van Mao, 1989), *Pseudodoniella chinensis* (Tran Quang Tan, 2004), and *Agrobacterium tumefaciens* (Nguyen Trung Tin, 1998, Nguyen Vu Thanh, *et al.*, 1999, Tran Quang Tan, 2004). However, these studies almost focused on indentifying species and assessing damage levels of some main pests on cinnamon. The preventive and exterminative measures have not been recommended. The objectives of this study were: (1) to determine pest composition on cinnamon, and (2) to build the models of Intergrated Pest Management (IPM) for *Cinnamomum cassia* in Van Yen district, Yen Bai province.

Materials and methods

Study area

The study was conducted in Van Yen district ($21^o35'$-$22^o10'$ N, $104^o23'$-$104^o60'$ E), which is located in Yen Bai province. The area experiences a tropical monsoon climate with relatively cold winters and relatively hot summers; the mean annual temperature is 22.5 ºC, the mean annual moisture is 88% and the annual average rainfall is 1,450 mm (VYDPC, 2013). The area of forestry land is 104,403.94 ha accounting for 75.03% of total production land area; the planned land for planting cinnamon is 15,345.21 ha.

Data collection

Cinnamomun cassia belonging to the family Lauraceae is a medium-growing tree species between 10 m and 20 m in height. Cinnamon bark is used for essential oil distillation, medicine and spice (Vo Van Chi, 2012). The cinnamon plantations age from 8 to 10 can give 6 tons of bark per ha. Cinnamon leaves are also used for essential oil distillation (Le Tran Đuc, 1997; Pham Van Tuan, *et al.*, 2007).

In our study, cinnamon plantations were investigated on three age classes (three years per one class: 1-3 years, 4-6 years and 7-9 years). Monitoring the composition, development and growth laws of insect and disease pests on cinnamon was followed the national technical standard of the method of plant disease detection survey: QCVN 01-38:2010/BNNPTNT (MARD, 2010b).

In order to determine pest composition on cinnamon, 30 quadrat plots (25 x 20 m each) were randomly selected in each age class of plantations (total 90 plots) in 10 communes: Dai Son, Vien Son, Xuan Tam, Mo Vang, An Thinh, Dai Phac, Na Hau, Tan Hop, Phong Du Thuong, Phong Du Ha. In each plot, 30 standard trees were selected for investigation, sample collection, sample identification, damage ratio assessment and damage index of pests (Tran Van Mao, 1997; Nguyen The Nha, 1997).

Experimental design

Before building the models of IPM, we conducted a pilot study in 2013 with two experimental plots (1000 m^2 each) on the sites. The plot 1 - Applying the biological measure: using two biological productions (*Beauveria bassiana* and *Metarhizium anisopliae*). The plot 2 - Applying the chemical measure: using some specific remedies (Tasodant 600EC, Rigell 800WG and Oncol 25 WP). Both experimental plots were for purposes of preventing and exterminating *Synanthedon sp.*, *Phalera flavescens*, *Zeuzera sp.*, and *Arbela baibarana*. In the plot 2, we also used Boocdo 1.0%, Lime sulphur, Kasuran 47WP, Carbenzim 500FL and Sulox 80WP for preventing and exterminating the disease species *Pestalotiopsis funerae*.

Building the models of Intergrated Pest Management (IPM)

Based on the results of two experimental plots, we selected the effective preventive and exterminative measures in order to build the models of IPM for the age classes of cinnamon trees (age classes: 1-3, 4-6 and 7-9), the damage insect species (*Phalera flavescens*, *Arbela baibarana*, *Synanthedon sp.* and *Zeuzera sp.*) and for the disease species *Pestalotiopsis funerae*. This helps to apply easily for concrete conditions. These models were all carried out by the measures as follows: cleaning bushes, thinning trees, prunning dead branches, maintaining proper densities (age 1 to 3 years: 3,300 trees/ha, 4 to 6: 1,100 trees/ha, and 7 to 9: 800 trees/ha) and adding microorganism organic fertilizer (2kg/tree).

Three models were built and assessed from February 2014 to November 2014. Each model had a 1000 m^2 experimental plot and a 1000 m^2 controlled plot for comparison.

Model 1: Cinnamomum cassia plantations at the age class 1-3 in Dai Son commune

Characteristics: Cinnamon trees were strongly damaged by the insect species *Zeuzera sp.* and *Phalera flavescens*, and by the disease species *Pestalotiopsis funerae*. Applied measures: beside using the common measures mentioned above, we used the insecticide "Oncol 25 WP" with a dose of 200 ml/50 water liters/1000 m^2, and disease repellent "Kasuran 47 WP" with a dose of 100 g/50 water liters /1000 m^2. After 15 days, a second spraying was applied with the same dose. These treatments were conducted in March 2014 for damage insects and in May 2014 for damage diseases. The controlled plot was not apllied any measure.

Model 2: Cinnamomum cassia plantations at the age class 4-6 in Xuan Tam commune

Characteristics: Cinnamon trees were strongly damaged by insect species *Arbela baibarana*. Applied measures: beside using the common measures, we used the insecticide "Oncol 25 WP" with a dose of 200 ml/50 water liters/1000 m^2. These treatments were conducted in March 2014. The controlled plot was not apllied any measure.

Model 3: Cinnamomum cassia plantations at the age class 7-9 in Dai Son commune

Characteristics: Cinnamon trees were strongly damaged by the insect species *Synanthedon sp.*. Applied measures: beside using the common measures, we also used the insecticide "Oncol 25 WP" with a dose of 200 ml/50 water liters/1000 m^2. After 15 days, a second spraying was applied with the same dose. These treatments were conducted in March 2014. The controlled plot was not apllied any measure.

Data analysis

Damaged tree ratio: $P(\%) = \frac{n}{N} \times 100$ (MARD, 2010b)

Where: P: damaged tree ratio
n: number of damaged trees
N: total number of investigated trees

Disease index/Damage index (%) =

$$\frac{[(N_1 \times 1) + (N_3 \times 3) + (N_5 \times 5) + ... + (N_n \times n)]}{N \times n} \times 100$$ (MARD, 2010b)

Where: N_1: diseased leaveas at Class 1
N_3: diseased leaveas at Class 3
N_n: diseased leaveas at Class n
N: total number of investigated leaves
n: the highest Class of diseased leaveas (Class 9)

Classses 1, 3, 5, 7 and 9 are equivalent to < 1%, 1-5%, > 5-25%, > 25-50% and > 50% of damaged leaf area, respectively.

The preventive and exterminative effect of chemical substances on pests was calculated by the formular Henderson-Tilton (MARD, 2010a)

$$\text{Effect (\%)} = (1 - \frac{T_a \times C_b}{T_b \times C_a}) \times 100$$

Where: T_a: Desity of living insects after spraying
T_b: Desity of living insects before spraying
C_a: Desity of living insects after spraying in the pilot plot
C_b: Desity of living insects before spraying in the pilot plot

Results

Pest composition and natural enemies of Cinnamon trees in Van Yen

By investigating on 90 plots, we determined 12 pest insects, 5 diseases and 6 natural enemies. Twelve pest insects were *Phalera flavescens*, *Culcula paterinaria*, *Leucoptera susinella*, *Leptocorisa varicormis*, *Arbela baibarana*, *Zeuzera sp*., *Synanthedon sp*., *Pandemis sp.*, *Adoretus sp*., *Pauropsylla depressa*, *Latoialepida sp.* and *Coleophora sp*., in which there were four main pests: *Phalera flavescens*, *Arbela baibarana*, *Synanthedon sp*., *Zeuzera sp.* Five diseases were *Pestalotiopsis funerae*, *Phyllosticta sp*., *Glomerella cingulata*, *Capnodium sp*. and *Aspergillus sp*, in which *Pestalotiopsis funerae* was dominant. Six natural enemies consisted of *Formica fusca*, *Oecophylla smaragdina*, *Coccinella sp*., *Manti religiosa*, *Amblyseius sp*. and *Crocothemis servilla*.

The results of the pilot study on some main preventative and exterminative measures in Van Yen

Table 1: Effects of the biological productions

Formular	*Synanthedon sp.*			*Phalera flavescens*			*Zeuzera sp.*			*Arbela baibarana*		
	Before treatment	First treatment	Second treatment	Before treatment	First treatment	Second treatment	Before treatment	First treatment	Second treatment	Before treatment	First treatment	Second treatment
	Density (no. per tree)	Effect (%)	Effect (%)	Density (no. per tree)	Effect (%)	Effect (%)	Density (no. per tree)	Effect (%)	Effect (%)	Density (no. per tree)	Effect (%)	Effect (%)
Beauveria bassiana	14.3	8.4	14.7	1.9	9.3	25.6	2.9	0.0	0.0	1.3	0.0	0.0
Metarhizium anisopliae	17.0	5.5	9.6	1.8	17.9	38.4	3.0	0.0	0.0	1.7	0.0	0.0
Controlled plot	16.1	0.0	0.0	2.1	0.0	0.0	2.7	0.0	0.0	1.6	0.0	0.0

Table 2: Effects of the chemical substances

For-mular	*Synanthedon sp.*			*Phalera flavescens*			*Zeuzera sp.*			*Arbela baibarana*		
	Before treatment	First treatment	Second treatment	Before treatment	First treatment	Second treatment	Before treatment	First treatment	Second treatment	Before treatment	First treatment	Second treatment
	Density (no. per tree)	Effect (%)	Effect (%)	Density (no. per tree)	Effect (%)	Effect (%)	Density (no. per tree)	Effect (%)	Effect (%)	Density (no. per tree)	Effect (%)	Effect (%)
Tasodant	19.3	55.7	93.1	2.5	84.3	92.7	2.2	34.3	80.6	1.3	7.9	29.0
Rigell	20.7	74.5	96.8	2.0	86.3	94.1	2.6	29.5	76.9	1.4	11.6	27.9
Oncol	21.5	60.6	94.7	2.3	85.5	95.5	2.4	31.9	77.7	1.1	6.3	40.7
Controlled plot	20.7	0.0	0.0	2.1	0.0	0.0	2.7	0.0	0.0	1.6	0.0	0.0

Table 3: Effects of the preventative and exterminative measure for *Pestalotiopsis funerae*

Formular	Before treatment	First treatment	Second treatment
	Damage index (%)	Damage index (%)	Damage index (%)
Boocdo	33.3	34.8	35.6
Lime sulphur	34.1	35.6	36.3
Sulox	31.1	34.1	34.8
Kasuran	34.8	35.6	35.6
Carbenzim	33.3	34.8	36.3
Controlled plot	32.6	38.5	42.2

The results in Table 1, 2 and 3 showed that:

For *Synanthedon sp.*, the use of Tasodant 600EC, Rigell 800WG and Oncol 25WP gave a high effectiveness reaching over 90%, whereas the biological production *Beauveria bassiana* had a low one (14.7%). For *Phalera flavescens*, Tasodant 600EC, Rigell 800WG and Oncol 25 WP were clearly effective (over 90%) and *Metarhizium anisopliae* reached a effect of 38.4%. For *Zeuzera sp.*, the effect of Tasodant 600EC, Rigell 800WG and Oncol 25 WP reached from 76.9 to 80.6%. For *Arbela baibarana*, Oncol 25WP gave a effect of 40.7%. The biological productions (*Beauveria bassiana* and *Metarhizium anisopliae*) had no effect on *Zeuzera sp.* and *Arbela baibarana*.

For *Pestalotiopsis funerae*, the development of disease was prevented after two treatments of Kasuran 47WP (the damage index decreased by 0.8%).

In brief, Oncol 25 WP can be used to deal with *Phalera flavescens*, *Arbela baibarana*, *Synanthedon sp* and *Zeuzera sp.*, while the use of Kasuran 47WP was for *Pestalotiopsis funerae*.

The results of building the models of IPM in Van Yen

Model 1: Cinnamomum cassia plantations at the age class 1-3 in Dai Son commune (the application of chemical measure)

Table 4: The results of observing the state of the main inesct and disease pests and natural enemies in the model 1

Object	Unit	February		March		April		May		June	
		Model	Controlled	Model	Controlled	Model	Controlled	Model	Controlled	Model	Controlled
Phalera flavescens	no. per tree	2.9	2.7	0.3	2.8	0.3	3.0	0.3	3.1	0.4	3.2
Zeuzera sp.	no. per tree	2.5	2.3	0.6	2.3	0.6	2.4	0.6	2.6	0.8	2.6
Pestalotiopsis funerae	Damaged leaf ratio (%)	-	-	-	-	32.6	30.4	34.1	34.8	34.1	35.6
Object	**Unit**	**July**		**June**		**September**		**October**		**November**	
		Model	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**
Phalera flavescens	no. per tree	0.6	3.2	0.8	3.2	0.1	0.8	0.0	0.0	0.0	0.5
Zeuzera sp.	no. per tree	0.9	2.7	1.0	2.7	1.0	2.7	0.1	1.1	0.0	0.2
Pestalotiopsis funerae	Damaged leaf ratio (%)	33.1	37.0	31.2	38.5	30.7	40.7	28.5	41.3	24.2	41.3

The data of table 4 exhibited that the damaged ratios and the density of some main insect pests were significantly lower in the model than in the controlled plot. By using Oncol in March 2014, the density of *Phalera flavescens* decreased to 0.3 insects per tree (controlled plot: 2.8 insects per tree), and the density of *Zeuzera sp.* decreased to 0.6 insects per tree (controlled plot: 2.3 insects per tree). In November 2014, the densities of insects in both treated plot and controlled plot were approaching to zero because this month is the ending phase of the insect life cycle.

After using Kasuran 47 WP in May 2014, the ratio of *Pestalotiopsis funerae* decreased to 24.2% in November 2014, whereas this ratio increased from 30.4% to 41.3% in the controled plot.

Model 2: Cinnamomum cassia plantations at the age class 4-6 in Xuan Tam commune (the application of chemical measure)

Table 5: The results of observing the state of the main inesct and disease pests and natural enemies in the model 2

Object	Unit	February		March		April		May		June	
		Model	Controlled	Model	Controlled	Model	Controlled	Model	Controlled	Model	Controlled
Arbela baibarana	no. per tree	1.5	1.3	0.6	1.3	0.5	1.5	0.4	1.5	0.4	1.6
Synanthedon sp.	no. per tree	2.2	2.1	0.2	2.4	0.3	2.4	0.4	2.7	0.5	2.7
Object	**Unit**	**July**		**June**		**September**		**October**		**November**	
		Model	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**
Arbela baibarana	no. per tree	0.4	1.6	0.4	1.7	0.4	1.7	0.0	0.7	0.0	0.2
Synanthedon sp.	no. per tree	0.2	1.5	0.2	1.7	0.2	1.9	0.0	2.2	0.0	2.3

The data of table 5 presented that the densities of *Arbela baibarana* and *Synanthedon sp.* were controlled well. By using Oncol in March 2014, the density of *Arbela baibarana* decreased to 0.6 insects per tree (controlled plot: 1.3 insects per tree), and the density of *Synanthedon sp.* decreased to 0.2 insects per tree (controlled plot: 2.4 insects per tree). Similarly to the model 1, in November 2014 the densities of insects in both treated plot and controlled plot were also approaching to zero.

Model 3: Cinnamomum cassia plantations at the age class 7-9 in Dai Son commune (the application of chemical measure)

Table 6: ***The results of observing the state of the main inesct and disease pests and natural enemies in the model 3***

Object	Unit	February		March		April		May		June	
		Model	Controlled	Model	Controlled	Model	Controlled	Model	Controlled	Model	Controlled
Synanthe-don sp.	no. per tree	18.7	19.0	0.4	19.2	0.4	19.3	0.5	19.4	0.7	19.6
Object	**Unit**	**July**		**June**		**September**		**October**		**November**	
		Model	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**	**Model**	**Controlled**
Synanthe-don sp.	no. per tree	0.5	4.9	0.3	3.2	0.1	5.1	0.0	6.5	0.0	7.2

The densities of *Synanthedon sp.* were significantly lower in the model 2 compared to the controlled model. By using Oncol in March 2014, the density of *Synanthedon sp.* decreased to 0.4 insects per tree (controlled plot: 19.2 insects per tree). In November 2014, the density of insects in the model 2 was 0 whereas the one in the controlled plot was 7.2.

Discussions

At the areas of cinnamon plantations in Van Yen, the effective models of IPM for *Cinnamomum cassia* were built for four main insect pests (*Phalera flavescens*, *Arbela baibarana*, *Synanthedon sp*. and *Zeuzera sp.*) and one main disease species (*Pestalotiopsis funerae*). The aim of cleaning bushes, thinning trees, prunning dead branches, maintaining proper densities at three age classes and adding microorganism organic fertilizer was to supplement the nutrients for cinnamon trees and to increase soil loose, and therefore it may help to enahnce the growth ability and the resistance to pests of cinnamon trees. In fact, *Cinnamomum cassia* trees are planted continuously in the same area for many years and the nutrients are rarely added, making soil tight and poor in nutrients.

Model 1: After being treated by Oncol in March 2014, the densities of *Phalera flavescens* and *Zeuzera sp.* were controlled well. *Phalera flavescens* starts the period of adult emergence in September and *Zeuzera sp*. is in October, thus the densities of pests approached to zero in the next coming months. Using Kasuran 47 WP controlled *Pestalotiopsis funerae*. From July to November, the ratio of disease decreased due to the leaves shed and new leaves did not be infected (Table 4).

Model 2: After being treated by Oncol in March 2014, the densities of *Arbela baibarana* and *Synanthedon sp.* were controlled well. *Arbela baibarana* starts the period of adult emergence in July and *Synanthedon sp.* is in October, thus the densities of pests approached to zero in the next coming months (Table 5).

Model 3: After being treated by Oncol 25 WP in March 2014, the density of *Synanthedon sp.* was controlled well. *Synanthedon sp.* starts the period of adult emergence in October, thus the densities of pests approached to zero in the next coming months (Table 6).

Conclusion

Three models of IPM designed for *Cinnamomum cassia* in Van Yen gave positive results. Cleaning bushes, thinning trees, prunning dead branches, maintaining proper densities (age 1 to 3 years: 3,300 trees/ha, 4 to 6: 1,100 trees/ha, and 7 to 9: 800 trees/ha) and adding microorganism organic fertilizer (2kg/tree) in combination with using the Oncol 25 WP have effectively prevented and controlled the species *Phalera flavescens*, *Arbela baibarana*, *Synanthedon sp*. and *Zeuzera sp.* Using the Kasuran 47 WP controlled the disease species *Pestalotiopsis funerae*.

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