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SUSTAINABLE VALUE CHAIN ISSUES, INSECT TRAPS AND SOLUTIONS FOR COFFEE BERRY BORER IN THE NORTH OF VIETNAM

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ABSTRACT

In the world and including Vietnam, scientists has thought of using traps, alcohol traps to reduce generations of insects, reduce female insects that are harmful. There are some factors that influence traps for example: wind direction, climate, etc.

The reason for scientists to limit chemical pesticides and move to other methods to eliminate coffee berry borer is that chemicals will be harmful for coffee products, for farmers and for consumers. That's why we present and compare traditional and new approaches to monitor CBB and traps to reduce CBB generation.

This study was conducted not only to assess the CBB infestation, but also propose solutions to eliminate CBB generations well. We find out that less damages when we process CBB with alcohol traps and use *Beauveria bassiana* to control CBB, compared to chemical pesticides. We also perform analysis on agriculture sustainable value chain in order to propose suitable solutions for coffee crops and for farmers to have more benefits sustainably.

Keywords: Sustainable agriculture; value chain; Coffee Berry Borer; branch borer; *Beauveria bassiana*.

INTRODUCTION

First, We Analyze Bad Effects of Stem Borers, Coffee Branch Borers

From the name we can easily recognize the harmful effects of this pest. They often attack the trunk and branches (including fruit-bearing branches and main branches) causing death of the trunk and upper branches [1-4]. In the absence of suitable cultivation and treatment measures, with favorable conditions, they will easily develop into epidemics, causing serious harm to coffee gardens [5,6].

Stem borer - branch borer often attacks coffee gardens established and commercialized in the early years. Reduce yield, plant death, in case the tree can withstand it, it will also grow slowly, yellow leaves stunted, branches and stems are easily broken. Some common symptoms when suffering from stem borers [7,8].

The tree has all the leaves at the top with yellowing, the lower leaves are still green, the tree grows more shoots.

On the body there are ridges emerging in rings, the shell is cracked, there are holes with a diameter of 2-3 mm.

The hole caused by the pink stem borer can also be seen extruding worm droppings, easy to see with the naked eye.

Parts of trees and branches affected by borers are easily broken horizontally at the location where the worms live.

Splitting along the trunk, there were deep grooves, and young worms were detected.

Johnson et al. [9] investigated invasion biology of CBB by examining (1) how it was introduced into each particular region and the response to its invasion, (2) flight activity and infestation patterns, (3) economic impacts, and (4) management strategies. We highlight research conducted over the last ten years in Hawaii as a case study for the development and implementation of an effective integrated pest management (IPM) program for CBB.

Then, Hollingsworth et al. [10] said A limited number of insecticides (primarily *Beauveria bassiana*) are used to control CBB with minimal disruption in this agroecosystem. They evaluated two insecticide spray strategies across eight coffee farms in the Kona and Kaʻu districts of Hawaii Island. Scientists also showed Natural occurrence of the entomopathogenic fungus Beauveria bassiana had been observed and reported infecting adults of coffee berry borer (CBB) in many coffee producer countries. This fungus is considerate the major natural mortality factor of CBB around the world. Spores of this natural fungus have the capacity to germinate and penetrate inside the CBB body causing the dead of the pest in 3-5 days (Aristizabal, 2019).

Greco and Wright [11] mentioned effect of three rates of a commercial formulation of Beauveria bassiana Strain GHA was evaluated against the coffee berry borer (CBB) Hypothenemus hampei Ferrari (Coleoptera: Curculionidae: Scolytinae), at three commercial coffee farms located at different altitudes on the island of Hawaii. Study showed rates of infested berries with visually detectable signs of B. bassiana were similar among the B. bassiana treatments, ranging from 0.44% to 4.24%, and those percentages were larger than the treatments without B. bassiana. The percentage of females killed by Beauveria ranged from 69% to 95%.

Next, We see statistics in below figure:

Rank	Countries	2006		2007		% Change 2006 - 2007		Share of Exports (%)	
		Volume (MT)	Value ($1,000)	Volume (MT)	Value ($1,000)	Volume (%)	Value (%)	2006	2007
	Green coffee	**980,878**	**1,217,167**	**1,229,233**	**1,911,463**	**25.3**	**57**	**100**	**100**
1	Germany	150,660	192,674	177,015	278,180	17.5	44.4	15.4	14.4
2	United States	130,889	166,428	134,966	212,666	3.1	27.7	13.3	11.0
3	Spain	75,440	90,085	95,662	150,832	26.8	67.4	7.7	7.8
4	Italy	53,409	66,567	90,922	143,788	70.2	116	5.4	7.4
5	Switzerland	42,632	55,399	80,321	115,769	88.4	109	4.3	6.5
6	Japan	35,234	44,923	46,606	76,422	32.3	70	3.6	3.8
7	Belgium	22,072	28,176	45,523	72,317	6.2	56.7	2.3	3.7
8	Indonesia	4,377	5,854	41,390	60,692	845.6	936.7	0.4	3.4
9	Netherlands	27,058	32,451	32,440	51,303	19.9	58.1	2.8	2.6
10	United Kingdom	41,725	51,554	32,130	47,758	-23	-7.4	4.3	2.6

Fig. 1. Top ten markets for green coffee from Vietnam (2006-2007)

(source: MARD, General customs office)

In Son La provinces where 97% of labor force involving in agriculture, farmers have approached new ways to kill Coffee berry borer, for instance, with alcohol trap, instead of tradition methods such as : chemicals pesticide (Chlorpyrifos and Methidathion therefore are limited to use). The reason is CBB has caused 10% damages in coffee yield.

METHODOLOGY

Place of Study

We uses study conducted at Son La province, Mai Son district, Chieng Ban village.

Methods

Authors conduct experiments in coffee villages in Son La province for CBB infestation and CBB traps solutions and propose agriculture sustainable solutions for farmers.

Qualitative (synthesis, inductive) combined with quantitative analysis methods were used.

MAIN FINDINGS

CBB Infestation

Here Bui Thi Suu, Dinh Tran Ngoc Huy, Lan Duc Doan [12] has showed and presented CBB infestation in below experiment:

In general, study find out in the 1st flowering there is highest infested rate of 19.7% and lowest in the 2nd proportion of 9.21%. And the ratio of berries damaged by CBB on the 1st and 4th flowering was higher than others. Percentage of berry infestation increased throughout time and the pick was observed in September 2016 (Fig. 2).

Beside, Fotso et al. (2018) formulated a deterministic epidemiological control model that describes the infestation of coffee berries by the CBB. We have designed an optimal control problem that consists in maximizing the yield of healthy berries at the end of the cropping season, while minimizing the CBB population for the next season. We have computed the basic offspring number and investigated the existence and stability of equilibria in the absence of controls [13-15]. We have showed that an optimal control exists and that it can be characterized using the Pontryagin's maximum principle. Furthermore, we have solved numerically the system to assess the role of controls on dynamics of CBB population. This numerical result shows that, the application of these controls reduce the CBB population and increase the healthy berries at the end of the cropping season.

(source: https://team.inria.fr/epitag/files/2018/09/CARI2018-_Fotso_Yves.pdf, access date 14/9/2021)

Next, in Laos and Vietnam scientists have investigated Diseases of Coffee in Central Highlands.

Coffee Berry Borer (CBB)

- They attack on both Arabica and Robusta coffee.
- It was the main problem in 1980's, and damage can reached up to 40%.
- Due to the better market price of coffee, most farmers practiced a good sanitation of their plants, i.e. to harvest all berries (including the dropped berries) from the fields. This eventually interrupted the lifecycle of the CBB.
- Sanitation could reduce the damage by about 50% (from 10% to 5% damaged in beans)
- The use of chemical insecticides to control CBB is very minimal.
- Farmers used of locally produced biocontrol agent (Beauvaria sp.).
- In some cases CBB also attacked beans in the storage. Major problem in post-harvest warehouse (about 13% infection).
- Serious problems and need to control.
- Potential species for collaboration with CABI.

(source: https://assets.publishing.service.gov.uk/media/57a08b8e40f0b652dd000d46/CABI-CDF-CBB-in-LaosVietnam-2008.pdf, access date 14/9/2021)

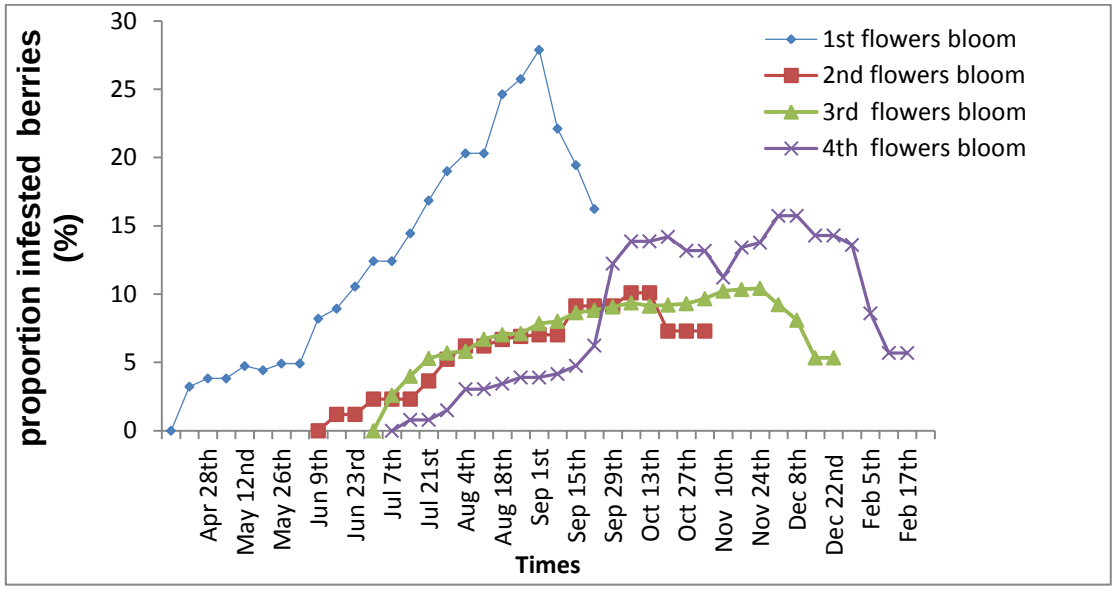

Fig. 2. CBB infestation

(source: Suu Thi Buu, Lan Duc Doan, Dinh Tran Ngoc Huy, 2021) [12].

Fig. 3. CBB investigation

The First Solutions for Coffee Branch Borer

First we see traditional measures to prevent coffee branch borers

Cultivation measures:

+ Regularly clean the garden, create ventilation, limit plants that are common hosts of weevils
+ Apply the right coffee care process to make plants healthier, better resistant to pests and diseases
+ In the period of strong pests, it is necessary to regularly check the garden, detect early and destroy the branches showing signs of being attacked by weevils.
+ Use strong-growing, disease-resistant coffee varieties

Chemical measures: It is recommended to spray the room at least once a year with insecticides with deep penetration and strong drainage. When we see a lot of weevils appear, spray 2-3 times each time 7-10 days apart. The drugs containing active ingredients Diazinon, Abamectin, Alpha-cypermethrin + Chlorpyrifos Ethyl, Abamectin + Matrine showed high efficiency in preventing and destroying branch borers. The above chemical measures can also be applied to prevent coffee mealybugs, coffee mites, coffee branch borers, aphids…

We see below Fig.4:

The New Approach: Monitoring Coffee Berry Borer with Alcohol Trap

We found a statistically significant difference in the average number of adult coffee berry borers caught weekly per trap at three heights that were 0.5, 1.0, and 1.5 m from the ground. The Tukey test revealed significant pairwise differences between a height of 1.0 m and another height. When setting the trap at the height of 1.0 m, the captures were highest (Table 1).

Scientists and researchers have formed Traps , using 2.0 litter bottles which are transparent and plastic (initially a container - soft drink) and used a small window (13 x 18 cm) , so over the bottom 9.0 cm. Then they form a killing agent by Water (200 ml) with liquid detergent (2 ml) added to bottom of the bottle trap , this is for preserving dead adult CBB. A 15 ml amber glass vial with a rubber cover (originally used as a medicine antibiotic powder container) was used as a alcohol dispenser. Absolute Ethanol and Methanol (1:1) were used in average about 868mg day. Inside bottle - The vial was hung, 20cm above the trap bottom. 12 m was distance b.t traps within a block, and 30 m b.t blocks. Plot was put in randomized design with three replicates. Scientists set /arranged 20 traps for every coffee farm. Scientists have to replace Water with liquid detergent and alcohol weekly. In order to perform research assessments, researchers has removed water with dead insects for counting and the weighted vial to determinate mean volatile release rates. Nuber CBB adults captured per trap and proportion berry infestation were record once a week.

Fig. 4. Chemical pesticides as traditional method now use limited

(source: internet)

Table 1. Mean number (± SE) of adult coffee berry bores weekly trapped by trap tested either at heights of 0.5, 1.0 and 1.5 m (January 27th – April 9th)

Trap height (m)	Caught beetles (CBB/Trap/7 days)					
	March 05	**March 12**	**March 19**	**March 26**	**April 02**	**April 09**
0.5	3.6 ± 0.6^{ab}	3.2 ± 0.4^{ab}	3.3 ± 0.6^{a}	17.6 ± 1.4^{b}	19.6 ± 1.4^{b}	21.7 ± 2.0^{b}
1.0	5.7 ± 1.2^{a}	4.4 ± 0.5^{a}	4.2 ± 1.3^{a}	20.6 ± 2.4^{a}	24.9 ± 1.4^{a}	26.3 ± 1.5^{a}
1.5	1.9 ± 0.7^{b}	2.4 ± 0.5^{b}	2.1 ± 0.4^{a}	12.6 ± 1.0^{b}	15.6 ± 1.5^{b}	16.9 ± 1.2^{c}

Note: Different letters in the same column indicate statistical differences according to Tukey test with $P < 0.05$, $n = 9$. (source: made by authors)

In a survey for CBB -monitoring dispersing, *Stephanoderes Hampei* Ferrari (Coleoptera: Curculionidae: Scolytinae), with alcohol-baited bottle traps plus quantified ratio (%) of berry infested on four farming households of coffee growing in two locations in Son La province, Vietnam. Activity of flight was recorded. Mean number of CBB adults was highest in May and June with an average of 7.5 to 101.4 CBB for each trap per week. The average highest infested berry percentage (5.9 to 7.3 %) was recorded in october. Flight activity was highest during period of 2–3 months in post-harvest season (April through May) when only young berries on coffee plants. The average number CBB catched and the proportion of infected CBB in two farms, where culture control (pick up all cherry to fall to the ground or remain on trees; pruning) were practiced better, were lower than remain coffee farms (Fig. 4). A linear correlation (positively) between no. of CBB adults catched and ratio (%) of berry infestation was obserb on this research ($r^2 = 0.3035$).

Sustainable Value Chain Solutions

The expansion of cooperation is a great opportunity for Vietnamese agricultural products to participate in international markets, especially in developed markets to improve added value.

Integration is a great advantage for Vietnam when agricultural products have arrived most countries in the world, especially the markets of developed countries large scale and high export value such as the US, EU, Japan,.. Demand and opportunity from the export market is very large. The problem is, how far does the Vietnamese side take advantage of the opportunity?

This is completely dependent on state policies, farmers' participation and How can businesses create products that meet the standards and requirements that other companies have? specified by this market.

The government restructures and supports the agricultural sector towards sustainability, using high technology and clean/organic products.

Decision No. 899/2013/QD-TTg approving the agricultural restructuring plan (ARP) in the direction of enhancing added value and sustainable development, was issued on June 10, 2013. The long-term goals for agriculture are reflected of the three main sustainability pillars are:

Economic: maintaining strong agricultural growth and capacity building industry competition, primarily through improvements in productivity, efficiency, and value increase, and better respond to consumer needs and preferences Social: continue to improve farmers' incomes and rural life, reduce impacts and the severity of rural poverty, and food security and national and household nutrition security.

On the environment: improving natural resource management, minimizing impacts,contribute to get environmental benefits and build capacity to manage problems related to weather and other natural disasters in Vietnam.

To improve linkages in agriculture, the Government has just issued Decree No 98/2018/ND-CP on policies to encourage the development of cooperation and association in production and consumption of agricultural products. According to the Decree, cooperation and association in production with consumption of agricultural products (association) is an agreement, voluntary co-investment,production and consumption of agricultural products by farmers, individuals, cooperatives, enterprises industry (collectively referred to as the parties to the association) to improve production efficiency and quality quantity of agricultural products. In which, the associated projects will be funded by the State budget The country supports the cost of link building consultancy, link service infrastructure and support agricultural extension, training, training [16-18].

To reduce risks for farmers, the Government has also issued policies to support farmers support farmers (especially poor farmers) to participate in insurance such as Decree No 58/2018/ ND-CP, Decision No. 22/2019/QD-TTg, to support agricultural insurance premiums for most agricultural products. According to these regulations, farmers- poor people are supported from 80-90% of agricultural insurance premiums, the rest 20%.

Opportunities to expand production scale through land accumulation from industrialization and production linkages.

Science and technology has developed rapidly in recent times, applying science and technology In the context of science and technology and the rapid development of commercialization, the products and applications of science and technology are no longer too difficult barriers for customers farmers [19-22]. The core and decisive issue is the requirements and standards output. Therefore, the tendency to form large-scale agricultural production areas is the main.

An important association to help investors apply science and technology to improve product quality and production efficiency.

We summarize in a SWOT analysis below:

Strengths	Weaknesses
- The value chain is also a tool to describe the relationship between a series of subjects, performing activities, service providers, consumers, supporting institutions, and supply chain.	- Identify barriers for manufacturers small wants or is trying to join the value chain.
Opportunities	Threats
- In most agricultural production chains, Farmers are more beneficial when participating in linkage models, at least in the short term; In the long run, it is necessary to build large production organizations to create more sustainable development	- Vietnam's agricultural growth also causes major environmental consequences land degradation and pollution, deforestation, the level of using chemical pesticide need to be controlled more

(source: made by authors)

Arifin (2007) studies the relationship between regulations on sustainable development globally with the coffee supply chain in Indonesia indicates that buyers play a decisive role trends and changes in supply chain structure in coffee-producing regions.

Sustainable coffee standards and regulations require farmers and cooperatives rural areas have sufficient organizational capacity to participate in the supply chain [23,24]. The author also gives recommends cooperation from the very beginning of the chain as coffee growers as well as the institutional change in the organization of the supply chain to match the top-down relationships of NGOs and the private sector international personnel (decided by the buyer)

CONCLUSIONS AND RECOMMENDATIONS

Our study results show that damages by CBB reduced more with the use of Beauveria bassiana (which showed lower % of berry damaged), compared to chemical pesticide usage.
Also we find out in October time, there is the highest of berry infestation. And farmers can consider to use bottle traps with alcohol to eliminate CBB females and their generation.

Moreover, When setting the trap at the height of 1.0 m, the captures were highest. The caught CBB adults trap-1 was highest in May and June. The highest proportion of berry infestation was recorded in October. The trials that control CBB using Beauveria bassiana showed a lower percentage of berry damaged by CBB than the percentage of berry damaged by CBB on plot application of chemical insecticide. Based on these results, alcohol trap and Beauveria bassiana should be implemented as a part of integrated pest management CBB to reduce the use of chemical insecticides toward a sustainable food system. Bottle traps using alcohol attractants will help farmers kill CBB females and monitor CBB adult flight to determine the best timing for insecticide (chemical, entomopathogenic fungi) spray.

Bui Thi Suu, Vu Quang Giang, Vu Phuong Lien, Dinh Tran Ngoc huy, Ha Thi Lan [12] stated that farmers have to deal with the negative factor, or insect, coffee berry borer (CBB), which cause losses by Design of TBU Auto-infection Trap : The TBU auto-infection trap (TBU-AIT) was designed to attract Stephanoderes hampei females, contaminate them with B. bassiana conidia, and disperse the entomophathogen to the environment after the beetles run away from the trap (see below Fig.5).

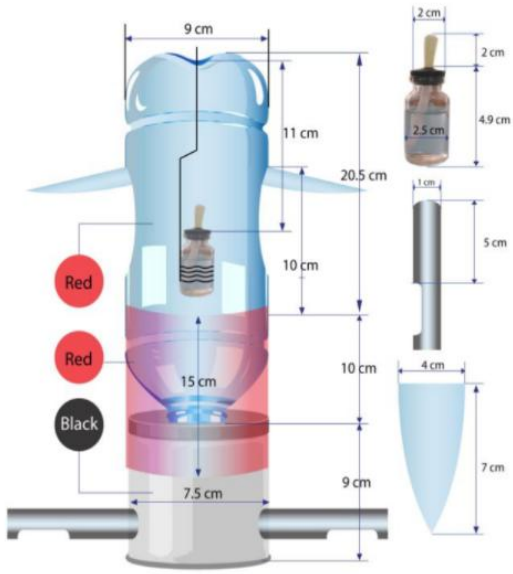

Fig. 5. Infection system design

(source: Bui Thi Suu, Vu Quang Giang, Vu Phuong Lien, Dinh Tran Ngoc Huy, Ha Thi Lan, 2021)

Farmers also need to regular care, timely detection, cutting off damaged toothpicks or pruning branches, especially after fruit harvest. Balanced fertilization helps trees grow healthy. Spraying properly according to the principle of "4 Right in Vietnam" , avoid overuse of pesticides causing ecological imbalance.

Green Value Chain Development

According to Odeyale et al (2014), there are 5 decision criteria used for the evaluation Green supply chain management is: green design, green manufacturing, green procurement, green market, and environmental management. Accordingly, developing value chains in a green direction help countries make efficient use of their natural resources without sacrificing efficiency results and quality.

The case of the coffee supply chain shows that, thanks to production certificates in the direction of Green helps the link between actors in the chain (both cross-linking and linking vertical) stronger, especially in coffee growing areas. This means that there is no direct guarantee of benefits for households participating in the certificate in terms of an addition to the selling price of coffee (Giovannucci and Ponte, 2005).

Then, "value chain" reflects the fact that value added to conventional products by combining them with other resources, such as human resources, knowledge and skills, or tools, etc.

A product goes through different stages of a value chain, the value of the product that is increased.

Global agricultural value chains are activities that create added value from from production to processing and distribution of products to consumers. Stages in the value chain can be vertically or horizontally linked with together. The actors in the chain can participate in one or more other stages each other in the value chain; This depends on the goals, strategies and capacity of participation of those subjects.

RESEARCH LIMITATION

We need to expand more data and analysis for other crops and sustainable solutions as well.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adriano E. Pereira, Evaldo F. Vilela, Ricardo S. Tinoco, José Oscar G. de Lima,

Andreza K. Fantine, Elisângela G.F. Morais, Christiane FM. França. Correlation between numbers captured and infestation levels of the Coffee Berry-borer, *Hypothenemus hampei*: A preliminary basis for an action threshold using baited traps, International Journal of Pest Management. 2012;58:2:183-190.

2. Hac LD, Huy DTN, Thach NN, Nhung PTH, Thang TD, Anh TT. Enhancing risk management culture for sustainable growth of Asia commercial bank -ACB in Vietnam under mixed effects of macro factors. Entrepreneurship and Sustainability Issues. 2021 ;8(3). Available:https://econpapers.repec.org/article/ssijouesi/v_3a8_3ay_3a2021_3ai_3a3_3ap_3a291-307.htm
3. Hansen H, Tarp H. Aid and growth regressions. Journal of Development Economics. 2001;64:547-570.
4. Hang TTB, Nhung DTH, Nhung DH, Huy DTN, Hung NM, Dat PM. Where beta is going - case of Vietnam hotel, airlines and tourism company groups after the low inflation period. Entrepreneurship and Sustainability Issues. 2020;7(3) :2282-2298. Available:https://ideas.repec.org/a/ssi/jouesi/v7y2020i3p2282-2298.html
5. Huy DTN, Dat PM, Anh PT. Building and econometric model of selected factors' impact on stock price: a case study. Journal of Security and Sustainability Issues. 2020 ; 9(M) :77-93. Available:https://cibg.org.au/index.php/cibg/article/viewFile/9/journal/article_8416.html
6. Huy DTN, Hien DTN. The backbone of European corporate governance standards after financial crisis, corporate scandals and manipulation. Economic and Business Review. 2010;12(4):2015-2040. Available:http://ojs.ebrjournal.net/ojs/index.php/ebr/article/download/101/30
7. Huy DTN, Loan BT, Anh PT. Impact of selected factors on stock price: a case study of Vietcombank in Vietnam. Entrepreneurship and Sustainability Issues. 2020;7(4) :2715-2730. Available:https://ideas.repec.org/a/ssi/jouesi/v7y2020i4p2715-2730.html
8. Huy DTN. The critical analysis of limited south asian corporate governance standards after financial crisis. International Journal for Quality Research. 2015;15(1):741-746. Available:http://www.ijqr.net/paper.php?id=378. Access: Jan. 11, 2021.
9. Johnson MA, Diaz CPR, Manoukis NC, Rodrigues JV. Coffee Berry Borer (*Hypothenemus hampei*), a Global Pest of Coffee: Perspectives from Historical and Recent Invasions, and Future Priorities, Insects. 2020;11(882). DOI:10.3390/insects11120882
10. Robert G. Hollingsworth, Luis F. Aristizábal, Suzanne Shriner, Gabriel M. Mascarin, Rafael de Andrade Moral and Steven P. Arthurs. Incoporating *Beauveria basssiana* into an intergreated pest managerment plant for coffee berry borer in Hawaii. Frontiers in sustainable foof systems. 2020;4:Article 22
11. Greco E, Wright MG. Efficacy of Beauveria bassiana applications on coffee berry borer across an elevation gradient in Hawaii, Biocontrol Science and Technology. 2018;28(2). DOI:10.1080/09583157.2018.1493088
12. Buu Thi Suu, Vu Quang Giang, Vu Phương Lien, Dinh Tran Ngoc Huy, Ha Thi Lan.. The Auto-infection Trap with the Native Entomopathogenic Fungus, Beauveria Bassiana for Management of Coffee Berry Borer (Stephanoderes Hampei Ferrari) in the Northwest Region of Vietnam, Alinteri Journal of Agriculture Science. 2021;36(1): 191-198.
13. Hollingsworth RG, Aristizabal LF, Shriner S, Mascarin GM, Moral RA, Arthurs SP. Incorporating *Beauveria bassiana* Into an Integrated Pest Management Plan for Coffee Berry Borer in Hawaii, Front. Sustain. Food Syst. 2020;3. DOI:https://doi.org/10.3389/fsufs.2020.00022
14. Mathieu F, Brun LO, Fre´rot B. 1997a. Factors related with native host abandonment by the coffee berry borer Hypothenemus hampei (Ferrari)

(Coleoptera: Scolytidae). J Appl Entomol. 121:175–180.

15. Mathieu F, Brun LO, Marchilaud C, Fre´rot B. Trapping of the coffee berry borer Hypothenemus hampei (Ferrari) (Coleoptera: Scolytidae) within a mesh enclosed environment: interaction of olfactory and visual stimuli. J Appl Entomol. 1997b;121:181–186.
16. Vu HT. The Research on Arabica coffee cultivation technical toward sustainable development for Northwest ecological region. In national conference on Crop Science I. 2013;897-906.
17. Vega FE, Benavides P, Stuart JA, O'Neill SL. Wolbachia infection in the coffee berry borer (Coleoptera: Scolytidae). Ann. Entomol. Soc. Am. 2002;95:374–378.
18. Vega FE, Infante F, Johnson AJ. The genus Hypothenemus, with emphasis on H. hampei, the coffee berry borer. In Bark Beetles: Biology and Ecology of Native and Invasive Species; Vega, F.E., Hofstetter, R.W., Eds.; Academic Press: San Diego, CA, USA.2015;427–494.
19. Melissa A. Johnson, Claudia Patricia Ruiz-Diaz, Nicholas C. Manoukis and jose carlos verle rodrigues. Coffee Berry Borer (*Hypothenemus hampei*), a Global Pest of Coffee: Perspectives from Historical and Recent Invasions, and Future Priorities. Insects. 2020;11:882.

    DOI:10.3390/insects11120882
20. Mendesil, E.; Jembere, B.; Seyoum, E. Population dynamics and distribution of the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae) on *Coffea arabica* L. in southwestern Ethiopia. Sinet 2004;27:127–134.
21. Posada-Flórez FJ. Production of *Beauveria bassiana* fungal spores on rice to control the coffee berry borer, *Hypothenemus hampei*, in Colombia. 13pp. Journal of Insect Science. 2008;8:41.

    Available: insectscience.org/8.41
22. Yobana A. Mariñoa , Maria-Eglée Pérezb, Fernando Gallardoc, Marella Trifilioa, Michelle Cruza, Paul Bayman. Sun vs. shade affects infestation, total population and sex ratio of the coffee berry borer *(Hypothenemus hampei*) in Puerto Rico. Agriculture, Ecosystems and Environment. 2015; 2016:222:258–266.
23. Johnson MA, Ruiz-Diaz CP, Manoukis NC, Verle Rodrigues JC. Coffee berry borer (*Hypothenemus hampei*), a global pest of coffee: perspectives from historical and recent invasions, and future priorities. Insects. 2020;11(12):882.

    DOI:https://doi.org/10.3390/insects11120882
24. Kulandaivelu Velmourougane, Rajeev Bhat, Thirukonda Nannier Gopinandhan. Coffee Berry Borer (*Hypothenemus hampei*)—A Vector for Toxigenic Molds and Ochratoxin A Contamination in Coffee Beans. Foodborne Pathogens And Disease. 2010;7(10).

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