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Further Analysis on Alcohol Trap and application local *Beauveria bassiana* for Control Coffee Berry Borer (CBB) In the Concept of Agricultural Sustainable Value Chain

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Abstract
Until now, Vietnamese farmers has killed Coffee berry borer (CBB) by Prevention -Cultivation method: Collecting damaged fruits, dried fruits on trees and falling on the ground to focus on destroying. After harvesting, remove weevils or boil them in boiling water to kill weevils. And they use Chemical measures, i.e Spraying on fruit right from the stage when the fruit is still green. However, there is negative aspects of using chemical pesticides in agriculture. Authors perform researches to make assessment of CBB infestation and presented bad sides and damages of Coffee berry borer in the world as well as in Vietnam. The caught CBB adults trap-1 was highest in May and June, with an average of 7.5 to 101.4 CBBs per trap/week. The trials that spraying Beauveria bassiana for control CBB showed a lower percentage of berry damaged by CBB. Therefore, people can consider to control CBB using alcohol trap and in fact, Alcohol traps could help farmers to monitor CBB populations.
Last but not least, we consider to use agricultural sustainable value chain and model in coffee crops in order to create value addition for coffee farms as well as farmers.

Keywords: Chemical pesticides reduction, Alcohol trap, CBB infestation, *Beauveria bassiana*

1. Introduction

Perez et al (2015) stated It has become evident that the coffee berry borer scientific community could greatly benefit from having access to a bibliography of the literature related to the insect. Such an information source would allow scientists to find out what research areas have been explored throughout the many coffee berry borer-infested countries after more than 100 years of research on the topic. It could also help to direct lead future research efforts into novel areas, and away from topics and ideas that have been thoroughly investigated in the past.

And Baker et al (1992) stated in Mexico, coffee berries removed and placed on the ground 4 days after infestation, developed significantly ($p < 0.0001$) larger number of eggs than number of berries remaining on the trees. Apparent mortality of adults progeny rarely exceeded 10%. The main cause of mortality were pathogens that either attacked the endosperm causing the female to abandon the berry in lots of cases, or attacked insect directly.

According to wikipedia, The coffee borer beetle or coffee berry borer (*Hypothenemus hampei*) is a small beetle native to Africa. It is among the most harmful pests to coffee crops across the world where coffee is cultivated. Spanish common names of the insect include *barrenador del café*, *gorgojo del café*, and *broca del café*.

Figure 1- CBB entering and invasion

Entry hole

Coffee borer beetle entering and exiting a coffee cherry.

(Source: wiki)

Beside, Results of researchers find out that it is hard to manage Coffee berry borer (extremely hard), and the reason is all of the cryptic life cycles are in the coffee berry (Rehner et al., 2006).
Adult coffee berry borers feed and breed inside the berries. Males have short wings and do not fly; they remain in the berries for their 3 month life span. Females are fertilised a few days before they leave the berries to find other berries in which to lay their eggs.
Each female can produce 30–50 eggs in 2–7 weeks. The eggs generally hatch within a week and larvae start to feed on the bean. After about 2 weeks, the larvae pupate and emerge as adults 4–9 days later. The full life cycle takes 4 weeks.
The borers overwinter by remaining inactive in dry berries on the plant or ground.

(source: https://www.dpi.nsw.gov.au/biosecurity/plant/insect-pests-and-plant-diseases/coffee-berry-borer,access date 19/10/2021).

In Indonesia, Using traps is the new CBB control method and the Brocap trap is a trap specially designed for Hypothenemus hampei developed by CIRAD and PROCAFE in El Salvador (Dufour, 2002; 2008). The trap is considered as a useful addition to IPM for CBB control in Indonesia. Before using the Brocap trap in Indonesia, ICCRI and CIRAD considered it important to validate the trap under local conditions. (source: https://agritrop.cirad.fr/550189/1/document_550189.pdf, access date 19/10/2021).

In Son La province in the north of Vietnam, farmers have used Chlorpyrifos and Methidathion as insecticides for controlling CBB and even though many countries have used Traps in order to monitor CBB to reduce females lead to reduce next generations, traps have not been researched carefully in fields in the Northern region of Vietnam.

2. Methodology

2.1 Research location

Chieng Ban village (21°14’20”N 103°55’57”E), Mai Son district, Son La province.

Scientists has discovered it is difficult to manage CBB. Son La province is the biggest province in the Northwestern region of Vietnam with area of 14.055 km2.

In these coffee farms, CBB has been recognized to cause damages for coffee beans and has reduced 10% coffee crop productivity.

2.2 Control and monitor CBB

We begin on the coffee crop, April-May every year and make assessment of CBB infestation on 4 key flowerings.

Scientists has made about twenty alcohol traps for each coffee farm and they take advantage of bottles 2.0 litre to make traps with alcohol, ethanol and methanol.

2.3 Qualitative analysis

Author also use a combination of analytical and explanatory methods, observation and recording, interviews and experiments at coffee farms.

3. Main findings

3.1. Bad aspects of Coffee Berry borer CBB infestation in the world

First, Rudinsky (1962) mentioned Beetles of the subfamily Scolytinae are among the most damaging insects in the world: Their life cycle inside the host plant makes these insects difficult to control .

Vega (2002) mentioned Coffee Berry borer CBB has invaded the beans and make holes inside the coffee beans and survey showed CBB has caused damages of over 500 m USD per year and it damaged quality and productivity of coffee crops.

Next, Chi, N.K (2016) investigated and collected 138 samples in which there are 11 types including Beauveria bassiana, Metarhizium anisopliae, and Paecilomyses. Beauveria bassiana has developed much more in the temperature 25-30 degree Cencius.

In the world there are many researches on CBB. And CBB is considered in the most harmful insects in coffee plantations and farms if farmers do not consider to use effective prevention methods.

CBB is classified as in the genus Hypothenemus, involving over 181 species and could be found in fungi, plants, etc.

Figure 2- CBB is the most harmful insect

(source: internet)

- *In India, scientists discovered CBB (* Hypothenemus hampei) *invasion:* the pest was first noticed on a few plantations in the Nilgiris during early 1990. Coffee berry borer will attack and damage: Pin hole at the tip of the berries (novel region); Severe infestation - two or more holes may be seen; Female beetle bores into the berries through the navel region make tunneling and feed inside content; and Powdery substance pushed out through the holes

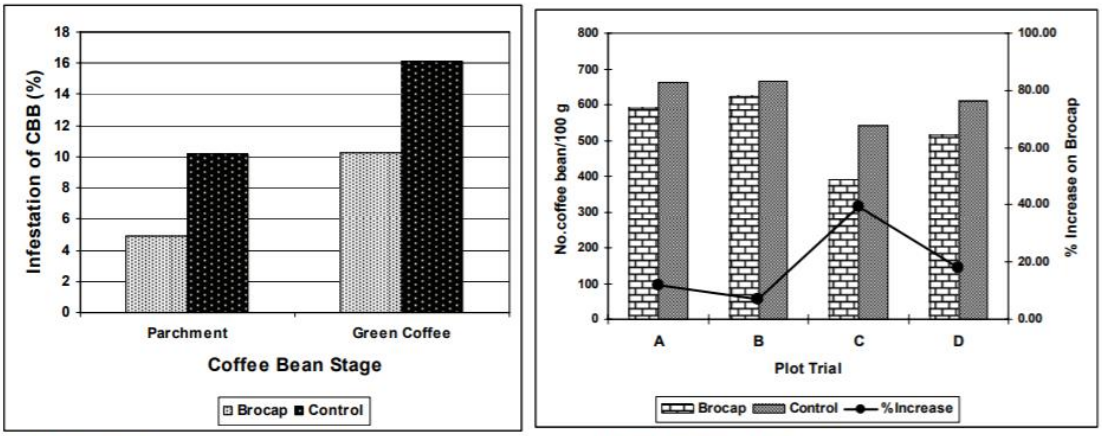
Figure 3 - Damage by CBB

(source: https://agritech.tnau.ac.in/crop_protection/coffeepest/coffee_2.html,access date 19/10/2021)

Last but not least, Woodill et al (2021) stated The coffee berry borer (CBB), Hypothenemus hampei, is one of the most destructive pests worldwide. In Hawaii, coffee farmers have adjusted their farm management practices to deal with CBB since its introduction in 2010. And One of the major obstacles to coffee production worldwide is the damage caused by the coffee berry borer *Hypothenemus hampei* (Ferrari; Coleoptera: Curculionidae). When searching for host fruits, females are attracted to the volatiles the fruits release (Roblero and Malo, 2013). And it is one of the plagues with the highest incidence and affectation in the coffee plantation in Colombia (Mesa et al, 2017).

Finally, In Indonesia from 2005-2007 period, scientists recognized that: CBB infestation on parchment and green coffee (left) and effect of Brocap trap on green coffee production (right) processed from coffee samples taken on the last observation in the Brocap trap trial in Lampung, Indonesia. Treatment and control plots were significantly different according to the SNK test at the 5.0% level. The distribution analysis results revealed that the CBB population was fitted to a negative binomial distribution, both for the high population early in the trial and for the low population at the end of the trial. Infestation was also significantly lower in treatment plots compared to the control plots.

Figure 4 - CBB infestation in Indonesia



CBB infestation

Nb coffee beans/100 g
Trial plot

(source: https://agritrop.cirad.fr/550189/1/document_550189.pdf, access date 19/10/2021)

3.2. Monitoring CBB with alcohol trap

A linear correlation (positively) between no. of CBB adults caught and ratio (%) of berry infestation was observed in this research (r^2 = 0.3035)

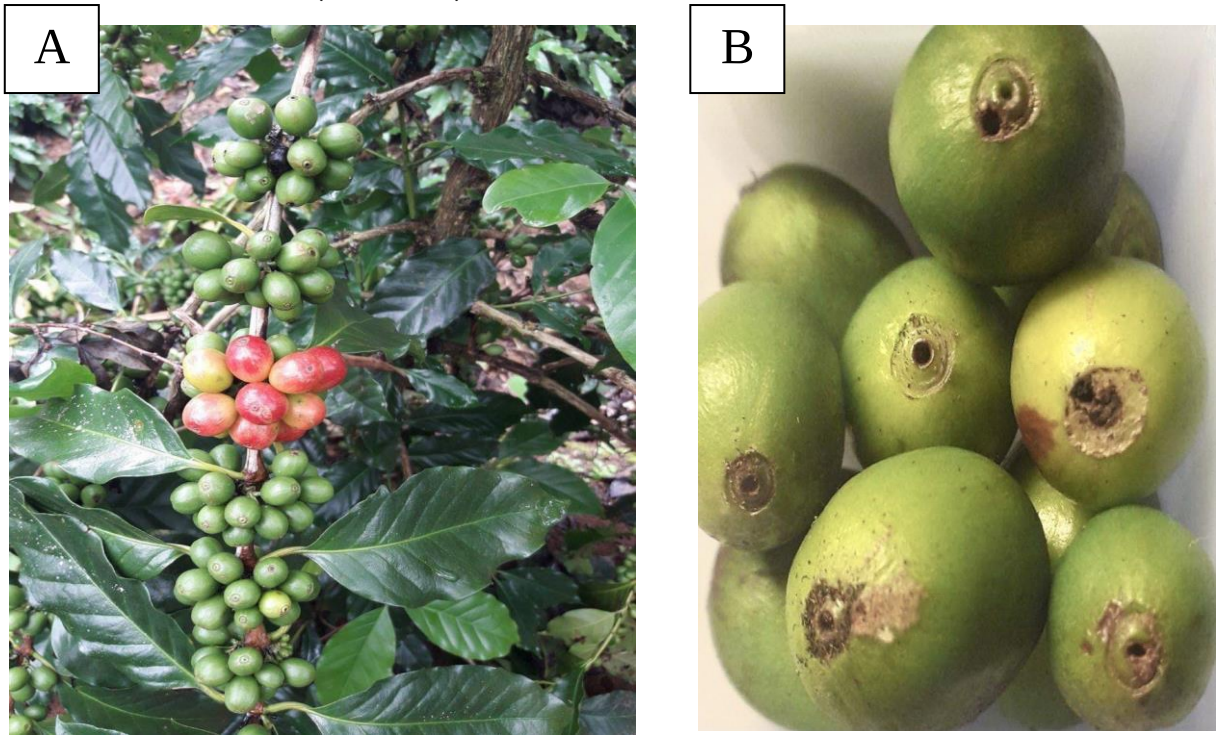


Figure 4 - Monitoring CBB in Son La province, Vietnam using red bottle traps. (A). Coffee tree with matured berries; (B) The infected berries by CBB

Photos were taken in Son La province, Vietnam

Figure 5.Monitoring CBB in Son La province, Vietnams using red bottle traps. (C) The bottle trap using monitoring CBB; (D) Coffee tree with matured berries. Photo taken in Son La province, Vietnam

Again, the above figure 5 shows us the way with using bottle trap (pet bottle) to attract female insect CBB and then kill their next generation.

3.3. Making Further assessment of *Beauveria bassiana* for monitoring Coffee Berry Borer

The percentage of berry damaged by CBB was different between treatments significantly (Figure 7). All of the experimental fields were similar to increases and decreased the ratio of berry damaged by CBB through the year. The trials show a low proportion of berry damaged by CBB at the beginning of the experiments. The percentage of berry damaged by CBB increased significantly from August until the end of November. Scientists have found out 13.7% as a ratio of berry damaged by CBB, highest, on chemical insecticide plot application, which is 13.70%. And the ratio of 6.33% as a lower percentage of berry damaged by CBB, in an application of *Beauveria bassiana.*

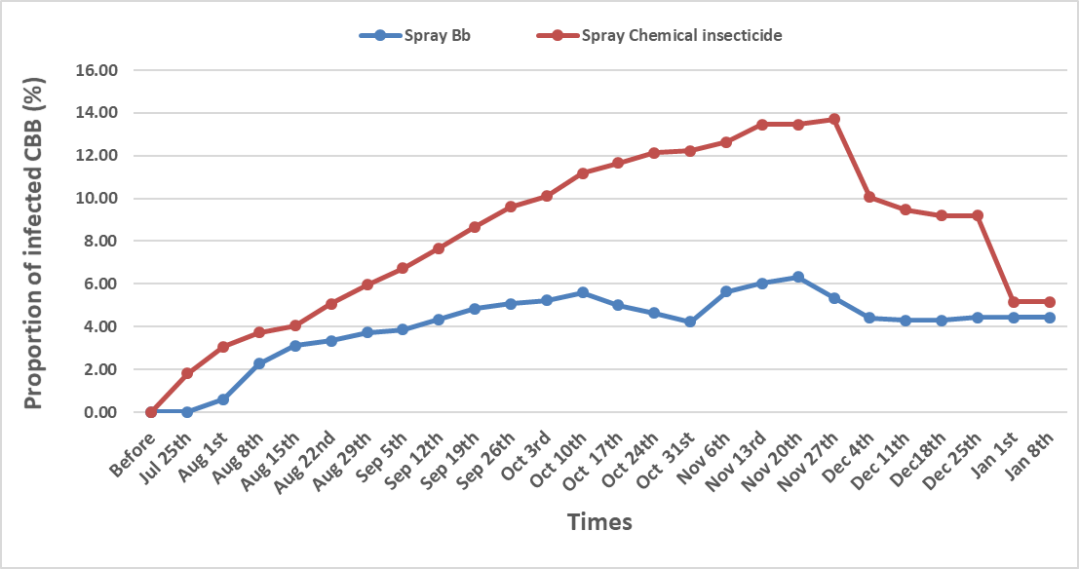


Figure 6 - Proportion of infested CBB (%) in plots application of local *Beauveria bassiana* and plots application of chemical insecticide

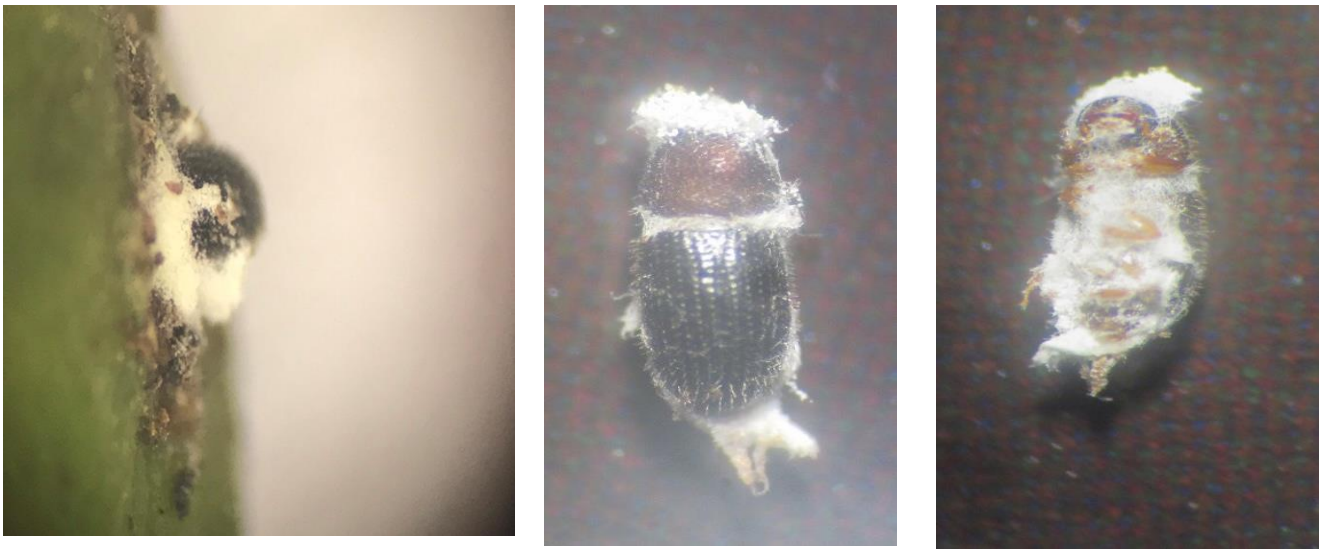


Figure 7 - Coffee berry borer was damaged by local *Beauveria bassiana.*

Photo taken in Son La province, Vietnam

(source: Bui Thi Suu et al, 2021).

3.4 The concept of agricultural sustainable value chain

According to Gareffi and Fernandez-Stark (2011)3, "a value chain is simply understood as the totality of activities performed by businesses and workers to bring products from production to consumers".
Similarly, UNIDO, IFAD and DIIS (2011) define "value chains are entities that are vertically connected along the chain of production, processing and delivery of goods and services to the final consumer through a series of sequenced operations. To help operate well, the value chain needs coordination and it depends on services such as transport infrastructure, finance, electricity, water, information, knowledge support, laboratories, etc.
Each vertical stage of the chain has a certain function such as production, primary processing, secondary processing, or marketing.
Global agricultural value chains are activities that create added value from from production to processing and distribution of products to consumers.
A stage 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, strategy and capacity of participation of those subjects.

In below figure wee see coffee export in the world in 2011 (60kg package)

Figure 8 - Coffee export globally

		5/2011	6/2011	7/2011	8/2011	9/2011	10/2011
Tổng		**9,370,066**	**9,095,069**	**7,537,789**	**7,525,318**	**7,378,540**	**7,109,194**
Colombian dịu		**691,878**	**672,803**	**547,230**	**435,924**	**521,196**	**647,424**
Dịu khác		**2,689,202**	**2,454,306**	**1,963,743**	**1,661,207**	**1,657,848**	**1,388,477**
Brazil tự nhiên		**2,427,051**	**2,527,880**	**1,965,625**	**2,738,958**	**2,792,797**	**2,838,034**
Robustas		**3,561,936**	**3,440,080**	**3,061,191**	**2,689,229**	**2,406,699**	**2,235,259**
Angola	R	1,150	300	285	1,685	750	500
Benin	R	0	0	0	0	0	0
Bolivia	A	700	6,400	7,500	8,800	9,000	8,000
Brazil	A/R	2,642,312	2,729,778	2,062,327	2,916,401	2,928,085	3,088,725
Burundi	A	17,000	18,000	20,000	22,000	25,000	30,000
Cameroon	R/A	70,033	49,850	21,280	17,000	15,100	15,000
Central African Republic	R	5,348	2,619	734	500	0	500
Colombia	A	592,673	575,894	474,532	383,618	470,799	602,693
Congo, Dem. Rep. of	R/A	17,307	15,407	9,066	10,000	10,000	10,000
Congo, Rep. of	R	0	0	0	0	0	0
Costa Rica	A	156,644	126,676	73,849	41,140	27,266	42,036
Côte d'Ivoire	R	147,610	123,455	125,832	79,001	68,367	57,733
Cuba	A	302	0	258	0	0	0
Dominican Republic	A	7,253	9,140	11,485	13,377	5,379	561

Malawi	A	1,153	2,489	1,000	1,000	500	500
Mexico	A	380,152	294,465	256,828	215,247	199,362	177,763
Nicaragua	A	207,253	119,028	98,750	70,485	26,654	37,443
Nigeria	R	31	1,290	50	50	50	50
Panama	A	2,295	5,043	6,000	4,000	3,000	2,000
Papua New Guinea	A/R	91,075	134,799	165,092	144,021	134,470	120,000
Paraguay	A	1	0	0	0	0	0
Peru	A	175,000	350,000	400,000	450,000	475,000	450,000
Philippines	R	64	97	715	63	137	500
Rwanda	A	5,775	2,610	20,000	20,000	20,000	20,000
Sierra Leone	R	567	3,136	3,000	3,000	3,000	3,000
Tanzania	A/R	29,935	44,267	28,671	10,759	27,014	29,443
Thailand	R	22,700	4,200	4,300	7,100	5,400	10,000
Timor-Leste	A	7,002	4,110	2,000	2,000	2,000	2,000
Togo	R	14,119	11,648	15,866	38,030	5,839	5,000
Uganda	R/A	253,290	370,924	375,813	308,739	340,378	215,315
Venezuela, Bol. Rep. of	A	350	350	500	500	500	500
Vietnam	R	1,575,000	1,300,000	1,200,000	950,000	850,000	800,000
Yemen	A	1,985	1,696	1,000	1,000	1,000	1,000
Zambia	A	0	0	500	1,000	1,500	15,000
Zimbabwe	A	1,000	1,000	1,000	1,000	1,000	1,000

(source: ICO, 2011)

4. Discussion

Native to Africa, the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae: Scolytinae), has gradually invaded most coffee-growing areas worldwide. Adult females colonize the coffee berry and oviposit within galleries in the coffee seeds. Larvae and adults consume the seeds, resulting in drastic reductions in yields and quality, negatively affecting the income of approximately 20 million coffee-growing families (~100 million people) in ~80 countries, with losses surpassing more than $500 million annually (Vega et al. 2015).

Beside, in the world, scientists have consider to use entomopathogenic fungi in coffee crops and decrease using level of insecticides.

Mathieu et al. (1999) also reported a positive correlation between CBB captured number and infested rate, using funnel traps.

Marino et al. (2016) and Gallardo & Gonz alez (2015) suggest entomopathogenic fungus B. bassiana application for control CBB.

Bui Thi Suu et al (2021) stated that the coffee crop need to eliminate insect, coffee berry borer (CBB), which causes losses and damages for farmers.

Conclusions and recommendations

This study emphasizes the using of alcohol traps to eliminate CBB and bottle traps used could kill CBB females, therefore, alcohol trap and Beauveria bassiana should be implemented as a part of integrated pest management CBB to reduce the use of chemical insecticides.

The research focused on assessing the percentage of berries damaged by Coffee berry borer (CBB) on Son La fields, monitoring CBB by alcohol traps to predict CBB. Study shows that the CBB infestation rate on the 1st and 4th flowering was higher than others. The highest percentage of berries damaged by CBB in the 1st flowering was 19.7%. The number of CBB adults trap-1 was highest in May and June, with an average of 7.5 to 101.4 CBBs per trap/week. As consequences, the CBB adult flight was monitored to determine the best

timing for spraying insecticide (chemical, entomopathogenic fungi), and using Beauveria bassiana could be applied as a part of integrated pest management CBB for sustainable coffee pest control strategies.

Other recommendations for building sustainable value chain

Beside, Ta Quang Minh (2011) said construction activity status building a famous agricultural product brand is still quite modest.

Statistically, we have about 800 famous agricultural products in most local, but to now there are 59 collective brands,12 certification marks, 29 only registered geographical indications and 53 supported agricultural products building trademarks, geographical indications.

Thus, we are only at the stage the beginning of branding famous agricultural products.Practice shows that, in order to build and agricultural product brand development,Need to raise people's awareness people, businesses and institutions authorities on the importance of Branding.

Last but not least, Zapata et al (2021) stated a strong control aimed at increasing coffee quality may impoverish the market diversity, independently of the consumers' budget limitations and corresponding preference for either high or low quality.

Finally, a global value chain differs from a value chain in that a value chain can encompass only a single geographical location or even a single company (such as a type of fruit).

The tree is grown, packaged, and consumed only in one country. Meanwhile, a string Global value can be divided by many different companies and geospatial

can be spread across many different countries (Duke GVCC, 2019).

Previously, according to C. Miller and L. Jones (2010), "global value chains are activities value-added activities from production to consumption, through processing and commercialization. Each stage of the chain has one or more forward and backward links.

That is, value chains are increasingly closely linked with each other

stages, between subjects in the chain.

Research limitation

We need to expand further solutions for other insects damaging crops also.

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