COFFEA CANEPHORA PIERRE SUSCEPTIBILITY TO THE COFFEE BERRY BORER *HYPOTHENEMUS HAMPEI* FERRARI (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE)

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ABSTRACT

The Coffee Berry Borer is the most notorious pest in coffee plantation, due to the most causing loss in plantation and it spreads that now is almost no restriction. This research was aimed to find out susceptibility level of Robusta coffee to this pest which this information is useful for breeding purposes. The population was formed from crossing of the two groups of *C. canephora*, Congolese x Conilons, was used in this study, compared to population of intra group crossing Congolese x Congolese. After observing during four years in which the site is located at endemic area, separating level of susceptibility, which indicated by infestation rate in the berry, was well formed when the observation conducted at mid of harvest time rather than at fully immature green berry condition. Three susceptibility groups were formed with infestation rate in the less susceptible group was 19.4% in average. However, inheritance of susceptibility trait to CBB between the two populations studied was found not following the mendelian perspective.

Key words: *C. canephora*, susceptibility, *Hypothenemus hampei*, coffee berry borer.

INTRODUCTION

The Coffee Berry Borer (CBB), *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae: Scolytinae), is actually endemic in Central African but became the most notorious pest of coffee in many of the world's coffee producing countries (le Pelley 1968) including Indonesia. Today, there are only two producing countries which still consider free from this pest namely China and Nepal (Jaramillo *et al*., 2011). Spreads of this pest is always limited by altitude (le Pelley 1968). However, recently found that CBB is able to attack coffee in the highland, as consequence of climate change which causes increasing temperature globally (Jaramillo *et al*., 2009). On the other hand, warming condition also affected to shorter life cycle of CBB from egg to imago (Jaramillo *et al*., 2009), making spread of this pest is become faster to infect the coffee berries. World counts of losses caused by CBB are exceeding US $500 million annually (Jaramillo *et al*., 2011). The losses caused by CBB is actually not only by decreasing yield in term of fall of young berries (le Pelley, 1968), but also decreasing bean density caused by holes inside the beans, and lower price of green beans because of its low quality due to high number of defective beans.

Indonesia is one of the biggest country producing Robusta coffee in the world (United States Department of Agriculture, 2011) which the production are come from 90% of Indonesian total coffee area (Direktorat Jenderal Perkebunan, 2006). Unfortunately, those amount of green bean production are come from low productivity of farm which only reached 504 kg/ha year^{-1} in national average (Direktorat Jenderal Perkebunan 2006) due to production constrains in which CBB is one of them. Even CBB was found for a century in Indonesia (Cramer, 1957), no commercial resistant variety of Robusta, either Arabica, is available until now although variation of infestation rate have been reported in this species (Cramer, 1957), the most commercial *C. arabica* (Alvarez-Sandoval *et al*., 2001; Alvarez-Sandoval *et al*., 2002; Romero & Cortina-Guerrero 2004a; Romero & Cortina-

Guerrero 2004b) and among *Coffea* species (Cramer, 1957; Sera *et al*., 2010) which suggest that breeding effort to find out resistant plant can be developed.

In this report, we would like to explore the variation of infestation rate in the most importance coffee species in Indonesia, *C. canephora*, and look for the chance of highest resistance level to CBB that can be reached in this species by taking an advantage of using the populations which the parents were coming from two distinct group of Robusta, the Congolese and Conilon (SG1), and compared to inter group crossing of Congelese x Congolese. However, the most important thing of using this species in this study is because of this species was reported as the most suspicious of original host of CBB in commercial coffee species (Jaramillo *et al*., 2009). Furthermore, this species has broadest genetic variability in the genus of *Coffea* (Cubry *et al*., 2008) which hopefully can give good description in the variation of infestation rate. This information will useful in the next breeding program for resistance to this pest.

MATERIAL AND METHODS

Research was conducted in Lampung province which known as one of three biggest producer provinces of Robusta coffee in Indonesia (Direktorat Jenderal Perkebunan, 2006). Location of the research site is surrounded by coffee farm of smallholding farmer which CBB is always presence over year. The populations observed were originated from two Congolese (BP409 and BP961) and one Conilons (Q121) parents. Observations were carried out on 90 progenies of each population of BP961 x Q121 (population A) and BP409 x BP961 (population C), which in the previous work shows high polymorphism level identified by RFLP markers (Priyono *et al*., 1999). Half of progenies had also verified of their true-to-types by Priyono *et al*. (2001). Whole progenies were single tree planted, single stem grown technique, and managed according to the standard protocol of coffee cultivation in Indonesia (Pusat Penelitian Kopi dan Kakao, 1997). No chemical pesticide applied, or others methods to control CBB attack during conducting this research.

Since the CBB start to infest on immature berries, observation of CBB infestations rate were done in two different times namely 1) at the fully developed immature berry and 2) at mid of harvest time, under field condition during four year. Rate of infestation was represented by percentage of attacked berries in four randomized branches sample (Wiryadiputra *et al*., 2008) per genotype on each observation time.

Cluster analysis was used to identify group of susceptibility using hierarchical clustering method of complete linkage with Euclidean distance. Analysis was only done on the genotype which can full fill 4 years observation. Simple descriptive statistic was also used to explore the data.

RESULT AND DISCUSSIONS

CBB infestations were observed in two different maturation times namely at fully green berry stage and in the middle of harvest time. Actually the infestation can be started before bean starting to ossify which causing berry drop (Cramer, 1957; le Pelley, 1968), but we considered that the infestation of CBB will only take place in the condition of ossify bean because the site of this trial is located at wet climate area where the coffee berry always presence over years even in small number, making unlimited feed source and place to breed in the favorable condition. Finally, the analysis was

Infestation rate at fully immature green berry

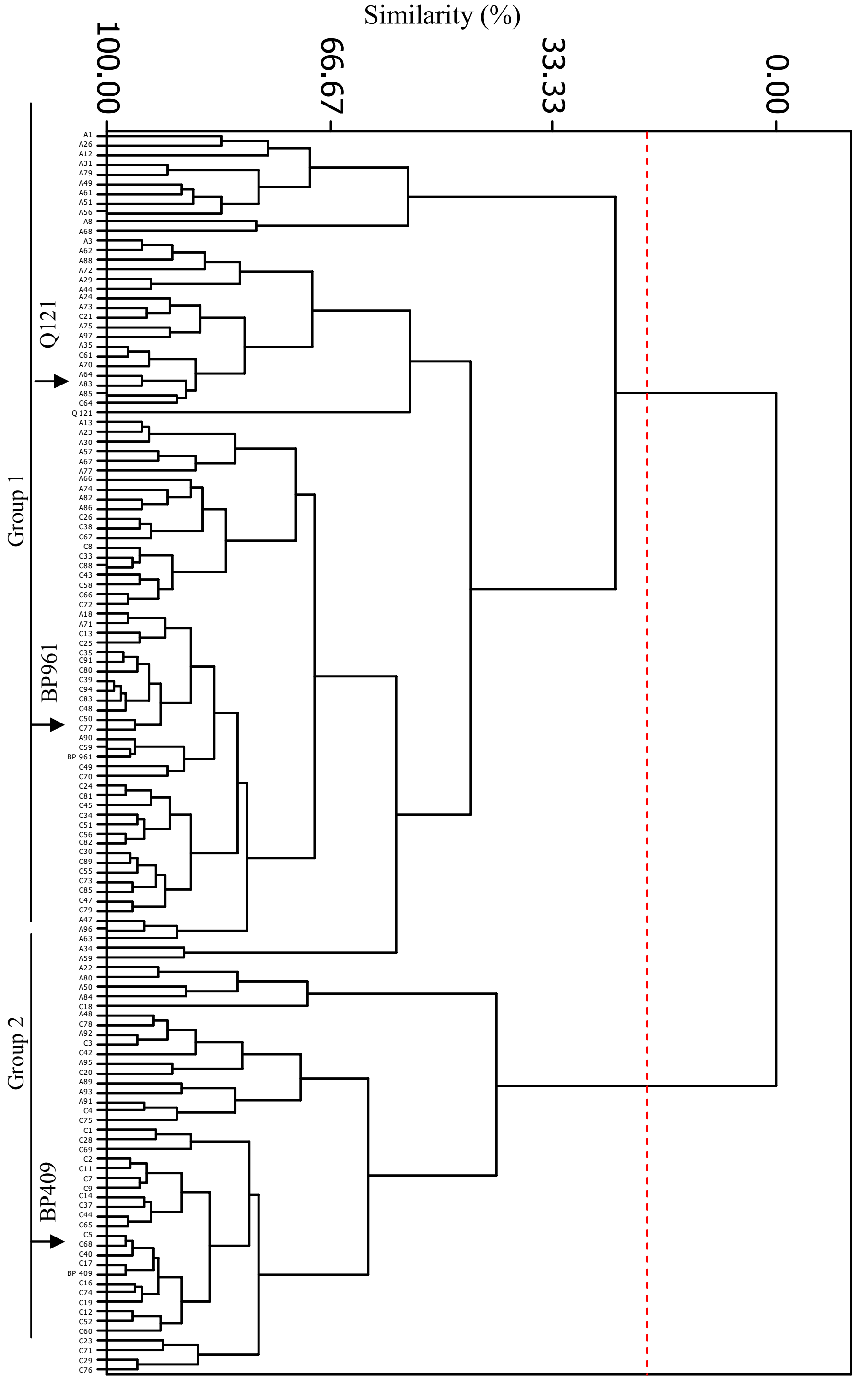

Figure 1. Susceptible groups of *C. canephora* at fully immature green berry condition under field trial. The arrows show position of parents.

only done on 130 progenies, including the three parents, from those two populations which can full fill 4 years of observation.

In the fully immature green berry condition, we found two susceptible groups of those populations as showed in Figure 1, formed at 20% of similarity. According to the data presented in Table 1, group 2 has the similar susceptibility level with group 1. Furthermore, the range of infestation rate of group 1 was covering the range of group 2. These conditions were suggested for actually no difference of susceptibility level between the two groups. As shown in Table 1 also, from those 3 parents, Q121 seems as the most susceptible parental to CBB according to the mean value, while the two others have similar lower susceptibility level. However, because actually no differentiation of susceptibility group in this observation time, the different infestation rate among the three parents could be considered not significant.

Although group separation of susceptibility level could not be defined, but this data shows that CBB infestation at fully immature green berry condition were consider high which reaches up to 14.6% in the year average, ranged from 6.9% to 26.4% among observed genotypes. From those population, we found only 12.3% of progenies were infested less than 10%. Mainly, infestations of CBB were recorded from 10% to 20 for 75.4% progenies. The rest of 12.3% progenies were infested >20%.

Infestation Rate at Mid of Harvest Time

At mid of harvest time, the CBB infestations were higher rather than in fully immature green berry condition due to longer stay of berry in the field from green to red ripe that gives enough time of CBB to breed, spread and infest wider in the field. Furthermore, red berry is more attracting CBB to infest rather than the green one (Ortiz *et al*., 2004). In this observation time, groups of susceptibility were formed into three levels, at 45% of similarity as shown in Figure 2. According to data of each group in Table 2, A is the most susceptible group with 33.9% of infestation in average, followed by group B (27.2%) and then C (19.4%). Range profile among those three groups were shows decreasing rate, suggest the well-formed of this cluster compared to previous clustering in fully immature green berry condition. On the other hand, the parents had different infestation rate which confirmed by their separated group positions. The Q121 found has the fewest rate of CBB infestation among the parents. However, this data is in the contrary with Cramer (1957) which reported that this type was more susceptible to CBB rather than the Congolese. Our recorded data in Table 3 shows that Q121 was always less infested by CBB during this research, except for first year of observation.

The data we showed previously were the average of four years rate of infestation, which actually varies among year to year of observations. We recorded the worst rate of infestation at mid

Table 1. Description of susceptibility groups at fully immature green berry condition.

Group	CBB infestation (%)		
	Mean	Minimum	Maximum
1 (87 members)	14.0	6.9	26.4
2 (43 members)	15.7	11.2	24.5
Parental Q 121*	18.5	4.4	31.7
Parental BP 409*	12.1	1.3	36.0
Parental BP 961*	12.2	2.1	29.3
Total members	14.6	6.9	26.4

* Range data were calculated from yearly observation.

of harvest time observations was occurred in 2009, where the rate of infestation had reached up to 100% in each population, as presented in Table 4. According to this data, actually all of the genotypes observed are susceptible to CBB which only 21.2% in the minimum rate of infestation can be reached. If bean index (conversion from coffee berries to coffee beans) of Robusta is 0.8 (Sumirat *et al*., 2007), at least minimum one bean attacked by CBB per berry, and the bean attacked by CBB is completely loss, so we can count that minimum 13% of coffee beans will loss from production. It has to noticed here that the loss of coffee production caused by CBB is not only considered came from the loss of the beans from available berries harvested, but also came from berries drops which occurred since the CBB could attack at pinhead stadium (le Pelley, 1968).

According to Table 4 also, susceptibility level between two populations of Conilon x Congolese and Congolese x Congolese is not significantly different, though the Conilon parents have different susceptibility level to others two Congolese. Not only the same susceptibility level of those two populations, distributions of progenies from each population in each group of susceptibility were also in similar pattern as shown in Table 5. This evidences shows that genes regulating resistance characteristics to CBB is not following mendelian perspective. This two

Table 2. Description of susceptibility group at mid of harvest time.

Group	CBB infestation (%)		
	Mean	Minimum	Maximum
A (70 members)	33.9	29.1	43.7
B (41 members)	27.2	22.0	32.4
C (19 members)	19.4	10.6	23.4
Parental Q121	21.6	3.6	47.7
Parental BP409	25.7	7.6	76.6
Parental BP961	35.0	9.3	86.7
Total members	29.7	10.6	43.7

Table 3. Rate of infestation among the parents during four years of observation.

Parents	Rate of infestation (%)			
	2007	2008	2009	2010
BP409	8.1	7.6	76.6	10.4
BP961	31.5	9.3	86.7	12.7
Q121	26.1	3.6	47.7	8.8

Table 4. Infestation rate of CBB during four years of observation.

Year	Rate of infestation (%)			
	Population A		Population C	
	Mean	Range	Mean	Range
2007	16.5	3.7-39.8	9.9	0.5-40.0
2008	12.2	5.5-29.5	10.0	0.0-21.3
2009	78.9	21.2-100.0	81.6	37.2-100.0
2010	15.6	6.8-32.0	14.1	4.5-29.0
Average	30.7a	10.6-41.7	28.9a	15.7-43.7

The same letter following number in one row is not significantly different based on analysis of variance at 5% significance level. Data was transformed by 1/x before analysis done.

evidences needs to be next explored to find out role of genes behind resistance characteristic of *C. canephora* to CBB. Since this research was conducted under field condition, many factors could influence to the data such as the abundance of infestation (CBB), number of available cherries in the field, and field management.

Until now, the resistance factors of coffee trees to CBB could not well defined even many suspected defense characteristics have been reported. Those of defense characteristics could be in

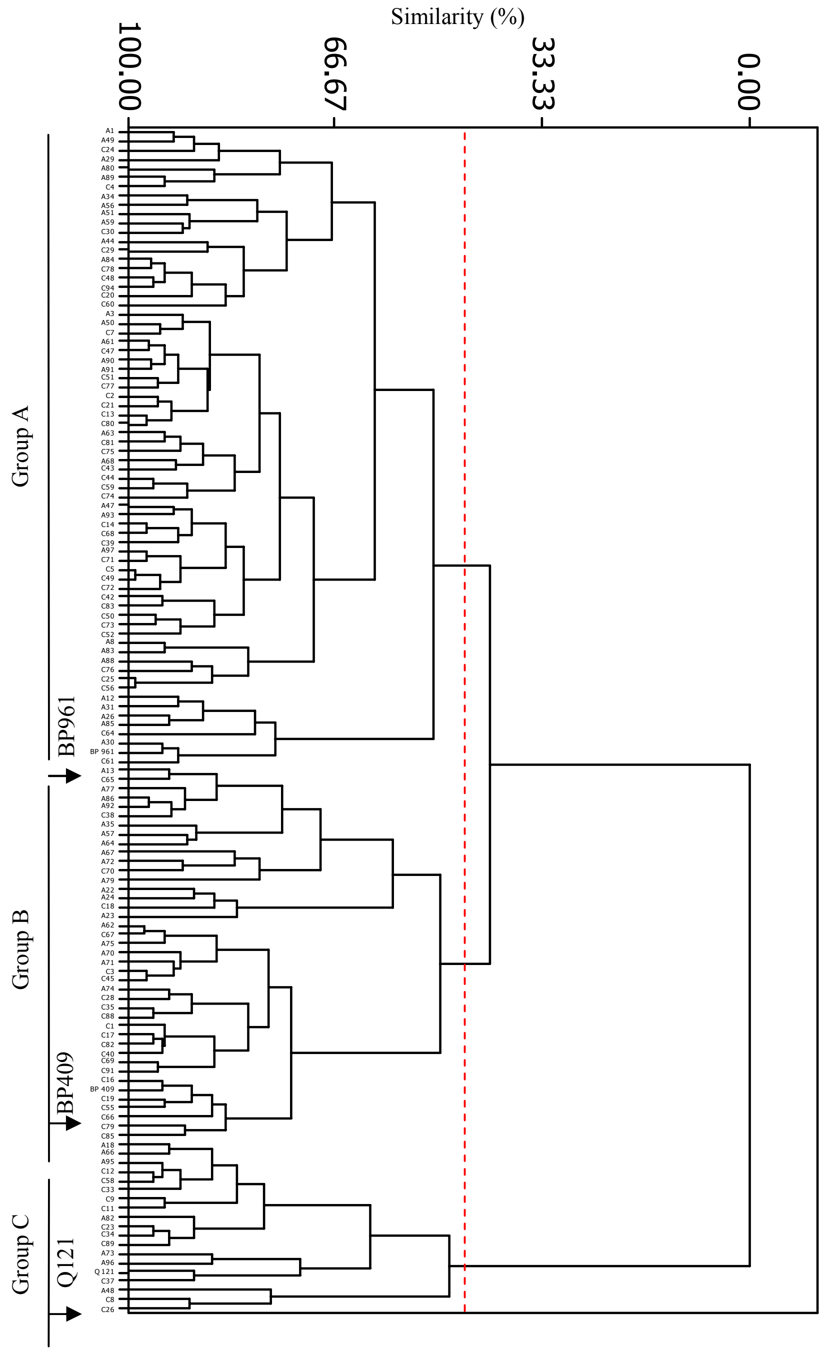

Figure 2. Susceptible groups of C. canephora at mid of harvest time under field trial. The arrows show position of parents.

Table 5. Member composition of each group from two crossing populations averaged from four years of observations.

Population	Distribution (%) in		
	Group A	Group B	Group C
BP961 x Q121 (A)	61.2	25.4	13.4
BP409 x BP961 (C)	66.2	23.0	10.8

* Range data were calculated from yearly observation.

term of antixenosis and antibiosis mechanism. In the antixenosis mechanism, perhaps hardness of parchment skin is the most suspected characteristic blocking the infestation of CBB (Cramer, 1957). However, the antibiosis mechanism may play a more important role rather than antixenosis against CBB in coffee (Gongora *et al*., 2008). This could be showed by Romero & Cortina-Guerrero (2004b) which found different ability of CBB adult to breed inside coffee beans which lead to various total numbers of individuals. Unfortunately, the caffeine, a biochemical compound important in coffee which suspected having a role in antibiosis mechanism against CBB finally, was reported not correlated to the resistance (Filho and Mazzafera, 2003). On the other hand, recently reported the jasmonic acid could be one of biochemical compound responsible in the antibiosis mechanism against CBB (Gongora *et al*., 2008).

CONCLUTION

Our result is also concluded for the needs of laboratory evaluation which now is not yet available especially for large genotypes evaluation. This method could be one of important effort in the early step to reveal defense characteristics and eliminate most of problems occured in the field observations. On the other hand, next evaluation should also involved all seven genetic groups of *C. canephora* (Cubry *et al.,* 2012; Montagnon *et al*., 2012) to better exploring the ability of this species against CBB.

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REFFERENCES

Alvarez-Sandoval, J.H., H.A Cortina-Guerrero, and J.F. Villegas-Mejía. 2001. Métodos para evaluar antibiosis a *Hypothenemus hampei* en café bajo condiciones controladas. Cenicafé. 52:205-214.

Alvarez-Sandoval, J.H., H.A Cortina-Guerrero, and J.F. Villegas-Mejía. 2002. Método para evaluar antixenosis a *Hypothenemus hampei* en café bajo condiciones controladas. Cenicafé. 53:49-59.

Cramer, P.J.S. 1957. A review of literature of coffee research *In* Indonesia. in F.L. Wellman (*eds).* SIC Editorial, Inter-American Institute of Agriculture Sciences. Turrialba. Costa Rica.

Cubry, P., P. Musoli, H. Legnaté, D. Pot, F. de Bellis, V. Poncet, F. Anthony, M. Dufour, and T. Leroy. 2008. Diversity in coffee assessed with SSR markers: structure of the genus *Coffea* and perspectives for breeding. Génom. 51:50-63.

Cubry, P., F. De Bellis, D. Pot, P. Musoli, and T. Leroy. 2012. Global analysis of *Coffea canephora* Pierre ez Froehner (Rubiaceae) from the Guineo-Congolese region reveals impacts from climatic refuges and migration effect. Genet. Resour. Crop Evol. DOI: 10.1007/s10722-012-9851-5.

Direktorat Jenderal Perkebunan. 2006. Statistik Perkebunan Indonesia 2004-2006: Kopi. Jakarta. 86 p.

Filh, O.G. and P. Mazzafera. 2003. Caffeine and resistance of coffee to the berry borer *Hypothenemus hampei* (Coleoptera: Scolytidae). J. Agric. Food Chem, 51:6987-6991.

Gongora, C., S. Idarrag, A. Sanchez, A. Gaitan, L. Rivera, M. Cristancho, M. Yepes, and R. Buell. 2008. Differential gene expression response of *Coffea arabica* and *C. liberica* to Coffee Berry Borer attack. Prosiding of 22th ASIC conference. pp. 863-867.

Jaramillo, J., A. Chabi-Olaye, C. Kamonjo, A. Jaramillo, F.E. Vega, H. Poehling, and C. Borgemeister. 2009. Thermal tolerance of the coffee berry borer *Hypothenemus hampei*: Predictions of climate change impact on a tropical insect pest. *Plos One*, v4, www.plosone.org.

Jaramillo, J., E. Muchugu, F.E Vega, A. Davis, C. Borgemeister, and A. Chabi-Olaye. 2011. Some like it hot: The influence and implication of climate change on Coffee Berry Borer (*Hypothenemus hampei*) and coffee production in East Africa. Plos One, v6, www.plosone.org.

Le Pelley, R.H. 1968. Pest of coffee. Longmans Green and Co. Ltd. 590 p.

Ortiz A., F.E. Vega, and F. Posada. 2004. Volatile composition of coffee berries at different stages of ripeness and their possible attraction to the coffee berry borer *Hypothenemus hampei* (Coleoptera: Curculionidae). J. Agric. Food Chem. 52:5914-5918.

Priyono, A. Henry, A. Deshayes, B. Purwadi, and S. Mawardi. 1999. The polymorphism level of *Coffea canephora* in several clone couple, restriction enzymes and probe sources. Pelita Perkebunan. 15:152-161.

Priyono, A. Henry, A. Deshayes, B. Purwadi, and S. Mawardi. 2001. Verification of hybrid progenies by using RFLP technique on *Coffea canephora* Pierre. Pelita Perkebunan. 17:1-9.

Pusat Penelitian Kopi dan Kakao. 1997. Pedoman teknis budidaya tanaman kopi (Coffea *sp*.). *In* A.M. Nur, P. Rahardjo, R. Hulupi, S. Abdoellah, G. Suprijadji, B. Odang, Saidi, S. Wiryadiputra, and C. Ismayadi (*eds.*). Pusat Penelitian Kopi dan Kakao, Jember.

Romero, J.V. and H. Cortina-Guerrero. 2004a. Fecundidad y ciclo de vida de *Hypothenemus hampei* (Ferrari) en condiciones controladas. Cenicafé, 55:221-231.

Romero, J.V. and H. Cortina-Guerrero. 2004b. Evaluación de germoplasma de café por antixenosis a *Hypothenemus hampei* (Ferrari) en condiciones controladas. Cenicafé, 55:341-346.

Sera, G.H., T. Sera, D.S. Ito, C.R. Filho, A. Villacorta, F.S. Kanayama, C.R. Alegre, L. Del Grossi. 2010. Coffee Berry Borer resistance in coffee genotypes. Braz. Arch. Biol. Technol. 53:261-268.

Sumirat, U., S. Priyono, and Mawardi. 2007. Seleksi genotipe-genotipe unggul *Coffea canephora* Pierre pada populasi bastar terkontrol menggunakan metode analisis gerombol. Pelita Perkebunan. 23:89-103

United States Department of Agriculture. 2011. Coffee: World Markets and Trade. Circular Series, December. http://www.fas.usda.gov/psdonline/circulars/coffee.pdf. [11January 2012]

Wiryadiputra, S., C. Cilas, and J.P. Morin. 2008. Effectiveness of the brocap trap in controlling the coffee berry borer (*Hypothenemus hampei* Ferr.) in Indonesia. Proceedings of 22th ASIC conference, p. 1405-1408.