Journal of Experimental Biology and Agricultural Sciences

http://www.jebas.org

ISSN No. 2320 – 8694

EFFICACY OF THE INSECTICIDE IMIDOR SL 200 (Neonicotinoid) AGAINST THE MIRIDS OF COCOA (*Theobroma cocoa* VARIETY AMELONADO) IN CENTER CÔTE D'IVOIRE

AKPESSE Akpa Alexandre Moïse*, LIABRA Guy Joseph, BOGA Jean-Pierre, COULIBALY Tenon, YAPI Ahoua, and KOUASSI Kouassi Philippe

Laboratory of Zoology and Animal Biology, UFR - Biosciences, University Félix Houphouët-Boigny, BP 582 Abidjan 22 Cote d'Ivoire.

Received – October 20, 2014; Revision – November 01, 2014, Accepted – November 14, 2014
Available Online – December 20, 2014.

KEYWORDS

Neonicotinoids efficacy

Effective doses

Mirids

Cocoa tree

ABSTRACT

The aim of this study was to test the efficacy of new kinds of insecticides i.e. Neonicotinoids on cocoa mirids to confirm the minimum effective dose of IMIDOR SL 200 and to determine the number of treatments applied per year following the development of the population over time after spraying the insecticide. Study was conducted in the center of Ivory Coast in state owned plantations in Toumokro near Yamoussoukro. Results of the study revealed that mirids have found generally very sensitive to various level of insecticide used. The efficacy of IMIDOR SL 200 substance proved best @ doses of 0.175 L/ha and 0.150 L/ha, and it is showing effectiveness just like CABOSSE PLUS 50 EC and CONFIDOR. These substances effectively control mirids. The recommended minimum dose that controls at least 90% of mirids was 0.150 L/ha or 30 g.ai/ha. From the results of the study it can be concluded that two times per year application are sufficient to protect cocoa trees against mirids.

* Corresponding author

E-mail: alexakpesse@yahoo.fr (AKPESSE Akpa Alexandre Moïse)

Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

Production and Hosting by Horizon Publisher (www.my-vision.webs.com/horizon.html).

1 Introduction

The cocoa tree (*Theobroma cocoa* L.) is an important crop worldwide (Thresh et al., 1988). In 2013, the cocoa production in Africa was estimated 2.813 million tons, i.e. 71%, for a global production (Anonymous, 2013). Côte d'Ivoire alone has produced 37 to 40% of the total world production, i.e. a production of around 1.4 million tons (Anonymous, 2013). This crop contributes total 15% in GDP of Côte d'Ivoire (ICCO, 2006; Anonymous 2014) and thus stands as one of the most important pillars for the Ivorian economy. Above mentioned facts are enough to prove the importance the this crop in Côte d'Ivoire, but recently cocoa growing regions are now facing several constraints such as ageing plantations and the pressure of the pests on the crops. Among these mirids, represent a major scourge harmful to cocoa growing in the world (Lavabre, 1977; Wheeler, 2000; Cassis & Shuch, 2012).

The mirids grubs feeds on the sap of young twigs and pods that they sting. Their bites create black spots on pods that eventually make them to rot in case of recurrent attacks. Then, young twigs and suckers become dry. This results in low yields of the cocoa crops and poor quality of cocoa beans. The solution that has always been considered as the most affective to fight against cocoa mirids is to use of insecticides (Sonwa et al., 2008). However, it was found that regular use of these insecticides developed resistance against organophosphates in target organisms (Bisseleua et al., 2011). Now, most of products used against cocoa mirids are of the neonicotinoid family and cause a systemic action. Aim of the present work was to assess the efficacy of IMIDOR SL 200, minimum effective dose, number of treatment required every year and to evaluate the efficacy of this products on other cocoa pests.

2 Materials and Methods

2.1 The study site

The studies were conducted from August 2010 to January 2011 in the state owned plantations in Toumokro (7 ° 15 'N - 5 ° 28' W) near Yamoussoukro in the center of Côte d'Ivoire. The local climate is called "baouléen" and is characterized by a humid tropical seasonal variation (Ardoin-Bardin, 2004) with two seasons viz rainy season (April to October) and dry season (November to March). The average annual rainfall is below 1100 mm. The average monthly temperature ranges between 22 - 31°C. The relative humidity varies between 75 and 85% (Ardoin-Bardin, 2004).

The plant material used was the cocoa tree *Theobroma cocoa*, variety *Amelonado* (Malvaceae). This variety widly cultivated in industrial and local plantations for high yield. The plantation of cocoa surveyed hasn't been treated for last ten years.

2.2 Insecticides

The insecticides tested were IMIDOR, CONFIDOR, and CABOSSE PLUS. With regard IMIDOR, three doses were used (0.125 L/ha, 0.150 L/ha and 0.175 L/ha). The formulations and active ingredient of insecticides are given in table 1.

2.3 Experimental design

The experimental was designed in randomized complete block design with 5 treatments with 3 repetitions. Three insecticides were tested: IMIDOR, CONFIDOR and CABOSSE PLUS.

A basic plot covering 300 m2 (20 x 15 m) with 40 trees. The basic plots are separated from each other by a strip of at least 10 m wide. Six treatments were performed and compared with the control trees.

2.4 Application of Insecticides and monitoring of insect's populations

Before applying insecticides, trees were observed to determine the initial population of mirids present. For this study, the treatments were started from the threshold of two mirid per tree. The cocao trees were treated two times viz the first treatment has given in the month of July and August while the second treatments has been given in the month of December and January. These periods correspond to the peaks of pullulations of mirids.

After giving treatments, the insect's population was monitored every month. For this purpose five different mirids host trees were selected from each of the treated plots. The day before treatment, tarpaulins 16 m2 (4m x 4m) were plated directly above the marked trees. Insecticides were applied by using a SOLO based spray; total 40 liters of insecticide were sprayed per hectare.

Table 1 Different formulation of insecticides, chemical group and their concentrations used.

Entry Name	Formulation	Active ingredient	Chimical group	Tested doses
IMIDOR	200 SL	Imidacloprid	Neonicotinoids	0.125 L/ha, 0.150 L/ha and 0.175 L/ha
CONFIDOR	200 SL	Imidacloprid	Neonicotinoids	0.125 L/ha
CABOSSE PLUS	50 EC	Imidacloprid (30 g/l) and Bifenthrine (20 g/l)	Neonicotinoids	0.500 L/ha

The treatment was done at early morning between 6 am and 9 am, according to the standard method. The counting of dead mirids has been done after 5 h, 24 h, 48 h, 96 h and 120 h of treatments applying. The counting of insects killed by leaching was done 5 h after these treatments. Insects are collected and stored in pill alcohol 70°C and grouped by type of treatment. After 120 h, the PROTEUS 170 O-TEQ (double dose) was applied to the same five trees sheeted, with goal to kill insects spared.

2.5 Assessing the efficacy of different chemicals

After each sampling, the efficacy rate of each product has been calculated by the below mentioned formulas:

% Efficacy = (**Mk / (Mk + MI)) x 100**
Where,
Mk = number of mirids killed by the chemicals applied
MI = number of mirids killed by leaching
Mk + MI = total number of mirids killed

2.6 Data Analysis

The collected data have been analyzed by the "Statistica" software (version 7.0) by one way analysis of variance (ANOVA), was performed. They made it possible by separate the various averages obtained using Duncan and the Newman-Keuls tests at the selected threshold probability of $p < 0.05$.

3 Results

3.1 Initial population of mirids

The level of mirids infestation in basic plots was assessed on monthly basis. Thus, from the third month, the population of mirids started increasing in the plots treated with IMIDOR SL 200 @ 0.125 L/ha. While the Plots treated by IMIDOR SL 200 @ 0.175 L/ha and reference products (CONFIDOR 200 SL @ 0.125 L/ha and "CABOSSE PLUS 50 EC" @ a dose of 0.500 L/ha) have less than 2 mirids per tree (Figure 1). From the fourth month, the mirids thresholds per tree were started increasing and reached more than two in all the treated plots. While in case of untreated plots, the mirids damage threshold was continually increased till fifth month. Based on the information generated, needs of the insecticide application was felts and it can be recommended that insecticides should be used as per the threshold levels. The number of mirids per tree remained within the damage threshold for all the treatment except for IMIDOR SL 200 @ 0.125 L/ha for this treatment threshold value was above the reference value. Thus, treatments with IMIDOR SL 200 @ 0.150 L/ha and IMIDOR SL 200 @ 0.175 L/ha in the month of "July-August" helps in protected the cocoa against mirids' attacks until the second treatment that was performed in "December-January". Two treatments per year were enough to protect trees when the IMIDOR @ 0.150 L/ha or 0.175 L/ha is used. The CONFIDOR 200 SL @ 0.125 L/ha and CABOSSE PLUS 50 EC @ 0.500 L/ha are good reference.

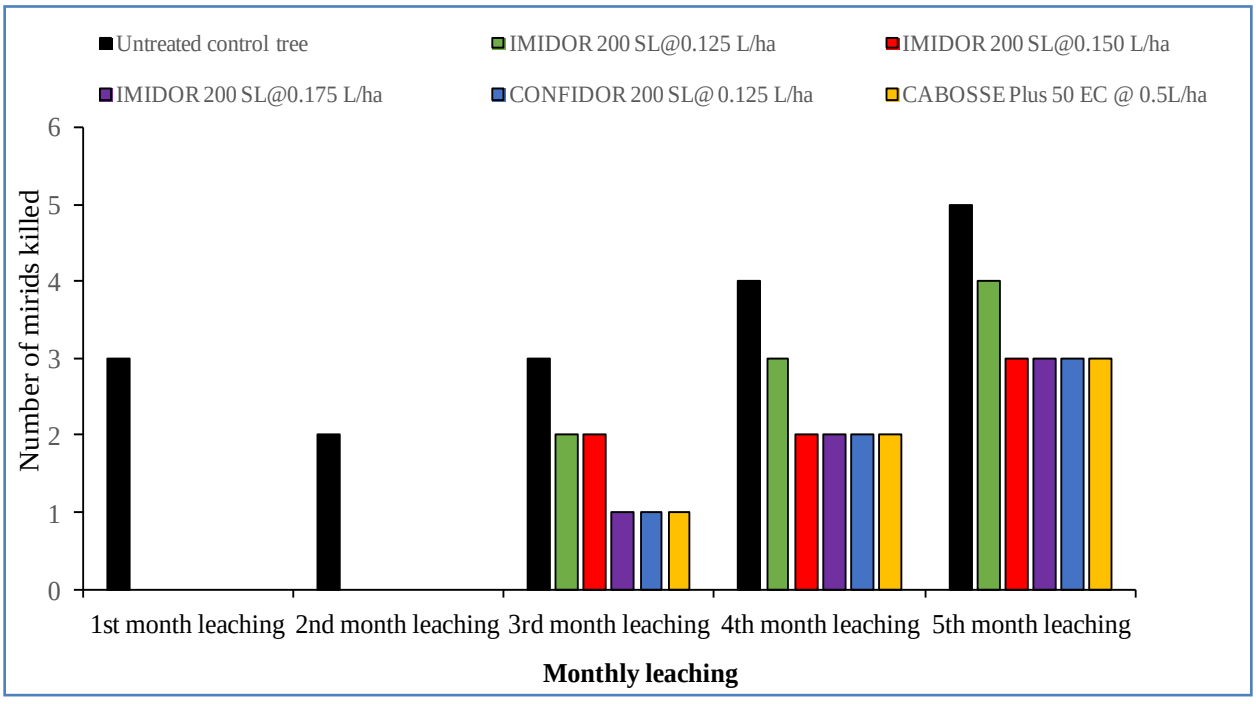

Figure 1 Number of mirids (grubs + adults) at each leaching in order to induce the treatment.

3.2 Development of mirids populations after initiating the treatment

The Student Newman Keuls (SNK) multiple comparisons test at the 5% threshold indicates that highest reduction ($p < 0.0049$) in the average numbers of mirids was reported in the treatment of IMIDOR SL 200 @ 0.150 L/ha, this reduction was followed by the IMIDOR SL 200 @ 0.175 L/ha treatment from the third month, which reflecting a resurgence of mirids (**Table 2**). Mirids outbreaks continued within the fourth and fifth months, indicating that "IMIDOR SL 200" based products at 0.150 L/ha and 0.175 L/ha have a persistence of three months. Products CONFIDOR 200 SL, 0.125 L/ha and CABOSSE PLUS 50 EC at 0.500 L/ha proved their effective control over mirids (Table 1). Significant differences ($P < 0.0001$) were observed between the untreated control and all the insecticides treatments, since the first month of leaching until the end of the experiment (5 months). The only significant differences between the various treatments by insecticides were observed between the 4th and 5th month.

3.3 Mirids' mortality (grubs + adults) during the different treatments over time

An analysis of variance based on the combined populations of mirids and grubs in treated and untreated plots revealed that mortality rates were low during the early hours for all treatment with IMIDOR SL 200, irrespective of the dose. In contrast, the mortality rate was quite high for treatment containing CONFIDOR 200 SL @ 0.125 L/ha and CABOSSE PLUS 50 EC @ 0.500 L/ha with respective values of 36% and 41% (Table 3). After 72 hours, all treatment reached over 55% cumulative mortality for treatment containing IMIDOR SL 200 and the mortality rate reached 100% for the reference products i.e. CONFIDOR 200 SL @ 0.125 L/ha and CABOSSE PLUS 50 EC @ 0.500 L/ha. The active ingredient of IMIDOR SL 200 indisputably performs effectively on mirids after 48 h. These observations would suggest that the selected doses of IMIDOR SL 200 were quite effective against the mirids.

3.4 Assessment of the efficacy of different chemicals on mirids

All the treatments containing insecticides except IMIDOR SL 200 at 0.125 L/ha were performed effectively against mirids. Indeed, the efficacy percentages obtained were higher than reference value (90%). Treatment with IMIDOR SL 200 @ 0.175 L/ha and CONFIDOR @ 0.125 L/ha were the most effective and owing the percentages of 94% (Figure 2). These treatments are followed by CABOSSE PLUS 50 EC @ 0.5 L/ha and IMIDOR SL 200 @ 0.150 L/ha with efficiencies of 92% on the mirids.

Table 2 Effect of various treatments on the development of mirids populations (grubs + adults).

	1st	2nd	3rd	4th	5th
	1 months	2 months	3 months	4 months	5 months
Untreated control tree	15 ^{a}	12^{a}	14^{a}	21^{a}	24^{a}
IMIDOR SL 200 @ 0.125L/ha	1^{b}	1^{b}	12^{ab}	14^{b}	18^{ab}
IMIDOR SL 200@ 0.150L/ha	0^{b}	1^{b}	9b^{c}	12^{c}	17^{ab}
IMIDOR SL 200@ 0.175L/ha	0^{b}	1^{b}	7^{c}	10^{d}	17^{ab}
CONFIDOR 200 SL@ 0.125L/ha	0^{b}	1^{b}	7^{c}	8^{d}	13^{b}
CABOSSE PLUS 50EC@0.5 L/ha	0^{b}	1^{b}	6^{c}	8^{d}	13^{b}
Standard deviation	0.66	1.11	2.06	1.74	2.98
Coefficient of variation	24.69	39.2	22.37	14.35	17.48
Associated probability with repetitions	0.3541	0.6772	0.2126	0.417	0.9057
Associated probability to products (p)	**0.0001**	**0.0001**	**0.0049**	**0.0001**	**0.0118**

The value given in tables are the mean of three replicates, averages followed by the same letter in the same column are not significantly different. The averages comparisons are performed only when the associated probability is less than or equal to 0.05

Table 3 Percentage mortality of mirids with different insecticides per time slots (h).

Treatments	5h – 24 h	48 h – 72 h	96 h – 120 h
IMIDOR SL 200 @ 0.125 L/ha	4%	55%	100%
IMIDOR SL 200 @ 0.150 L/ha	10%	61%	100%
IMIDOR SL 200 @ 0.175 L/ha	7%	59%	100%
CONFIDOR 200 SL @ 0.125 L/ha	36%	100%	-
CABOSSE PLUS 50 EC@ 0.5L/ha	41%	100%	-

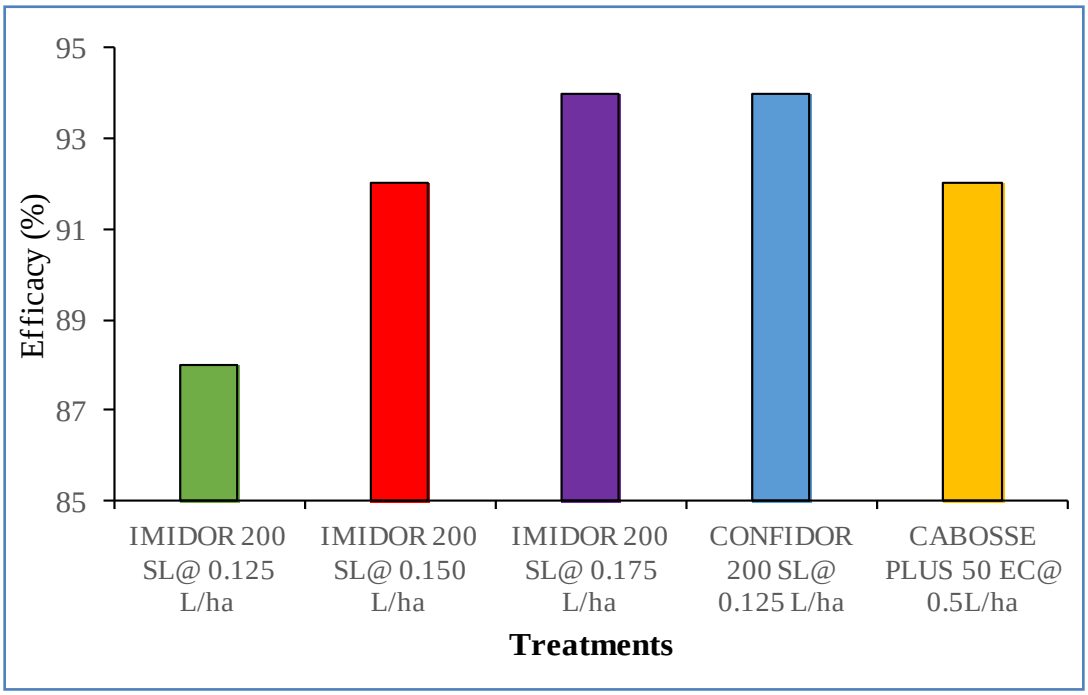

Figure 2 Efficacy of tested insecticides on the mirid populations (in percentage) after 120 h of application.

Discussion

The results of the study suggested that IMIDOR SL 200 was highly effective as the CONFIDOR 200 SL and CABOSSE PLUS 50 EC against Mirids, only few exceptions was reported. Similar types of results were obtained at field level plantation and at laboratory level by many authors in previous studies on the same active ingredient, but at varying doses (N'Guessan & Coulibaly, 2000; Gerken et al., 2001; Asogwa et al., 2004, Asogwa et al., 2006; Anikwé et al., 2009). A total of 238 mirids were collected when the plots were treated by IMIDOR SL 200 with three different doses while this number was only 125 in the plots treated by two reference products. These results are in agreement with Anikwé et al. (2009). The only difference being that these authors conducted four successive treatments compared to our study in which only two treatments were performed. Furthermore, results of the present study confirmed that two treatments per year would be sufficient to protect cocoa trees against mirids. The efficacy of IMIDOR SL 200 would decrease over time and this would be a good reference chemical against mirids. Previous tests performed with neonicotinoids and imidacloprid on mirids and other Hemipteras highlight the Knockdown effect of these chemicals (Biney, 2005; Asogwa et al., 2006; Anikwé & Okelana, 2009). It is well eastablished that efficacy of these chemicals decreased with the time.

These insecticides caused mortality rate of over 95%, after 24 hours of the treatment (Biney, 2005; Asogwa et al., 2006; Dwomoh et al., 2007; Anikwé et al., 2009). According to Anikwé et al., (2009), the insecticide 'Actara 25 WG' would perform effectively on adult mirids than on nymphs. The neonicotinoids act on acetylcholine receptors, resulting in paralysis of the nervous system of the insect leading to the death (NRA, 2001; Dwomoh & Boakye, 2003). The applied doses of insecticides also played a very significant role in the efficacy of a product. Results of this study suggest the required dose of IMIDOR SL 200 @ 0.175 L/ha compared to 6g/L in the work of Anikwé et al., (2009), in Nigeria. The vegetative state of the plots treated with IMIDOR SL 200 suggests that this product could be considered in the fight against this complex pest of young cocoa trees and saplings in the nursery. These same remarks were made for the chemicals such as CONFIDOR 200 SL and Proteus 170 O-TEQ (Kenne et al., 2003; Dormon et al., 2007; Asogwa & Dongoh, 2009). The synthetic pyrethroids generally proved less effective than carbamates and organophosphates and they are not generally used in the "anti-mirid" fight (Ojoladé et al., 2005; Anikwé et al., 2009).

From past few years, the active ingredients of the neonicotinoids family including thiamethoxam and imidacloprid, entered the chemical pesticides market intended for the cocoa cultivation. These active materials have the advantage of being less toxic and highly systemic thereby making them fit for use with hand pressure sprayer (Opokou et al., 2006; Babin, 2009). All the products used, as well as the reference a substance seems to perform very effectively on the cocoa pests; namely mirids populations.

The second treatment provides 100% mortality of mirids because the spreading was heavy. Insects are especially intoxicated by inhalation or contact, so that re-infection might be due to migrant adults or molting insects at the time of

applying the treatment. Poisoning by ingestion seldom occurs, but we still don't know about the behavior of the insect in the presence of dew drops that may contain suspension or emulsion of lethal doses. So, it makes sense to eliminate all grubs turned into females before they become able to lay eggs.

Conclusions

The use of insecticides has always been and is still the most widely used method in the fight against cocoa mirids. Indeed, these pests proved to be generally very sensitive to the different active ingredients used. The efficacy of chemical ingredients IMIDOR SL 200-based was reported highest at doses of 0.175 L/ha and 0.150 L/ha, just like those of 'CABOSSE PLUS 50 EC' and CONFIDOR 200 SL. These substances effectively control mirids. The recommended dose that can controls at least 90% of mirids is 0.150 L/ha, i.e. 30 g.ma/ha. Two treatments per year are sufficient to protect cocoa trees against mirids. Pest control should be conducted according to treatment schedules based on a thorough knowledge of seasonal variations in populations of mirids. Thus, the most widely recommended schedule, suggests a treatment during the populations' growing period (June-July) and another application of insecticide after the harvest (November-December) so as to limit attacks on the foliage of cocoa trees, which are the most damaging to culture. It is recommended that each insecticide application includes two separated treatments of one month interval; the second treatment is meant to remove grubs emerging from eggs that survived the first treatment.

References

Anikwé JC, Asogwa EU, Ndubuaku TCN, Okelana FA (2009) Evaluation of the Toxicity of Actara 25 WG for the Control of the Cocoa Mirid *Sahlbergella singularis* Hagl. Crop protection Division, Cocoa Research Institute of Nigeria. African Journal of Biotechnology 8:1528-1535.

Anikwé JC, Okelana FA (2009) Evaluation of field damage and chemical control of outbreak of *Sahlbergella singularis* Hagl. In cocoa plantation in Ibadan, Nigeria. World Journal of Agricultural Sciences 5:190-194.

Anonymous (2014) Côte d'Ivoire : Campagne 2013, les satisfécits du Conseil Café-cacao. Available on http://www.koaci.com/cote-d% E2%80%99 ivoire-campagne-2013-satisfecits-conseil-cafe-cacao-81517.html, access on 21st March, 2014.

Anonymous (2013) L'offre mondiale de cacao a été déficitaire de 160.000 tonnes au cours de la campagne 2012-2013. Available on http://www.investiraucameroun.com/agriculture/0512-4861-l-offre-mondiale-de-cacao , access on 21st March, 2014.

Ardoin-Bardin S (2004) Variabilité hydroclimatique et impacts sur les ressources en eau de grands bassins hydrographiques en zone soudano-sahélienne. Thèse de Doctorat en Sciences de l'Eau. Université Montpellier II. 294 p.

Asogwa EU, Anikwe JC, Mokwunye IU (2006) Report and recommendation based on the evaluation of ANVL/TORNADO WFB 18 AC motorized knapsack sprayer for protection of cocoa in Nigeria. 44 pp. Agriculture and Biology Journal of North America 2: 415-420.

Asogwa EU, Anikwe JC, Ndubuaku TCN (2004) Report and recommendation based on the evaluation of Kizan SC KJ- 16 knapsack sprayer for protection of cocoa in Nigeria. Tech. Rep. CRIN, Ibadan, Nigeria, 120 p.

Asogwa EU, Okelana FA, Mokwunye IU Anikwe JC (2004) Evaluation of Engeo K 247 SC for routine protection of Cocoa farms against the brown cocoa mirid *Sahlbergella singularis* Hagl. in Nigeria. Journal of Tropical Insect Science 14: 12-23.

Asogwa EU, Dongo LN (2009) Problems associated with Pesticide Usage and Application in Nigeria Cocoa Production: A review. African Journal of Agriculture 4: 675-683.

Babin R (2009) Contribution à l'amélioration de la lutte contre les mirides du cacaoyer *Sahlbergella singularis* Hagl. (Hemiptera: Miridae). Influence des facteurs agro écologiques sur la dynamique des populations du ravageur. Ph.D. thesis submitted to University Paul Valéry, Montpellier, France.

Biney PM (2005). Pesticide applicator's Hand-book: Plant Protection and Regulatory Services Division, Ministry of Food and Agriculture, Accra, Ghana.

Cassis G, Schuh RT (2012) Systematics, Biodiversity, Biogeography, and Host Associations of the Miridae (Insecta: Hemiptera: Heteroptera: Cimicomorpha) Annual Review of Entomology 57: 377-404.

Dormon EN, Van Huis A, Leeuwis C (2007) Effectiveness and profitability of integrated pest management for improving yield on smallholder cocoa farms in Ghana. International Journal of Tropical Insect Science 27: 27-39.

Bisseleua DHB, Yede B, Vidal S (2011) Dispersion Models and Sampling of Cacao Mirid Bug *Sahlbergella singularis* (Hemiptera: Miridae) on *Theobroma cacao* in Southern Cameroon. Environmental Entomology 40: 111-119.

Dwomoh EA, Afun JVK, Ackonor JB (2007) Evaluation of Karaté EC, Cyperdim EC and confidor SL for control of *Heloptis schoutedeni reuter* (Hemiptera: Miridae) on cashew in Ghana. Journal of Science and Technology 27 (1): 1-8.

Dwomoh EA, Boakye DB (2003) Field evaluation of *chlorpyrifos*, *lambacylothrin* and *Bacillus thuringiensis* for control of mirids in Ghana. Tropical Agriculture 4: 211-214.

Gerken A, Suglo J, Braun M (2001) Crop protection policy in Ghana. ICP/MOFA, Pokoase, Ghana. 12 p.

ICCO (2006) Organisation Internationale du Cacao. *Rapport Annuel*. ICCO: 41 p.

Kenne M, Djiéto-Lordon C, Orivel J, Mony R, Fabre A, Dejean A (2003) Influence of insecticides treatments on ant-hemiptera associations in tropical plantations. Journal of Economic Entomology 96: 251-258.

Lavabre EM (1977d) Importance économique des mirides dans la cacaoculture mondiale. In *:* EM Lavabre (Ed) Les mirides du cacaoyer.., G-P. Maisonneuve et Larose, Paris, pp 139-153.

N'Guessan FK, Coulibaly N (2000) Rapport d'essai d'efficacité du Confidor contre les mirides du cacaoyer : confirmation de la dose minimum efficace. Rapport CNRA Côte d'Ivoire, Mars 1999. 22 p.

NRA: National Registration Authority for Agriculture, Veterinary Chemical (2001) Public release summary and evaluation of new *thiametoxam.* Kingstonnet 2604: 34 p.

OjoladéK TM, Anikwé JC, Idowu OL (2005) Comparative Evaluation of Miricidal Efficacy of some Insecticides for the control of the brown cocoa mirid *Sahlbergella singularis* Hagl. in Nigeria. Journal Applied Tropical Agriculture 10: 46-53.

Opoku IY, Gyasi EK, Onyinah GK, Opoku E, Fofié T (2006) The National Cocoa Diseases and Pests Control (CODAPEC) Programme : Achievements and Challenges, Proceedings of the 15th International Cocoa Research Conference, San José, Costa Rica 9-14th October 2006. Pp 1007-1013.

Sonwa DJ, Coulibaly O, Weise SF, Akinwumi Adesina A, Janssens MJJ (2008) Management of cocoa: Constraints during acquisition and application of pesticides in the humid forest zones of southern Cameroon. Crop Protection 27: 1159-1164.

Thresh JM, Owusu GK, Boamah A, Lockwood G (1988) Ghanaian cocoa varieties and swollen shoot virus. Crop Protection 7: 219 – 231.

Wheeler AG Jr (2000) Plant bugs (Miridae) as plant pests. In: Heteroptera of economic importance, De Carl W. Schaefer & António Ricardo Panizzi *Eds, CRC Press*, USA, Pp 37-83.