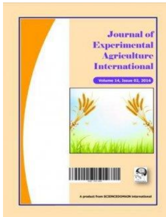


Journal of Experimental Agriculture International

19(3): 1-11, 2017; Article no.JEAI.36477
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Pesticide Usage and Implications of the Diurnal and Seasonal Dynamics of Cocoa Hemipteran Pests on their Management in South Western Cameroon

Henry Andukwa Andukwa[1,2*], Nelson N. Ntonifor[3] and Eric B. Fokam[1]

[1]Department of Zoology and Animal Physiology, Faculty of Science, University of Buea, P.O.Box 63, Buea, Cameroon.
[2]Institute of Agricultural Research for Development (IRAD) Ekona, Cameroon.
[3]Department of Agronomic and Applied Molecular Sciences, Faculty of Agriculture and Veterinary Medicine, University of Buea, P.O.Box 63, Buea, Cameroon.

Authors' contributions

This work was carried out in collaboration between all authors. Author NNN designed the study, wrote the experimental procedures and the first draft of the manuscript. Author HAA performed the studies supervised by authors NNN and EBF. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2017/36477
Editor(s):
(1) Edgar Omar Rueda Puente, Professor, Department of Agricultural , Livestock, The University of Sonora, Mexico.
(2) Marco Aurelio Cristancho, Professor, National Center for Coffee Research, CENICAFÉ, Colombia.
Reviewers:
(1) Godwin Michael Ubi, University of Calabar, Nigeria.
(2) Mariah Baggio-Deibler, USA.
(3) Julian Chen, Chinese Academy of Agricultural Sciences, China.
Complete Peer review History: http://www.sciencedomain.org/review-history/22479

Original Research Article

Received 29th August 2017
Accepted 12th December 2017
Published 27th December 2017

ABSTRACT

Aims: To investigate the various synthetic chemical formulations, equipment and methods that farmers use to control cocoa insect pests and also study the abundance, diurnal and seasonal population fluctuations of these pests in South Western Cameroon. This was in a bid to factor how such information can be exploited to improve on their current control methods.
Study Design: Random interview of cocoa farmers and testing of different pest management methods in a randomized block design.
Place and duration of Study: Interview of cocoa farmers in Fako. Field experiment at Research farms in Ekona and Muyuka, South Western Cameroon from November 2010 to October 2011.

**Corresponding author: E-mail: handukwa@yahoo.com;*

Methodology: Structured questionnaires administered to 200 farmers to document how they managed mirids (Capsids) on their cocoa. There was also random sampling of cocoa plants in order to study the diurnal, seasonal and population dynamics of these mirids (capsids).
Results: Most farmers, 120(60%) perceived capsids as the most important insect pest in cocoa farms. Among the insects caught, 420(84%) were *Bathycoelia thalassina,* 70(14%) *Sahlbergella singularis*, 10(2%) *Distantiella theobroma*. Higher densities of the insects were recorded during the dry season (November – March) compared to the rainy season. The diurnal population dynamics of the various insects showed that the highest numbers were observed early in the morning followed by the evening and least around noon. Most of the farmers used conventional synthetic pesticide to control the capsids and black pod diseases. Insecticides with a wide range of trade names were used against the pests which all contain synthetic pyrethroids, neonicotinoids and organophosphate as active ingredients. Cypermethrine (cypercal®) was the most frequently used while the neonicotinoid, imidaclopride were the least used. Most farmers 128(64%) used knapsacks, 20(13%) used other types of sprayers and 19(9.5%) used mist blowers.
Conclusion: Integrating the judicious use of appropriately formulated insecticides and farm sanitary practices, could be exploited in the proper temporal spatial timing of insecticide application as a component of the integrated management of insect pest on cocoa to minimise residues on cocoa beans and environmental pollution.

Keywords: Pests; Distantiella theobroma; cocoa mirids; population dynamics; insecticides.

1. INTRODUCTION

Cocoa, *Theobroma cacao* L. (Sterculiaceae) cultivated for its beans is an important export crop in Cameroon accounting for about 25-30% of non – petroleum exports [1]. Cocoa is also considered such a prestigious crop that it can be used to claim land ownership in some areas of Cameroon [2]. Despite the importance of cocoa, its increased sustainable production in Cameroon is hampered amongst others mainly by pests and diseases notably the black pod disease caused by various species of *Phytopthora.* Prominent among the pests are the brown cocoa mirid, *Sahlbergella singularis*Hagl, the black cocoa mirid, *Distantiella theobroma* Distant (Hemiptera: Miridae), and the cocoa shield bug, *Bathycoelia thalassina* (Hemiptera: Pentatomidae). The nymphs and adults of these pests feed on pods and shoots and cause the drying up of leaves and a quick destruction of the cocoa canopy. These major pests account for losses of up to 30% of the world's annual cocoa harvest [3].

The lesions produced by mirids on cocoa pods often develop into cankers which weaken the trees and also serve as avenues for infections by parasitic fungi such as *Calonectria rigidiuscula* [4]. The entry of the parasitic fungi, *C. rigidiuscula* and *Fusarium deomcellulae* spread through the plant tissue if not early detected and controlled can cause dieback and eventually death of the plant [5].

Similarly, if adequate control measures of the mirid and fungi damage are not implemented, their combined effects can lead to a rapid decline of the cocoa tree yield [6]. Currently in West and Central Africa, this mirid problem is controlled by a few farmers through shade management and through the use of insecticides by most cocoa farmers. Unfortunately, in view of the high cost of the most suitable insecticide application methods in cocoa farms coupled with the expensive nature and often unavailability of the more modern effective insecticides against these insects, it is usually difficult for many small-scale farmers to control these pests. The few farmers who can afford for the appropriate insecticides and application equipment often adopt a calendar for prophylactic treatment program in spite of the known negative effects of insecticides to non-target organisms as well as to human and environmental health in general. Consequently, in view of the current increase in the global environmental health awareness, it is imperative to resort to more judicious use of reduced-risk insecticides and/or to seek for alternatives or complements to these toxic insecticides. One logical and sensible ways of using these chemical insecticides judiciously is through the proper timing and/or targeting of their applications to attain the pests in questions with minimal environmental contamination. To do this requires a detail ecological study of the daily and seasonal abundance of the targeted pests on the various parts of the cocoa plant.

2. MATERIALS AND METHODS

2.1 Study Site

The study was carried out in six cocoa farms from four villages (Ekona, Mautu, Maumu and Muyuka) found in Buea and Muyuka sub divisions. (latitude4°150' 45''N, longitude9°28' 431''E, altitude 378 m,). Muyuka is located in the rainforest agro-ecological zone of Cameroon and has sandy soils and high temperature ranges from 20-28.1°C. The climate is equatorial and conducive for cocoa production with two seasons; the rainy season that runs from March to September with rainfall (>1200 mm) and the dry season from October to April. The villages are located in a predominantly agrarian area where most of the farmers practice small-scale (subsistence) farming as the primary economic activity.

2.2 Cocoa Pest/Disease Control Survey

A structured questionnaire was used in the survey. A total of 200 cocoa farmers spread over four areas; Muyuka (100), Ekona (50), Mautu (20) and Maumu (30) were interviewed within their farming areas. Farmers were selected on the basis that each had been producing cocoa for at least two years. The farmers were interviewed at home in broken English (pidgin) assisted by an agricultural extension worker of the area. Information was collected on (a) the kind of indigenous and/or modern methods used by farmers for cocoa pests and disease control and their constraints (b) the kind and names of chemical/synthetic pesticides used and their limitations and (c) the methods adopted in the applications of these synthetic pesticide.

2.3 Population Dynamic Studies

One cocoa farm was randomly selected each from Ekona and Muyuka for the study. Each selected farm was sampled once per week throughout the rainy and dry seasons. Sampling was done each day in each farm three times; morning from 7:00 – 8:00, afternoon 12:00 – 13:00 and in the evening 17:00 – 18:00 hrs. During each sampling, 20 cocoa plants from each selected farm were observed to count all the hemipteran insects on the leaves, branches and pods with the aid of a ladder on plants above 2 meters tall. The tree branches, flower buds, flower cushions, basal chupons, cherelles and pods, and axial leaf surfaces were closely observed by counting in situ all cocoa mirids and shield bugs on them. The insects were separated into species based on published pictorial guides [7].

2.4 Statistical Analysis

The frequencies of the respondents were analyzed with Chi square (x^2) tests and the data summarized in percentages and bar charts. For the population dynamics data differences between group mean and standard deviation (SD) were compared using analysis of variance (ANOVA).

3. RESULTS

3.1 Cocoa Production Survey

Respondents revealed that cocoa plantations covered over 60% of available agricultural land in the study area while 15% was occupied by Robusta coffee, oil palm plantation and other fruit trees, 15% by food crops and 10% by animal husbandry (Fig. 1). Capsids were perceived as the most important insect pests in cocoa farms as reported by 60% (120) of the participants.

Irrespective of the village, most of the farmers used conventional synthetic pesticides to control capsids and black pod disease on their cocoa (Table 1). There was very limited knowledge about the use of botanical and/or indigenous methods of pest and disease control in the study area.

The different conventional pesticides used to combat pest and disease problems in the study area varied with the cocoa production constraint (Table 2). All the farmers used different types of copper-based fungicides to combat the cocoa black pod disease in their farms. Nordox 50WP®, a contact fungicides was the most widely used fungicides (26%), followed by Kocide 101® (21.5%). The systemic fungicide, Callomill® and Ridomil® were only used by 7.5% and 5% of the respondents, respectively.

Insecticides with a wide range of trade names were used against the various insects damaging cocoa in the study area (Table 2). However, the active ingredients in all these insecticide were mostly in the synthetic pyrethroid, neonicotinoids and organophosphate groups. The pyrethroid cypermethrine (Cypercal®) was the most frequently used (6%) while the neonicotinoid, imadaclopride was the least widely used (1.5%). Some of the respondents actually mentioned the common names of some of the insects controlled by some to the insecticides.

Participants revealed that 64% (128) of the farmers used knapsacks, 13% (26) used other types of sprayers and 9.5% (19) used mist blower to spray their cocoa trees (Fig. 2). Other indigenous methods used to combat capsids and diseases included pruning, clearing, physical killing of capsids using a machete or application of wood ash, using fire, removing infected pods, shaking of the trees to dislodge the insects etc.

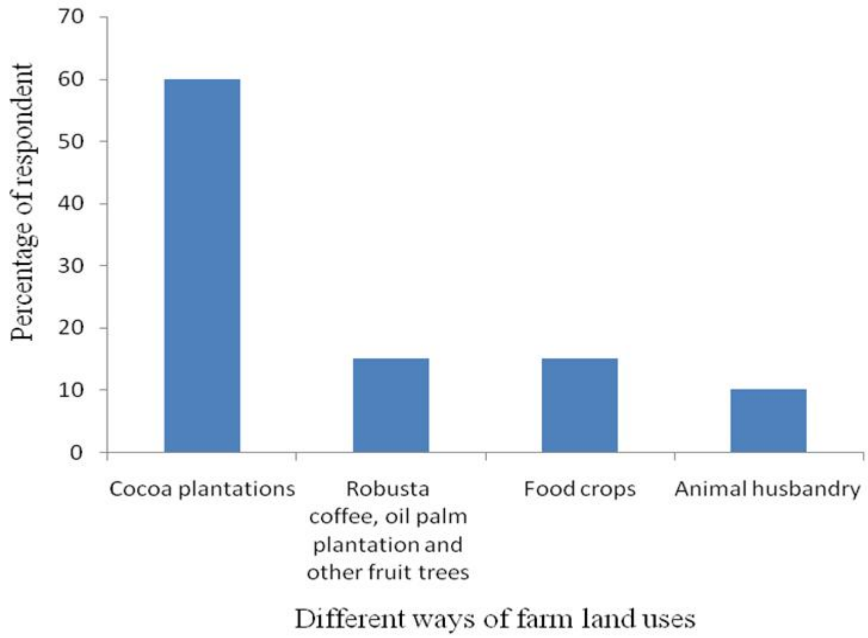


Fig. 1. Percentages of farmers growing different crops on their farm land

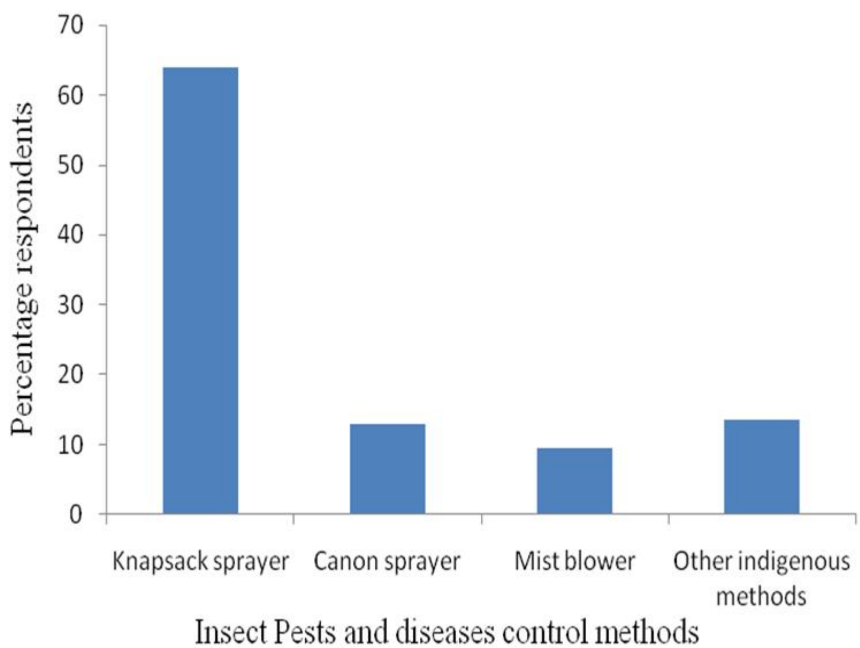


Fig. 2. Percentages of Farmers using different types of sprayers and methods of mirid control

Table 1. Number and percentage of respondents who used different pest control methods against capsids/black pod disease in four villages of the study area

Control methods	Town / Village			
	Muyuka 100%	**Ekona 50%**	**Mautu 20%**	**Muea 30%**
Conventional Insecticide	92 (90%)	45 (45%)	20 (100%)	30 (100%)
Botanical pesticide	4 (4%)	3 (6%)	0 (0%)	0 (0%)
Other indigenous methods	4 (4%)	2 (4%)	0 (0%)	0 (0%)

Table 2. Classification and frequency of most widely used fungicides and insecticides by cocoa farmers in Fako against cocoa black pod disease and capsids/mirids (n = 200)

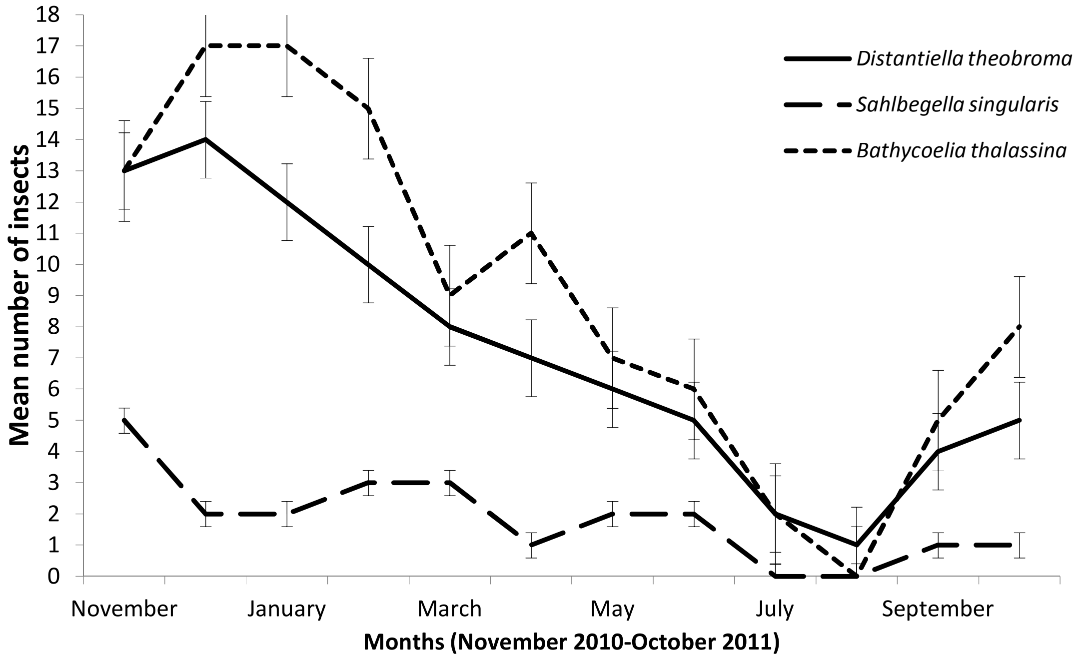
Name of Pesticide	Class	Frequency	Types
Fungicide			
Nordox 50 WP®	Cuprous oxide (75%)	52	Contact fungicide
Kocide 101®	Cuprous hydroxide (50%)	43	Contact fungicide
Coacobrasundoz®	Cuprous oxide (50%)	16	Contact fungicide
Callomill plus 72 WP®	12% metalaxyl + 60% Cuprous oxide	15	Wide spectrum Systemic fungicide
Ridomil plus 72 WP®	12% matelaxyl+ 60% Cuprous oxide	10	Wide spectrum Systemic fungicide
Insecticide			
Cypercal 50 and 12 EC®	Cypermethrine 50g/1 and 12 g/1	12	Contact insecticide for capsids control
Dursband 4 EC®	Ethylchloropyriphus	11	Insecticide for ant and Achae caterpillar control
Parastat 40 EC®	12 g/Imidaclopride + 20 g/1 lambdacyhalothrine	9	Powerful contact insecticide
Actara 25 WG®	Thiomethoxam 20 g/kg	9	Systemic insecticide
Callisufan 350 EC®	350 g/litre Endosulfan	8	Most preferred insecticide against capsids
Gawa®	Imidaclopride 30 g/1	7	Systemic insecticide
Thionex® 500-350 EC	Endosulfan 350 g/1	5	Insecticide against capsids/mirids
Iron 70 WG®	Imidaclopride 700 g/1	3	Systemic insecticides
Total		200	

Regarding constraints or limitations for using conventional pesticides, 48.5% (97) of respondents pointed out that high prices were the greatest constraints, 29.5% (59) mentioned the unavailability of the chemicals within their locality while 11% (22) indicated both high prices and unavailability of the pesticide, and 11% (22) had no respond.

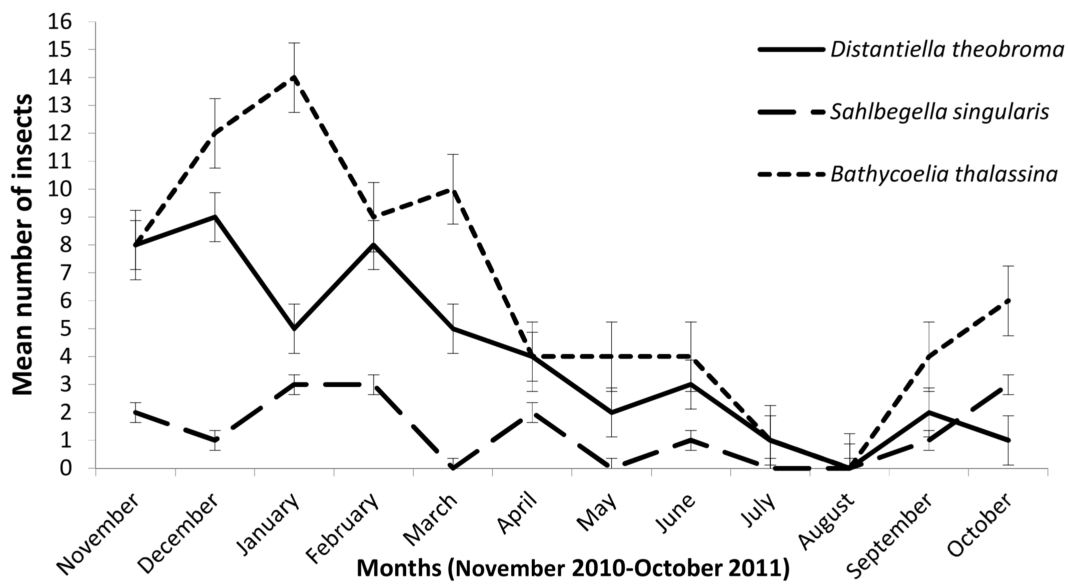
3.2 Pest Abundance and Dynamics on Cocoa Plants

Throughout the study periods, it was observed that the cocoa shield bug, *Bathyceolia thalassina* was the most prevalent and abundant hemipterous pest species on cocoa followed by the brown cocoa mirids, *Sahlbergella singularis* and then the black cocoa mirid *Distantiella theobroma* (Fig. 3). Among the 500 insects counted, 84% (420) were *B. thalassina*, 14% (70) were *S. singularis*, 2% were *D. theobroma*. Higher densities of the insect population on the cocoa plant were recorded during the dry season (November – March) compared to the rainy season. There was a significant different ($p<0.05$) in the population of capsids between the dry and rainy seasons of the year with the months of November, December, January, February having the highest number of capsids while the months of August and September had the lowest population densities of shield bugs and capsids.

The populations of all these bugs gradually increased from October (onset of the dry season) to a peak of about 17 bugs per 20 cocoa plants in December. These populations then gradually decreased to a trough of less than 2 bugs per 20 plants in August before starting to rise again from September. The trends of these insects were the same in the various study sites of Muyuka and Ekona.



A. Ekona

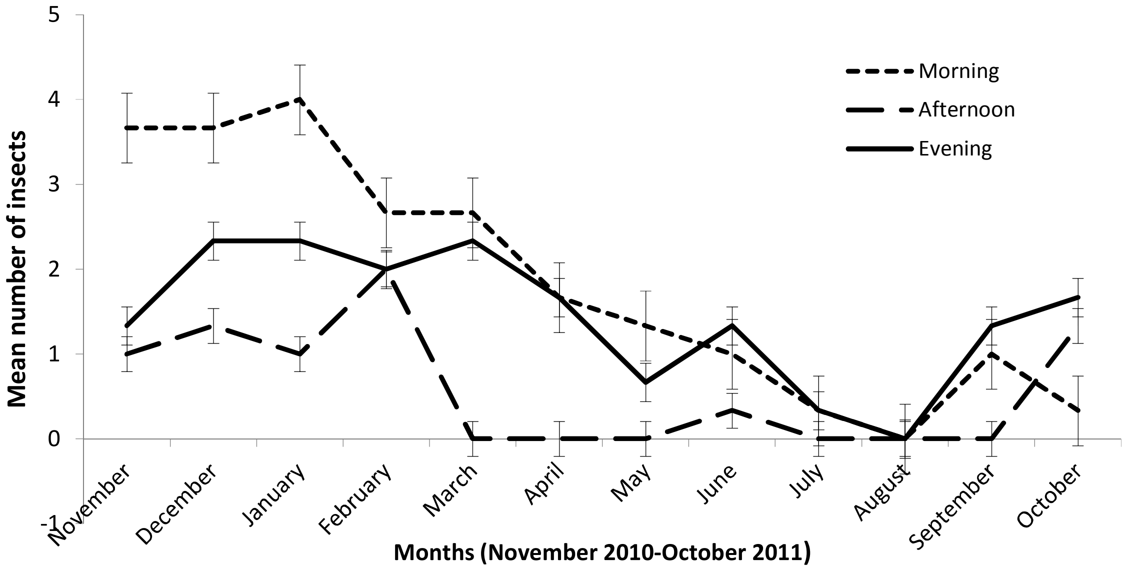


B. Muyuka

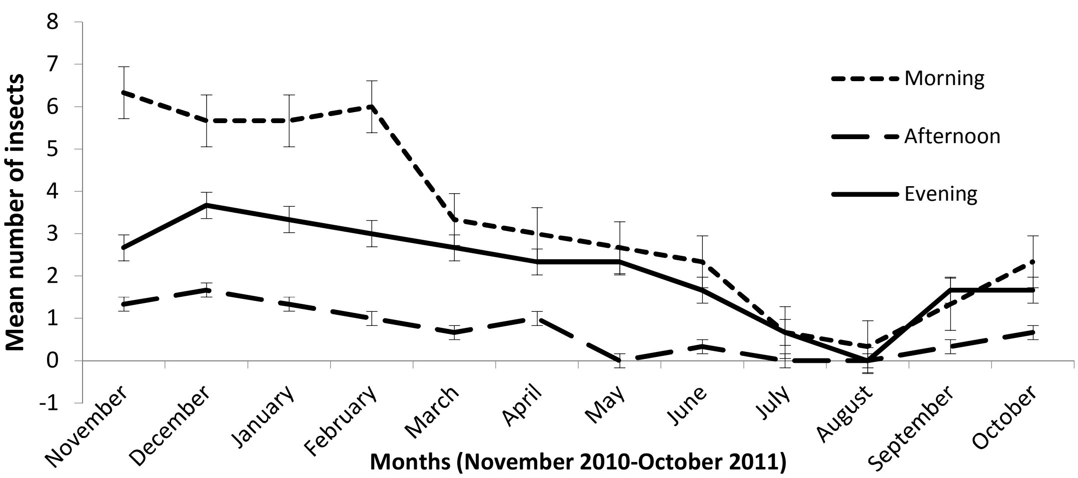
Fig. 3. Monthly mean numbers (±SEM) of major Hemiptera insect pests in cocoa farms at (A) Ekona and (B) Muyuka for November 2010-October 2011

The Ekona farm had the highest number of capsids and shield bugs than Muyuka throughout the study period.

Regarding the diurnal population dynamics of the various bug species, irrespective of the study site, the highest numbers of insects were observed early in the mornings (07:00-09:00 am) followed by the evenings (17:00-18:00 pm) and least around noon (12:00-13:00 pm) as shown in (Fig. 4).



A. Ekona

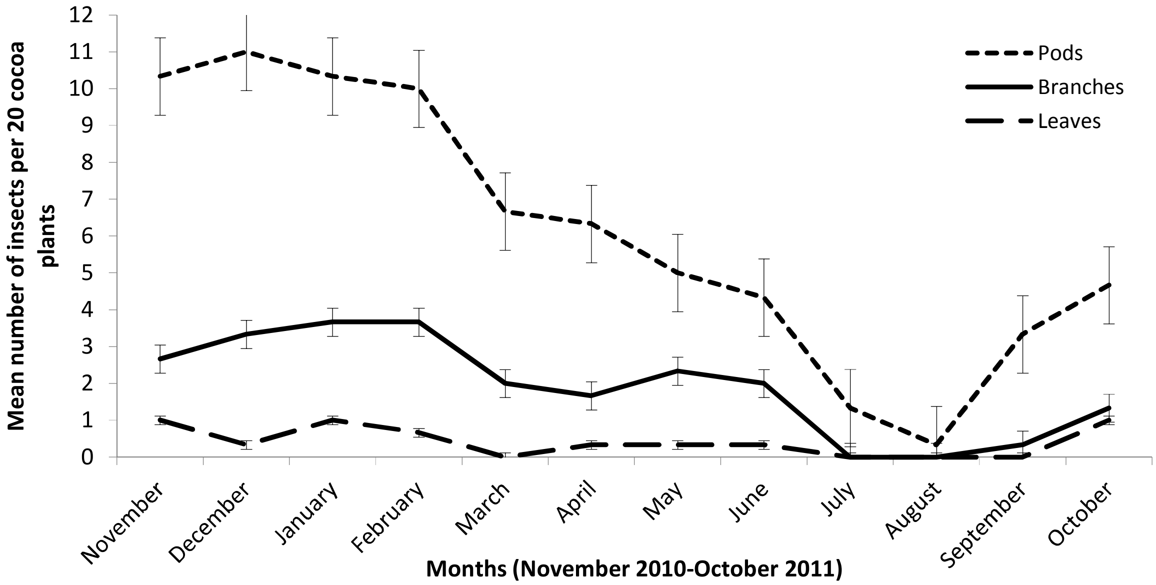


B. Muyuka

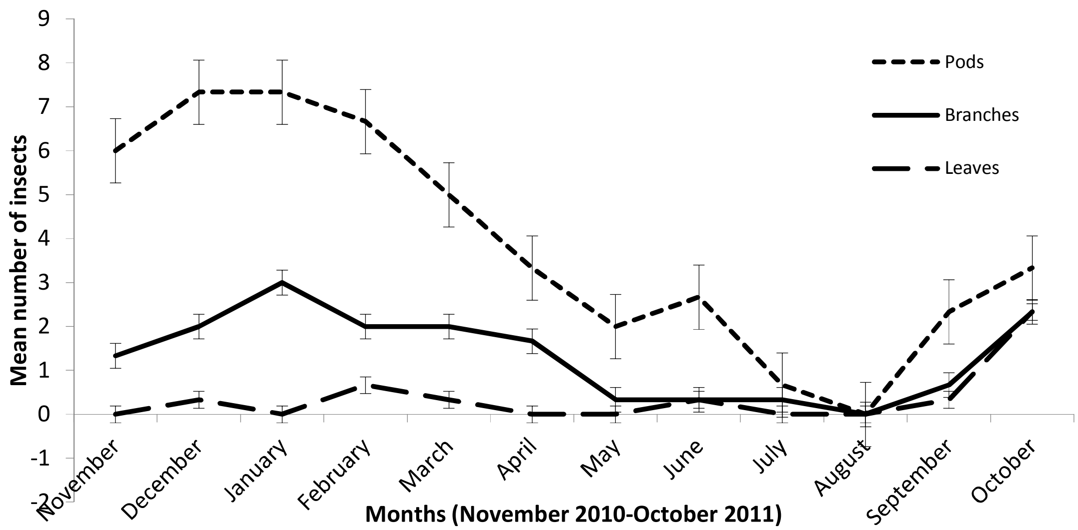
Fig. 4. Monthly mean numbers (±SEM) of major Hemiptera insect pests in cocoa farms at 07:00-09:00 (morning), 12:00-13:00 (afternoon) and 17:00-18:00 (evening) at (A) Ekona and (B) Muyuka for November 2010-October 2011

The numbers of insects observed in the morning were more than those counted in the evening. Also, early in the morning, it was easier to collect the bugs when theyare roosting on the various cocoa plant parts compared to the other periods of the day.

As it concerns the spatial distribution of the various bug species on the cocoa plants, irrespective of the study site, the highest densities were on pods, followed by the branches and least on the leaves (Fig. 5). The numbers of the various bug species on the cocoa pods each month were at least double those that were more than that on the branches while those on the leaves were relatively very low.



A. Ekona



B. Muyuka

Fig. 5. Mean total numbers (±SEM) of shield bugs and capsids on different parts of the cocoa plant at (A) Ekona and (B) Muyuka for November 2010 to October 2011

4. DISCUSSION

The cocoa farmers revealed that capsids and black pods were the most important pests and disease respectively in cocoa agro-ecosystems in the study area as in other West African countries and Ghana in particular [8,9]. Mirids have always been the main insect pest targeted by farmers for control. However, these insects are still very abundant in these cocoa farms probably due to poor insecticide coverage and/or timing, use of adulterated chemicals coupled with lack of other supplementary eco-friendly control measures such as good cocoa farm sanitation practices. Throughout the field visits and sampling of insects, the number of *Bathycoelia thalassina* greatly outnumbered that of *Sahlbergella singularis*. This may imply that *S. singularis* and *D. theobroma* are more susceptible to the insecticides in current use in the study area or *B. thalassina* has higher reproductive rates. It is also possible that as a result of repeated use of insecticides over several decades, *B. thalassina* and some of the mirids have become resistant to the frequently used chemicals. Insects are known to easily develop resistance to insecticides when exposed to a specific chemical for extended periods or if the pest can multiply quickly or if there is limited immigration of unexposed individuals [10]. Farmers need to be better trained on insecticide use and their unexpected consequences if not appropriately used. Also it is important for the farmers to alternate the classes of insecticide used over short periods of about two years in order to minimize the chances of the insects building resistance to the chemicals [11]. The study also revealed that farmers are interested in new approaches of protecting their cocoa from pests due to ineffectiveness of some of the insecticides used. This is encouraging for agricultural technology dissemination since these farmers are willing to try alternative pest management methods. Therefore it is important for agricultural researchers to seek for alternative and/or insecticide complementary methods of managing the insect pests of cocoa in this area for dissemination to the farmers. The farmers used a wide range of synthetic fungicides and insecticides on their cocoa probably because cocoa is considered a high value crop to the farmers in Cameroon [12] and hence they will strive to minimize any pest-inflicted losses of the crop by all possible means. Though insecticides with a wide range of trade names were used against the insect pests of cocoa, most of these insecticides contain the active ingredients like imidaclopride, thiomethoxam, cypermethrine, lambdacyhalothrine and ethyl-chloropyriphos which are all approved for use on cocoa with the exception of endosulfan which is banned for use on the crop [13,14]. This is evident that most of these farmers are aware of the insecticides recommended for use on cocoa in order to reduce environmental pollution and insecticide residue on the cocoa beans. At least 65% of the respondents use various types of knapsacks to apply the pesticide and only about 5% of them use motorized mist blowers. Though the pneumatic knapsack sprayers are relatively cheaper and easy to use, its main disadvantage is that it does not give adequate canopy cover in tree crops like cocoa [15]. This problem is even exacerbated in the study area in south western Cameroon where most of the cocoa trees are up to four meters tall or above thus rendering effective tree canopy coverage using knapsack sprayers difficult. The study also showed that the highest population densities of the pest were on the pods, followed by branches and lastly the leaves. This is understandable since most of the capsids feed on the fruits of the cocoa plants generally known as the cocoa pods and also on young shoots or chupons. This is partly in conformity with [16] who stated that pod losses due to capsids and disease alone ranges from 60 to 100%.

The availability and influence of pods on the annual population patterns of capsids was also evident in the result since the pest population started building-up from August till October which coincided with increases in the number of pods in the fields. This relationship corroborates the findings of [15] that mirid populations build up in August, September and October in Ghana.

The highest mirid and shield bug populations occurred from October to February representing the dry season when there are few or no fruits and less growths on other surrounding alternative food host plants of these insects. As such most of these mirids and shield bugs concentrated on the cocoa plant to feed on the chupons, pod leftovers after harvest and the mummified pods on the plants.

In contrast, the mirids number were very low on cocoa plants during the peak of the rainy season of June, July and August which experience high relative humidity as compared to the dry season. The high relative humidity levels may encourage the growth of entomopathogens of the pest leading to decrease in their populations. These results agree with earlier reports of Mariau [16].

The Ekona cocoa farms in the study show that it had higher numbers of shield bugs and mirids compared to the Muyuka farms. This is because the Ekona cocoa farms had many surrounding forest trees which might be serving as reservoir and or alternative host plants of these pests which may use these trees as refugees during and after insecticide applications on the farms. In addition, the Ekona cocoa farms also had very tall cocoa trees which rendered effective insecticide applications difficult since knapsack – sprayed chemicals could not attain the topmost portions of these tall trees. This is also confirmed by [17] who suggested that cutting down unwanted alternative host trees and also eliminating mummified husks at the beginning of the season followed by weekly sanitation harvesting, would reduce the level of capsids infestation and subsequently black pod related diseases.

5. CONCLUSION

Most farmers in South Western Cameroon relied on synthetic chemicals to control hemipteran insect pests of cocoa compared to the use of botanicals and indigenous methods. The different hemipteran pests of cocoa were more frequent during dry than rainy season months. Knowledge of these insect pest population dynamics provides a good basis for the development of an ecologically-based method of pest management like inclusion into integrated pest management programmes in Sub-Saharan Africa as it is based on local materials.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committees and have therefore been performed in accordance with the ethical standards laid down in the 1964 declaration of Helsinki.

ACKNOWLEDGEMENTS

The authors thank the cocoa farmers of Muyuka, Ekona, Mautu, Muea and Maumu villages for providing necessary information on the questionnaire and also providing some cocoa farms for some of the experiments. Authors are also grateful to Dr. Justin N. Okolle and Mr Simon Andukwa Ebunji for their financial and moral assistance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. AGRI-START, Annuaire des startistiques agricole 1999/2000, MINADER, YAOUNDE, 114.
2. Coulibaly O, Mbila D, Sonwa DJ, Adesina A, Bakala J. Responding to economic crisis in Sub-Saharan Africa: New farmer-developed pest management strategies in cocoa-based plantations in Southern Cameroon. IPM Reviews. 2002;7:165-172.
3. Cilas C, Despreaux D. (eds). Improvement of cocoa tree resistance to phytophthora disease. CIRAD. In: Coping with Cocoa Disease Spore. 2004;112(11):176.
4. Crowdy SH. Observation on the pathenogenicity of *Calonectria rigidiuscula* (Berk. And Br.) Sacc. On *Theobroma cacao* L. Ann. Appl. Biol. 1947;34:45-59.
5. Mohali S, Burgress TI, Wingfield MJ. Diversity and host association of the tropical tree endophyte *Lesiodiplodia theobromae* revealed using simple sequence repeat markers. Forest Pathology. 2005;35:385–396.
6. Williams G. Field observation on the cocoa mirids (*Sahlbergella singularis* Hagl. and *Distantiella theobroma* (Dist) in the Gold Coast PART II. Geographical and Habitat distribution. Bull. Entomol. Res. 2009; 44:27.
7. Mathews GA. Pesticides: Health, safety and the environment. Blackwell Publishing Ltd, Oxford. 2006;235.
8. Lavabre EM. Les mirides du cacaoyer. Ed. by Lavabre EM, G-P maisonneuve et Larose, Paris. 1977;366.
9. Kim S, Roh J, Kim D, Lee H, Ahn Y. Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis.* J. Stored. Prod. Res. 2003;39: 293-303.
10. Antwi-Agyakwa AK, Osekre EA, Adu-Achampong R, Ninsin KD. Insecticide use practices in cocoa production in four regions of Ghana. WAJAE. 2015;23(1):39-48.
11. Sonwa DJ, Coulibaly O, Adessina AA, Weise SF, Tchatat M. Integrated pest management in cocoa agroforests in Southern Cameroon: Constraints and overview. IPM Review. 2002;17:191-199.
12. Mahob RJ, Ndoumbe-Nkeng M, Ten Hoopen GM, Dibog L, Nyasse S, Rutherford M, Mbenoun M, Babib R, Amang A. Mbang J, Yede Y, Bilong Bilong CF. Pesticide use in cocoa sector in Cameroon: Characterization of supply source, nature of active ingredients, fashion and reasons for their utilization. IJBCS. 2014;8(5):1976-1989.
13. Asogwa EU, Dongo LN. Problems associated with pesticide usage and application in Nigeria cocoa production: A review. Afri. J .Agric. Res. 2009;4(8):675-683.
14. Opoku, IY, Appiah AA, Akrofi AY, Owusu GK. *Phytophthora megakarya*: A potential threat to the cocoa industry in Ghana? Ghana J. Agri. Sci. 2002;33:237–248.

15. Afreh-Nuamah K. Insect pest of free crops in Ghana: Identification, damage and control measures. Burck Press Inc. 1999;65.
16. Mariau D. (Ed). Integrated pest management of tropical perennial crops. Science Publishers, Inc., USA. 1999;167.
17. Tondje PR, Berry D, Bakala J, Ebandan S. Intérêt de diverses pratique culturales dans la lute contre la pourriture brune des cabosses du cacaoyer due a phytophtora tome: Principes et application de la lute biologique. Marjham. 1993;5-15.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/22479