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Environmental Effects and Damage Pattern of Insect Pests on Cocoa Production in Ibadan, Oyo State

O.M. Azeez

Department of Crop and Soil Science, University of Port Harcourt, Choba, Nigeria

Abstract: Paucity of information in recent times on major and minor insect pest status of cacao plantations in Nigeria necessitated this survey. Knowledge of the insect pest complex associated with any crop is essential for developing effective control strategies for such pests. A survey was conducted on the insect fauna associated with *Theobroma cacao* on a 10-ha cacao plantation in Ibadan from 2005 to 2014. Insect abundance and the damages caused by each identified insect pest type were noted and described. The insects were monitored and assessed annually over the span of 10 years (2005-2014). Weather parameters such as rainfall, temperature and relative humidity were collected from CRIN meteorological station. Data were analyzed through Excell and SPSS packages using descriptive statistics. There were myriads of insect pests identified with variations in percent damage by the observed insect pests, *P. Njalensis* (15%), *Z. variegatus* (15%), *M. bellicocus* (5%) and *S. derogata* (10%) are abundant during the dry spell, whereas *Carlibatus* spp (10%), *B. thalassina* (15%), *E. Biplaga* (10%), *S. sjostedti* (10%), *S. singularis* (25%) caused a lot of cacao damage during the raining season. The incidence of *Sahlbergella singularis* was observed throughout the period of investigation but most abundant/prevalent in the months of August to December. The physical environmental factors that recorded greater influence on the abundance of field insect pests of cacao, was rainfall. This study has provided information on relative importance of the environmental factors on activities of cacao insect pests which is vital for the development of sound and effective control measures.

Key words: Environmental factor · Major · Minor · *Sahlbergella singularis* · Cacao yield · Abundance

INTRODUCTION

Plant phenology describes changes in plant's behavioural characteristics in relation to the environment. Moisture, temperature and rain distribution are considered to be important factors in field crop production. Thus, a tree species which grows well in one location is a function of annual rainfall, seasonality of rains, length of dry period and mean annual temperature. Cocoa is widely cultivated in the tropical rain forest and the adjoining rain-fed ecologies in Nigeria, especially cocoa is grown in most parts of Southern Nigeria extending from the Northern parts having 1, 100 mm annual rainfall to the Southern areas with 2500 mm annual rainfall. Fourteen states of the country namely: Ondo, Osun, Ogun, Cross Rivers, Oyo, Ekiti, Kwara, Kogi, Edo, Delta, Abia, Taraba, Adamawa and Akwa-Ibom produces cocoa in varying quantities. The Southwest Nigeria produces more than 60% of the annual national cocoa output [1]. Cocoa beans is the major raw material for the production of chocolate, cocoa butter and mucilage, cocoa wine, beverages, cosmetics and many other products [2]. The beans of cocoa is also used for production of semi-finished products such as cocoa mass used in making chocolate, biscuits and confectioneries [3]. It is also used in making sweets and sweetening products, while the cocoa butter is used in making chocolate, perfume, body and hair creams, pharmaceuticals, chocolate powder, chocolate bars, cocoa cake and various chocolate-based products [3]. Locally, cocoa leaves are used in cooking soup that has semblance to okra and in treating various abdominal problems [2].

Pests and diseases constitutes very important matter of study to derive the limitations and potentials of agroforestry systems in tropical environments. It is well known that the more diversified an ecosystem is, the more resistant it will be to pests and diseases. The incidence of diseases and pests is of utmost importance in the humid

Corresponding Auhtor: O.M. Azeez, Department of Crop and Soil Science, University of Port Harcourt, Choba, Nigeria.

tropics. The cacao agro-ecosystem is inhabited by myriad of insect species, a few of which are of economic importance. The most economically important species in Nigeria are the brown cacao mirid, *Sahlbergella singularis*, Hagl. (Hemiptera: Miridae), cacao pod borer, *Characoma stictigrapta* Hmps (Lepidoptera: Noctuidae), shoot feeders, *Anomis leona* Schaus, *Earias biplaga* WIK. (Lepidoptera: Noctuidae) and *Sylepta retractalis* Hmps (Lepidoptera: Pyralidae).

In areas where the cacao swollen shoot virus disease is prevalent, the mealybug vectors of the disease, *Planococcoides njalensis* Laing, *Planococcus citri* Risso and *Ferrisiana virgata* CkII. (Homoptera: Pseudococcidae) could also be important [1, 4, 5, 6, 7, 8]. Among the minor pests of cacao, the shield bug, *Bathycoelia thalasina* (H & S) (Heteroptera: Pentatomidae), the pod miner, *Mamara* species (Lepidoptera: Lithocoletidae), the root feeding termites, *Macrotermes bellicosus* (Smeath) and (*M. nigeriensis*) (Sjost) are significant. These and others minor pests such as the sap-sucking psyllid, *Mesohomotoma* (*Tyora*), *tessmanni* Aulman (Homoptera: Psyllidae) and the cacao thrips, *Selenothrips rubrocinctus* Giard (Thysanoptera: Thripidae), are occasionally very important. These pests have tendency of attaining major pest status if there is change in the ecological factor of the environment, especially when agro-ecological conditions in young cacao or ageing cacao plantations, which are undergoing rehabilitation, become more favourable to them [9] and [10]. The direct effects of some major environmental factors such as temperature, rainfall, relative humidity and illumination on the activities and abundance of some major and minor pests of cacao have not been clearly defined. This difficulty arose out of the high interaction which often exists between environmental factors and host plant factors, such as the production and availability of suitable pods for feeding and breeding as well as favourable temperature and relative humidity which are required for the survival of the insect pests.

This study determines the relationship between the cacao insect pest dynamics and the general weather conditions from 2005-2014 on a cacao plantation in Ibadan. Also to determine the relationship between the general distribution of the insect within trees and micro-climatic factors such as temperature and relative humidity.

MATERIALS AND METHODS

The cacao plantation of F3 Amazon established over the years and planted at 6m by 6m spacing with a total of 278 stands per hectare. The study area was confined to zones 1 and 2 at the Cocoa Research Institute of Nigeria (CRIN), Ibadan which contained Amazon cocoa selections. Monthly record of yields was monitored and recorded with weight balance which cummulated into annual yields of cocoa production. Ibadan has an annual rainfall average of 2000 mm with a bimodal pattern. CRIN is located in the humid rainforest ecosystem with mean solar radiation of 18mj/m2/day. It lies between the latitude 7°30'N and longitude 3054'E at an altitude of 200 m above sea level [11]. Weather from this zones were monitored over the years on rainfall, temperatures, sunshine hours and relative humidity. The daily meteorological data were collected from the automated meteorological station of CRIN located within the estate of the experimental site. The meteorological station has internal server through which data were downloaded with the aid of computer. Insects were monitored and assessed over the span of 10 years, 2005-2014 and data were analyzed through Excell and SPSS packages as reputed using descriptive statistics.

RESULTS

Table 1 shows the period of abundance, spatial and temporal distribution and damage characteristics of insect pest found within the cacao growing seasons under study. Several species of insect pests were identified on cacao. Some major insect pests were evenly distributed all seasons while others were found occasionally. The most economically predominant species (major) were *Sahlbergella singularis*, the *Characoma stictigrapta, Earias biplaga* and *Planococcoides njalensis* in areas where the Cacao Swollen Shoot Virus diseases were prevalent. Among the minor pests of cacao observed during the period of study were the *Bathycoelia thalassina, Carlibatus* spp, *Stictoccocus sjostedti, Toxoptera aurantii, Macrotermes bellicosus*, *Mesohomotoma* (*Tyora*) *tessmanni*. Estimated percent damage were allocated to the insect pests and the periods of occurence in cacao plot. It was not uncommon to encounter fresh temite infestation and grasshoppers especially during the dry season. Fig. 2 showed the influence of biotic factor and abiotic factors as it affects annual production of cacao. The highest cacao production (448, 739 kg) was recorded in the year 2012 whereas the least was 195, 316 in 2013, this might due to unevenly distribution of environmental factor e.g. Rainfall.

Estimate percent damages were recorded over the years as shown in Fig. 3. There were variations in the percent damages implicated by the specific months of the year of their abundance and prevailing weather condition

Table 1: Insect species associated with cacao, their period of abundance and damage characteristics

Insects	Period of abundance	Percent damage	Damage characteristics
Carlibatus spp	Mar - May	10%	Shoot feeder
Bathcoelia thalassina (H &S)	May - October	15%	Pod miner
Earias biplaga WIK	Mar - June	10%	It eats up the apical buds & flush leaves
*Characoma stictigrapta*Hmps	Jan - Dec	15%	Larvae bore and bind leaves together
Stictoccocus sjostedti CIK	Feb - Nov	10%	Shoot feeder
Toxoptera aurantii Fan	Jan - Nov	5%	Feeding wrinkles the flush leaves
Planococcoides njalensis	Jan - Nov	15%	Vector; feed in clusters onstems/leaves
Mesohomotoma tessmanni	Mar - Dec	10%	Nymphs caused damage to flush leaves
Sahlbergella singularis Hagl	Aug - Dec	25%	Feeding causes lesions, canker & dieback
Sylepta derogata F.	Jan - May	10%	Shoot feeders; lay eggs in rolled leaves
Macrotermes bellicosus S.	Sept. - April	5%	Tunnelled roots; distort conducting tissues
Zonocerus variegatus L.	Oct. - Mar	15%	Shoot feeder

Adapted from Pest Management in Mature Plantations of Cacao, Cola, Cashew, Coffea & Tea in Nigeria [Unpublished]

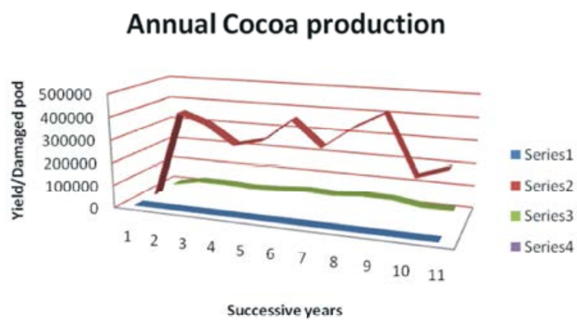

Fig. 2: Annual cacao production determined by biotic and abiotic factors from 2005 - 2014

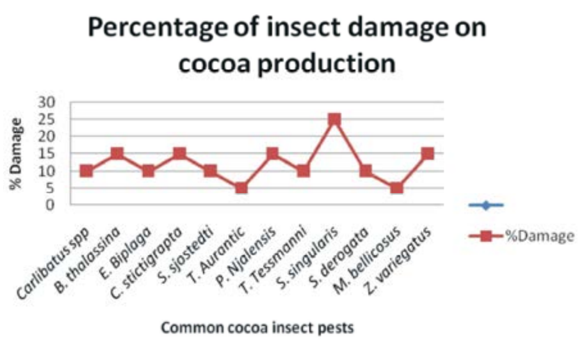

Fig. 3: Percent damage pattern of insect pests of cacao

recorded for each year. Insects such as *P. Njalensis* (15%), *Z. variegatus* (15%), *M. bellicocus* (5%) and *S. derogata* (10%) were abundant during the dry spell (October, November, December, January, February and March). However, it could be deducted that moderate temperatures (25-30°C coupled with a mean monthly rainfall of less than 130 mm causes an increase in the population of *B. thalassina* in the field. Insects like *Carlibatus* spp (10%), *B. thalassina* (15%), *E. Biplaga* (10%), *S. sjostedti* (10%), *S. singularis* (25%) caused a lot of cacao damage during the raining season (April, May, June, July, August and September), while *C. stictigrapta* (15%), *T. Aurantii* (5%) and *T. Tessmanni* (10%) were regularly present through out the year.

Maximum Rainfall and corresponding high relative humidities were recorded for the ten years duration of study (2005 to 2014). The peak of the rainfall and relative humidity coincided with the second and third quarters of the year (May, June, July, August, September and October). However, the dry spell was recorded on the first and fourth quarters of the year (October, November, December, January, February and March). The temperature were relatively stable over the years, however the maximum temperature was recorded generally in the months of March and April, while the lowest value was recorded in the months of November, December and January of each year (Fig. 1a-j).

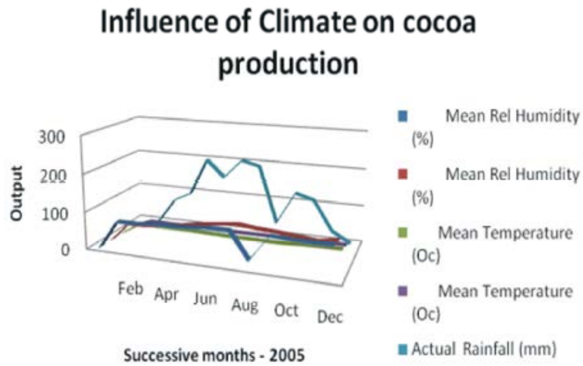

Fig. 1a: Yearly distribution of climatic factor, 2005

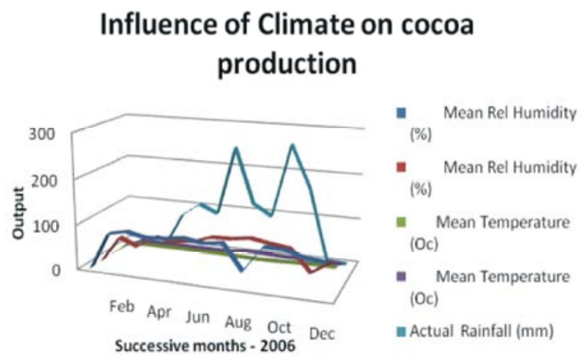

Fig. 1b: Yearly distribution of climatic factor, 2006

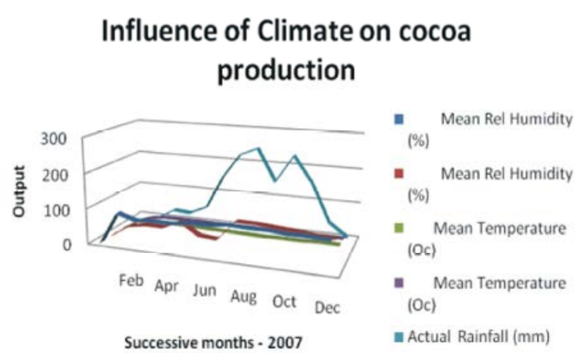

Fig. 1c: Yearly distribution of climatic factor, 2007

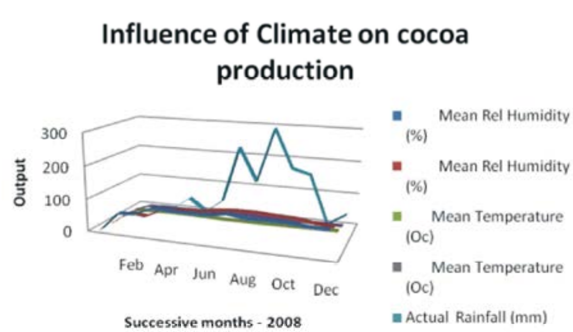

Fig. 1d: Yearly distribution of climatic factor, 2008

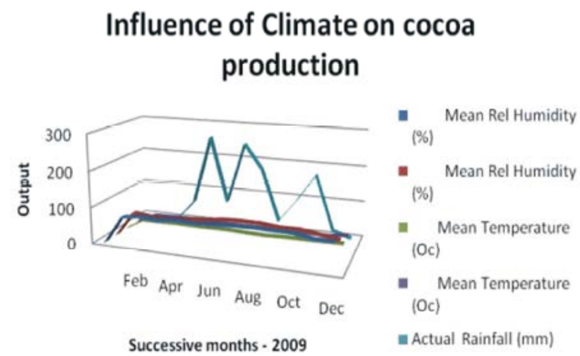

Fig. 1e: Yearly distribution of climatic factor, 2009

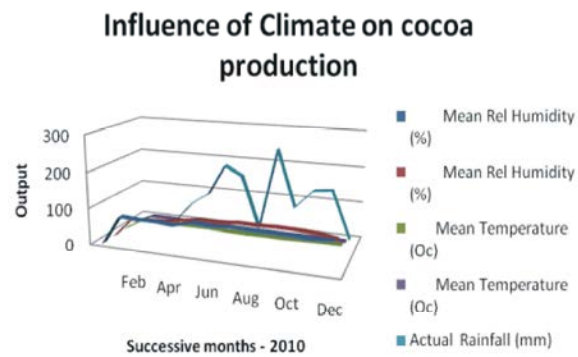

Fig. 1f: Yearly distribution of climatic factor, 2010

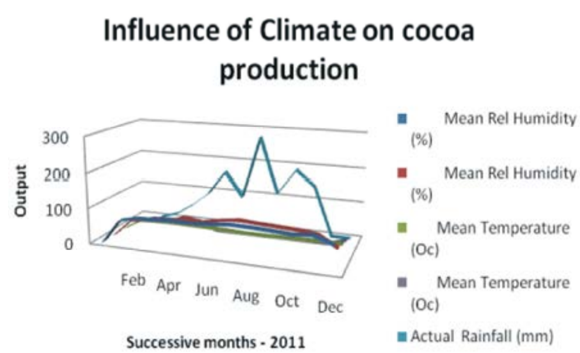

Fig. 1g: Yearly distribution of climatic factor, 2011

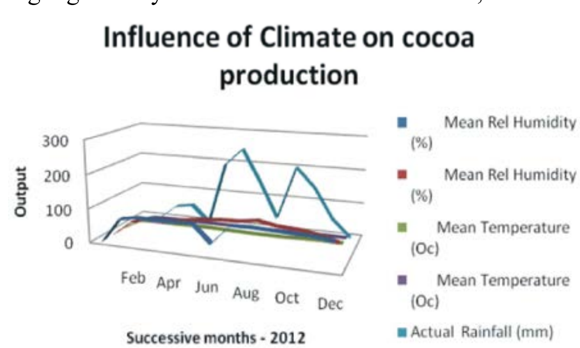

Fig. 1h: Yearly distribution of climatic factor, 2012

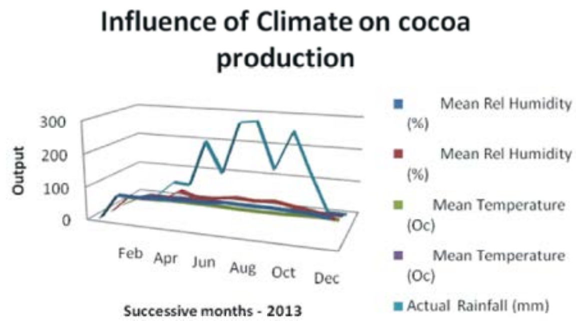

Fig. 1i: Yearly distribution of climatic factor, 2013

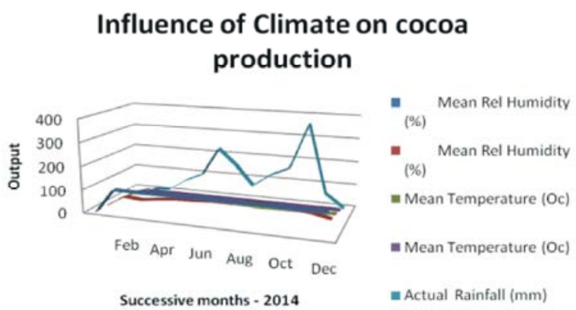

Fig. 1j: Yearly distribution of climatic factor, 2014

DISCUSSION

The incidence of most insect pests recorded during the period of study were higher at the onset and during the rainy season, this can be attributed to the abundance of food sources and breeding sites due to the prevailing favourable climatic conditions. Some species of insect pests were widely distributed and identified on cacao. The most economically predominant species (major) were *Sahlbergella singularis*, *Characoma stictigrapta, Earias biplaga* and *Planococcoides njalensis* in areas where the Cacao Swollen Shoot Virus disease were prevalent. It is pertinent to know that, however low the population of the major insect pests may be, they can still cause devastating and severe damages on cacao. The incidence of this low density pest did not take a particular pattern of distribution as its occurence was isolated and uncommon. They appear to undergo several generations per year and are thus present in cacao plantation through out the year under favourable conditions. The insect pests were present throughout the period of survey with severe infestation levels. This corresponded to the period of high rainfall distribution pattern and high relative humidity. Ojo, [1] assessed damage caused by various pests, *S. singularis, C. stictigrapta, Mamara* spp and *Characoma* spp in cacao producing areas of Nigeria by determining the percentage of trees or pods which had damage symptoms.

The preceding dry season and the cessation of the early rains determine the occurence and distribution pattern of insect and for example the mirid, *S. singularis* population was lowest between February and July but attaining a mean peak population in the months of August, September, October, November and December. Also, the population of the cacao mirid, *S. singularis* in mature fruiting farms is usually low with the abatement of rains when the atmospheric relative humidity is also usually low [12]. Thus, in Nigeria mirid infestation is usually lowest between February and July and highest between August and November/December depending on the severity of the preceding dry season or the onset of the "August break" and the cessation of the early rains, respectively. In rehabilitated farms, the trend had been observed to be similar to that which is obtained in mature plantations. However, this depends on the availabilty of adequate number of suitable pods and young tissues as well as suitable canopy or shade required for resting, feeding and reproduction of cacao mirids in such farms [13]. Field observation confirmed that fresh damage symptoms mostly occured on young leaves, tender stems and tender flower stems. Feeding sites were marked by black lesions and in some cases, exuded gum. Severe attack of shoot may cause dieback due to bug saliva in combination with fungi infection [14, 15, 16]. It is known that disease infections can reduce the vigour of plants and enhance their susceptibility to termite attack.

Minor pests occassionally attain the status of major pests when agro-ecological conditions in young cacao or ageing cacao plantations, which are undergoing rehabilitation, become more favourable to them [17] and [10]. Some insect pests were found occasionally such as *Bathycoelia thalassina, Carlibatus* spp, *Stictoccocus sjostedti, Toxoptera aurantii, Macrotermes bellicosus*, *Mesohomotoma* (*Tyora*) *tessmanni* on cacao plantation. However, studies on the seasonal distribution of the shield bug, *B. thalassina* in Amelonado and Amazon cacao [18] and the effect of environmental factors on the populations of this bug [19] showed that the pest occurred on cacao trees throughout the year, with marked seasonal and yearly variation and two populations peaks per year.

Maximum Rainfall and corresponding high relative humidities were recorded over the studied period of 2005 to 2014. Rainfall seems to be the most important single physical factor that regulates the abundance of *B. thalassina*, Rainfall was observed to wash away the first three larval instars in the field and this would have resulted to the loss of larvae due to rainfall. The eggs tend to get soaked in rain and if the eggs are soaked for more than 48 hours, they fail to hatch [20]. It has been reported that relative humidities of 30% or below are lethal to both eggs and the first instar larvae [20]. Temperature has been shown to have effect on the rate of development and flight activity of *B. thalassina* [21]. Temperature, therefore, tends to influence the distribution and abundance of the pest indirectly. Owusu-Manu, [22] reported that *B. thalassina* were found inside the canopy and on the trunk where the daily temperature is lower than that above the canopy. He also observed the insect pests were found more in the morning than any other time of the day. *Bathycoelia thalassina* has been found to hide under cocoa leaves during the sunny hours of the day, probably to avoid the heat of the day and the direct sunlight [22]. Therefore, there is possibility of cacao intercrops to serve as host for the insect pests under cacao intercropping system.

CONCLUSION

This study has shown the relative importance of observed insect pests and also provided a baseline information on the ecology of insect pests attacking cacao in Nigeria, which is critical to the development of sound and sustainable control options. The economic relevance of the cacao mirids has almost completely diverted attention from intensive studies on most of the minor insect pests of cacao. Some of these minor pests have been found to attain major pest status in some years of sporadic outbreaks. In most of tropical regions, rainfall and relative humidity are the major factors influencing the development of insect population, far exceeding the influence of temperature.Therefore, rainfall and humidity strongly interacted with other parameters to determine the population of these observed insect pests. Information on relative importance of the observed pests on tree crops especially cacao, is vital for the development of sound and effective control measures. Future research efforts should therefore be concentrated on the identification of biological and environmental factors which currently keep insect pest population below economic injury levels. It is only through this direction that the natural balance existing between the minor pests and the host plant (cacao) would not be upset. Also, the phenologies and effects of local parasites, predators and diseases of cacao mirids should be monitored and evaluated regularly.

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