International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 26-11-2021, Accepted: 13-12-2021, Published: 28-12-2021
Volume 3, Issue 2, 2021, Page No. 54-57

Resistance of three genotypes of cashew trees (*Anacardium occidentalis*) to *Helopeltis anacardii* miller (Hemiptera: Miridea) attacks in the region of Korhogo (Northern Ivory Coast)

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Abstract
Cashew is a new source of income for many small-scale farmers in northern Côte d'Ivoire. Despite the excitement and hope generated, cashew orchards in northern Côte d'Ivoire are severely attacked by *Helopeltis anacardii*. At the CNRA (National agricultural research center) station in Lataha, located 22 km from Korhogo, three genotypes (LA X3264, LA X4297 and LA Z330) were being tested. This study aimed to evaluate the susceptibility of these three cashew genotypes to attacks by this mirid with a view to proposing control methods. The insects were captured on cashew trees of these three genotypes using a mowing net. The number of attacked leaves on each tree was recorded and the attack rates were calculated. The results showed that the population of *H. anacardii* increased during the rainy season to reach a peak in November. Then in the dry season the population of the insect decreased until it reached zero in the very hot season from March to June. *H. anacardii* was particularly fond of young leaves. The genotypes LA X4297 and LA Z330 with respectively 49.83 ± 18.07% and 45.90 ± 20.81% of attack rate were the most sensitive to the insect attacks. The genotype LA X3264 with 21.76 ± 11.71 % of attacked leaves had the lowest attack rate. It would be interesting to study the results obtained in the coming years, by identifying refuge areas and setting up an effective and sustainable control method against this pest.

Keywords: cashew tree, *Helopeltis anacardii*, attacks, genotypes, Côte d'Ivoire

Introduction

Since the late 1990s, cashew has become one of the most important export products in West Africa and the main cash crop along with cotton in a broad Sahelo-Sudanese climatic band stretching from Senegal to Nigeria [1]. The crop is a new source of income for many small farmers and also offers the opportunity for significant development of labour-intensive agribusinesses [1]. The cashew tree is used for both fruits, namely the cashew apple and the cashew nut. The cashew nut contains the kernel and the cashew balsam [2]. The gross domestic product (GDP) of cashew has increased slightly to 6% of national production [3]. This steady increase has encouraged a 'natural' planting movement throughout northern and central Côte d'Ivoire [4]. This has made Côte d'Ivoire the world's leading cashew producer, with an estimated production of 673,238 tonnes in 2017, an increase of 3.6% compared to 2016. It has to produce nuts not only in quantity but in quality [5]. Despite the enthusiasm and hope generated by this crop in the production regions, producers are confronted with numerous phytosanitary problems, linked to the attacks of numerous insect pests. At all stages of development, cashew trees are subject to numerous insect pests [6,7] . In the north of Côte d'Ivoire, cashew orchards are subject to severe attacks by a mirid, *Helopeltis anacardii* (Hemiptera: Miridae). This mirid attacks the leaves of cashew plants, causing severe damage and considerably reducing the farmer's yield and income [8]. Indeed, losses due to this pest are estimated at 60-80% of production. According to Djaha et al. [9], *H. anacardii* attacks hinder the flowering and fruiting process. Of all the insects infesting cashew, Analeptes trifasciata is the one that causes serious branch and/or stem losses to the crop [10]. Thus, it appears necessary to develop an effective control strategy against this species. Among the means of control is the development of genotypes resistant to the insect pests. It is within this framework that the National Agricultural Research Centre (CNRA), at the Lataha station, is working to propose new varieties to producers. The aim of this study is therefore to evaluate the sensitivity of three cashew genotypes to attacks by *Helopeltis anacardii*, a real pest in this area, which is one of the major cashew production zones in Côte d'Ivoire.

Methodology

Study area

The study was conducted in 2015 and 2016 at the CNRA research station of Lataha. The study was conducted in 2015 and 2016 at the CNRA research station of Lataha located in the department of Korhogo in the north of Côte d'Ivoire (9°34' N and 5°34' W). The climate in these two areas is Sudanese with two seasons: a dry season from November to April and a rainy season from May to October. Annual rainfall varies between 800 and 1500 mm with an average temperature varying between 22°C and 28°C. The vegetation is mainly made up of wooded and grassy savannahs.

Experimental design

The experimental design is a one hectare (1 ha) woodlot subdivided into 12 blocks with five (5) year old cashew seedlings. Each block consists of three (3) lines of cashew plants. In each line, cashew plants of the three tested genotypes (LA X3264, LA X4297 and LA Z330) were planted randomly. The spacing between cashew plants was 5 m and 5 m between rows. These plants were pruned to keep their size constant, in order to facilitate the experimental studies.

Capture of *H. anacardii*

H. anacardii were caught three (3) times a week (Monday, Wednesday, Friday), very early in the morning (from 6am to 9am). In each block, sampling consisted of observing one (1) cashew plant per type of genotype tested (i.e. three plants per line and 9 plants in total per block. Each cashew plant observed was virtually split into four (4) parts. For each given part, the branches were carefully inserted into the swath net and then lightly tapped for a few seconds to avoid damaging the leaves. The captured insects are kept in labelled pillboxes. This action was repeated for all branches of the tree. A total of 108 plants were observed during the study. Rainfall data were collected at the study sites.

Assessment of *H. anacardii* damage

Damage assessment consisted in counting individually the leaves damaged by *H. anacardii* and the healthy leaves on each part of the observed cashew plant. Damage to the leaves can be recognized by distortions and angular lesions along the main veins. The type of attacked leaves (young or old) was noted. The attack rate per plant and per genotype was calculated according to the formula:

$$Ta = \frac{\text{Nfa X100}}{\text{Nft}}$$

Where
Ta= Attack rate
Nfa = Number of attacked leaves per genotype
Ntf = Total number of leaves per genotype

Statistical analysis of the data

The effect of climatic factors on the insect population was tested for correlation using STATISTICA version 7.1 software. The sensitivities of cashew genotypes were assessed using an analysis of variance (ANOVA) at the 5% threshold, and means were ranked using the Student Newman Keuls test. A Spearman correlation test verified the correlation between rainfall and insect abundance.

Results

Dynamics of *H. anacardii* in relation to rainfall

In both years, *H. anacardii* appeared on cashew trees in July, during the rainy season (Figure 1). As soon as they appear, the abundance of insects increases according to the rainfall to reach their peak at the end of the rainy season in November with respectively 644 and 475 insect pests collected in 2015 and 2016. This period of high insect abundance corresponds to the vegetative phase of the cashew tree. Temperatures were low.

However, insect abundance decreases sharply from December until it disappears completely from March to June. This period corresponds to the flowering and fruiting phase with the highest temperatures. The population in 2016 varied in the same direction as that observed in 2015. In 2015, a strong positive significant correlation was noted between the abundance of insects and rainfall (r= 0.97; P= 0.000). In 2016, similar correlations were noted (r= 0.91; P= 0.000).

Sensitivity of cashew organs to attack by *H. anacardii*

The sensitivity test of cashew trees to *H. anacardii* attack on leaves showed that the proportion of damage was variable depending on the nature of the leaf (young or old). The highest rates of insect attack were observed on young leaves. The damage observed in young leaves ranged from 12 to 88%, with an average of 44.83 ± 19.25%, while in adult leaves the damage varied between 0 and 34% with an average of 10.06 ± 5.89%. Statistical treatments revealed a highly significant difference between attack rates at leaf level (t-test; P < 0.01) (Figure 2).

Sensitivity of cashew genotypes on leaves

Our results showed that the susceptibility of the genotypes was variable. Genotypes LA X4297 and LA Z330 were the most susceptible to insect attack with damage rates of 49.83 ± 18.07% and 45.90 ± 20.81% respectively. The genotype LA X3264 recorded the lowest attack rate with 21.76 ± 11.71 % of attacked leaves. This genotype is therefore the least susceptible. The analysis of variance shows that the attack rates of *H. anacardii* on the leaves vary from one genotype to another (P < 0.01) (Fig. 3).

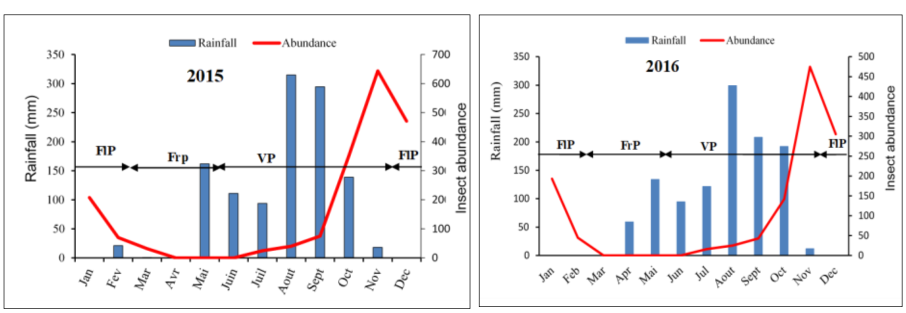

Fig 1: Dynamic of *H. anacardii* on cashew in 2015 and 2016 as a function of to rainfall FrP: Fructification Phase; FlP: Flowering Phase; VP: Vegetative Phase

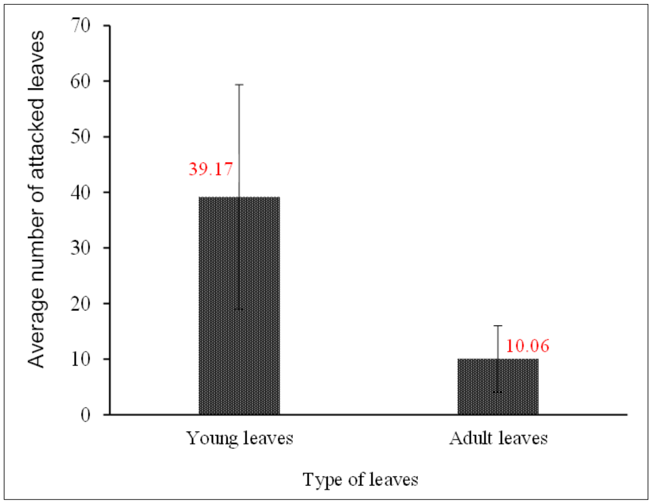

Fig 2: Average number of leaves attacked per tree

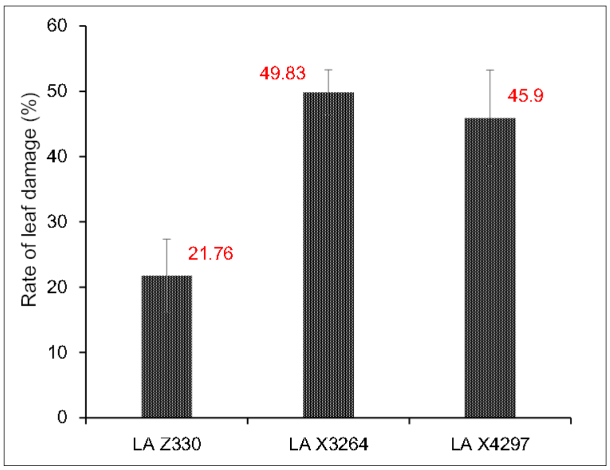

Fig 3: Rate of leaf damage per cashew genotype

Means with the same letters are not statistically significant according to the Student-Newman-Keuls test

Discussion

The monitoring of the population dynamics of *Helopeltis anacardii* allowed us to understand its annual fluctuation. *H. anacardii* is only present in cashew orchards from July to November. This period corresponds to the Vegetative Phase (PV) which coincides with the rainy season in the north of the country. Indeed, the cashew tree has three phases in its development: the Vegetative Phase (VP), the Flowering Phase (FlP) and the Fructification Phase (FrP). The vegetative phase is the period of production of young tender leaves. These young leaves would constitute a food source for *H. anacardii*. The results obtained show that these insects particularly appreciate the leaves to the detriment of the other organs of the cashew tree, especially the young leaves. As *H. anacardii* is a biting-sucking insect, it would have great difficulty in removing the sap from adult leaves because of the fragility of the rost. The same observation was made on the same insect by Hill in Kenya [8]. Work carried out with other insects of the genus *Helopeltis* such as *H. schoutedenii* [11] and *H. antonii* [12] in Ghana and Indonesia respectively, has shown that these insects only find their subsistence through young leaves. The absence of young leaves on cashew trees negatively influences their population. The fluctuation of the population of *Helopeltis antonii* on cashew trees is strongly influenced by rainfall. The abundance of the insects increases with rainfall to reach its peak at the end of the rainy season in November, then the population of *Helopeltis antonii* decreases and is cancelled out by May. In Indonesia, Siswanto et al., [12] revealed that the population of the same species started to increase during the rainy season and reached its maximum in November before decreasing. In the Haut-Sassandra region of Côte d'Ivoire, the study of seasonal variations in cocoa mirid populations also showed that mirids are only present from June to November and their population decreases sharply during drought periods [13] . In this study, the relationship between variations in insect populations and temperature was not obvious. However, Kouamé et al., [13] , observed that periods of high outbreaks coincided with the lowest temperatures of the year. Finally, Babin [14] determined the period of fluctuation of the *Sahlbergella singularis* population which runs from July to December which also corresponds to the rainy season. The population of *H. anacardii* is low at the beginning of the Flowering Phase. Three reasons could explain these results. Firstly, the decrease in the number of young leaves on cashew plants at this time of the year would cause competition for food, thus leading the insects to find other host plants. Secondly, flowering attracts other groups of insect pollinators (*Apis melifera*) and predators such as *Centris tarsata*. These insects are able to devour *H. anacardii*. Finally, the decrease in the insect population from December to June is thought to be linked to an increase in temperature at this time of year. According to Hill [8], drought is a hindrance to the spread of *H. anacardii*, which is sensitive to heat. The results obtained revealed that the cashew genotypes (LA X3264, LA X4297 and LA Z330) do not present the same sensitivities to *H. anacardii* attacks. The LA X3264 genotype, with 21.76 ± 11.71% of leaves attacked, is the most resistant genotype to insect attacks. The resistance of this genotype would be linked to a modification of the tissues or the quality of the sap of these young leaves, reducing the palatability of these leaves for the insect pests. However, the present study did not assess the tissue and sap quality of the three genotypes.

Conclusion

The study of spatio-temporal fluctuation indicates that the population of *H. anacardii* increases during rainy periods (from June) to reach a peak in November.

The population then declines sharply from December onwards. At the organ level, *H. anacardii* particularly likes young leaves to the detriment of adult leaves. In young leaves, the average damage rate was 44.83 ± 19.25%, while in adult leaves, damage was estimated at 10.06 ± 5.89%. Concerning the susceptibility of the genotypes, LA X3264 was more resistant to the insect pest attacks, with the lowest rate of leaves attacked. The genotype LA X4297 is more sensitive with the highest attack rate.

Authors' Contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript

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