

Impact of insect pests on cashew tree production: Case of the stem borer *Diastocera trifasciata* Fabricius, 1775 in the sub-prefecture of Didievi (central cote d'ivoire)

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Abstract

Cashew (*Anacardium occidentale*) represents an important source of income for smallholder farmers. Unfortunately, its production is constrained by attacks from the stem borer *Diastocera trifasciata*, which cause branch breakage. The objective of this study was to assess the impact of *D. trifasciata* on cashew production. Damage was evaluated through direct observations in 16 cashew orchards and smallholder farmers surveys in the Didiévi department. In each orchard, 32 randomly selected trees located at the center of the plantation were inspected. The number of trees and branches cut or girdled was recorded, and the diameter of the girdled section attacked by *D. trifasciata* was measured using a tape. Attack rates ranged between 10 and 20% across orchards in four localities. The total girdled diameter (cm) for 32 trees surveyed varied between 45 and 58 cm. Attack intensity was low in Koffikro and N'da Akissikro ($I \leq 0.5$) and moderate in Bodo and Groyakro ($0.5 < I \leq 1$). Yields were highest in Koffikro (582.5 kg/ha) and N'da Akissikro (492.5 kg/ha), lowest in Groyakro (331.25 kg/ha), and intermediate in Bodo (424.25 kg/ha). Moreover, the average total girdled diameter was greater in orchards aged 10-20 years (51.11 cm), resulting in significant sap loss and reduced yield (404.67 kg/ha). The most common control method against *D. trifasciata* was mechanical removal. The use of biopesticides could provide an effective alternative for managing this pest.

Keywords: Cashew, damage, *Diastocera trifasciata*, yield, Côte d'Ivoire

Introduction

The cashew tree (*Anacardium occidentale* L., *Anacardiaceae*) is native to northeastern Brazil, where it was cultivated by indigenous peoples long before its discovery by the Portuguese, who later introduced it to some of their colonies in Africa and Asia. This species thrives in regions characterized by warm and humid climates, with annual rainfall ranging between 1000 and 2000 mm (Diarrasouba, 2003) [10]. In Côte d'Ivoire, the first cashew plantations were established in the late 1950s and early 1960s by two state-owned companies, SATMACI and SODEFOR (Gouma, 2003) [12]. Cashew is cultivated for its fruit, which consists of two parts: the cashew apple and the cashew nut. The nut is the subject of international trade and gives cashew its global reputation, whereas the apple remains underutilized despite its nutritional value (Lacroix, 2003; Houssou *et al.*, 2016) [13-18]. Due to its high production, Côte d'Ivoire has become the world's leading producer, with more than 700,000 tons in 2016 (Mallikarjuna, 2017) [20]. However, cashew orchard yields in Côte d'Ivoire remain low, averaging only 350 kg/ha (Rica, 2019; Diabaté & Tano, 2020) [8-22]. Cashew represents one of the main export crops in the northeastern region of Côte d'Ivoire. Like other crops cultivated for food and economic purposes, cashew is threatened by numerous harmful organisms, including insect pests, diseases, and competition from weeds during the early stages of growth. The first damage caused by the stem borer *Diastocera trifasciata* Adibauer, 1993 (formerly *Analeptes trifasciata*) was observed in 1964 at the forest stations of Kokondekro and Bamoro, as well as in many village plantations around Bouaké (Brunck & Fabre, 1970) [6]. Since the work of these authors, no study has been conducted on the biology and

ecology of this species to determine effective control methods. Consequently, this pest has spread to cashew plantations in several production regions of Côte d'Ivoire and Africa. *D. trifasciata* Fabricius causes significant damage to cashew trees by girdling branches (Diabaté & Tano, 2020) [8]. Attacks by *D. trifasciata* on cashew trees may be related to nutritional and reproductive needs (Asogwa *et al.*, 2011; Kra *et al.*, 2017; Diabaté & Tano, 2020) [5-8-17]. Studies by Kra *et al.* (2017) [17] in the Béré and Iffou regions, and Diabaté & Tano (2020) [8] in the Tonkpi region, showed that attack rates on cashew trees ranged between 1% and 10%. These attacks are more pronounced in orchards of Katiola department, with cashew tree infestation rates ranging between 53% and 96%, affecting up to six branches per tree. Consequently, this insect represents a serious threat to smallholder farmers yields and to the national economy (Akesan *et al.*, 2015) [3]. The attacks of *Diastocera trifasciata* Fabricius, 1775 vary between 2% and 10% (Diabaté *et al.*, 2020). However, very few studies have been conducted on the impact of insect pests on cashew production in the Didiévi department. In this context, the present study was initiated with the general objective of assessing the impact of *D. trifasciata* attacks on cashew productivity in the area. To achieve this, three specific objectives were defined:

- To determine the damage caused by *D. trifasciata* Fabricius, 1775 in cashew orchards;
- To evaluate the impact of *D. trifasciata* attacks on cashew orchard yields;
- To assess smallholder farmers' perceptions of cashew nut production and alternative control methods adopted against this pest.

Materials and Methods

Biological Material

The biological material used in this study consisted of both plant and animal material.

- **Plant material:** Cashew trees (*Anacardium occidentale* L.) showing damage caused by the stem borer *Diastocera trifasciata* Fabricius, 1775. The orchards selected met the following criteria:
 - Had been subjected to stem borer attacks,
 - Covered a minimum area of one hectare (1 ha),
 - Were accessible in all seasons,
 - Had not undergone any insect control interventions during the study period.

The study was conducted during the pre-flowering stage of cashew, considered representative for observing damage.

- **Animal material:** Individuals of the stem borer *Diastocera trifasciata* were collected directly from the cashew trees under study.

Technical Material

The technical equipment used in this study consisted of a GPS device, employed to record geographic coordinates and delimit the orchards, and a Portworld tablet, used for photographic documentation and data collection in the field.

Methods

Determination of the sociodemographic characteristics of cashew smallholder farmers

Surveys were conducted with sixteen (16) cashew smallholder farmers, each owning at least one hectare of cashew orchard. Four smallholder farmers were interviewed per village, for a total of four (04) villages in the sub-prefecture of Didiévi: Koffikro, N'da Akissikro, Bodo, and Groyakro. The surveys were carried out according to the availability of the smallholder farmers, using pre-established questionnaires. The questions focused on the sociodemographic characteristics of the smallholder farmers (origin, age, level of education, and gender), as well as their ability to recognize damage caused by cashew insect pests. In addition, alternative control methods against these pests, as well as yields obtained before and after the application of good agricultural practices, were evaluated. The information collected was grouped by locality and by variable. Regarding age, four classes were defined: under 35 years, 35-45 years, 45-55 years, and 55 years and above.

Determination of the emergence period of *Diastocera trifasciata* attacks

Data collection was scheduled for September 2024. This period was chosen based on smallholder farmers availability and the phenological stages of cashew trees. The study was conducted in four villages of the Didiévi sub-prefecture (Koffikro, Bodo, Groyakro, and N'da Akissikro), with the objective of assessing the damage attributed to *Diastocera trifasciata* Fabricius, 1775.

Damage assessment

To evaluate the damage caused by *D. trifasciata* in each orchard studied, 32 cashews trees were randomly selected from the center of the plantation. The number of trees and branches cut or girdled was recorded, and the diameter of the girdled section attacked by *D. trifasciata* was measured

using a measuring tape. A tree was considered attacked when at least one branch was scarred, girdled, or cut.

The attack rate and the intensity of attacks in cashew orchards were calculated. The attack rate (Ta) was determined according to the following formula :

$$Ta = \frac{Na}{Nt} \times 10$$

Where

- Na = number of attacked trees
- Nt = total number of trees surveyed

The intensity of attacks was calculated using the following formula:

$$I = \frac{N}{Nt} \quad (1)$$

Where

- N = number of cashew branches attacked by *Diastocera trifasciata* Fabricius, 1775
- Nt = total number of cashew trees surveyed (32 per orchard)

The intensity index (I) was interpreted as follows

- $I = 0$: no infestation (no branch cut)
- $I \leq 0.5$: low infestation (1 to 16 branches cut)
- $0.5 < I \leq 1$: moderate infestation (17 to 32 branches cut)
- $I > 1$: high infestation (more than 32 branches cut)

Yield evaluation of cashew orchards

Cashew yields were assessed based on information collected through survey forms administered to smallholder farmers. These forms allowed for the systematic collection of data related to the production of the different plantations.

Statistical analysis

The variables studied, namely the number of cashew trees attacked by *Diastocera trifasciata* Fabricius, 1775, the attack rate, the average number of branches, the intensity of attacks in orchards, and plantation yield, were subjected to analysis of variance (ANOVA with main effects, significance threshold set at $p < 0.05$). Statistical analyses were performed using SPSS Statistics version 20. Mean comparisons were subsequently carried out with XLSTAT 2016 software, applying Fisher's LSD test ($p < 0.05$).

Results and discussion

Results

Sociodemographic characteristics of cashew smallholder farmers

The surveys revealed that 94% of cashew smallholder farmers are men, while 6% are women. Regarding educational level, 88% of smallholder farmers are illiterate, 10% have primary education, and 2% have higher education. The majority of respondents are natives, representing 97% of smallholder farmers, compared to non-natives who account for 3%. In terms of

age distribution, 42% of smallholder farmers are 55 years and above, 41% are between 45 and 55 years, 15% are between 35 and 45 years, and 2% are under 35 years.

Damage caused by *Diastocera trifasciata* Fabricius, 1775 by locality

The attack rates observed in cashew orchards across the four studied localities ranged between 10% and 20%. Statistical analysis revealed no significant differences among the localities of Bodo, Groyakro, Koffikro, and N'da Akissikro regarding the number of cashew trees attacked and the attack rate (Table I). In N'da Akissikro, the average number of attacked cashew trees was 4.25 out of 32 surveyed, corresponding to an attack rate of 13.28%. In Bodo, six

cashew trees were attacked, representing an attack rate of 18.75%. In Groyakro and Koffikro, the average number of attacked trees was 5.25 and 5, with attack rates of 16.41% and 15.63%, respectively. Regarding branches, the average number of branches attacked by *D. trifasciata* ranged between 15 and 18 per 32 surveyed trees. Attack intensity varied between 0.4 and 0.6. In N'da Akissikro, the average number of attacked branches was 15.25, with an intensity of 0.48. In Groyakro, 17.75 branches were attacked on average, with an intensity of 0.55. In Bodo and Koffikro, the values were 16.75 and 16 attacked branches, with intensities of 0.52 and 0.50, respectively. Thus, attack intensity was less than or equal to 0.5 in Koffikro and N'da Akissikro, while it ranged between 0.5 and 1 in Bodo and Groyakro.

Table 1: Attack rate and attack intensity of cashew trees according to locality

Locality	Average number of attacked trees / 32 ± SD	Attack rate (%)	Average number of attacked branches (N) ± SD/32	I=N/Nt
Bodo	6 ± 4.41	18.75	16.75 ± 0.96	0.52
Groyakro	5.25 ± 0.96	16.41	17.75 ± 0.96	0.55
Koffikro	5 ± 0.82	15.63	16 ± 1.63	0.5
Ndaakissikro	4.25 ± 0.96	13.28	15.25 ± 1.5	0.48
F-value	1.85	1.85	2.70	2.70
p-value	0.19	0.19	0.09	0.09

Nt = 32 cashews trees surveyed

Damage caused by *Diastocera trifasciata* Fabricius, 1775, according to orchard age

None of the surveyed smallholder farmers owned plantations younger than five years. Statistical analysis revealed no significant differences between orchards aged 5-10 years and those aged 10-20 years, whether in terms of the number of cashew trees attacked, the attack rate ($F = 1.66$; $p = 0.22$), the average number of branches cut, or the intensity of attacks

($F = 1.06$; $p = 0.32$) (Table II). In orchards aged 10-20 years, the average number of attacked cashew trees was 5.44, corresponding to an attack rate of 17.01%. The average number of branches cut was 16.78, with an attack intensity of $I = 0.52$. In orchards aged 5-10 years, the average number of attacked cashew trees was 4.71, corresponding to an attack rate of 14.73%. The average number of branches cut was 16.00, with an attack intensity of $I = 0.50$.

Table 2 : Attack rate and attack intensity of cashew trees according to orchard age

Orchard age (years)	Average number of attacked trees ± SD/ 32 arbres	Attack rate (%)	Average number of branches attacked (N) ± SD/32 arbres	Attack intensity (I) (%)
[5- 10 ans]	4.71 ± 1.11	14.73	16.00 ± 1.63	0.50
[10- 20 ans]	5.44 ± 1.13	17.01	16.78 ± 1.39	0.52
F-value	1.66	1.66	1.06	1.06
p-value	0.22	0.22	0.32	0.32

I = Attack intensity, Nt = 32 cashews trees surveyed, SD = Standard Deviation

Impact of *Diastocera trifasciata* Fabricius, 1775 attacks on yield by locality

In the localities of Bodo (N 7.248415, W -4.475254), Groyakro (N 7.474654, W -4.472817), Koffikro (N 7.717349, W -4.513897), and N'da Akissikro (N 7.642833, W -4.483756), the total average diameter girdled for 32 cashews trees was lowest in N'da Akissikro (45.35 cm) and highest in Bodo (57.59 cm) (Table III). The bark diameter girdled by *D. trifasciata* in Groyakro and Koffikro was

intermediate, with values of 51.81 cm and 49.18 cm, respectively ($F = 3.63$; $p = 0.04$). Across the four localities studied, no significant differences were observed in the average diameter girdled per attacked branch ($F = 1.78$; $p = 0.20$) or per attacked tree ($F = 0.173$; $p = 0.91$). The average diameters girdled per branch and per attacked tree were 3.44 cm and 10.1 ± 2.96 cm in Bodo, 2.92 cm and 10.11 cm in Groyakro, 3.08 cm and 10.04 cm in Koffikro, and 3.00 cm and 11.11 cm in N'da Akissikro (Table III).

Table 3: Yield of cashew orchards in different localities

Locality	Total girdled diameter (cm) / 32 trees ± SD	Average girdled diameter per attacked branch (cm ± SD)	Average girdled diameter per attacked tree (cm ± SD)	Yield (kg/ha ± SD)
Bodo	57.59 ± 6.64 ^c	3.44 ± 0.37	10.1 ± 2.96	424.25 ± 66.87 ^b
Groyakro	51.81 ± 5.83 ^b	2.92 ± 0.27	10.11 ± 2.18	331.25 ± 44.79 ^c
Koffikro	49.18 ± 3.56 ^b	3.08 ± 0.15	10.04 ± 1.82	582.5 ± 135 ^a
Ndaakissikro	45.35 ± 5.08 ^a	3.00 ± 0.49	11.11 ± 2.77	492.5 ± 95.61 ^a
F-value	3.63	1.78	0.173	5.34
p-value	0.04	0.2	0.91	0.01

Means within the same column followed by the same letter are not significantly different (Fisher's LSD test, $p < 0.05$)

Impact of *Diastocera trifasciata* Fabricius, 1775 attacks on yield according to orchard age

No significant differences were observed in the total average girdled diameter ($F = 0.01$; $p = 0.93$), the average girdled diameter per attacked branch ($F = 0.46$; $p = 0.51$), the average girdled diameter per attacked tree ($F = 1.81$; $p = 0.20$), or in yield ($F = 4.50$; $p = 0.05$) between orchards aged 5-10 years and those aged 10-20 years. However, the total average girdled diameter was

higher in orchards aged 10-20 years (51.11 cm), which resulted in greater sap loss and lower yield (404.67 kg/ha). In orchards aged 5-10 years, the total average girdled diameter, average girdled diameter per attacked branch, average girdled diameter per attacked tree, and yield were 50.81 cm, 3.18 cm, 11.18 cm, and 525.71 kg/ha, respectively. In orchards aged 10-20 years, these values were 51.11 cm, 3.05 cm, 9.69 cm, and 404.67 kg/ha, respectively (Table V).

Table 4: Yield of cashew orchards in different localities

Orchard age (years)	Total average girdled diameter (cm) \pm SD	Average girdled diameter per attacked branch (cm) \pm SD	Average girdled diameter per attacked tree (cm) \pm SD	Yield (kg/ha) \pm SD
] 5-10 ans]	50.81 \pm 6,57	3.18 \pm 0,34	11.18 \pm 2.24	525.71 \pm 128.66
] 10- 20 ans]	51.11 \pm 7,13	3.05 \pm 0,40	9.69 \pm 2.18	404.67 \pm 100.06
F-value	0.01	0.46	1.81	4.50
p-value	0.93	0.51	0.2	005

$Nt = 32$ cashews trees surveyed per orchard, SD = Standard Deviation

Discussion

This study allowed us to evaluate the impact of *Diastocera trifasciata* Fabricius, 1775, on cashew production in the sub-prefecture of Didiévi. The confinement of *D. trifasciata* Fabricius, 1775, to the sub-prefecture of Didiévi could be explained by climatic conditions, particularly high rainfall and moderately low temperatures (around 25 °C). These results are similar to those obtained by CCA (2015) [7]. Indeed, this region is characterized by a four-season climate, unlike the northern area where the species is absent and only two seasons occur. It therefore appears that seasonal variation has a significant effect on the development and distribution of the insect. According to Akessé *et al.* (2018) [4], the population of *D. trifasciata* Fabricius, 1775, increases in cashew orchards during the major rainy season. Similarly, studies by Asogwa *et al.* (2011) [5] in Nigeria, Dwomoh *et al.* (2008) [11] in Ghana, and Agboton *et al.* (2017) [2] in Benin showed that the species is widely distributed in central regions due to favorable environmental factors such as rainfall above 100 mm, temperatures around 25 °C, and relative humidity of 70%. Furthermore, *D. trifasciata* Fabricius, 1775, causes significant damage to cashew trees by girdling branches (Diabaté & Tano, 2020). The attack rate of cashew trees ranges between 13% and 19%, and the number of branches attacked averages 15 to 17 per 32 surveyed trees in the sub-prefecture of Didiévi. These results are similar to those of Kra *et al.* (2017) [17], who reported attack rates ranging from 1% to 10% in the Béré and Iffou regions. The attack rate of cashew trees and the number of branches attacked per tree in Didiévi are higher but close to those obtained by Asogwa *et al.* (2011) [5] and Diabaté & Tano (2020) [8], who showed that attack rates of *D. trifasciata* Fabricius, 1775, in cashew orchards aged 4-10 years ranged between 2% and 10%. These authors also demonstrated that insect attacks decrease with orchard age, with attacks on young cashew trees being limited to feeding (Asogwa *et al.*, 2011 ; Diabaté & Tano, 2020) [5-8]. The high attack rate observed in the sub-prefecture of Didiévi may be linked to environmental conditions that are more favorable to the establishment and expansion of this insect. Similar findings were reported by Kra *et al.* (2017) [17], who indicated that the appearance of this insect generally occurs during rainy seasons. In addition, the phenological stage of the host plant could be a triggering factor for severe pest attacks. These attack rates remain low compared to those

reported by Koné *et al.* (2019) [16] in Konékaha (Katiola), who showed that this insect can cut up to six branches per attacked cashew tree, with attack rates ranging between 53% and 96%. According to Koné *et al.* (2019) [16], such attacks may be related to reproductive needs. Moreover, the phenological stage of the host plant could also trigger severe pest attacks. The results corroborate those of Tchibozo & Braet (2004) [23], Akessé *et al.* (2018) [3], and Ouali *et al.* (2020) [21], who demonstrated that during the pre-flowering and flowering stages of cashew trees, *D. trifasciata* Fabricius, 1775, attacks a maximum number of branches and stems, as this period coincides with the species' reproductive phase. Addressing these issues would significantly increase national production and enable Côte d'Ivoire to maintain its position as a global leader in cashew production. To control this pest, most smallholder farmers favor mechanical control, which consists of manually killing the beetle using a tool (Asogwa *et al.*, 2011; Lebailly *et al.*, 2012; Afouda *et al.*, 2013) [1-5-19]. The mechanical control method employed by smallholder farmers is ineffective in eliminating the pest and preventing it from girdling branches and stems. The girdled parts, whether hanging on trees or fallen to the ground, often contain eggs and larvae that are not properly managed. They are usually piled up inside or outside the orchards without consideration of the presence of eggs, which will constitute the next generation. The most effective method consists of gathering all these parts and burning them (Brunck & Fabre, 1970) [6]. This practice is the only one that ensures the destruction of eggs and larvae contained in the girdled parts. Unfortunately, it is rarely used by smallholder farmers, which favors the proliferation of the pest year after year. Consequently, the impact of the pest on cashew nut production is becoming increasingly noticeable in the surveyed areas. Despite the extent of the damage caused, most smallholder farmers consider its impact to be low or moderate, even though infestation by the beetle pest is becoming increasingly alarming in the Béliér and Gbêkê regions. Indeed, new plantations provide better yields than older ones, where some trees do not produce at all (Troukou *et al.*, 2012) [24]. The number of girdled branches increases over time. Moreover, pest attacks have little influence on production because, in general, smallholder farmers do not remove the girdled or suspended parts, thereby avoiding the loss of flowers on branches bearing inflorescences (Asogwa *et al.*,

2011) ^[5]. However, some smallholder farmers believe that the impact of the girdler is very high on yield, which may be due to insect attacks or to high planting density. In general, spacing standards between cashew trees are not respected, leading to canopy overcrowding, reduced photosynthesis due to insufficient light, and consequently lower orchard yield (Konan & Ricau, 2010) ^[14].

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