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Impact of the *Zea mays* L. (Poaceae)-*Chromolaena odorata* L. (Asteraceae) crop association on insect pest dynamics and maize yield in the Daloa department (Côte d'Ivoire)

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Abstract
Maize accounts for 41% of world cereal production. It is one of the three most widely produced crops in the world, after wheat and rice. This study aimed to improve maize production through cultural control. Maize was grown in association with *Chromolaena odorata*. Each elementary plot contained eight pitfall traps and eight colour traps, arranged according to the FAO method. Eight maize plants were selected at random from each elementary plot for manual insect trapping. The insects were collected before sunrise every three days. As for yield loss, 10 mature ears of maize were collected at random from each elementary plot. A total of 1610 insects were identified, including two pest species, *Spodoptera frugiperda* (Lepidoptera) and *Zonocerus variegatus* (Orthoptera). This population was made up of 7 orders (Coleoptera; Diptera; Lepidoptera; Orthoptera; Hemiptera, Hymenoptera and Dictyoptera), belonging to 50 families and 74 species. The plot with *C. odorata* recorded 834 individuals, i.e., 51.80% of the population. The plot without *C. odorata* (Control) recorded 776 individuals, representing 48.20% of the total insect population. The most abundant insect order was Coleoptera (23.40% in the control, 25.53% in the plots with *C. odorata*). Yield losses were not significantly different, at 20.82% for the plot with *C. odorata* and 30.57% for the control. The study concluded that combination of maize and *Chromolaena odorata* did not affect insect activit.

Keywords: *Zea mays*, *Chromolaena odorata*, insects, mixed cropping, Côte d'Ivoire

Introduction

Maize, *Zea mays* L (Poaceae), is one of the three most widely produced crops in the world, after wheat and rice (FAOSTAT, 2023) [10]. World production is 1.2 billion tonnes (Konan *et al.*, 2023 [15]. In sub-Saharan Africa, it is around 84.6 million tonnes (Agenceecofin, 2025) [1].

Maize plays a vital role in food security. More than 300 million people depend on maize as a source of food and subsistence (Macauley & Ramadjata, 2015) [17]. It is also used in animal feed and as a raw material in certain industries (Boone *et al.*, 2008) [5].

In Côte d'Ivoire, annual production is estimated at 1025000 tonnes (FAO, 2017) [8]. After 2017, it is estimated at 600000 tonnes/year (PUA-CI, 2024) [25]. This reduction in production is the result of attacks by pests, particularly insect pests. Insects cause damage to all parts of the plant in fields and during storage of maize grains (Yoboue *et al.*, 2022) [32]. Faced with these constraints, farmers resort to the use of chemical products (Harrison *et al.*, 2019; Balasha and Fyama, 2020; Zongo *et al.*, 2023) [4, 12, 33]. Despite their effectiveness (Sisay *et al.*, 2019) [27], they have harmful effects on the environment and human health (Djagni and Fok, 2019) [7]. It therefore seems necessary to consider new strategy approaches to reduce production losses. The use of biological control, particularly through intercropping, represents a promising approach.

Studies have shown that maize pest infestation is reduced by combining it with certain cultures (Midega *et al.*, 2018 ; Girma *et al.*, 2018 ; Tanyi *et al.*, 2020) [11, 19, 29]. In Togo, maize-cassava and maize-soybean intercropping significantly reduced infestation (40-56%) of the fall armyworm (Tchegueni *et al.*, 2022) [30]. However, in Côte d'Ivoire, these crop associations (maize-peanut, maize-cajunus, maize-cowpea and maize-soybean) focused on improving soil fertility (Kouakou *et al.*, 2021) [16]. The choice of this species for mixed cropping must be related to its ability to control pests and increase production. This maize-*C. odorata* intercropping, the first in Ivory Coast, is due to the permanent presence of *C. odorata* in fallow land, especially to its insecticidal properties (Ileke and Olabimi, 2019; Nor *et al*, 2024)[13, 23].

The aim of this study, which is part of a drive to improve maize production, is to assess the impact of combining *Zea mays* and *C. odorata* crops on the dynamics of insect pests and maize yields in the Daloa department in western Côte d'Ivoire.

Materials and Methods

Study Area

The experiments took place in the Daloa department (Fig. 1), at Blakro, about 12 km from Daloa, on the Daloa-Bouaflé road. This choice was justified by the abundance of *Chromolaena odorata* on the site. The town of Daloa is located in the Haut-Sassandra region, in the centre-west of Côte d'Ivoire. It lies at 6°53 north latitude and 6°27 west longitude (Yao *et al.*, 2020) [31]. Its population is estimated at 266000 with an area of 3876 Km² (RGPH, 2014) [26]. The average temperature is 27.5°C and rainfall is between 1000 and 1500 mm. The climate is tropical with ferralitic soil (Soro *et al.*, 2024) [28].

Experimental Set-Up

The experimental set-up is Fischer's. This 704 m2 (32 m × 22 m) set-up is divided into two 120 m² (12 m × 10 m) blocks 3 metres apart. Each block is made up of 4 elementary plots separated by 2 metres (Fig. 2). Each elementary plot is 20 m² (4 m × 5 m). Block 1 consisted entirely of maize plants. For block 2, each of the elementary plots is a combination of maize and 20 *Chromolaena odorata* plants. Sowing was carried out using the method of

Akanvou *et al.* (2009) [2], with 80 cm between rows and 40 cm between bunches. Once the seedlings had been separated, each elementary plot consisted of 70 maize plants, giving a total of 560 maize plants in the plot.

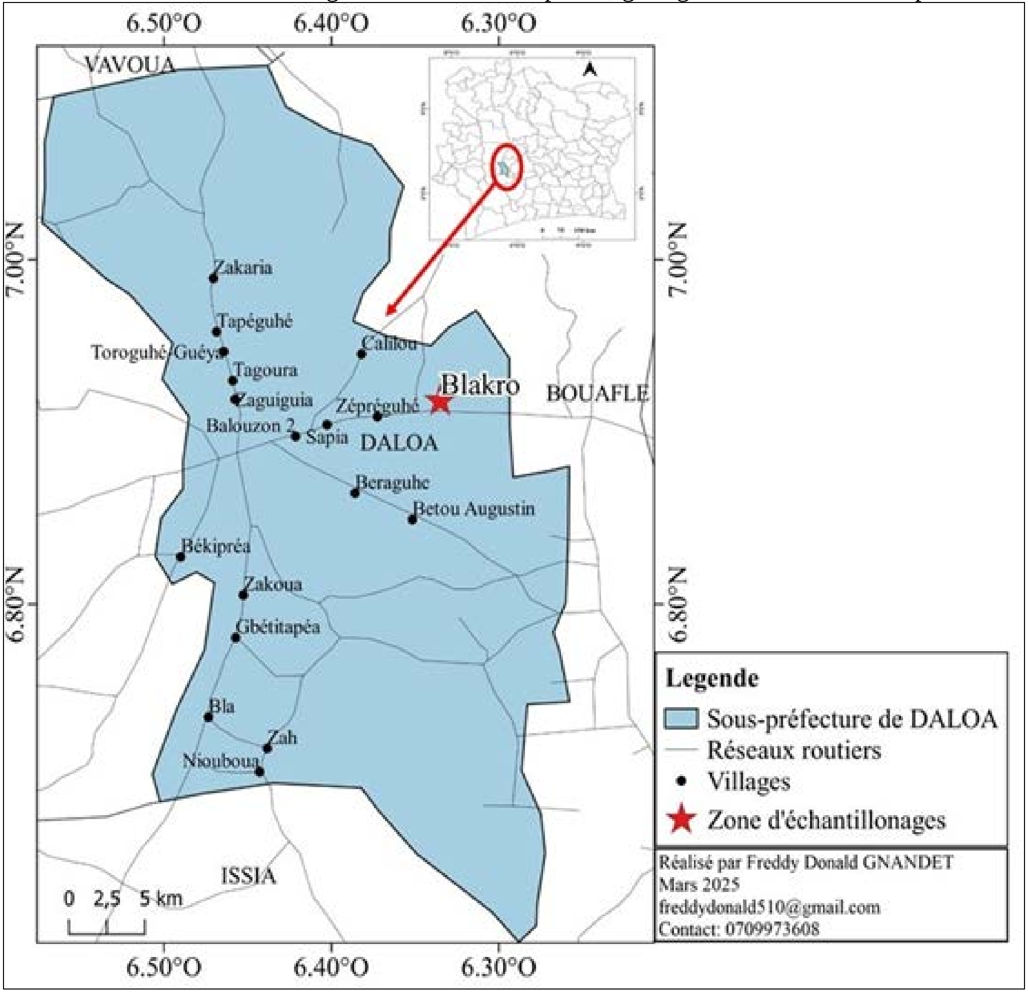


Fig 1: Location of the town of Daloa

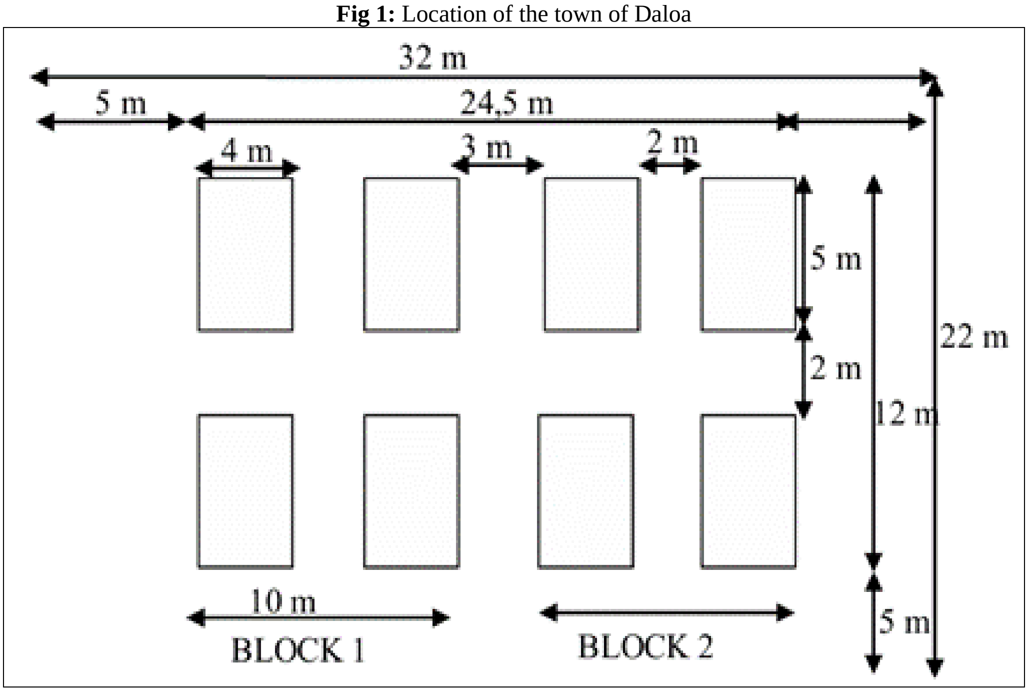


Fig 2: Experimental set-up for the trial
Block1: Control (maize), Block2: Maize and *Chromolaena odorata*

Maintenance of the crop

Fifteen (15) days after sowing, the C. odorata plants are pruned every seven days according to the height of the maize plants to prevent them from smothering the latter. Urea was applied on days 15 and 30. NPK was applied on days 45, 60 and 75.

Capturing insects in maize crops

Two techniques are used on the 15th day after sowing. These are manual capture and capture using traps (pitfall trap and coloured trap), filled with soapy water to half their height. Each elementary plot contained sixteen traps, including eight pitfall traps and eight coloured traps. The trial focused on maize plants located beyond those at the edge of the field to avoid edge effects. To cover a large proportion of the experimental plot, the traps were arranged according to the FAO method w (2018) [9]. In each plot, the eight maize plants are also selected according to the FAO method (2018) [9], while respecting the edge effect. The insects were collected very early in the morning before sunrise, three days after the traps had been set. The trapped insects (larvae and adults) were preserved in 70% alcohol and subsequently identified by hand (Mike *et al*., 2004) [21].

Assessment of yield loss

In each elementary plot, 10 ears of mature maize, located after the first lines of the border, were harvested according to the FAO method (2018) [9]. The cobs were divided into two batches and weighed. One batch of infested ears and another of uninfested ears.

The yield loss (WL) was calculated using the following formula:

$$WL(\%) = \frac{(Wt - Wn)\ X\ 100}{Wt}$$

WLYield loss,

Wt= Average weight in kilograms (kg) of 10 cobs of maize collected,

Wn = Average weight in kilograms (kg) of healthy maize cobs.

Statistical Analysis

Statistical analysis of the results obtained was carried out using Statistica version 7.1 software. Student's t-test was used to evaluate significant differences between treatments at the α = 0.05 threshold.

Results

Specific richness of the insects caught

Six hundred and sixty (660) insects were captured using both techniques during our experiment. This entomofauna was made up of 6 orders (Coleoptera; Diptera; Hemiptera; Hymenoptera; Lepidoptera and Orthoptera), belonging to 19 families and 27 species (Table I).

The most numerous insects were orders of beetles, Orthoptera representing 72.42 % of the total population.

In the presence of C. odorata, 343 insects were identified, representing 51.97% of the total insect population. These were represented by 6 orders, 19 families and 23 species. The Orthoptera order contained the largest number of individuals, Orthoptera 79.70 % of the total number of insects captured. These were followed by Hemiptera (11.47%), Coleoptera (5.88%), Lepidoptera (2.35%) and Hymenoptera (1.47%). The smallest number of Diptera was observed (0.58%).

In the absence of C. odorata, 317 insects (48.03%) were captured. This insect population comprised 17 families and 23 species. Orthoptera was still the most abundant order, with a proportion of 65.10%. Hemiptera, Coleoptera and Lepidoptera, accounted for 18.87%, 11.32%, and 2.83%, of the total numbers respectively, in the absence of C. odorata. The order Hymenoptera and Diptera contained the lowest abundance (0.94%). Of the 27 species, 4 Lagria villosa, Eupompha elegans, Hyphantria cunea, Pseudopomala sp. (4 species) were found only in the presence of C. odorata and 4 species: Trilophidia sp., Grillus bimaculatus, Aulacophora foveicollis, and Crioceris duodecimpunctata in the absence of C. odorata.

Table 1: Number of insects caught

Orders	Families	Species	Presence of *C. odorata*	Absence of *C. odorata*	Total
Coleoptera	Coccinelidae	*Henosepilachna vigintioctomaculata*	1	1	2
	Tenebrionidae	*Lagria villosa*	2	0	2
	Chrysomelidae	*Systena sp.*	4	7	11
		Crioceris duodecimpunctata	0	1	1
		Aulacophora foveicollis	0	2	2
	Buprestidae	*Agrilus sp*	1	6	7
	Meloidae	*Eupompha elegans*	1	0	1
		Lytta auriculata	3	8	11
	Scarabaeidae	*Pentodon bidens*	3	6	9
		Euetheola humilis	5	5	10
Diptera	Diopsidae	*Diopsis sp.*	2	3	5
Hemiptera	Aphrophoridae	*Aphrophora sp*	20	45	65
	Membracidae	*Centrotus cornutus*	6	6	12
	Coreidae	*Paradasynus spinosus*	2	1	3
	Plataspidae	*Megacopta sp.*	6	6	12
	Pyrrhocoroidae	*Dysdercus voelkeri*	3	2	5
Hymenoptera	Cephidae	*Cephus sp.*	5	3	8
Lépidoptera	Noctuidae	*Spodoptera frugiperda*	4	6	10
	Lycaenidae	*Lycaena phlaeas*	3	3	6
	Arctiidae	*Hyphantria cunea*	1	0	1
Orthoptera	Gryllidae	*Brachytrupes membranaceus*	197	128	325
		Grillus bimaculatus	0	3	3
	Pyrgomorphidae	*Zonocerus variegatus*	41	52	93
	Acrididae	*Chortophaga sp.*	30	21	51
		Pseudopomala sp.	1	0	1
		Schistocerca gregara	2	2	4

		Trilophidia sp.	0	1	1
6 Orders	19 Famille	27 Species	343	317	660
Percentage of insects caught			51,97 %	48,03 %	100 %

Number of insects by phenological stage

Vegetative stage of maize

A total of 160 insects were identified. This entomofauna comprised 6 orders, made up of 17 families and 20 species. Orthoptera were in the majority (54.37%). They were followed by the orders Hemiptera (23.13%), Coleoptera (12.5%), Lepidoptera (5.62%), Hymenoptera (3.13%) and Diptera (1.25%)

In the presence of C. odorata, 78 individuals were collected. These insects comprised 5 orders, 14 families and 14 species. With an abundance of 61.54%, Orthoptera was the most represented order (Fig. 3 A). It was followed by Hemiptera (15.38%), Coleoptera (11.54%) and Lepidoptera (6.41%). The least abundant insect order was Hymenoptera (5.13%).

As for the plots without C. odorata, 18 species of insects belonging to 16 families and 6 orders were caught. All these species represent a population of 82 individuals. The most abundant insect order was also Orthoptera (47.56%). It was followed by the following orders (Fig. 3 B): Hemiptera (30.49%), Coleoptera (13.41%), Lepidoptera (4.88%), Diptera (2.44%) and Hymenoptera (1.22%) accounted for the smallest number.

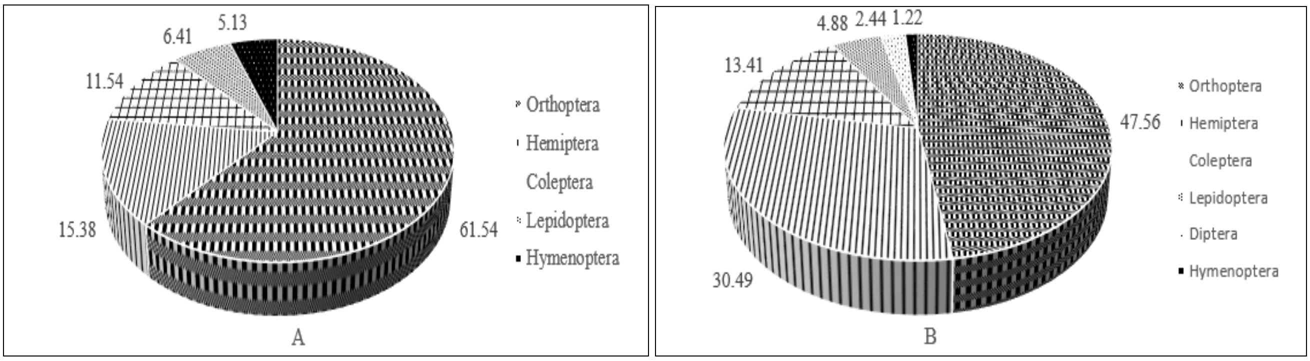


Fig 3: Abundance of orders at the vegetative stage of maize A: Presence of *C. odorata;* B: Absence of *C. odorata*

Maize reproduction stage

Two ninety-one (291) insects were counted, including 158 in the presence and 133 in the absence of C. odorata. They were comprised 5 orders, grouped into 17 species and 14 families.

Five (5) orders subdivided into 14 species and 12 families were observed in the presence of C. odorata. On the other hand, 15 species and 14 families belonging to 5 insect orders were caught in the absence of C. odorata. The most abundant order was Orthoptera, with averages of 87.34% and 69.92% respectively in the presence (Fig. 4 A) and absence (Fig. 4 B) of C. odorata.

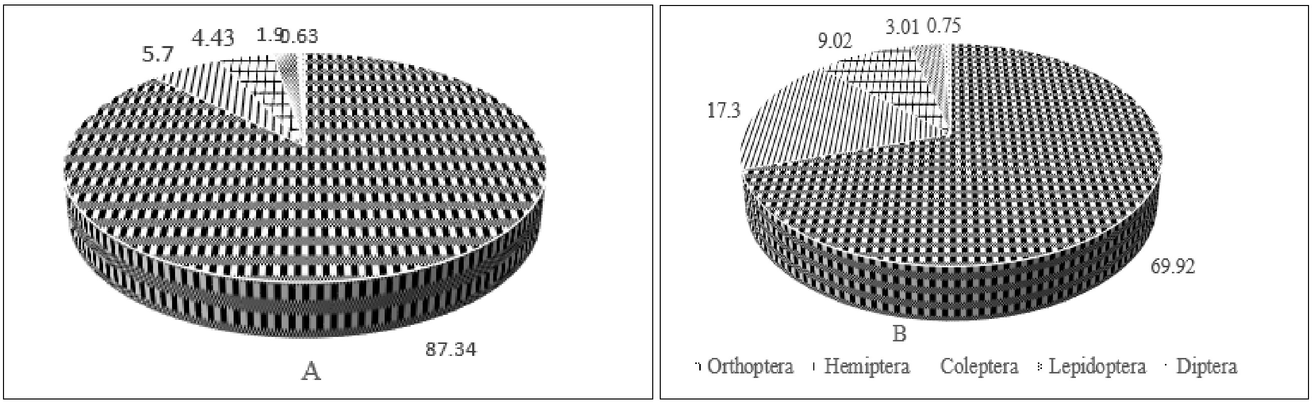
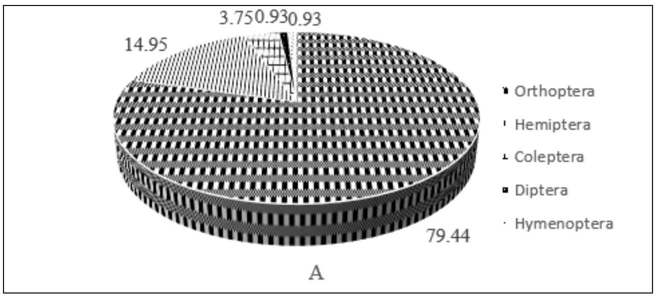


Fig 4: Abundance of orders at the reproductive stage of maize A: Presence of *C. odorata*; B: Absence of *C. odorata*

Maturation stage of maize

Four hundred and eighty-nine (209) insects were sampled. This population was belonging to 6 orders, 19 species and 17 families. In the presence of C. odorata, 107 insects belonging to 5 orders, 15 species and 13 families were recorded. In the absence of C. odorata, 102 insects, 5 species, 15 species and 14 families were recorded. Majority orders were Orthoptera, Hemiptera and Coleoptera in the presence and absence of C. odorata (Fig. 5 A).



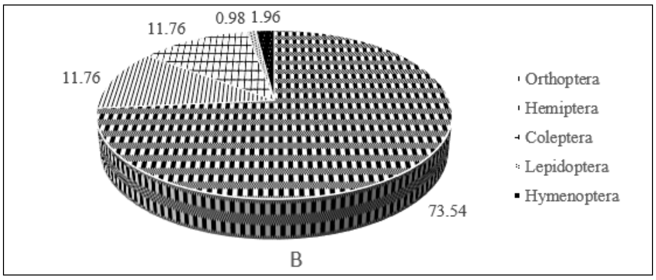


Fig 5: Abundance of orders at the stage of maize maturation
A: Presence of *C. odorata*; B: Absence of *C. odorata*

Damage and loss of ear yield

Damage to ears was higher in the presence than in the absence of C. odorata (Table II). Damage was (80.00 ± 14.14 %) in the presence of C. odorata and (67.50 ± 5.00 %) in its absence. Yield loss was higher (30.57 ± 5.01 %) in plots without C. odorata. Student's t-test showed that these differences were not significant (Damage: P=0.14, Yield loss: P=0.19).

Table 2: Damage and loss of yield of ears

	Presence of *C. odorata*	Absence of *C. odorata*	t-test	ddl	P
Damage (%)	80.00±14.14a	67.50±5.00a	1.66	6	0.14
Yield loss (%)	20.82±12.49a	30.57±5.01a	-1.44	6	0.19

Numbers with the same letter on the same line are not statistically different according to Student's t-test.

Discussion

Six hundred and sixty (660) insect's pests, were identified in the Blakro area. Our results differ from those of Coulibaly (2018) [6] , who listed 3.743 insects. This difference could be linked to the maize variety. Indeed, this author used the EV 8728 variety, which differs from ours, the LG501 variety. Also, the difference in numbers observed could be linked to abiotic factors in the growing areas, in particular temperature and relative humidity. The lower number of insects recorded in our study can be explained by the experimental period. Our experiment took place during the rainy season. The abundance of rain diluted the soapy solution used to trap the insects and filled the trapping jars (pitfall and coloured traps). This would be responsible for the escape of the trapped insects.
During the reproduction and maturation stages, the number of insects caught was higher. These results are consistent with those of Assi et al. (2018) [3], N'Goran-Sanwouly et al. (2019) and Yoboue (2022) [32], who reported high insect numbers on eggplant and cucumber during the fruiting period. This high number of insects is thought to be due to the presence of a kairomone, produced during inflorescence, which attracts insects. Also, the great specific richness at these last two phenological stages (reproduction and maturation stage) would be linked to the abundance of food (leaf, fruit, nectar, pollen, flower).
During the three phenological stages, Orthoptera was the most abundant order (78.78 % with C. odorata and 65.30% without C. odorata). This majority would indicate the favorable ecological conditions for their proliferation provided by okra. Therefore, it could be said that C. odorata is a food source for these Orthoptera.
These early attacks are thought to be due to the rapid establishment (off-season) of the crop. In fact, this rapid establishment led to a strong presence of insects on young maize plants, the only plot with greenery during the drought period.
This finding would mean that C. odorata, when cultivated, does not have an insecticidal effect capable of repelling or reducing the number of insects. These results could also mean that C. odorata is repellent or insecticidal when its secondary metabolisms are in contact with insect pests and not by diffusion of volatile compounds. Our results differ from those of Matur and Davou (2007) [32]; Osariyekemwen et al. (2017) [24]; Nor Ilya et al. (2024) [23]. According to these authors, C. odorata has an insecticidal action. For Osariyekemwen et al. (2017) [24], in addition to the insecticidal effect, C. odorata also has a repellent action. Indeed, Osariyekemwen et al. (2017) [24] after exposing Callosobruchus maculatus adults to grains treated separately with C. odorata root, stem and leaf powders claimed that all three parts of the plant significantly repelled C. maculatus and showed insecticidal activity. Also, the aqueous extract of C. odorata tested on Simulium larvae recorded a 100% mortality rate at concentrations of 100; 10 and 1 mg/ml (Matur and Davou 2007) [32].
The high number of insects captured in the presence of C. odorata could mean that this plant attracts insects. It could also be explained by the fact that these insects are pests of C. odorata.
Damage and yield loss on plots with and without C. odorata were statistically identical. This finding would mean that C. odorata does not have an insecticidal effect capable of repelling or reducing insect numbers (Mike et al. 2004) [21].

Conclusion

660 insects were identified during the experiment: maize-C. odorata cropping associations.
These individuals were divided into 6 orders (Coleoptera; Diptera; Lepidoptera; Orthoptera; Hemiptera and Hymenoptera), 19 families and 27 species.
The plots with C. odorata recorded 343 individuals, i.e. 51.97% of the population. The control plot (without C. odorata) recorded 317 individuals, representing 48.03% of the total number of insects collected. The majority order was Orthoptera (65.30% in the control, 78.78 % in the plots with C. odorata).
Evaluation of the damage to the ears in the presence (80.00 ± 14.14%) and absence (67.50 ± 5.00%) of C. odorata showed that C. odorata had no influence on the number of insect pests, which increased from day to day in the plot. Yield losses were not significant and ranged from 20.82 ± 12.49 to 30.57 ± 5.01%.
In view of our results, a combination of maize and C. odorata does not affect insect activity.

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