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Research Article

EFFECTIVENESS OF INSECTICIDES AGAINST THREE LEPIDOPTERAN PESTS OF *BRASSICA OLERACEA* IN MAN DISTRICT, WEST-COTE D'IVOIRE

***[1]AKA Ahou Jeanne-Debora, [2]DIABATE Dohouonan, [3] FONDIO Drissa, [1]AKPA Akpesse Alexandre Moïse and [4]TANO Yao**

[1]Université Félix Houphouët-Boigny, UFR Biosciences, Laboratoire des milieux naturelles et environnement, 22 BP 582 Abidjan 22, Côte d'Ivoire
[2]Département Agronomie et Foresterie, UFR Ingénierie Agronomique Forestière et Environnementale, Université de Man, BP 20 Man, Côte d'Ivoire
[3]Laboratoire d'Amélioration de la Production Agricole, UFR Agroforesterie, Université Jean Lorougnon Guédé, BP 150 Daloa, Côte d'Ivoire
[4]Université Nangui Abrogoua, 02 BP 801 Abidjan 02, Côte d'Ivoire.

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ABSTRACT

Brassica oleracea is a widely consumed vegetable in Côte d'Ivoire. It is rich in vitamins and minerals and contributes to food security. This study was conducted to evaluate the effectiveness of five insecticides against three main lepidopteran pests of *B. oleracea* in Man district. The experimental design was a Fischer's block with four replications on five half-hectare plots. Lepidopteran larvae and their damage were recorded ten times during the trial on twelve cabbage plants per plot. The insecticide Magic Force Gold 44 EC (Acetamiprid 29 g/l + Lamda-cyhalothrin 15 g/l) demonstrated the highest effectiveness against *Plutella xylostella* (0.25 larvae), *Hellula undalis* (0.25 larvae), and *Spodoptera exigua* larvae (1.25 larvae). The plants attack rates were 100%, 31.25%, 14.58%, 16.67%, and 70.83%, respectively, on the control plots, treated with Vipère 46 EC (Indoxacarb 30g/L + Acetamiprid 16 g/L), Tihan 175 OD (Spirotetramat 75 g/L + Flubendiamid 100 g/L), Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15g/l) and Capaas 80EC (Ememectin benzoate 20 g/L + Abamectin 20 g/L + Acetamiprid 40 g/L) ($F = 142.191$; $p = 0.0001$). The damage intensity was type IV on untreated plots (72.92%), type III on cabbage plots treated with Capaas 80EC (37.50%), type II with Vipère 46 EC (12.50%) and type I on plots treated with Tihan 175 OD (3.65%) and Magic force gold 44 EC (4.17%). Spirotetramat 75/l + Flubendiamid 100g/l and Acetamiprid 29 g/l + Lamda-cyhalothrin 15 g/L can be used to the control of *P. xylostella*, *H. undalis*, and *S. exigua*.

Keywords: *Brassica oleracea*, insecticides, *Plutella xylostella, Hellula undalis, Spodoptera exigua.*

INTRODUCTION

Brassica oleracea is an important vegetable prized for its protein, vitamins, minerals, carotenoids, and antioxidants that supplement the nutritional needs of populations (Willcox *et al*., 2003; Kopsell *et al*., 2004; Singh *et al*., 2010; Diabaté, 2016; Patra *et al*., 2024). This vegetable has a medicinal value and was rich in chlorophyll, which promotes the production of hemoglobin in the blood and helps heal ulcers. However, the production of *Brassica* sp. is seriously affected by biotic stress caused by numerous insect pests. The most significant of these are the Lepidoptera *Plutella xylostella* Linnaeus (Lepidoptera: Noctuidae), *Hellula undalis* Fabricius (Lepidoptera: Pyralidae) and *Spodoptera exigua* Hübner (Lepidoptera: Noctuidae) (Diabaté, 2016; Mpumi *et al*., 2020; Choyon *et al*., 2022; Malik *et al*., 2025). Lepidoptera account for 21% of insects that feed on cabbage, coming after hymenoptera, which account for 51% of insects (Chakrabarty and

*Corresponding Author: AKA Ahou Jeanne-Debora, Université Félix Houphouët-Boigny, UFR Biosciences, Laboratoire des milieux naturelles et environnement, 22 BP 582 Abidjan 22, Côte d'Ivoire. Email: akaahoudebora@gmail.com.

Shashank, 2025). These insects attack all phenological stages of the cabbage plant's life cycle and significantly reducing its market value and yield (Déclert, 1990; Diabaté and Tano, 2014; Diabaté, 2016; Malik *et al*., 2025). The cabbage moth *P. xylostella* is the main pest of *B. oleracea* (Diabaté and Tano, 2014; Diabaté, 2016; Chaubey and Murthy, 2018; Mpumi *et al*., 2020). The larvae of this Lepidoptera species are defoliators and can cause 31 to 90% yield loss despite the pesticide's application (Diabaté and Tano, 2014; Diabaté, 2016; Chaubey and Murthy, 2018). Ouali-N'Goran *et al*. (2021) found that the lepidoptera species *H. undalis* and *P. xylostella* caused attack rates on cabbage plants ranging from 57 to 89% and attack intensities ranging 18 to 39% in Korhogo, northern Côte d'Ivoire. To overcome these biotic constraints in Côte d'Ivoire, market gardeners use synthetic pesticides such as carbamates, pyrethroids, and neonicotinoids, which increase cabbage yields. However, these pesticides are often misused with only 27% of those used by market gardeners being approved (Soro *et al*., 2008; Doumbia and Kwadjo, 2009; Mpumi *et al*., 2020). Furthermore, these pesticides are persistent and accumulate in water, soil, and air, as well as in food (Tudi *et al*., 2021). Excessive pesticides use has negatively affected beneficial fauna, particularly hymenopterans, which are necessary for biological control and pollination (Horváth *et al*., 2013; Mpumi *et al*., 2020; Tudi *et al*., 2021; Diabaté *et al*., 2025). Furthermore, lepidoptera are becoming increasingly resistant to commonly used insecticides. This study aims to evaluate the effectiveness of five insecticides against three main lepidoptera, *P. xylostella*, *H. undalis*, and *S. exigua*, which are pests of cabbage *B. oleracea* in the Man district.

MATERIALS AND METHODS

Study sites

This study was conducted on five cabbage farms in the Man district of the Tonkpi region, western Côte d'Ivoire. The five half-hectare plots were established by the farmers in the same agroecological zone, at Libreville (7°24'50.7798"N, 7°33'29.88072W), Doyagouiné (with two plots : 7°23'38.69736''N, 7°33'48.92832''W), Sari (7°24'4.97376''N, 7°33'23.1282W) and Houphouët ville (7°22'54.975''N, 7°33'51.9534W). The climate is monomodal, characterized by a dry season and a rainy season. The average annual temperature is 25°C. The average annual rainfall is 1,632 mm and the average humidity is 82%. Ferralitic soils with average chemical fertility are largely dominant (Tiessé, 2020).

Experimental setup

The experimental setup consists of a Fischer block with four replicates in five (5) half-hectare plots. The cabbage plants were transplanted onto ridges that were 5 m long and 1.5 m wide, with 40 cm spacing between rows and within rows. There were four rows of 12 cabbage plants per ridge. The spacing between ridges was 1 m within each treatment. One ridge constitutes one repetition. Weeding of the plots was carried out as needed. Each cabbage field was divided into four elementary plots. Insecticide treatments of the cabbages were carried out once a week.

Insecticides sprayed on cabbage plants

The insecticides used were Vipère 46 EC (Indoxacarb 30g/L + Acetamiprid 16 g/L) : T1, Tihan 175 OD (Spirotetramat 75 g/L + Flubendiamid 100 g/L): T2, Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/L): T3 and Capaas 80EC (Ememectin benzoate 20g/L + Abamectin 20 g/L + Acetamiprid 40g/L : T4, respectively in the cabbage plots of Houphouët ville, Doyagouiné, Libréville and la Sari. All of these insecticides act by contact and ingestion. Only the control plot (T0) was untreated and was established in Doyagouiné (Table 1).

Insects' conservation and identification

The insects were collected and preserved in labeled pill bottles containing 70% alcohol. Each label indicated the sample number, date, time, and location of collection. The insects were identified using a binocular magnifying glass, which allowed the distinctive characteristics necessary for their classification to be observed, based on dichotomous keys for determining insect orders and families (Roth, 1974).

Table 1. Insecticides used in cabbage farms.

Plot	Insecticides	Active ingredients	Dosage
Control	T0 (untreated)	None	-
Houphouët-ville	Vipère 46 EC (T1)	Indoxacarb 30 g/L + Acetamiprid 16 g/L	40 ml/15L
Doyagouiné	Tihan 175 OD (T2)	Spirotetramat 75 g/L + Flubendiamid 100 g/L	100ml/3L
Libréville	Magic force gold 44 EC (T3)	Acetamiprid 29 g/L + Lamda-cyhalotrin 15 g/L	40ml/15L
Sari	Capaas 80EC (T4)	Ememectin benzoate 20 g/L +Abamectin 20 g/L + Acetamiprid 40 g/L	0.5 L/ha

Sampling of insect's larvae

The larvae of the three lepidoptera species and the damagethey caused were counted ten times during the trial on 12 cabbage plants per plot, once per week, through direct observation. The observations were made from the 20th to the 76th day after transplanting, from 6 a.m. to 8 a.m., three days after each treatment on the leaves. The upper and lower surfaces of the cabbage plants were examined to determine the presence or absence of insects (Diabaté, 2016). During these specified visit periods, the levels of infestation or damage caused by these pests were clearly visible (Diabaté, 2016). The collected larvae were then stored in labeled pill bottles containing 70% alcohol. The insects were identified using a binocular magnifying glass and literature (Roth, 1974; Diabaté *et al*., 2024). The number of plants attacked by the three Lepidoptera and the leaf area attacked were recorded. The attack rate of the plants and the intensity of the attacks caused by these Lepidoptera were calculated.

Attack rate on cabbage plants

The attack rate on *B. oleracea* leaves was calculated using the following formula:

$$Ta = \frac{N * 100}{Nt} \quad (1) \quad ,$$

where:

Ta = Attack rate (%)

N = Number of B. oleraceae plants attacked per treatment

Nt = Total number of plants sampled per treatment

Intensity of attacks on cabbage plants

The intensity of attacks on *B. oleracea* (I) plants by the three lepidoptera species is calculated using the following formula (Aléné *et al*., 2006 ; Diabaté *et al*., 2023) :

$$I = \frac{(P1 x 25\%) + (P2 x 50\%) + (P3 x 75\%) + (P4 x 100\%)]}{[Ps + P1 + P2 + P3 + P4]} \quad (2)$$

With : **Ps** = number of healthy plants, **P1** = number of plants with minor damage, **P2** = number of plants with moderate damage, **P3** = number of plants with severe damage, **P4** = number of plants with very severe damage.

The severity of the attacks is then grouped into four classes (Aléné *et al*., 2006 ; Diabaté *et al*., 2023) :

Class 1 : 0% < I ≤ 10%, the severity of the damage is low (DT1) ;

Class 2 : 10% < I ≤ 30%, the severity of the damage is moderate (DT2) ;

Class 3 : 30% < I ≤ 50%, damage intensity is high (DT3);

Class 4 : 50% < I ≤ 100%, damage intensity is very high (DT4).

Statistical treatments

The number of healthy and attacked cabbage plants, as well as the attack rates, and attack intensity, were analyzed using ANOVA (main effects, p < 5%) with SPSS version 20. The means obtained were discriminated using XLSTAT 2016 software (Fisher's test, p < 5%).

RESULTS AND DISCUSSION

The larvae of the lepidoptera species *P. xylostella*, *H. undalis*, and *S. exigua* consume cabbage leaves and reduce the photosynthetic activity of cabbage plants (Figure 1). The insecticides T1 (Vipère 46 EC: Indoxacarb 30 g/L + Acetamiprid 16 g/L), T2 (Tihan 175 OD: Spirotetramat 75/L + Flubendiamide 100 g/L), T3 (Magic force gold 44 EC: Acetamiprid 29 g/L + Lamda-cyhalothrin 15g/L), T4 (Capaas 80EC: Ememectin benzoate 20 g/L + Abamectin 20 g/L + Acetamiprid 40 g/L) significantly reduced the number of *P. xylostella* (F = 11; p = 0.001), *H. undalis* (F = 47.20; p = 0.001) and *S. exigua* larvae (F = 19.40; p = 0.001) larvae on cabbage plots compared to untreated plots. The insecticide T3 (Magic Force Gold 44 EC : Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/L) significantly reduced the number of *P. xylostella* larvae (0.25 *P. xylostella* larvae) on cabbage plants compared to insecticides T1 : Vipère 46 EC (39.75 *P. xylostella* larvae), T2 : Tihan 175 EC (23.75 *P. xylostella* larvae) and T4: Capaas 80EC (31.75 *P. xylostella* larvae), which have similar efficacy (F = 11; p = 0.001) (Table 2).

The four insecticides used were T1 : Vipère 46 EC (Indoxacarb 30 g/L + Acetamiprid 16 g/L), T2 : (Tihan 175 OD : Spirotetramat 75 g/L + Flubendiamide 100 g/L), T3 : (Magic Force Gold 44 EC : Acetamiprid 29 g/L + Lambda-cyhalothrin 15 g/L), T4 : (Capaas 80EC : Ememectin benzoate 20 g/L + Abamectin 20 g/L + Acetamiprid 40 g/L) were effective against the lepidopteran *H. undalis* (F = 47.20; p = 0.001). *H. undalis* larvae were not recorded on cabbage plants treated with insecticides T1 and T2. The number of *H. undalis* on the plots treated with the insecticides T3 and T4, were 0.5 larvae and 0.25 larvae, respectively (F = 47.20; p = 0.001) (Table 2).

The insecticides used against *S. exigua* were more effective than the control and had similar efficacy (F = 19.404; p = 0.001). Insecticides T2 (Tihan 175 OD: Spirotetramate 75/l + Flubendiamide 100g/l), T3 (Magic force gold 44 EC: Acetamiprid 29 g/l + Lamda-cyhalothrin 15g/l) and T4 (Capaas 80 EC: Ememectin benzoate 20g/l + Abamectin 20g/l + Acetamiprid 40g/l) prevented *S. exigua* larvae from colonizing cabbage plants. On plots treated with the insecticide T3 insecticide, an average of 1.25 larvae were collected per 12 plants (F = 19.40; p = 0.001) (Table 2).

Figure 1. Cabbage plant showing damage caused by lepidopteran larvae.

Table 2. Effectiveness of insecticide treatments on larvae of the three lepidoptera, *P. xylostella, H. undalis, and S. exigua*

Treatment	*Plutella xylostella* ± SE	*Hellula undalis* ± SE	*Spodoptera exigua* ± SE
T0	62.75 ± 0.55 c	4 ± 0.82 b	4,5±1,73 b
T1	39.75 ± 16.90 b	0 a	0 a
T2	23,75 ± 3.69 b	0 a	0a
T3	0.25 ± 0.50 a	0.5 ± 0.58 a	1.25 ± 0.96 a
T4	31.75 ± 25.46 b	0.25± 0.50 a	0a
F	11	47.2	19.404
p	0.001	0.001	0.001

T0: control; T1: Vipère 46 EC (Indoxacarb 30 g/L + Acetamiprid 16 g/L); T2: Tihan 175 OD (Spirotetramat 75 g/L + Flubendiamid 100 g/L); T3: Magic force gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalotrin 15 g/L), T4: Capaas 80EC (Ememectin benzoate 20 g/L +Abamectin 20g/l + Acetamiprid 40 g/L), SE: Standard Error.

The insecticides T2 : Tihan 175 OD (Spirotetramate 75/L + Flubendiamide 100 g/L), T3 : Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lambda-cyhalothrin 15 g/L) significantly reduced attacks and attack intensity on cabbage plants by the larvae of the phytophagous lepidoptera *P. xylostella, H. undalis,* and *S. exigua* compared to insecticides T1 : Vipère 46 EC (Indoxacarb 30g/l + Acetamiprid 16g/l) and T4 : Capaas 80EC (Ememectin benzoate 20g/l + Abamectin 20g/l + Acetamiprid 40g/l) used. The insecticide T4: Capaas 80EC (Ememectin benzoate 20g/l + Abamectin 20g/l + Acetamiprid 40g/l) was the least effective insecticide.

The number of plants attacked, the attack rate, and the intensity of the attacks were higher on plot untreated plots than on plots treated with insecticides. The number of plants attacked and the attack rates were 12 plants attacked/12 plants, or 100%, 3.75 plants attacked, or 31.25%, 1.75 plants attacked, or 14.58%, 2 plants attacked, or 16.67%, and 8.5 plants attacked, or 70.83%, respectively, on plots T0, T1: Vipère 46 EC (Indoxacarb 30 g/L + Acetamiprid 16 g/L), T2: Tihan 175 OD (Spirotetramate 75/L + Flubendiamide 100 g/L); T3: Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/L) and T4: Capaas 80EC (Ememectin benzoate 20 g/L + Abamectin 20 g/L + Acetamiprid 40g/L) ($F = 142.191$; $p = 0.0001$). The intensity of attack was type IV on cabbage untreated plots (72.92%), type III on cabbage plots treated with insecticide T4: Capaas 80EC

(37.50%), type II on plots treated with Vipère 46 EC (12.50%) and type I on plots treated with insecticides T2: Tihan 175 OD (3.65%) and T3: Magic Force Gold 44 EC (4.17%) (Table 3).

Table 3. Attack rate and attack intensity of cabbage plants attacked by the larvae of the Lepidoptera *P. xylostella*, *H. undalis*, and *S. exigua*.

Treatment	Number of healthy plants ± SE	Attacked plants ± SE	Attack rate (%)	Attack intensity (%)
T0	0 ± 0d	12 ± 00 d	100d	72.92d
T1	8.25 ± 1.71b	3.75 ± 1.71b	31.25b	12.50b
T2	10,25 ± 1.41a	1.75 ± 1.41a	14.58a	3.65a
T3	10 ± 1.29a	2 ± 1.29a	16.67a	4.17a
T4	3.5 ± 5.35c	8.5 ± 5.35c	70.83c	37.50c
F	142.191	142.191	142.191	127.369
p	0.0001	0.0001	0.0001	0.0001

T0: control; T1: Vipère 46 EC (Indoxacarb 30 g/L + Acetamiprid 16 g/L); T2: Tihan 175 OD (Spirotetramat 75 g/L + Flubendiamid 100 g/L); T3: Magic force gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalotrin 15 g/L), T4: Capaas 80EC (Ememectin benzoate 20 g/L +Abamectin 20g/l + Acetamiprid 40 g/L), SE: Standard Error.

The insecticide Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/L) was effective on the larvae of the three Lepidoptera species *P. xylostella*, *H. undalis*, and *S. exigua*. These results are similar to those of Vuković *et al*. (2014), who showed that insecticides containing the active ingredient Lamda-cyhalothrin are more effective against the Lepidoptera, especially the cabbage moth *P. xylostella* than pyrethrinoids and organophosphorus insecticides. Furthermore, Abamectin 20 g/L + acetamiprid 40 g/L and emamectin benzoate are not very effective against Lepidoptera (Teja *et al*., 2019). According to these authors, emamectin benzoate had a lower LC50 and persistence toxicity than several insecticides. This lowest efficacy is thought to be due to the resistance of Lepidoptera larvae to these active ingredients. The work of Teja *et al*. (2019) also demonstrated that *P. xylostella* had developed a highest level of resistance to emamectin benzoate. Thus, treatment with Emamectin benzoate 20 g/L + Abamectin 20 g/L + Acetamiprid 40 g/L had a lowest efficacy compared to the other treatments used in cabbage fields. In addition, all of the insecticides tested, Vipère 46 EC (Indoxacarb 30 g/L + Acetamiprid 16 g/L), Tihan 175 OD (Spirotetramat 75 g/L + Flubendiamide 100 g/L), Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/l) and Capaas 80EC (Ememectin benzoate 20 g/L + Abamectin 20 g/L + Acetamiprid 40 g/L) significantly reduced the population of *H. undalis* and *S. exigua*. These insecticides contain toxic and appetite-suppressing active that killed the insects *H. undalis* and *S. exigua*, and caused their population to decline. The attack rates and the intensity of attacks on plots treated with the various insecticides ranged from 14% to 17% and from 3% to 37%, respectively. These rates are similar to those obtained by Ouali-N'Goran *et al*. (2021) in Korhogo, northern Côte d'Ivoire, who showed that the Lepidoptera species *H. undalis* and *P. xylostella* caused attack rates ranging from 57 to 89% and attack intensities ranging from 18 to 39% on *B. oleraceae*. The insecticides Tihan 175 OD (Spirotetramate 75g/L + Flubendiamide 100 g/L) and Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/L) significantly reduced the attack rates and intensity of attacks on cabbage plants by the Lepidoptera *P. xylostella*, *H. undalis*, and *S. exigua*. These insecticides active ingredients have toxic, appetite-suppressing, and repellent effects on lepidopteran pests of cabbage, which reduced the attacks of *B. oleracea* plants. Similar results were reported by Diabaté *et al*. (2024), who showed that the active ingredients of these insecticides prevent feeding and reduced the attack of cotton bolls by the lepidopteran *Helicoverpa armigera*.

CONCLUSION

The insecticides Vipère 46 EC (Indoxacarb 30 g/l + Acetamiprid 16 g/l), Tihan 175 OD (Spirotetramat 75 g/L + Flubendiamide 100 g/L), Magic Force Gold 44 EC (Acetamiprid 29 g/L + Lamda-cyhalothrin 15 g/L) and Capaas 80EC (Ememectin benzoate 20g/l + Abamectin 20 g/L + Acetamiprid 40 g/L) significantly reduced the number of the lepidoptera species *P. xylostella* larvae, *H. undalis* and *S. exigua* larvae on the cabbage plants. The number of attacked plants, the attack rate, and the intensity of attack were higher on the untreated plots than on plots treated with the insecticides. The intensity of the attack was type IV on the cabbage untreated plots (72.92%), type III on the cabbage plots treated with the insecticide Capaas 80EC (37.50%), type II on the plots treated with Vipère 46 EC (12.50%) and type I on the plots treated with insecticides Tihan 175 OD (3.65%) and Magic force gold 44 EC (4.17%), respectively. The insecticides Tihan 175

OD (Spirotetramate 75/l + Flubendiamide 100g/l) and Magic Force Gold 44 EC (Acetamiprid 29 g/l + Lamda-cyhalothrin 15g/l) are effective in controlling of the Lepidoptera species *P. xylostella*, *H. undalis*, and *S. exigua*.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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