



# Comparative Efficacy of Three Doses of COLAM 247 SC in the Management of Cabbage Insect Pests in Western Burkina Faso

Alizèta Sawadogo <sup>a\*</sup>, Rabieta Simdé <sup>a</sup>, Elias Mano <sup>b</sup>  
and Issaka Zida <sup>a</sup>

<sup>a</sup> Centre National de la Recherche Scientifique et Technologique, Institut de l'Environnement et de Recherches Agricoles, Centre Régional de Référence en fruits et légumes, Laboratoire Central d'Horticulture, BP 910 Bobo-Dioulasso, Burkina Faso.

<sup>b</sup> Centre National de la Recherche Scientifique et Technologique, Institut de recherche en Sciences Appliquées et Technologies, Centre Régional de référence en fruits et légumes, Laboratoire Central d'Horticulture, BP 910 Bobo-Dioulasso, Burkina Faso.

## Authors' contributions

This work was carried out in collaboration among all authors. Authors AS and IZ designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author AS managed the analyses of the study. All authors read and approved the final manuscript.

## Article Information

DOI: <https://doi.org/10.9734/jabb/2024/v27i101528>

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/124487>

Original Research Article

Received: 01/08/2024

Accepted: 02/10/2024

Published: 16/10/2024

## ABSTRACT

**Aims:** Contribute to protect Cabbage crops by evaluating the biological efficacy of a new binary, COLAM 247 SC.

**Study Design:** A completely randomized Fisher block with five treatments and four replicates.

\*Corresponding author: E-mail: [alizsaw@yahoo.fr](mailto:alizsaw@yahoo.fr), [atezila82@gmail.com](mailto:atezila82@gmail.com);

**Cite as:** Sawadogo, Alizèta, Rabieta Simdé, Elias Mano, and Issaka Zida. 2024. "Comparative Efficacy of Three Doses of COLAM 247 SC in the Management of Cabbage Insect Pests in Western Burkina Faso". *Journal of Advances in Biology & Biotechnology* 27 (10):1062-72. <https://doi.org/10.9734/jabb/2024/v27i101528>.

**Place and Duration of Study:** The efficacy of some insecticides on Cabbage's insect pests was carried out in a farming environment on the developed perimeter of the Vallée du Kou, region of Hauts Bassins, Burkina Faso between September and December 2022.

**Methodology:** Treatments included Colam 1 (0.075 l/ha), Colam 2 (0.15 l/ha), Colam 3 (0.25 l/ha), K-optimal (1 l/ha) and the untreated control. Each elementary plot covered an area of 24 m<sup>2</sup>. The distance between elementary plots was 1 m and that between blocks was 2 m. Plant spacing was 0.5 m between bunches and 0.8 m between rows, for a total of 60 plants per elementary plot

**Results:** More than 80% of Aphids populations was reduced by the three doses of Colam 247 SC and K-optimal. The low reduction rates of diamondback moth larvae population were observed with the three doses of Colam 247 SC (14.36 to 21.79%) while K-optimal failed to reduce the larvae population of this insect pest. Chemical insecticide used contributed to improve cabbage yield (74.5 to 89.30 t/ha) as compared to the control (73.50 t/ha) even though statistical analyses did not reveal any significant difference ( $P > .05$ ).

**Conclusion:** The Colam 247 SC at the dose of 0.15 l/ha can be used by farmers as an additional insecticide in the control of cabbage insect pests.

**Keywords:** Cabbage crop; density; yield; insecticide; chemical control; caterpillar.

## 1. INTRODUCTION

In Burkina Faso, agriculture employs 80% of the population and contributes an average of 33% to gross domestic product [1]. The area of arable land is estimated at 9 million hectares and includes cereal, cash and vegetable crops [2]. Market gardening is generally practiced in the dry season and helps to combat unemployment and the food crisis [3]. They are grown in areas where water is accessible, i.e. in low-lying areas, rivers and dams [4]. Several types of vegetable are produced, both exotic and local. Among these, cabbage (*Brassica oleracea* L.), from the Brassicaceae family, is one of the main vegetable crops produced in Burkina Faso. It is one of the most widely grown vegetable crops in the world. According to statistics of the [5], cabbage is grown in almost 150 countries, with an annual production of 70 million tons. In Burkina Faso, this crop ranks third after bulb onions and tomatoes, with national production of 107,476 tonnes. Almost all of this production is marketed (99.1%), with relatively high-income levels for producers. The annual profit generated by cabbage growing is estimated at over 14.47 billion F CFA, or 18% of total vegetable production [6]. The most productive regions in Burkina Faso are Centre, Centre-Ouest and Hauts-Bassins [6]. It is renowned for its nutritional values, notably its richness in vitamins A, C, K, B6 and antioxidants [7]. Consumption of cabbage reduces the risk of contracting certain diseases such as cancer, cardiovascular disease, cataracts and diabetes [8]. However, this vegetable falls victim to the attacks of several insect pests, which constitute a major

constraint to its production. In Africa, the main insect pests infesting cabbage are diamondback moth (*Plutella xylostella*), cabbageworm (*Helula undalis*), cabbageworm (*Pieris brassicae*), cabbage aphid (*Brevycoryne brassicae*), cabbage looper (*Trichoplusia ni*) and green peach aphid (*Myzus persicae*) [9,10]. However, the diamondback moth and cabbageworm are the most destructive insect pests of Brassica vegetable crops in many parts of African countries, and are especially damaging in tropical and subtropical regions [11,12]. These insects attack the leaves, apical bud, head and stem, causing enormous damage to cabbage [13,14]. Indeed, insect pests can cause production losses ranging from 10 to 30% on crops [15]. These insect pests infest *Brassica oleracea* crops at different growth stages, causing enormous destruction to cabbage crops during the growing stages and resulting in huge yield losses in the fields [16,11]. Damage and its impact on yield depend on the cabbage variety grown and other ecosystem elements such as natural enemies, weather conditions, fertilizer and water availability [17,12].

Smallholder farmers in African countries rely intensively on the application of synthetic broad-spectrum pesticides to control cabbage insect pests [18]. Most pesticides (around 79%) used are synthetic broad-spectrum insecticides, including organophosphates (OPs) (profenofos, WHO class II), pyrethroids (cypermethrin and deltamethrin, WHO class II) and avermectin preparations (abamectin, WHO class Ib), with WHO class Ib considered very hazardous and WHO class II moderately hazardous [18,19].

Several products are used to control cabbage insect pests, most of them belonging to the pyrethroid group. These pyrethroids are a new generation of pesticide which, thanks to their liposolubility, pass through the insect membrane and act on the nervous system [20]. But the permanent and continuous use of the same product could lead to resistance in insect pests [18,21]. To help provide growers with a wide range of products, a new binary insecticide under the trade name COLAM 247 SC, consisting of Lambda-cyhalothrin 106 g/l + Thiamethoxam 141 g/l, was tested on farmers. It is a broad-spectrum, highly systemic, translaminar, long-acting contact insecticide, particularly suited to the control of larvae and adults of chewing, biting-sucking and sucking insects. It belongs to the neonicotinoid pyrethroid family. The general aim of this study is to assess the biological efficacy of COLAM 247 SC against aphid and caterpillar pests of cabbage. More specifically, the aim will be to determine the dose needed to reduce the population density of insect pests, and to compare this dose with that of the product commonly used by growers to manage these pests.

## 2. MATERIALS AND METHODS

### 2.1 Study Site

The study was carried out in a farming environment on the developed perimeter of the Vallée du Kou, region of Hauts Bassins, Burkina Faso. This perimeter is in the rural commune of

Bama, which is located 25 km, northwest of the city of Bobo-Dioulasso. It is located between 11°23'48" North latitude, 4°25'37" West longitude and at an altitude of 300 m.

### 2.2 Materials

The biological material used is the cabbage variety (*Brassica oleracea* var. capitata L) Oxylus F1. This variety can be grown all year round, with a cycle of 70-75 days. The technical equipment consisted of a 16 liters backpack sprayer and personal protective equipment (PPE). The phytosanitary products used were the test product, Colam 247 SC, with the active ingredients' lambda-cyhalothrin 106 g/l and thiamethoxam 141 g/l, and the reference product, K-Optimal, with the active ingredients' including lambda-cyhalothrin (15 g/l) and acetamiprid (20 g/l).

### 2.3 Methods

#### 2.3.1 Experimental device

The experimental device was a completely randomized Fisher block. Each block consisted of five treatments repeated four times. Each elementary plot covered an area of 24 m<sup>2</sup>. The distance between elementary plots was 1 m and that between blocks was 2 m. Plant spacing was 0.5 m between bunches and 0.8 m between rows, for a total of 60 plants per elementary plot (Fig. 1).



Fig. 1. Experimental set-up of the trial (KOP= K-Optimal; TNT= Control; Colam 1= dose of 0.075l/ha; Colam 2= dose of 0.15l/ha; Colam 3= dose of 0.25 l/ha)

### 2.3.2 Cultivation management

A nursery was set up and maintained to produce healthy and vigorous Cabbage's plants. No insecticide treatments were applied to the plants in the nursery. Regular watering was carried out while the plants were in the nursery. Four weeks later, the plants were transplanted according to the above-mentioned experimental device. A well-decomposed organic fertilizer was applied after transplanting. An application of 0.5 t/ha of NPK fertilizer (15-15-15) was made in two fractions of 0.25 t/ha. The first application was made two weeks after transplanting and the second after 45 days. Irrigation and weeding operations were carried out on demand.

### 2.3.3 Insecticide applications

Insecticide applications were made every 14 days to all cabbage plants in each elementary plot, in accordance with the dose and treatment indicated (Table 1). Three doses of COLAM 247 SC were compared with each other and with the effective dose of the reference product. The first application was made as soon as insect pests appeared in the cabbage plots. Sprays were applied with a backpack pressure washer, taking care to rinse the washer between treatments. A total of five treatments were carried out during this study.

### 2.3.4 Evaluation of insect pest population density

To assess the density of insect pests, a sample of 10 cabbage plants taken at random from the central rows of each elementary plot was selected for observation. These observations consisted in identifying and counting aphid populations and lepidopteran larvae (*Hellula*

*undalis* and *Plutella xylostella*). A first observation was made in all plots before the first application of the insecticides to assess the initial insect density (aphids and caterpillars), then at one-week intervals until the end of the experiment.

### 2.3.5 Evaluation of insect infestation levels on cabbage

The infestation rate of cabbage plants was assessed on 10 plants in each elementary plot. These plants were marked to avoid double counting. Careful observations were made on these plants to check for the presence of insect pests. A plant is considered non-infested if no insects or symptoms of damage are observed on it. It is considered infested if at least one insect pest is found. Infestation rates were assessed on 23<sup>th</sup> day after transplantation (DAT) (before the first treatment) and 30<sup>th</sup> DAT (one week after the first treatment). Infestation rates were calculated using the following formula:

$$T = \left( \frac{A}{B} \right) * 100 \quad T = \text{infestation rate; } A = \text{total number of infested plants; } B = \text{total number of observed plants}$$

### 2.3.6 Cabbage yield assessment

At maturity stage, all cabbages in the central rows of each elementary plot were harvested. They were then counted and weighed using a balance. All unheaded cabbages due to insect attack were also identified and counted in each elementary plot. The unheaded cabbages listed had characteristics such as the presence of several "heads" or completely perforated leaves. The presence of several cabbage "heads" is a plant response to *H. undalis* larvae attack.

**Table 1. Summary of objects to be compared**

Treatments	Active substance	Dose (l/ha)	Quantity of material / 96 m <sup>2</sup>
COLAM 1	lambda-cyhalothrine 106 g/l + thiaméthoxame 141 g/l	0.075	0.75 ml diluted in 5 l of water
COLAM 2	lambda-cyhalothrine 106 g/l + thiaméthoxame 141 g/l	0.15	1.5 ml diluted in 5 l of water
COLAM 3	lambda-cyhalothrine 106 g/l + thiaméthoxame 141 g/l	0.25	2.5 ml diluted in 5 l of water
K-Optimal	acétamipride 20 g/l + lambda cyhalothrine 15 g/l	1	10 ml diluted in 5 l of water
Untreated Control	-	-	-

## 2.4 Data Analysis

The data collected were subjected to Shapiro's and Fligner's tests using R software to verify normality and homogeneity of variances. As the data did not meet these criteria, a non-parametric Kruskal-Wallis test was performed to compare the different means. In the event of significant differences between treatments, the pairwise-test was used to separate the different means at the 5% probability threshold. The following formula of Henderson and ilton [22] was used to calculate the biological efficacy of insecticides tested during the study.

$$Ep(\%) = \left[ 1 - \left( \frac{DTa}{DTb} \times \frac{DCb}{DCa} \right) \right] \times 100, \text{ where}$$

DTb and DCb = pest density before pesticide application in treated and control plots respectively; and DTa and DCa = pest density after pesticide application in treated and control plots respectively.

The parameters considered in these analyses were:

- Average number of insects / cabbage plant according to observation and product application periods;
- Cabbage yield obtained for each treatment;
- Infestation rates.

## 3. RESULTS AND DISCUSSION

### 3.1 Results

#### 3.1.1 Cabbage insect pests' population fluctuations during the study

The most important insect pests found on cabbage plots during the study were aphids and larvae of the butterflies, *Plutella xylostella* and *Helilla undalis*. Aphids were the most abundant, with a total number of 14,196 individuals, followed in sequence by *P. xylostella* larvae (1,539 individuals) and *H. undalis* larvae (85 individuals).

##### 3.1.1.1 Aphid population fluctuations as a function of treatments

Fig. 2 illustrates the effect of treatments on aphid population fluctuation. In this figure, it can be seen that the three doses of COLAM 247 SC and K-Optimal significantly reduced aphid density compared with the control ( $P < .001$ ).

In fact, immediately after the first treatment, which was carried out at 23 days after transplanting (DAT), aphid density decreased in all treated plots and was cancelled out from 30<sup>th</sup> DAT onwards. Over the same period, aphid density in untreated plots increased rapidly until the end of the experiment. Aphid density reduction rates for Colam 1, Colam 2, Colam 3 and K-Optimal were 89%, 97.74%, 99.81% and 99.64% respectively, compared with the untreated control (Table 2).

**Table 2. Biological efficacy rate of different treatments on aphids**

Treatments	Mean efficacy rate (%)
Control	-
COLAM 1	89
COLAM 2	97.74
COLAM 3	99.81
K-Optimal	99.64

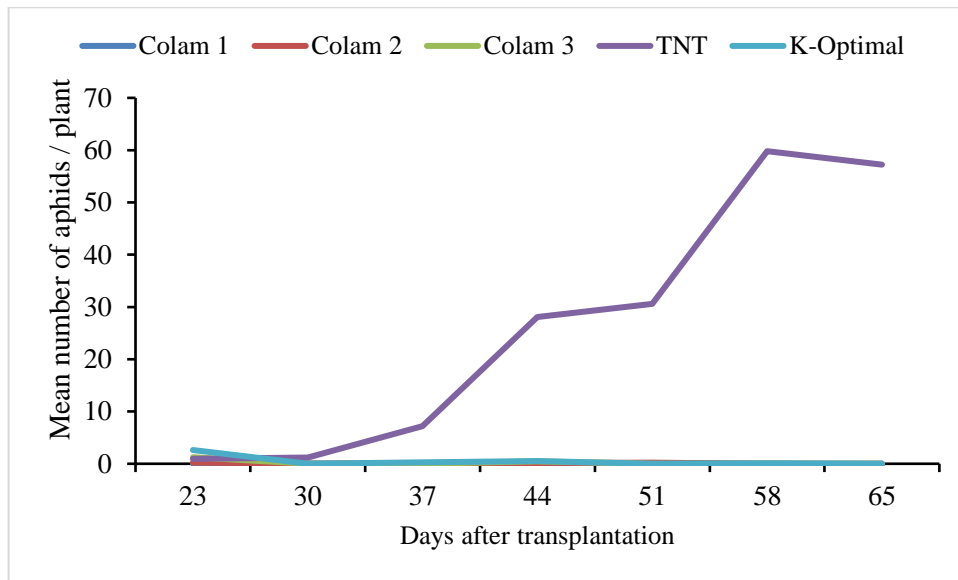
##### 3.1.1.2 Fluctuations in *P. xylostella* larvae populations as a function of treatments

The average number of *P. xylostella* larvae varied in a sawtooth pattern across all treatments (Fig. 3). After the first insecticide applications, the population density of *P. xylostella* larvae decreased in all plots, in contrast to the untreated plots. From the 37<sup>th</sup> DAT, when the second insecticide application took place, the density of the diamondback moth larvae increased significantly in plots treated with K-Optimal and Colam 2, before declining from the 44<sup>th</sup> DAT. The lowest pest larvae density was obtained with Colam 3.

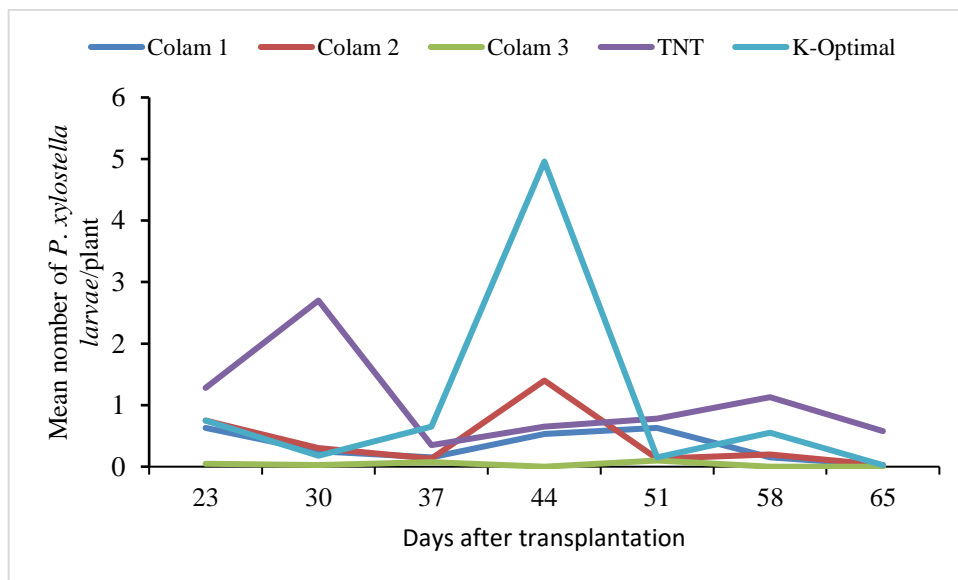
Observation of the variation curves for *P. xylostella* larvae population density shows that the different doses of Colam used were less effective in reducing *P. xylostella* larvae density. As for the K-Optimal, it was ineffective against *P. xylostella* larvae, so that plots treated with this product had a gain in insects compared with the untreated ones. Reduction rates were 14.36%, 16.06%, 21.79% and -193.20% respectively for Colam 1, Colam 2, Colam 3 and K-Optimal.

**Table 3. Biological efficacy rates of different treatments on *P. xylostella* larvae**

Treatments	Mean efficacy rate (%)
Untreated control	-
COLAM 1	14.36
COLAM 2	16.04
COLAM 3	21.79
K-Optimal	-193.20



**Fig. 2. Aphid populations' fluctuation depending on the treatments**



**Fig. 3. Fluctuation of the populations of *P. xylostella* larvae according to the treatments**

### 3.1.1.3 Fluctuation in *Hellula undalis* larvae populations according to the treatments

In both treated and control plots, the average number of *H. undalis* larvae was very low, ranging from 0 to 0.2 individuals/plant. Fig. 4 illustrates the fluctuating density of *H. undalis* larvae populations were highest in untreated control plots.

### 3.1.2 Effect of treatments on plant infestation levels

Table 4 shows the effect of different treatments on plant infestation levels. Statistical analyses

show a significant difference between treatments ( $P=.01$ ). Rates of infested cabbage plants ranged from  $43.75 \pm 21.34\%$  for those treated with K-Optimal to  $73.75 \pm 10.61\%$  for untreated controls. Plots treated with all three doses of colam had less infested cabbage plants compared with the control plot.

### 3.1.3 Cabbage yields

Cabbage yields recorded according to each treatment are presented in Table 5. Statistical analysis revealed no significant difference between treatments ( $P = .68$ ), but plots treated

with the three doses of Colam 247 SC and the single dose of K-Optimal were better (74.5 to 89.30 t/ha) than untreated plots (73.3 t/ha). These yields were related to the number of apples obtained, which was high, with larger apples in the treated plots than in the control plots. The average number of unapple cabbages obtained at harvest was higher in the control plots than in the treated ones.

**Table 4. Effect of the treatments on cabbage infestations by insect pests**

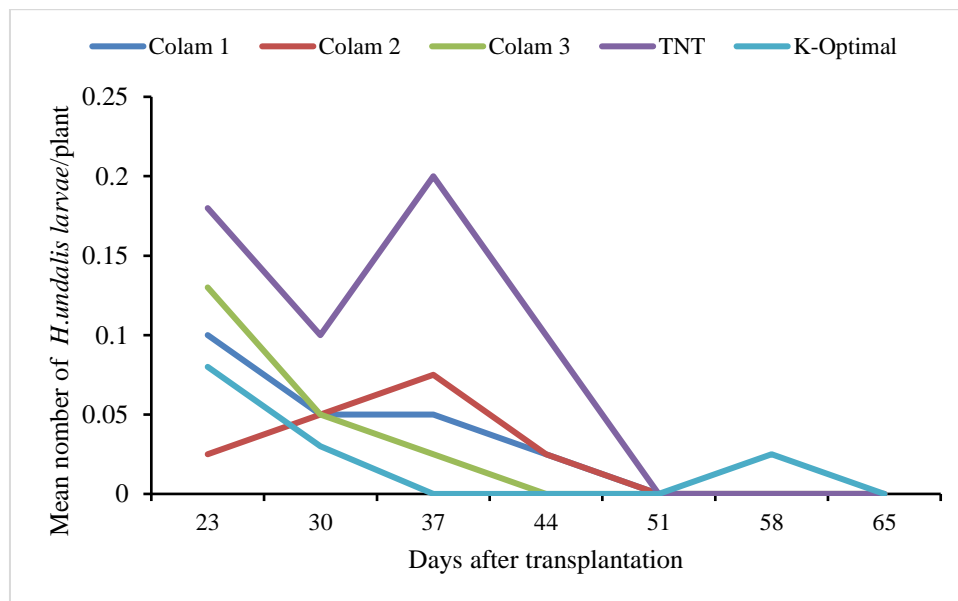
Treatments	Infestation rates (%)
Untreated control	73.75 ± 10.61 a
COLAM 1	46.25 ± 20.66 b
COLAM 2	46.25 ± 16.85 b
COLAM 3	40.00 ± 14.14 b
K-Optimal	43.75 ± 21.34 b
<i>P</i>	.01*

### 3.2 Discussion

The main insect pests observed on Cabbage plots during our study were already encountered in cabbage fields in other African countries such as Côte d'Ivoire, Senegal, Ghana and Tanzania [23,14, 20]. *Plutella xylostella* is an oligophagous species, and its larvae feed mainly on plants of the brassica family, such as cabbage [24,25]. The larvae of this insect pest can attack cabbage from the nursery to the field causing damage [26,18]. *H. undalis* larvae attack the "heart" of the

cabbage, which can lead to its death. A single larva can destroy an entire plant [27,28]. Aphids, for their part, have been found on both sides of leaves and can cause the death of the plant in the absence of any phytosanitary treatment. Attacks inflicted by these insect pests on cabbage limit its productivity and consequently economic losses [16,11]. To control these insect pests, several synthetic products are used with the aim of minimizing production losses [18,29].

The biological efficacy of the three doses of the chemical insecticide, Colam 247 SC, was evaluated in comparison with the reference control and the untreated control. Statistical analyses showed that the efficacy of Colam 247 SC varied significantly depending on the insect pest considered. In fact, the three doses of Colam 247 SC and the reference control (K-Optimal) reduced the aphid population by over 80% as compared to the untreated control. These products are broad-spectrum binary insecticides, acting by contact or systemically, and with active ingredients that certainly give them a better effect on aphids. These results corroborate those of Yao et al. [30] who found that K-Optimal rapidly reduced the aphid population density. These results are also in accordance with those presented by Labrie [31], who showed that the combined use of thiamethoxam + lambda-cyhalothrin significantly reduced aphid population density.



**Fig. 4. Fluctuation of populations *H. undalis* larvae according to the treatments**

**Table 5. Effect of treatments on cabbage yields**

Treatments	Average number of head cabbage	Average number of headless cabbages	Yield (t/ha)
TNT	123 ± 11.80	10 ± 2.12	73.30 ± 10.61
COLAM 1	123.75 ± 6.75	6.25 ± 1.65	74.50 ± 11
COLAM 2	124.25 ± 11.17	9.25 ± 2.95	77.20 ± 10.98
COLAM 3	137.25 ± 13.40	8.25 ± 2.39	88.50 ± 11.88
K-Optimal	142.50 ± 7.58	3.75 ± 1.38	89.30 ± 9.11
P	.45	.28	.68

As for *P. xylostella* larvae, the reduction rate was very low and varied from one dose of Colam 247 SC to another. The highest reduction rate (21.79%) was obtained with the high dose of Colam 247 SC. The use of K-Optimal did not control this insect pest compared with the untreated control, although this insecticide is commonly used by growers in the control of cabbage insect pests in Burkina Faso. These findings suggest that *P. xylostella* has developed a certain resistance to this insecticide, making it difficult to control its larval populations. Studies have shown that *P. xylostella* larvae are resistant to over 50 insecticides and to *Bacillus thuringiensis* [32,33,34,35,36]. In Burkina Faso, the Hauts-Bassins region is one of the most important cabbage-growing areas, and this crop is grown all the year round with insecticide treatments. This practice could lead to insecticide resistance in certain insect pests. Indeed, several authors have stated that in areas where cabbage is grown all the year round, the level of resistance is very high due to the continuous use of insecticides [37,29,38].

The density of *H. undalis* larvae found on the plants during the study was very low, so statistical analysis did not reveal significant difference between treatments. However, symptoms of damage caused by this insect pest were observed in the plots where cabbage plants were growing. Indeed, some cabbage plants with several heads were often observed in the field during the experiment, as also showed by Sall [39] in Senegal on plants attacked by *H. undalis* larvae.

The average infestation rates in plots treated with the three doses of Colam 247 SC and K-Optimal were significantly low compared to the untreated control; this was obvious given that the number of individuals of the various insect pests recorded was high in the control plots. Studies have shown that the degree of infestation of cabbage by insect pests was higher in control plots than in plots treated with chemical insecticides [10,28].

The results of statistical analyses on cabbage yield show that these infestations did not cause any damage that could affect the cabbage head. Therefore, in our study conditions, Cabbage yield was not correlated with insect pest's infestation rates. Although the effects were not significant, the average number of cabbages harvested in the treated plots was higher than in the untreated control, which translated into higher yields. In fact, the cabbage harvested in the treated plots were larger as compared to those recorded in control plots.

#### 4. CONCLUSION

The aim of this study was to evaluate the biological efficacy of three doses of Colam 247 SC on cabbage insect pests, compared with the reference control, K-Optimal, and the untreated control. From the analysis of the present findings, it can be concluded that all three doses of Colam 247 SC (0.075 l/ha; 0.15 l/ha; 0.25 l/ha) are more effective in controlling aphid populations in cabbage fields. The same applies to K-optimal, which was effective against aphids. On the other hand, *P. xylostella* larvae remained active in all plots throughout the trial, despite the treatments. The low density of *H. undalis* in the individual plots made it impossible to assess the efficacy of the product. According to the results of the statistical analyses, the treatments had no effect on marketable cabbage yields, but the numerical values showed an advantage in the treated plots. Findings of the current study showed that chemical insecticide are increasingly ineffective against cabbage's insect pests including *P. xylostella*. Therefore, alternative control strategies involving botanical pesticides and biopesticides, which can effectively control those insect pests should be developed.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image



generators have been used during the writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. PNDES. National Economic and Social Development Plan of Burkina Faso 2016-2020, Ouagadougou, Burkina Faso. 2016; 97.
2. PNSR. National Rural Sector Program, Ouagadougou, Burkina Faso. 2011;72.
3. MAHRH. Analysis of the market gardening sector in Burkina Faso. Ministry of Agriculture, Hydraulics and Fisheries Resources, Ouagadougou, Burkina Faso. 2007;127.
4. CAPES. Contribution of dry season crops to poverty reduction and improvement of food security, Ouagadougou, Burkina Faso. 120.
5. FAO, FAOSTAT. Food and Agriculture Organization of the United Nations. Food Security data and Definitions; 2011.
6. MAH. Market gardening module analysis report. Phase 2: General agricultural census 2006-2010. Ouagadougou, Burkina Faso.2011;318.
7. Agata K. Cabbage - family Vegetables, Nutritional Value and Recipes, University of Florida. 2018;4.
8. Nora Moreb, Amy Murphy, Swarna Jaiswal, Amit K. Jaiswal, Chapter 3 - Cabbage, Editor(s): Amit K. Jaiswal, Nutritional Composition and Antioxidant Properties of Fruits and Vegetables, Academic Press. 2020;33-54. ISBN 9780128127803, Available:<https://doi.org/10.1016/B978-0-12-812780-3.00003-9>.
9. Baidoo P, Adam J. The Effects of Extracts of *Lantana camara* (L.) and *Azadirachta indica* (A. Juss) on the Population Dynamics of *Plutella xylostella*, *Brevicoryne brassicae* and *Hellula undalis* on Cabbage. Sustainable Agriculture Research. 2012;1:229–234.
10. Baidoo PK, Mochiah MB. Comparing the effectiveness of Garlic (*Allium sativum* L.) and Hot pepper (*Allium frutescens* L.) in the management of the major pests of Cabbage *Brassica oleracea* (L.). Sustainable Agriculture Research. 2016;5(2):83. Available:<https://doi.org/10.5539/sar.v5n2p3811>.
11. Furlong MJ, Wright DJ, Dosedall, LM. Diamondback moth ecology and management: Problems, progress, and prospects. Annual Review of Entomology, 2013;58:517–541.
12. Labou B, Brévault T, Sylla S, Diatte M, Bordat D, Diarra K. Spatial and incidence of insect pests in farmers' cabbage fields in Senegal. International Journal of Tropical Insect Science. 2017;37(04):255-233. Available:<https://doi.org/10.1017/s1742758417000200>
13. Mensah ACG, Sikirou R, Assogba Komlan F, Yarou BB, Midingoyi S-KG, Honfoga J. et al. Cabbage in quantity and quality for food and nutritional security in Benin. Technical-Economic Framework (TEF). MAEP/INRAB/IFAD/ProCar/PADMAR/World Vegetable Center/Benin. Legal deposit No. 11558, dated 08/26/2019, National Library (BN) of Benin, 3rd quarter; 2019.
14. Ouali N'Goran S-W M, Kouassi MA, Coulibaly A. Assessment of damage by insect pests on cabbage's crops (*Brassica oleracea* var. *capitata* L.) in Korhogo, Northern Côte d'Ivoire. International journal of Biological and chemical science. 2021; 15(1):106-116.
15. Tewary DK, Bhardwaj A, Shanker A. Pesticide activities in five medicinal plants collected from mid hill of Western Himalayas. Industrial Crops and Products, Journal of applied Bioscience. 2005;3(4): 411-418.
16. Timbilla J, Nyarko K. A survey of cabbage production and constraints in Ghana. Ghana Journal of Agricultural Science. 2004;37:93–101.
17. Weinberger K, Srinivasan R. Farmers' management of cabbage and cauliflower pests in India and their approaches to crop protection. Journal of Asia Pacific Entomology. 2009;12:253–259.
18. Labou B, Brévault T, Bordat D, Diarra K. Determinants of parasitoid assemblages of the diamondback moth, *Plutella xylostella*, in cabbage farmer fields in Senegal. Crop Protection. 2016;89:6–11.
19. Kapeleka JA, Sauli E, Sadik O, Ndakidemi PA. Biomonitoring of Acetylcholinesterase (AChE) Activity among Smallholder Horticultural Farmers Occupationally Exposed to Mixtures of Pesticides in Tanzania. International Journal of

- Environmental Research and Public Health. 2019;1–11.
20. Richou-Bac L, Venant A. A new family of insecticides: synthetic pyrethroids. Bulletin of the French Veterinary Academy. 1985; 138-2(199-212):21.
  21. Mpumi N, Machunda RL, Mtei KM, Ndakidemi PA. Insecticidal Efficacy of *Syzygium aromaticum*, *Tephrosia vogelii* and *Croton dichogamus* Extracts against *Plutella xylostella* and *Trichoplusia ni* on *Brassica oleracea* crop in Northern Tanzania. Agriculture and Food. 2021;6 (1):185–202. DOI:10.3934/agrfood.2021012
  22. Henderson CF, Tilton EW. Tests with acaricides against the brow wheat mite. Journal of Economic Entomology. 1955;48: 157-161.
  23. Walangululu JM, Mushagalusa GN. The main pests of headed cabbage (*Brassica oleracea* var *capitata* subs *sabouda*) in Bukavu and its surroundings, Tropicultura. 2000;18(2):55-57
  24. Rahn R. Lepidoptera as pests of cabbage crops in western France. INRA Rennes, 1983;13.
  25. Monnerat RG. Interrelationships between the “Diamond Moth” *Plutella xylostella* (L.), its parasitoid *Diadegma* sp. (Hymenoptera: Ichneumonidae) and the entomopathogenic bacterium *Bacillus thuringiensis* Berliner. Agronomy thesis. Ecole Nationale Supérieure d’Agronomie, Montpellier. 1995;162.
  26. Sow G, Diarra K, Arvanitakis L, Bordat D. The relationship between the diamondback moth, climatic factors, cabbage crops and natural enemies in a tropical area. Folia Horticulturae. 2013;25:3–12.
  27. Sivapragasam A, Chua TH. Natural enemies for the cabbage webworm, *Hellula undalis* (Fabr.) (Lepidoptera: Pyralidae) in Malaysia. Population Ecology. 1997;39(1):3-10. Available:https://doi.org/10.1007/bf02765244
  28. Vaishnavi M, Trayde AR. Efficacy of Certain Insecticides and Biopesticides against Dimondback Moth *Plutella xylostella* (Linnaeus) on Cabbage, *Brassica oleracea* (Linnaeus). International Journal of Plant & Soil Science. 2022;34 (22):1071-1076
  29. Mpumi N, Machunda RL, Mtei KM, Ndakidemi PA. Selected insect pests of economic importance to *Brassica oleracea*, their control strategies and the potential threat to environmental pollution in Africa. Sustainability. 2020;12(9):1-22. Available:https://doi.org/10.3390/su12093824
  30. Yao BL, Gogoué DO, Nando PM, Tano K. Comparative study of the efficacy of aqueous extracts of eucalyptus leaves (*Eucalyptus camaldulensis*) and neem seeds (*Azadirachta indica* Juss.) against the main cabbage pests. International journal of Biological and chemical science. 2022;16(2):581-592
  31. Labrie G. Synthesis of the scientific literature on the soybean aphid, *Aphis glycines* Matsumura. Prime-Vert Program Volet 11. Grain Research Center Inc. (CÉROM). 2010;49.
  32. Sanchis V, Chaufaux J, Lereclus D. Use of *Bacillus thuringiensis* in crop protection and insect resistance. Cahiers Agricultures. 1995;4:405-416.
  33. Tabashnik BE, Liu YB, Finson N, Masson L, Heckels DG. One gene in diamondback moth confers resistance to four *Bacillus thuringiensis* toxins. Proceedings of the National Academy of Sciences of the USA. 1997;94:1640-1644.
  34. Guilloux T. Study of the biological, biochemical and genetic variability of populations of different geographical origins of *Cotesia plutellae* (Kurdjumov) (Hymenoptera: Braconidae), parasitoid of the brassica moth *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae). PhD thesis, Paul Valery University, Montpellier III. 2000;215.
  35. Kim SM, Hur JH, Han DS, Cho JM, Kim KJ. Diamondback moth (*Plutella xylostella* L.) resistance to organophosphorus and carbamate insecticides in Kangwon alpine vegetable croplands. Korean Society of Pesticide Science. 2001;5:24-30.
  36. Choyon M, Akhter N, Rahman MM, Hossain E. Effectiveness of Some Bio-Pesticides in Managing Major Lepidopteran Insect Pests of Cabbage (*Brassica oleracea* Var. *Capitata* L.). Asian Research Journal of Agriculture. 2022;15 (3):44-51. Available:https://doi.org/10.9734/arja/2022/v15i330160.
  37. Gnago J, Danho M, Agneroh T, Fofana I, Kohou A. Efficacy of neem (*Azadirachta indica*) and papaya (*Carica papaya*) extracts in the control of insect pests of okra (*Abelmoschus esculentus*) and

- cabbage Brassica oleracea in Côte d'Ivoire. International Journal of Biological and Chemical Sciences. 2011; 4(4). Available:<https://doi.org/10.4314/ijbcs.v4i4.63035>
38. Singh B, Singh N, Singh S. Population dynamics of insects' pests associated with Cabbage and Cauliflower and farmers' friendly IPM. Indian Journal of Entomology. 2022;1-3. Available:<https://doi.org/10.55446/ije.2022.804>
39. Sall Sy D. Point sur le suivi des ravageurs du chou dans les Niayes, ISRA CDH/UCAD/AUMN. 2013;26.

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*

<https://www.sdiarticle5.com/review-history/124487>