International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print); 2222-5234 (Online)
Website: https://www.innspub.net
Email contact: info@innspub.net
Vol. 27, Issue: 3, p. 177-185, 2025

RESEARCH PAPER OPEN ACCESS

Comparative effectiveness of BioArt and Rapax AS in reducing the main pests in plots of cabbage and tomato in the Niayes area

Toffène Diome*[1], Mamecor Faye[2], Ablaye Faye[1], Astou Faye[1], Mbacké Sembène[1]

[1]*Laboratory of Genomic, Department of Animal Biology, Faculty of Sciences and Technology, Cheikh Anta Diop University of Senegal, Senegal*

[2]*Laboratory of Parasitology, Department of Animal Biology, Faculty of Sciences and Technology, Cheikh Anta Diop University of Senegal, Senegal*

Key words: BioArt, Cabbage, Combat, Pests, Rapax, tomato

DOI: https://dx.doi.org/10.12692/ijb/27.3.177-185 Published: September 21, 2025

ABSTRACT

In Senegal, vegetable yield represents 83.04% of total horticultural production. Several speculations have contributed to this increase; this is the example of cabbage and tomato. However, the latter are subject to many predations, notably those of pest insects. To overcome these problems, farmers resort to the use of chemical inputs that are not only harmful to human health and the environment but also cause resistance from pests. It is in this context that this work which consists of testing the effectiveness of BioArt to combat these pests, with the aim of preserving tomato and cabbage crops in the Niayes area. The Fisher block was the experimental device used for both speculations. It consists of random blocks divided into nine elementary plots each, including 3 treatments (T0 = water, T1 = BioArt, T2 = Rapax AS (reference control) and three repetitions. The application of BioArt and Rapax in culture media has been shown to be ineffective on *Plutella xylostella*, *Hellula undalis* and *Pseudococcus* sp. ($p>0.05$). On the other hand, BioArt is very effective on *Helicoverpa armigera* ($p=0.03$) as well as Rapax. It should also be noted that BioArt is more effective against tomato and cabbage pests than Rapax and seems to have a positive effect on the yield and growth of the plant. The evaluated BioArt proved effective in safeguarding crops, highlighting its potential as a valuable tool in integrated pest management strategies.

***Corresponding author:** Toffène Diome ✉ toffene.diome@ucad.edu.sn

INTRODUCTION

In Senegal, diversification market gardens offer interesting alternatives during the dry season. Total horticultural production (fruits and vegetables) in Senegal at the end of the 2019-2020 season recorded an increase of 12.3% compared to the 2018-2019 season, according to data compiled by the Horticulture Authority (Savana, 2021). Vegetable yield is predominant, representing 83.04% of the total horticultural production in Senegal. Several speculations have contributed to the increase in vegetable production; it is the example of headed cabbage that comes first (+80.4% at 189.618 tonnes) and the cherry tomato (+10.4% at 78.396 tonnes). However, the latter face numerous predations notably those of insects such as *Helicoverpa armigera* often called the tomato moth (Nibouche *et al.*, 2007), *Plutella xylostella* (Lepidoptera, Plutellidae), *Hellula undalis* (Lepidoptera, Pyralidae) (Labou *et al.*, 2016) and the mealybug (Hemiptera, Pseudococcidae). *Helicoverpa armigera* is the most prevalent pest on tomato, with an occurrence of 91.8% in monitored plots and damage up to 28% on fruits (Diatte *et al.*, 2018).

In fact, in Senegal, cabbage moth has a much higher incidence than that of the *Hellula undalis* species because it is always present where cabbage plants grow (Labou *et al.*, 2016). It alone causes losses of up to 90% (Sarfraz *et al.*, 2005; Mondedji, 2015). In the Niayes (main horticultural area of Senegal), studies by Collingwood *et al.*, 1984 and Sow *et al.*, 2013, have shown that *P. xylostella* is a pest that causes significant yield losses.

To overcome these problems, farmers use many methods such as crop intensification, varietal selection, mechanisation of agriculture and massive supply of chemical inputs that have greatly improved the productivity of agro-systems (Kafadaroff, 2008). However, this success has been accompanied by alarming consequences such as problems of air, water and soil pollution (Kibblewhite *et al.*, 2008; Tilman *et al.*, 2002). Indeed, the excessive application of chemicals has led to an imbalance in ecosystems. Health of farmers as well as consumers and the appearance of pesticide resistance genes in pests are among the many consequences associated with excessive pesticide application. It is therefore essential to implement other control methods to strengthen those that already exist. The use of biopesticides is essential as main holistic strategy to reduce cabbage and tomato pest populations.

Natural substances from plants have been used as insecticides in recent years to reduce the damage caused by these pests, and results are encouraging (Ba *et al.*, 2019; Diome *et al.*, 2019; Ngom *et al.*, 2020). Studies have shown the effectiveness of *Azadirachta indica* on *Plutella Xylostella* (Ka, 2010). Similarly, *Calotropis procera* was used to combat *Caryedon serratus* (Thiaw, 2008). These substances have the advantage of being biodegradable, non-persistent in nature and accessible to small producers (Traoré *et al.*, 2015). However, no combination of different biocides, such as *Calotropis procera* and others like *Crataeva*, has yet been evaluated. In this context, we conducted the present study to assess the effectiveness of BioArt—a formulation combining these biocides in the management of tomato and sorghum pests

MATERIALS AND METHODS

Presentation of the study area

The study was conducted along the northern coast of Senegal, the Niayes area which is a strip of land 180 km long and about twenty kilometres wide from Dakar to St-Louis with a width ranging from 5 to 30 km (Ngom *et al.*, 2020) (Fig. 1). It constitutes an original environment characterized by dunes and depressions often flooded by the outcropping of the water table and by a climate quite favourable to market gardening. Located in the southern half of the Sahelian zone, the Niayes are characterized by the alternation of two seasons: a wet season concentrated over three months (July, August and September) and a dry season that lasts the other nine months and during which two cycles of market gardening take place. The climate of the Niayes is tropical, sub-Saharan with relatively high humidity. There occurs a very diverse fauna and flora.

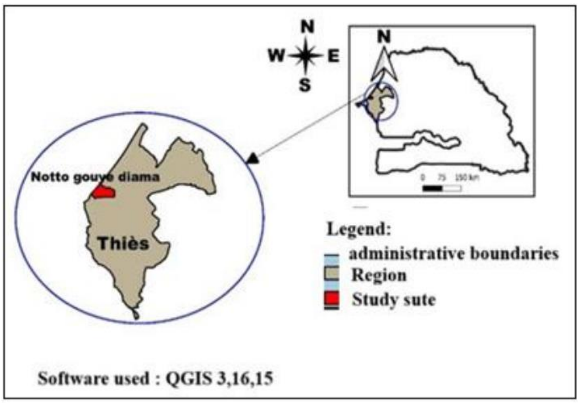

Fig. 1. Location of the study area.

Biological material

For the realisation of this study we used as biological material: *Helicoverpa armigera, Plutella xylostella, Hellula undalis, Mealybug farinaceous,* Tomato (*Lycopersicon esculentum*), Cabbage (*Brassica olerocera*), BioArt and Rapax AS.

Experimental equipment

We used as materials: a cord, a decameter, stakes and a hammer to delimit the plots. To plow the land, we have instruments such as a rake, a shovel, a stake and for daily water treatment, a watering can. Alveolar plates were used as support and substrate (soil) for the seedlings. For the treatments we used a 16 ml sprayer.

Experimental setup

The Fisher block is the experimental device that was used for both speculations. It consists of random blocks. Initial plots of 52m2 each are divided into 9 elementary plots of 3 m2 including 3 treatments and 3 repeats (Fig. 2). The elementary plots have 5 lines with 6 feet in each line for cabbage and for tomato, they have 3 lines with 4 feet for each line. Spacing between the cabbage stalks is 35 cm as well as for the lines and that of the tomato stalks is 75 cm and 60 cm between the stalks. Feet are numbered from 1 to 30 for cabbage and from 1 to 12 for tomato in a counterclockwise direction. A distance of 1 m separates elementary plots in the same block and this same distance separates repetitions and this is valid for both devices. Elementary plots were numbered from T_0 to T2 according to the applied treatment. T0 is the control that receives only water, T1 was treated by BioArt at a concentration of 1.515 L, and T2 by Rapax at a concentration of 1.503L.

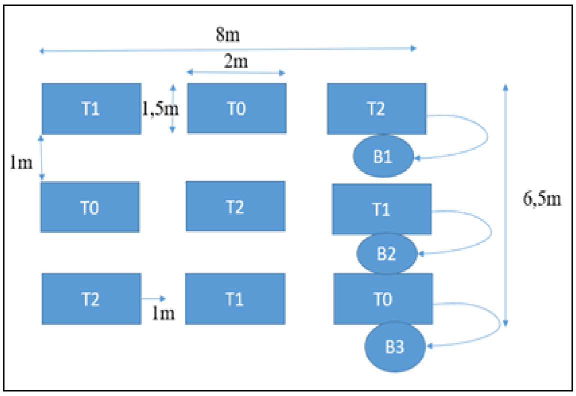

Fig. 2. Fisher's experimental device

Surface area of the elementary plot = 1.5m × 2 m = 3m²

Total surface area = 8 m × 6.5 m =52 m²

Sowing and nursery

The cabbage and tomato nurseries were set up on August 9, 2021 in cells filled with substrate for fertilization (soil). They were placed in a greenhouse to prevent damage caused by predators and isolated to limit contamination. Nurseries were watered every day for 4 weeks and diagnosed 2 days a week to monitor germination and control pest attacks. Healthy and vigorous plants were transplanted at 30 days of age in the elementary tilled plots.

Transplanting of plants

Using a watering can, a volume of 22 L was poured into each elementary plot to moisten the soil. The transplanting took place late in the evening around 6 PM to protect the plants from sunlight.

Farming maintenance

Plants were staked with bamboo stems to prevent fruits from touching the ground and rotting. To prevent the development of weeds and protect the soil from erosion, mulches have been installed. Treatments were carried out late in the evening. Application doses were 11 L/m2. Watering of the plants was carried out regularly when needed.

Elementary control plots were not subjected to any treatment, but went through all the tomato and cabbage cultivation procedures.

Observations and inventories

Observations were made 2 days before and after each treatment to see how the caterpillars evolved depending on the treatment. The counting of larvae was carried out twice before and after each treatment. During these counts, 10 tomato and cabbage plants were selected. For each foot chosen, the number of larvae was recorded.

Estimation of damage and determination of agronomic parameters

Estimation was made based on the damage scale described by Nagawa (2003). It is: 1= >25% no damage; 2= < 25% of the leaf surface destroyed ; 3 = 25-50% of the leaf surface destroyed ; 4 = 51-75% of the leaf surface destroyed ; 5 = >75% of the leaf surface destroyed.

Observations made it possible to determine the following parameters: Relative abundance: it is defined as the ratio between the number of species (ni) and the total number of individuals of the different species in the population (N).

Pi =ni/N

Frequency of occurrence: which is equal to the number of prospecting where the species is present compared to the total number of prospecting.

Incidence: PA (number of feet attacked by a species) over PT (total number of feet).

Fruit attack rate: was calculated by the ratio of the weight of attacked fruits to the total weight of harvested fruits multiplied by one hundred (Tano *et al.*, 2019).

Percentage of harvest loss (%) was calculated by subtracting the average harvest weight from the average marketable weight (Kg).
Yield= Total production/Area

Statistical analyses

The 2013 version of Microsoft Excel was used to classify the data obtained in the field and to draw graphs. The R software version 3.5.2 allowed us to analyse the results. Before the analyses, the Shapiro-Wilk normality test was applied to our data to check if it follows the normal distribution or not. These results had guided us to carry out the Kruskal-Wallis test to determine the effects of different products on pests.

RESULTS

Species abundance

Pests encountered during our sampling belong to the order of Lepidoptera and Hemiptera. During the entire duration of the test, 136 individuals divided into two species (*P. xylostella* and *H. undalis*) were recorded in the cabbage plots and 342 individuals in the tomato plots including 127 species for *H. armigera* and 215 for *Pseudococcus* sp. The majority species in cabbage plots was H. undalis with an abundance of 62% and the most abundant in tomato plots was *Pseudococcus* sp. with an abundance of 63% (Table 1).

Table 1. Abundance of occurring species

Speculations	Species	Ni	Pi
Cabbage	*P. xylostella*	51	38%
	H. undalis	85	62%
Tomato	*H. armigera*	127	37%
	Pseudococcus sp.	215	63%

Ni= Number of a species, Pi= Abundance

Frequency of occurrence and incidence of species

Analysis of Table 2 shows that *Pseudococcus* sp. was present consistently in the tomato plots with an occurrence frequency of 100%. The presence of *H. armigera* was noted at the beginning of fructification with an occurrence of 50% and an incidence of 39%. The species *H. undalis* had a frequency of occurrence of 70% at this period, which means that they were constant in cabbage plots, whereas *P. xylostella* was listed a few days after planting out and had an incidence of 13.3%.

Table 2. Frequency of occurrence and incidence of species

Orders	Families	Species	Occurrences	Incidence
Lepidoptera	Plutellidae	*P. xylostella*	20%	13,3%
	Crambidae	*H. undalis*	70%	15,9%
	Noctuidae	*H. armigera*	50%	39%
Hemiptera	Pseudococcidae	*Pseudococcus* sp.	100%	85%

Evaluation of the effect of treatments on the average number of larvae found

Analysis of Fig. 3A, representing the number of larvae of species according to treatments, reveals that the larvae that were in the cabbage plots were less abundant in the control plot (T0) than in treated plots (T1, T2). Thus the BioArt allowed to maintain the infestation by larvae at a lower level, on the other hand, the Rapax AS seemed to be less effective on larvae. However, the kruskal walis test revealed a non-significance between the different treatments used (p-value = 0.3092). Similarly, there is no significant difference between the different treatments applied to larvae (p. value = 0.771) in tomato plots. The average number of larvae on the control plot (T0) and the plot treated with T2 is nearly the same. However, the number of larvae in the plots treated with T1 is lower (Fig. 3B).

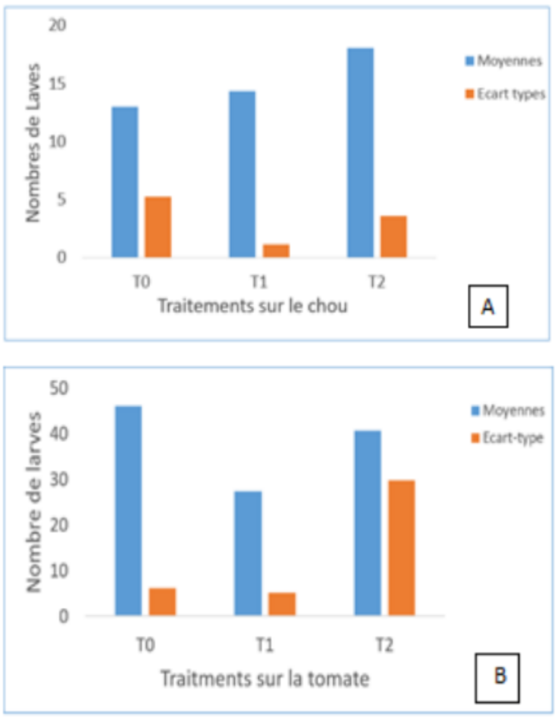

Fig. 3. Effect of BioArt and Rapax AS on the variation in the average number of larvae according to the non-parametric Kruskal-Walis test

Number of larvae before and after treatment

Results highlight that the evolution of the larval population in cabbage plots before and after treatment is important. BioArt (Q1) reduced larvae by 55%. But the mean comparison test showed no significance between plots, before and after treatment (p-value = 0.2477) (Fig. 4).

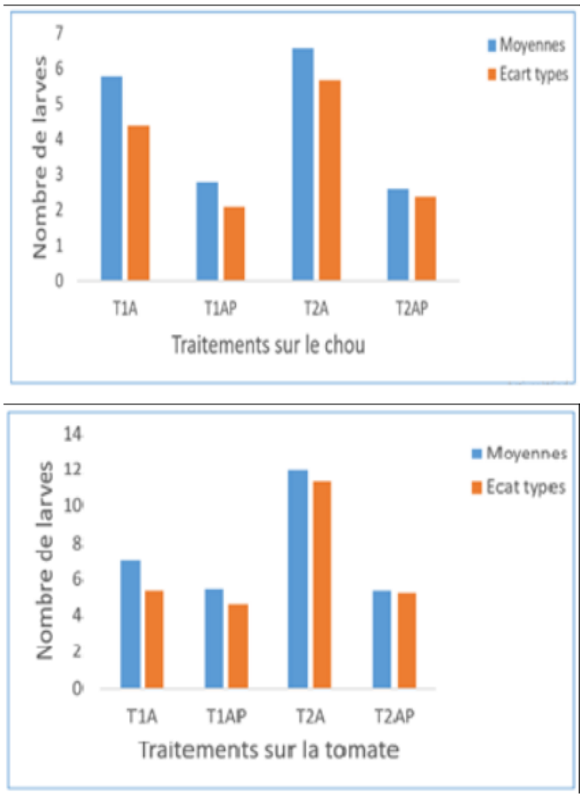

Fig. 4. Evolution of the population of larvae in plots of cabbage and tomato according to the non-parametric Kruskal-Walis test

Similarly, the number of larvae decreased by 55% after applying Rapax AS (T2). However, the difference is still not significant (p-value=0.6544). The average comparison between plots treated with T1 and T2 shows that the number of larvae found in the plots before treatments was practically the same, but after treatment a decrease in number is noted with 51.73% for the plots treated with T1 and 21,22% for plots treated with T2. Nevertheless, the Student test revealed a non-significance between the means before (T1A and T2A), and after treatment (T1AP and T2AP) with respective p-values of 0.8133 and 0.2212. For the tomato, the application of Rapax AS reduced the number of larvae by 55%. BioArt also reduced their number by 22% but this reduction is not significant (*p*-value = 0.461) as well as the decrease noted at the level of plots treated with T2 (*p*-value = 0.4). The number of larvae present in the plot that must be treated by T1 is lower than that of the plot that must be treated with T2, but after treatment the remaining number in both plots is the same. There is no significant difference between the treatments before T1A- T2A (*p*-value = 0.572) and after T1AP -T2AP (*p*-value = 0.518).

Effect of treatments on different species

Statistical analyses have shown that there is no significant difference between the different treatments on *P. xylostella*, *H. undalis* and *Pseudococcus* sp. ($p > 0.05$).

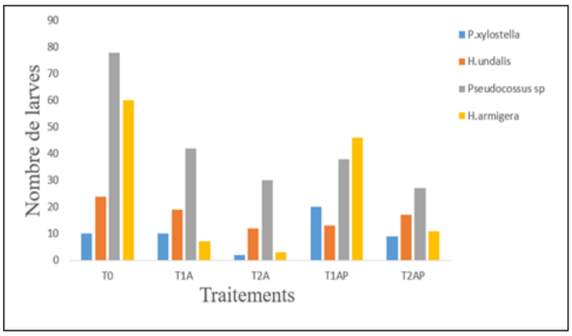

Fig. 5. Effect of treatments on different species according to the non-parametric Kruskal-Walis and Duntest

On the other hand, this one is significant in *H. armigera* (*p*-value = 0.03). This significance is shown in *H. armigera* between T0-T1 only (*p*-value = 0.0036). In plots treated with T1, a very significant decrease of 88% in the population of *H. armigera* compared to T0 was noticed. Similarly, the treatment with T2 reduced the larvae of *H. armigera* by 82% but this reduction is not significant compared to T0 as well as compared to T2. Treatments with T1 decreased larvae of *P. xylostella*, *H. undalis* and *Pseudococcus* sp. with 80%, 37%, and 29% reduction respectively. Similarly, treatment with T2 decreased the larvae of *P. xylostella* by 55% and those of *Pseudococcus* sp. by 29%, but it has no effect on *H. undalis*. It is important to note that T1 is more effective on *H. armigera* caterpillars (Fig. 5).

Effect of treatments on production and yield

Of the 270 feet of cabbage transplanted, 56 had apples, the rest was eaten by monkeys, rodents or attacked by insect larvae. The total weight of the crop was estimated at 39.5kg, of which 32.5kg was in good condition. The number of healthy apples harvested in plots according to treatments T0, T1, T2 was respectively 9; 30 and 10. For the tomato, 42kg was harvested from the 61 feet of tomatoes remaining after the application of treatments. The total weight obtained for each elementary plot was calculated. Thus the best yields were obtained in plots treated with T1 (19 t/ha) for cabbage and 261 t/ha for tomato then plots treated with T2 (9.4 t/ha) for cabbage and 11.7t/ha for tomato. The smallest yields were recorded in plots treated with T0 (Table 3).

Table 3. Yield based on treatments

Speculations	Total production (kg)			Yield (kg/m2)			Yield (t /ha)		
	T0	T1	T2	T0	T1	T2	T0	T1	T2
Cabbage	7	17	8.5	0.8	1.9	0.94	8	19	9.4
Tomato	7	23	10	0.89	26.1	1.17	8.9	261	11.7

DISCUSSION

The aim of this study was to compare the effectiveness of BioArt and Rapax AS in reducing the main pests of cabbage and tomatoes in the Niayes area of Senegal. This inventory reveals several insects that belong to four families (Plutellidae, Crambidae, Noctuidae, Pseudococcidae) and two orders (Lepidoptera and Hemiptera). The insects identified are abundant but not very diverse. In the tomato plots, we only inventoried two species (*H. armigera* and *Pseudococcus* sp.). These results are different from those obtained by Chougourou *et al.*, 2012 who, in their studies, show the presence of several species that belong to many different families in tomato culture. This difference may be due to the presence of heavy rains that reduce the population of these pests. This trend may also be related to the decrease in survival and development rate of pre-imaginal stages (Campos *et al.*, 2003; Badenes-Perez *et al.*, 2014). Similarly, in the cultivation of cabbage, there was only *P. xylostella* (38%) and *H. undalis* (62%). The latter have been reported as the major cabbage pest lepidoptera in previous studies (Labou *et al.*, 2017). On tomato, *Pseudococcus* sp. was present throughout the study and was the most abundant (63%) which is in line with the results of Son (2018). *Helicoverpa armigera* had an abundance of 37% but was the most devastating which joins the results of Nibouche (1994) which shows that the tomato is the preferred plant of *H. armigera* and that it is its main pest.

BioArt and Rapax AS in cabbage and tomato farming were not significant on *P. xylostella*, *H.undalis* and *Pseudococcus* sp. ($p > 0.05$). On the other hand, BioArt (T1) is very effective against *H. armigera* (p=0.03). The BioArt treatment reduced the larvae of *H. armigera*, 88% *P. xylostella*, *H. undalis* and *Pseudococcus sp.* with respectively 88%, 80%, 37%, and 29% reduction. Similarly, treatment with Rapax AS (T2) decreased the larvae of *H. armigera* by 82% of *P. xylostella* by 55% and those of *Pseudococcus sp.* by 29% but it has no effect on *H. undalis*. The bio-insecticidal activity of *C. religiosa* has been demonstrated by Diome *et al.* (2019), according to them, fresh leaves of *C. religiosa* are effective against the main pests of cabbage. Other authors have demonstrated the insecticidal effect of plant-based solutions, among them, Garba *et al.* (2017) showed the effectiveness of *A. indica*. Similarly (Traoré *et al.*, (2015) proved the effectiveness of neem extract on *H. armigera* larvae on tomato.

These results are also in line with those found by Ngom *et al.* (2020). The reduction of the mealy bug population is very low (29%) after the application of treatments. This may be due to the fact that the fight against the mealy bug is done by spraying black soap. The latter is made from natural plants to combat insect pests of cereal crops. All of these results show that the effectiveness of these aqueous extracts based on natural products depends on cultivated speculation. It should also be noted that BioArt is more effective on tomato and cabbage pests than Rapax AS.

The untreated plots had a higher infestation level and lower yield. Our results are similar to those of Sow *et al.* (2013) who showed that agronomic parameters were strongly affected by the level of infestation. The best yields were obtained in plots treated with T1 19 t/ha for cabbage and 261 t/ha for tomatoes, then plots treated with T2 with 9.4 t/ha for cabbage and 11.7 t/ha for tomatoes respectively. The smallest yields were recorded in control plots. The apples from the treated plots had a very high weight and volume that allow them to compete in the market. An accelerating effect of apple ripening is noted in plots treated with T1 compared to controls. Similar results have been obtained by several authors with the property of *C. procera* favoured fructification (Ngom *et al.*, 2020; Diome *et al.*, 2019) who noticed the same phenomenon during their studies. Plots of cabbage treated with plant extracts give the best yields compared to chemical pesticides according to Mondedji *et al.* (2014). However, the damage is more accentuated in T2. Rapax AS appears to be ineffective for larvae of *H. armigera*, *P. xylostella*, *H. undalis* and mealy bugs. On the other hand, plots treated with T1 have less loss compared to other plots. This is in line with the results of Ba *et al.* (2019) who show that aqueous solution based on *C. religiosa* significantly reduces attacks by *H. armigera* and *P. xylostella*. We can then say that the treatment based on BioArt seems to have a positive effect on the yield and growth of the plant.

CONCLUSION

The cultivation of tomatoes and cabbage are among the most important agricultural productions in Senegal behind onions. This study tested the effectiveness of a mixed solution of *C. lubricos*, *C. procera* and *A. indica* (BioArt) and Rapax AS on tomato and cabbage pests in the Niayes area of Senegal. Results revealed that BioArt is more effective on *P. xylostella*, *H. undalis* and *Pseudococcus* sp. On the other hand, it is significantly more effective on *H. armigera* (p=0.03). However, the Rapax AS seems to reduce the damage of *P. xylostella*, *H. undalis*, *H. armigera* and the mealy bug but not significantly (p>0.05). The best yield was obtained on the plots treated with BioArt for both speculations. In our experimental conditions, BioArt is the most effective solution to combat tomato and cabbage pests.

REFERENCES

Ba AR, Diome T, Cheikh AKMD, Sembene M. 2019. Use of plant biocisal substance based on *Crataeva religiosa* against *Tuta absoluta* (Lépidoptères : Gelichiidae) dévastateurs of tomate crops. International Journal of Engineering Technologies and Management Researche **6**(8), 63-71. https://doi.org/10.29121/ijetmr.v6.i8.2019.442

Badenes-Perez FR, Gershenzon J, David G, Heckel DG. 2014. Insect attraction versus plant defense: young leaves high in glucosinolates stimulate oviposition by a specialist herbivore despite poor larval survival due to high saponin content. PLoS One **9**(4), e95766. https://doi.org/10.1371/journal.pone.0095766

Campos WG, Schoeroder JH, Picanco MC. 2003. Performance of an oligophagous insect in relation to the age of the host plant. Neotrop Entomol **32**(4), 671-676. https://doi.org/10.1590/S1519-566X2003000400019

Chougourou DC, Agbaka A, Adjakpa JB, Koutchika RE, Kponhinto UGAEJN. 2012. Inventaire préliminaire de l'entomofaune des champs de tomate (*Lycopersicon esculentum* Mill) dans la commune de Djakotomey au Benin. International Journal of Biological and Chemical Science **6**(4), 1798-1804. http://dx.doi.org/10.4314/ijbcs.v6i4.34

Collingwood TR. 1984. This good-health regimen keeps employes fit--and school budgets trim. American school board journal **171**(4), 48-49.

Diatte M, Brévault T, Sylla S, Tendeng E, Sall-Sy D, Diarra K. 2018. Arthropod pest complex and associated damage in field-grown tomato in Senegal. International Journal of Tropical Insect Science, **38**(3), 243–253. http://dx.doi.org/10.1017/S1742758418000061.

Garba M, Adamou H, Mario DM, Ousmarou S, Gougari B, Ousmane T, Salifou A, Delmas P. 2017. Utilisation des extraits aqueux de neem (*Azadirachta indica*) dans la lutte contre la chenille mineuse de la tomate, *Tuta absoluta* (Meyrick 1972). Conférence international sur les ravageurs et auxiliaires en agriculture Monpellier 432-440p.

Ka S. 2010. Gestion intégrée des ravageurs du chou dans les Niayes de Sangalkam (Dakar Sénégal) Evaluation de l'efficacité d'un traitement à base d'association de culture (tomate /chou) et de combinaison de biopesticides (neem/Biobit). Mémoire, Université cheikh Anta Diop de Dakar Sénégal. 31 p.

Kafadaroff G. 2008. Agriculture durable & nouvelle révolution verte. Le publieur. ISBN-10, 2350610128, 398 p.

Kibblewhite MG, Ritz K, Swift MJ. 2007. Soil health in agricultural systems. Philosophical Transactions of the Royal Society. Biological Sciences **363**(1492), 685-701. https://doi.org/10.1098/rstb.2007.2178.

Labou B, Bordat D, Brevault T, Diarra K. 2016. Importance de la « Teigne du chou » dans les Niayes au Sénégal: interrelations avec la température et les cultivars utilisés. International Journal of Biological and Chemical Sciences **10**(2), 706-721. http://dx.doi.org/10.4314/ijbcs.v10i2.21.

Labou B, Bordat D, Brevault T, Diarra K. 2017. Spatiotemporal distribution and impact of diamondback moth parasitoids in the Dakar Niayes in Senegal. International Journal of Biological and Chemical **11**(3), 1288-1298. https://dx.doi.org/10.4314/ijbcs.v11i3.28

Mondedji AD, Nyamador WS, Amevoin K, Adéoti R, Abbey GA, Ketoh GK, Glitho A. 2015. Analyse de quelques aspects du système de production légumière et perception des producteurs de l'utilisation d'extraits botaniques dans la gestion des insectes ravageurs des cultures maraîchères au Sud du Togo. International Journal of Biological and Chemical Sciences **9**(1), 98–107. https://dx.doi.org/10.4314/ijbcs.v9i1.10

Nagawa F. 2003. Incidence of diamondback mot *Plutella xylostella* and its parasitoids on cabbage in Uganda, MSc thesis, Makéréré University, Uganda.

Ngom S, Diome T, Diop B, Sembene M. 2020. Effet des extraits aqueux de sur les principaux ravageurs du chou en culture au Sénégal. International Journal of Biological and Chemical Sciences **14**(5), 1600-1610. https://doi.org/10.4314/ijbcs.v14i5.9

Nibouche S. 1994. Cycle évolutif *d'Helicoverpa armigera* (Hubner.1808) (Lepidoptera. Noctuidae) dans l'ouest du Burkina-Faso. Biologie et variabilité géographique des populations. Thèse de doctorat. ENSA de Montpellier. France. 143 p.

Nibouche S, Guérard N, Martin P, Vaissayre M. 2007. Modelling the role of refuges for sustainable management of dual-gene Bt cotton in West Africa smallholder farming systems. Crop Protection **26**(6), 828-836.

Sarfraz, Keddie BA. 2005. Conserving the efficacy of insecticides against *Plutella xylostella* (L.) (Lep, Plutellidae). Journal of Applied Entomology **129**(3), 149-157. https://doi.org/10.1111/j.1439-0418.2005.00930.x

Savana A. 2021. Sénégal : Hausse de 12,3 % de la population horticole en 2019-2020.13p

Sow G, Arvanitakis L, Niassy S, Diarra K, Bordat D. 2013. Performance of the parasitoid *Oomyzus sokolowskii* (Hymenoptera: Eulophidae) on its host *Plutella xylostella* (Lepidoptera: Plutellidae) under laboratory conditions. International Journal of Tropical Insect Science **33**(1), 38–45. https://doi.org/10.1017/S1742758412000422

Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. 2002. Agricultural sustainability and intensive production practices. Nature **418**(6898), 671-677. https://doi.org/10.1038/nature01014

Thiaw C. 2008. Bioactives des extraits de *Calotropis procera* et de *Senna occidentalis* sur *Caryedon serratus* (ol.), ravageur des stocks et semences d'arachide au Sénégal. Thèse de doctorat, Université cheikh Anta Diop de Dakar. 196 p.

Traore O, Sereme A, Dabire CM, Some K, Nebie RH. 2015. Effet des extraits du thé de Gambie (*Lippia multiflora Moldenk*) et du neem (*Azadirachta indica* A. Juss.) sur *Helicoverpa armigera* et les Thrips de la tomate (*Lycopersicon esculentum* Mill.). Journal of applied Biosciences **95**, 8930-8936. https://doi.org/10.4314/jab.v95i1.2

Tano A, Oh Y, Fukushima K, Kurosa Y, Wakabayashi Y, Fujita K, Okawa A. 2019. Potential bone fragility of mid-shaft atypical femoral fracture : biomechanical analysis by a CT-based nonlinear finite element method. Injury **50**(11), 1876-1882.https://doi.org/10.1016/j.injury.2019.09.004