

Inventory, incidence of entomofauna and biological treatment of okra (*Abelmoschus esculentus* Moench) in Senegal

Toffène Diome¹, Mamecor Faye², Ablaye Faye¹, Mbacké Sembène¹

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

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

Abstract

The cultivation of okra (*Abelmoschus esculentus*) has many constraints, including those related to bio-aggressors that are often eliminated by chemical pesticides that are dangerous for the environment, human health and cause resistance in insects. To avoid the consequences of pesticide use, farmers are using pesticides. It is in this context that this study was proposed and has as its general objective to know the entomological fauna on the cultivation of okra and to determine the effect of neem and garlic-based bio-pesticides on the incidence of these insects on okra plants. To this end, an experimental system consisting of nine ^[9] beds 11 m long and 1.10 m wide with paths 50 cm in length was set up. Of the nine ^[9] beds, three were treated with a neem-based bio-pesticide, three with a garlic-based bio-pesticide, and the remaining three represented the control. Mainly 3591 individuals, divided into six ^[6] orders (Orthoptera, Hemiptera, Hymenoptera, Lepidoptera, Diptera and Coleoptera), seven ^[7] families (Ainidae, Coccidae, Aphidoidea, Fourmicidae, Geometridae, Aleyrodidae, Coccinellidae) and eight ^[8] species, have been identified in the experimental area. Analysis of the results shows that *Aphis gossypii*, *Pseudococcus viburni* and *Formica sp.* were present consistently with a frequency of occurrence of 100% and incidences of 30%, 42% and 35% respectively. Analysis of the results shows that *Aphis gossypii*, *Pseudococcus viburni* and *Formica sp.* were present consistently with a frequency of occurrence of 100% and incidences of 30%, 42% and 35% respectively. The effect of the treatment is significant on leaf attack; there are fewer leaves attacked on plots treated with garlic solution. Results of the treatment on the weight of the attacked fruits as well as on the yield of the production were not significant.

Keywords: Ail, bio-aggressors, bio-pesticide, cultivation, entomofauna, neem

Introduction

The okra, *Abelmoschus esculentus* is a species of tropical flowering plant belonging to the family Malvaceae and native to Africa. In Senegal, okra plays an important role in people's eating habits. It is present in almost every meal. However, it is difficult to quantify the importance of production and consumption of this vegetable. Nevertheless, there is a supply gap in some periods of the year (CDH, 1986) ^[3]. This crop is increasingly experiencing difficulties that affect its level of production. These include pests that directly affect production. Arthropod pests often cause real problems for producers due to the damage they cause (Diatte *et al.*, 2016) ^[5]. The latter do not spare the "Institut Supérieur d'Agriculture et Entrepreneurariat" (ISAE) station which could be a favourable site for the development of several arthropods. It is therefore necessary to make a diagnosis on the cultivation of okra in order to know the entomofauna for its management by a specific means of control. To remedy the constraints resulting from the use of synthetic pesticides (Boisclair and Estevez, 2006) ^[2], the station uses insecticidal plants such as neem. Pesticide plants are a promising alternative in West Africa context. According to Daly *et al.* (2000) ^[4] azadirachtin has shown high efficiency in producing marketable cabbages. According to Kulimushi (2014) ^[9], garlic bulb extracts used alone have a strong aphids-controlling effect. It is therefore necessary to identify arthropods pests in the station while testing their resistance against insect-killing plants such as neem and garlic.

The main objective of this study is to control the incidence of entomological fauna associated with okra cultivation in the ISAE station. This aim is stated into specific objectives: (i) to inventory the arthropods of okra cultivation in the ISAE station, (ii) to determine the effect of treatment on the incidence of these insects on okra plants, (iii) to determine the effect of treatment on okra yield.

Materials and methods

Presentation of the study site

Production of okra and works related to this crop were carried out in the field of experimentation of the "Institut Supérieur d'Agriculture et Entrepreneurariat" (ISAE), within the UCAD itself, located at N 14°41'19.68" and O 17°27'35.28'.

Field preparation and experimental setup

The field was first cleared, and then there was the placement of pockets, 24 pairs per plot. It is followed by pre-irrigation, to loosen the soil of clay-sandy texture and prepare it for semi. The experimental site was 14m long and 11m wide. It was organized in 9 beds of 11m length by 1m10 width with paths of 50cm according to the length and a spacing of 80cm between feet and lines (Figure 1).

The study was carried out disregarding the side plantings of beds in order to avoid edging effects. The inventory and the incidence of entomofauna were collected only on the sixteen plants in the middle of each bed, an area of 4.037 m² (width 1 m 10 m and length 3.67 m), previously delimited with posts.

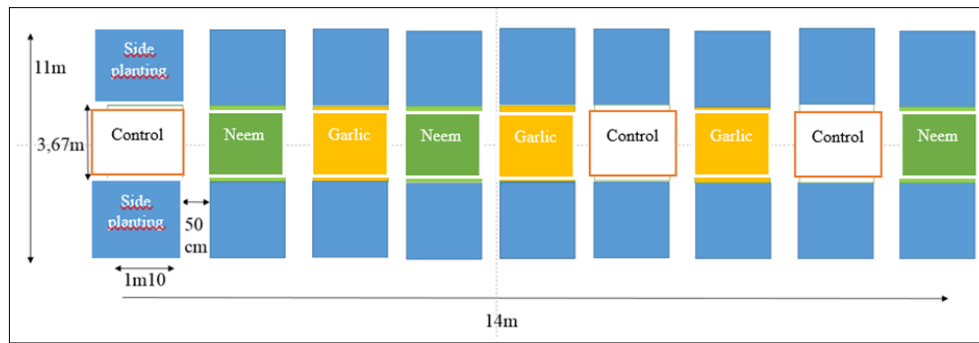


Fig 1: Experimental setup

Choice Variety and Seedling

The variety sown is Clemson Spineless okra which is a variety imported from the USA. The seeds come from Ndiaye Sarraut located in the city of Dakar opposite the Kermel market.

The seed was soaked in water the day before planting. Using a finger, at the level of each pocket, it was formed shallow grooves ready to receive seeds, given four seeds per pocket. Then beds were watered and weeded.

Fertilisation

The fertiliser was obtained by diluting the solution (blood + juice) from the fermentation of fish co-products. At the end of the 21st day, we brought the bio-fertilizer based on fish offal, rich in nitrogen, to the extent of 1 litre per seed hole. The application was done on the 30th day after sowing, a certain amount was added to each seed hole.

Treatments

Plants were treated twice throughout the entire crop. The first treatment was given 26 days after semi and the second 37 days after sowing. Two treatments were given, namely a neem solution and a garlic solution.

For neem extracts, two ^[2] kg of freshly chopped neem leaves have been soaked in 4 litres of water the day before treatment. After a whole night, a soap solution was added to the preparation, all diluted with 9 liters of water.

For garlic extracts, it was mixed 100 g of chopped garlic, 2 teaspoons of vegetable oil, and 10 litres of water and 10 ml of a soap solution. After spending the night, the preparation was diluted with 10 liters of water.

Insects Inventory

The inventory of insect pests was carried out on the various boards and was done on the entire plant. Only insects found on the organs (leaves, stems, fruits, flowers) of plants were identified and counted and then noted on sheets. Surveys were conducted early in the morning, before sunrise, two days before and two days after treatment. For incidence, all leaves were counted and inspected for those damaged and healthy in the vegetative and flowering phases.

Harvest

La récolte a débuté le 48^{ième} jour après semis. Elle se faisait chaque deux jours soit deux à trois fois par semaine. Le poids des fruits sains et le poids des fruits attaqués étaient pesés. Le nombre de fruits par plant était compté ainsi que le nombre de fruits sains et le nombre de fruits attaqués.

Studied Parameters

To know the entomological fauna of okra farming and their impact on plants, six parameters were studied.

- Relative abundance
- It is defined as the total number of individuals of each species in relation to the total sample.
- $P_i = N_i / N$
- **N_i**: number of individuals of the species
- **N**: total number of individuals in the population
- Frequency of occurrence
- Frequency of a species is defined as the number of surveys in which the species is noted out of the total number of surveys.
- $F = (V_i / VT) \times 100$
- **V_i**: number of surveys where species is recorded
- **VT**: total number of surveys
- Incidences

It is equal to the number of feet attacked in relation to the total number of feet.

$$I = AS / TS \times 100$$

SA: Stalks attacked

TS: Total stalks

- Diversity

Relative abundance is usually measured by diversity indices, one of the best known being the Shannon-Wiener.

$$H' = - \sum_{i=1}^S p_i \log_2 p_i$$

- **Percentage of damaged leaves**

According to Isirima *et al.* (2010) cited in Tano *et al.* (2019) ^[12], the percentage of damaged leaves was calculated as the ratio of the number of damaged leaves to the total number of sheets, all multiplied by one hundred.

$$\text{Percentage of damaged sheets} = (\text{Number of damaged sheets} / \text{Total number of sheets}) \times 100$$

- **Fruit attack rate**

According to Isirima *et al.* (2010) cited in Tano *et al.* (2019) ^[12], the attack rate of fruits was calculated by multiplying the number of fruits attacked by the total number of fruits harvested.

$$\text{Fruit attack rate} = (\text{Number of fruits attacked} / \text{Total number of fruits}) \times 100$$

- **Performance per m²**

It can be defined as the output of a crop.

$$\text{Yield} = \text{Total production (kg)} / \text{corresponding area (m}^2\text{)}$$

Data processing

Raw data are filed using the Microsoft office 2013 excel spreadsheet. Statistical tests were done with R software version 3.5.2. Quantitative data were submitted to the

Shapiro Wilk normality test (5% threshold) and non-parametric test of Kruskal Wallis made it possible to evaluate the number of damaged leaves and the attack rate of fruits by comparing the effectiveness of different treatments and control.

Results

Species abundance

A total of 3591 individuals belonging to eight (8) species, divided into seven (7) families (Ainididae, Coccoidea,

Aphididae, Fourmicidae, Geometridae, Aleyrodidae, Coccidae) have been listed. These families are divided into six (6) orders (Orthoptera, Hemiptera, Hymenoptera, Lepidoptera, Diptera, Coleoptera). Table 1 shows that aphids and cochineal were more abundant in the plots with 68.58% and 21.62%, respectively. They are followed by ants which were quite present with 7.57%, caterpillars, locusts, grasshoppers, ladybirds and whiteflies were poorly represented during the whole experiment.

Table 1: Abundance of different species

Species	Caterpillars	Ants	Aphids	Cochineal	Ladybirds	Locusts	Grasshoppers	Whiteflies	Total
Ni(strength)	16	275	2493	786	3	4	9	5	3591
Pi (abundance en %)	0.45	7.57	68.58	21.62	0.03	0.11	0.25	0.14	100

Occurrence frequency and species impacts

Analysis of table 2 shows that aphids, cochineals and ants were present consistently with a frequency of occurrence of 100% with incidences of 42%, 30% and 35% respectively. They are followed by caterpillars and whiteflies with an occurrence of 66.67%

and 44.44%, respectively. These two species were present at the beginning of cultivation, about ten days after semi but a decrease was noted in the second inventory after the first treatment. The presence of grasshoppers and locusts was noted in full vegetative phase with 66.67% and 33.33% occurrence.

Table 2: Frequency of occurrence and incidence

Orders	Families	Species	Incidences %	Occurrence %
Orthoptera	Acrididae	Grasshoppers	4	66.67
		Locusts	3	33.33
Hémiptera	Coccidae	Cochineal	30	100
	Aphididae	A. Aphids	42	100
Hymenoptera	Fourmicidae	Ants	35	100
Lepidoptera	Geometridae	Caterpillars	5	66.67
Diptera	Aleyrodidae	B. Whiteflies	3	44.44
Coleoptera	Coccidae	Ladybirds	2	11.11

Diversity index

The experimental plot of okra shows an abundance inequality between species with a high abundance of aphids that dominate other species, hence the value of the Shannon index H' = 0.843.

Effect of treatment on leaf condition

Results from analysis of the percentage of leaves attacked (Figure 2) show that the effect of treatment is significant. This significance is noted between the neem solution and the garlic one. In fact, there are fewer leaves attacked on the plots treated with garlic solution compared to the others with a significant difference (p = 0.0022 between neem and garlic) and not significant (p = 0.4299 between control and neem).

Effect of treatment on fruits weight

Les résultats du traitement par rapport au poids des fruits attaqués (Figure 3) se sont révélés non significatif (p = 0,5611). En effet, comme le montre la figure 22, les planches traitées avec la solution de neem ont subi le même degré d'attaque que celles traitées avec la solution d'ail et les témoins.

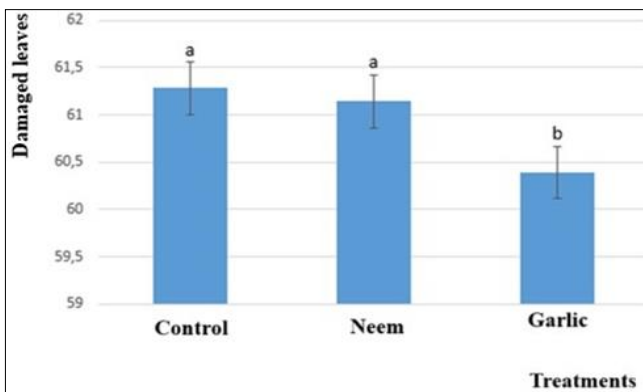


Fig 2. Effect of the treatment with regard to the percentage of damaged leaves

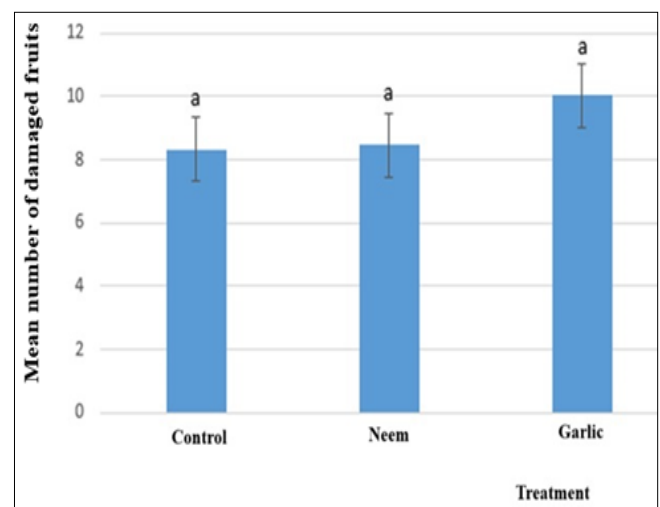


Fig 3. Effect of treatment with respect to the number of damaged fruits

Production yield as a function of treatment

Results of treatment on yield is not significant (p = 0.5611). Figure 4 shows that the beds treated with garlic and neem solution have the same performance as the controls.

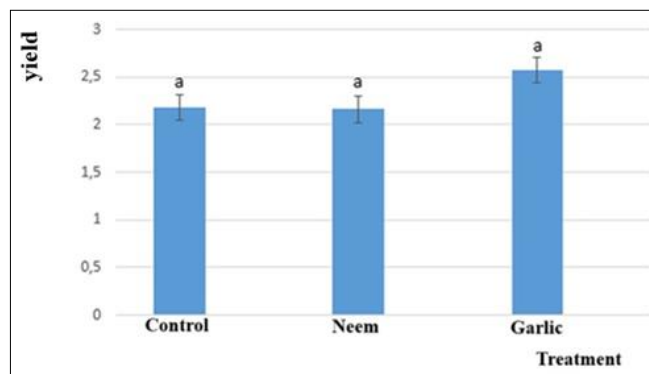


Fig 4. Effect of treatment in relation to yield (kg/m²)

Discussion

Insects abundance

During this study, a fairly large number of pest families were inventoried. However, these listed insects are still not very abundant and diversified based on the Shannon index (0.843). Aphids are more abundant in the plots and this high presence of aphids could be due to the climate (temperature and humidity) favorable for their development. Indeed, aphids were strongly present at the beginning of cultivation before the start of rains (mid-July and August) and at the end of cultivation (September). It should be noted that honeydew (aphids' droppings) is coveted by several insects, including ants, and allows the development of fumagine (Gourmel, 2014) [6]. Whiteflies, unlike aphids, were not abundant and had been noticed at the sensitive phenological stages of the crop. Observations made in Mali by Bagayoko (1986 cited by Badiane, 1995) [1], show that rains can have a depressive effect on the density of whitefly populations. This could also explain the low population of these in the station. Cochineals were also abundant and maintained throughout the gumbo cycle. With a thermal optimum of 27°C, the cochineal can grow in a temperature range between 15°C and 35°C (Minko 2009) [10]. The thermal preference range could explain the presence of the cochineal in the station. The locusts and grasshoppers being known as large crop pests were infrequent, their presence was noticed two weeks after sowing in early vegetative phase, this could also be related to the current temperatures of around 30°C with strong sunshine and global warming. According to PIP (2011) [11], hot and humid periods of the year, off-season crops, and the excessive use of pesticides that have eliminated natural enemies of *Zonocerus variegatus* are all favourable conditions for infestations. Grasshoppers are phytophages, while others are omnivores or predators of insects, snails or small vertebrates (Gourmel 2014) [6].

Effect of treatment on fruits condition

Treatments were not significant on the weight of the attacked fruits. The climate was not conducive to effective treatments due to rainfall and frequent rainy days. This explanation is in line with that of Hamon and Charrier (1986) [7] who claim that in tropical Africa, the optimum production of okra (variety Clemson spineless) is off-season and the Clemson variety is very well adapted to the dry tropical climate (Senegal).

Effect treatment on leaves condition

The effect of treatment on the percentage of damaged leaves was significant. The percentage of damaged leaves is lower

in plants treated with garlic solution than those treated with neem solution and controls. In fact, the presence of aphids on the leaves is one of the first infestations noticed in the field at the beginning of the vegetative phase. These results would therefore be related to the effectiveness of the first treatment that was done before the start of the rains. Garlic has proven to be a more effective treatment than neem solution on aphids. This explanation is in line with that of Kulimushi (2014) [9], who showed during a study on the evaluation of botanical insecticides effects on black bean aphids, that the aqueous extracts of garlic bulbs used alone have significantly reduced the effect of aphids attacking the flowers.

Effect of treatment on production yield

The effect of treatments on the crop yield is not significant since there is no great difference between the treated beds and the controls. The average yield obtained, less than 3t/ha is considered low based on studies by Thiaw *et al.* (2019) [13] who claim that the theoretical potential yield of Senegalese varieties varies between 8 and 20t/ha. Some factors have influenced the yield such as the crop period which was not very favourable for okra cultivation. Indeed, Hamon and Charrier (1986) [7] affirm that the cultivation of okra in ideal conditions can be very lucrative especially in off-season contrary to our experience during winter.

Conclusion

This study identified the insect pests of okra grown in the station, determined their impact on okra plants and assessed the effect of these pests on crop yield. Results revealed an important presence of pests of okra divided into different families (Acrididae, Aleyrodidae, Aphididae Aphidoidea, Fourmicidae, Geometridae, and Coccidae). These pests were not all plentiful in the crop and aphids far outnumbered the rest of the insects. These aphids, although numerous, did not have a direct influence on the yield. Indeed, their location on the leaves exposed them directly to treatments that have significantly reduced their number, including garlic solution. The fairly similar yields obtained in the controls and treated beds show the inefficiency of treatments, caused by precipitation. The damage on the capsules is negligible compared to the damage caused by the destruction of several flower buds causing a reduction in production.

References

1. Badiane D. Situation parasitaire entomologique du cotonnier au Sénégal et méthodes de contrôle. Mémoire de Titularisation, Centre de recherches agricoles (C.R.A), 1995, 92.
2. Boisclair J, and B. Estevez. Lutter contre les insectes nuisibles en agriculture biologique: intervenir en harmonie face à la complexité. *Phytoprotection*,2006;87(2):83-90.
3. CDH. Les cultures maraîchères au sénégal: Bilan des activités de 1972-1985 du centre pour le développement de l'horticulture" Dakar-Senegal: Institut Sénégalais de Recherches Agricoles Sénégal (ISRA), 1986, 269.
4. Daly P, Desvals L, De-Maleprade M, Deschamps M. Ravageurs des choux en Nouvelle calédonie Stratégie de maîtrise des chenilles de quelques lépidoptères. *Phytoma-La Défense Des Végétaux*,2000;532:64-67.
5. Diatte M, Brévault T, Sall-Sy D, Diarra K. Des pratiques culturales influent sur les attaques de deux

- ravageurs de la tomate dans les Niayes au Sénégal. In: International journal of biological and chemical sciences,2016:10(2):682-692.
6. Gourmel C. Catalogue illustré des principaux insectes ravageurs et auxiliaires des cultures de guyane. Coopérative Bio Savane, 2014, 78.
 7. Hamon et Charrier. Les Gombos. In: l'amélioration des plantes tropicales. Edition CIRAD et ORSTOM, 1997, 313-333.
 8. Jayaraman K. Manuel de statistique pour la recherche forestière. Inde: Kerala Forest Research Institute, 1999, 242.
 9. Kulimushi E. Evaluation des effets d'insecticides botaniques sur les pucerons noirs du haricot (*Aphis Faba*) à Goma en république démocratique du Congo, In: Cahiers africains des droits de l'homme et de la démocratie, 2014, 366-39.
 10. Minko D. Influence des facteurs écologiques (température et hygrométrie) sur le développement de la cochenille farineuse du manioc (*Phenacoccus maniholi* Matile-Ferrero, Homoptera: Pseudococcidae). In: Tropicultura,2009:27(1):21-25.
 11. PIP. Guide de bonnes pratiques phytosanitaires pour la pastèque (*Citrullus lanatus*) et le doubeurre (*Cucurbita moschata*) issus de l'agriculture conventionnelle ou biologique en pays aCP. Brussels-Belgium: éditeur le COLEACP, 2011, 74.
 12. Tano DKC, Tra Bi CS, Kouassi KA, Ossey CL et Soro S. Incidences des attaques de *Podagrica decolorata* Duvivier 1892 (Coleoptera: Chrysomelidae) sur la culture du gombo et contrôle de ces adultes au moyen du biopesticide NECO 50 EC (Daloa, Côte d'Ivoire). Journal of Applied Biosciences,2019:143:14692-14700.
 13. Thiaw MA, Ndiaye D, Séne M, Mbaye T, Baldé M. Evolution du rendement des six variétés de gombo dans les conditions agro-climatiques de sédhiou au Sénégal ». In: revue africaine d'environnement et d'agriculture,2019:2(1):69-72.