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EVALUATION OF THE EFFICACY OF NEEM OIL (*Azadirachta indica* A. Juss: Meliaceae) ON THE MAIN PESTS AND DISEASES OF CABBAGE (*Brassica oleracea L.: Brassicaceae*)

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ABSTRACT

In the context of food insecurity exacerbated by climate change, urban market gardening is emerging as an alternative. The aim of this study was to evaluate and compare the efficacy of Azadirachta indica oil with a synthetic chemical product in order to effectively control cabbage pests and diseases. The data collected and analysed during the two campaigns in 2023 and 2024 made it possible to observe the potential pests of Brassica oleracea, as well as their dynamics during the different growth stages. As for diseases, samples of diseased plant organs (leaves) were taken for laboratory analysis. The most representative species in the plots were aphids Brevicoryne brassicae (Linnaeus, 1758), followed by whitefly Aleyrodes proletella (Linnaeus, 1758). Defoliating caterpillars were the most closely targeted, namely Plutella xylostella (Linnaeus, 1758) followed by the whitefly Aleyrodes proletella (Linnaeus, 1758). Plutella xylostella (Linnaeus, 1758), Spodoptera exigua (Hübner, 1808), pieris brassica (Linnaeus, 1758) and Spodoptera littoralis (Boisduval, 1833) were the most common defoliating caterpillars. In terms of efficacy, the plots that received neem oil applications recorded the fewest plagues for the two campaigns, and yields varied between 29.51 and 11.86 t/ha for 2023 and 26.8 and 8.69 t/ha for 2024. Analysis of fungal diseases on cabbage leaves identified three species: Alternaria brassicae, Fusarium oxysporum and Aspergillus flavus. This study enabled us to assess the effectiveness of neem oil in reducing the threat of cabbage pests. It emerged that the integration by growers of the use of neem oil is an effective and efficient alternative to synthetic pesticides.

Keywords: Insecticide, Cabbage, Azadirachta indica, Disease, Pests.

1. INTRODUCTION

The urbanisation of African cities is leading to an increase in food demand for market garden produce and a change in the conditions of access to production factors. In Cameroon, it is predicted that by 2030, two out of three Cameroonians will live in urban areas. Faced with this urbanisation, vegetable production has increased in towns and their outskirts (Kamga et al. 2013). Given this situation, market gardening in Cameroon is a significant addition to the population's diet. For rural producers, it is seen either as the main source of income or as a supplementary source of income. In the western highlands, market gardening is produced in fairly large quantities and is one of the most profitable crops in terms of cash income (Temple 2001). There is substantial national and international trade in these crops in Cameroon and the Central African sub-region. Several vegetable species are grown during this activity, including tomatoes, okra, aubergines, chillies, cabbage, green condiments, carrots, beetroot, lettuce and tomatoes, which adapt well to the different seasons. These include cabbage [*Brassica oleracea* var. capitata (Linn.): Cruciferae], which is one of the most widely consumed vegetables in the world (Jhumar et al. 2024). It is grown intensively in tropical and temperate regions of the world, including Cameroon. Like all crucifers, it is rich in plant fibre, vitamins, minerals and trace elements (Pamplona-Roger 2002). Cabbage is mainly produced in Cameroon's western highlands, including the west and north-west regions, where the fairly cold climate favours its cultivation. This production ranged from 37268 tonnes to 549337 tonnes from 2014 to 2015 (INS, 2019). This crop, like other crops, faces major production constraints such as diseases and pests (Sotondji et al. 2022; Kouassi et al. 2022). Insects are the group of pests that cause the most damage because of the favourable climatic conditions for their development (Azonkpin et al. 2019; Ouali et al. 2021). Of the five main cabbage pests, *Plutella xylostella* (L.) is the most devastating and occurs in seven countries in East, West, Central and Southern Africa (Tewary et al. 2005; Yao et al. 2022). Losses due to *P. xylostella* are very high, as some authors have reported, such as Djomaha and Ghogomu, 2016 in Cameroon; Mondedji et al. 2016 in Togo and Kouassi et al. 2021 in Côte d'Ivoire. Chemical insecticides are the most widely recommended control method, and the active ingredients used are: cypermethrin, endosulfan, dimethoate, deltamethrin, malathion and alphamethrin (Hasheela et al. 2010). This control of insect pests using chemicals may be spectacular, but it has its limitations, such as capital investment, adverse effects on human health and the environment, the development of pest resistance to pesticides and higher levels of pesticide residues in food products (Koné et al. 2019). Faced with these many constraints, there is a crying need to develop appropriate alternatives to chemical pesticides to control pests while preserving the environment. The aim of this study is to evaluate the insecticidal efficacy of neem oil on the main cabbage pests and diseases, compared with a chemical product.

2. MATERIALS AND METHODS

2.1 Presentation of the study site and equipment used

The experiments took place over two successive cropping seasons, from November 2022 to March 2023 (heavy rainy season) and from November 2023 to March 2024 (short dry season). The cultivation sites were located on the experimental plots of the institute of agricultural research for development (IRAD) in Nkolbisson, in the Yaoundé 7 district, to the west of Yaoundé city center. These geographical coordinates lie between parallels 3°45' and 4.00' north latitude and meridians 11°20' east longitude (Ntongo et al., 2010). The average temperature in the study area was between 23 and 25°C and relative humidity between 40 and 60%. Average annual rainfall is between 1800 and 2000 mm and the climate is equatorial with 4 seasons per year.

- Biological plant material: The biological plant material is cabbage seed of the MADIBA variety purchased from JACO SA.
- Animal material: This is represented by the main insect pests of cabbage in Yaoundé.

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- Technical equipment: consisting of a 16 L backpack sprayer, gloves, protective goggles, suitable overalls, nose guard, tape measure, boots, etc.

2.2 Experimental set-up

➢ Setting up the nursery

A nursery was set up thirty (30) days before transplanting on the experimental site. A space was made in the shade in the form of a bed with well loosened light soil rich in humus. Parallel lines were then drawn about 1 cm deep and 20 cm apart. The seeds were sown inside the lines and covered with a thin layer of soil about 0.5 cm thick. The whole bed was covered with anti-insect netting to protect the young plants from attack. The plants were watered every evening at 6 pm, as the study was conducted during the dry season (November to March). Two weeks after sowing, the bed was weeded (Figure: 1A).

➢ Site preparation

The experimental site was set up by the following operations: clearing, ploughing, formation of beds, staking and labelling of sub-blocks. An application of 1/2 kg of decomposed chicken droppings treated with wood ash as a nematicide (1 spike/plant). The mixture was then stirred to homogenise it. All these operations were carried out one week before transplanting.

➢ Experimental set-up

The experimental set-up is a completely randomised block design or Fischer block design.
Fischer blocks, comprising: 4 replicates, 6 treatments. The space between plots was 80 cm and 1m between rows. 4 rows of 5 plants, i.e. 30 plants per subplot with a distance of $1m^2$ between two blocks and $0.5m^2$ under a block.

Transplanting phase for young plants

Transplanting was done in the evening at sunset, only healthy and vigorous plants with at least 5 true leaves were transplanted. The young plants were planted up to the level of the first leaves and watered copiously afterwards.

Insecticide treatment of plots

Table 1: Application rates for the various products

Treatment	Active ingredient	Quantity per Ha	Quantity for 15 L
T1	Emamectin benzoate 5% + Lufenuron 40%	375 mL	18,75 mL
T2	Emamectin benzoate 5% + Lufenuron 40%	300 mL	15,00 mL
T3	Emamectin benzoate 5% + Lufenuron 40%	225 mL	11,25 mL
T4	Grebtac 100 ec	300 mL	15,00 mL
T5	Huile de neem	2,5L	125 mL
T6	Control	Untreated	Untreated

2.2 Treatment applications and data collection

A MATABI brand sprayer with a capacity of 16 litres was used for the three treatments. The different doses of product were sprayed one after the other, after careful cleaning of the equipment. The Neem oil treatment consisted of making a homogenous pre-mix of one litre of water and the recommended volume of oil, combined with a spoonful of powdered soap for good homogenisation. Applications of the various insecticide treatments began on the 21st day after transplanting. The interval between two treatments was 21 days, i.e. three weeks. A total of four treatments were carried out.

- **Fertilising, watering and weeding the plot**

Five weeks after transplanting, NPK fertiliser (20-10-10) was applied at a rate of 300 kg/ha and irrigation was carried out every day. The first weeding took place two weeks after transplanting and the other two every three weeks.

- **Data collection in the plots**

Insects were counted every two days after the various treatments. In each elementary plot, 6 plants were observed on the median lines in order to minimise border effects (Kouassi et al. 2022). The choice of plants to observe could change with each observation. The lower and upper surfaces of the leaves and the main veins of the selected plants were examined. They were then collected using entomological forceps and a mower. The samples collected were identified at the Entomology Laboratory using a magnifying glass and a cabbage insect pest identification key.

- **Collection of yield parameters**

At maturity, cabbage heads were collected, weighed and the average weight was calculated. Yield data were obtained by weighing marketable heads (whole cabbage with no holes or cabbage with tolerable holes or cabbage completely rid of leaves with holes). Observations and harvesting to estimate yields were carried out on the 2 side rows only (Sotondji et al. 2022). Once the yield per useful area is known, by extrapolation, the yield per treatment per hectare is expressed using the following formula:

$$R = S1/PSu$$

Where: R = yield per hectare of treatment, S1 = area in hectare, PSu = production of useful area.

Figure 1: Healthy cabbage and cabbage affected by pests (caterpillars)

- **Evaluation of cabbage apple rot as a function of treatments and structure.**

Once the cabbage apples had been harvested, the samples were taken back to the laboratory for further observations. The aim was to assess the impact of the chemical treatments and the bio-insecticide under ambient storage conditions. Observations lasted 30 days, under ambient laboratory conditions (T=25°; RH=; Photoperiod 12D/12L.).

➢ Identify and determine the incidence and severity of diseases in the field

Data was taken using a parameter sampling sheet. Diseases were identified by precise observation of phenotypic anomalies in relation to the normal phenotype, and their evolution over time and space (Renard & Foucart, 2008). Samples of diseased plant organs (leaves) were taken for laboratory analysis. The susceptibility and degree of disease of the plants were assessed using the method proposed by Wangungu et al. (2011).

. Disease incidence is the degree or frequency of attack on plants by a disease within a given experimental unit it is therefore the proportion of diseased plants within a given experimental unit, irrespective of the severity of the individual attack on each plant; whereas severity is the degree of attack on an organ or an entire plant by a disease or pest. It measures the quantity of the disease on an organ of the plant. These two parameters are determined according to the formula of Botton BA. & Fevre MP (1990).

$$(\%) = \frac{N_{pm}}{N_{pt}} * 100$$

- N_{pm} : number of diseased plants
- N_{pt} : total number of plants

$$S\ (\%) = \frac{\sum(ab)}{N}$$

- S (%) : severity of disease expressed as a percentage
- $\sum(ab)$: sum of the number of diseased plant (a) having the corresponding degree of infection (b).
- N: total the number of diseased plants.

➢ Isolating and identifying fungal diseases in the laboratory

Isolating the fungus involved identifying and harvesting infected leaves showing symptoms of the disease. The infected leaves were then brought back to the laboratory, washed several times with tap water, disinfected using cotton wool soaked in 95% alcohol and then sterilised over a flame. Using a scalpel, the infected parts of the leaf (bearing the necroses) were removed and then incubated in the petri dish containing the culture medium (agar medium). The dish was resealed, sealed with cling film and incubated in a culture chamber at 22-24°C with a 12-hour photoperiod. The mycelia that developed from the explant reached sufficient growth after 05 days for purification. Purification was carried out by successively transferring an agar fragment taken from the mycelium growth front onto PDA medium. This operation was repeated as many times as necessary until pure cultures were obtained, which were stored in sterile distilled water in pillboxes (Soro et al. 2024). Fungi were identified on the basis of macroscopic and microscopic characteristics. Macroscopic characters were observed with the naked eye based mainly on the colour of the colonies, the appearance of the aerial or short mycelium and its pigmentation. The absence or presence of patterns (petaloid, star-shaped, rosette-shaped) was also observed. The microscopic characteristics were based on the morphological criteria for tree classification respectively by Tahri et al. (2017). They were carried out by removing a fragment of thallus using a lanceolate needle and placing it on a slide. These observations were made under a microscope.

Statistical analysis of the data

The information collected on the diversity and number of pests per cabbage plant was analysed and used to produce histograms with the pivot table and curves using Microsoft EXCEL© 2010. The significant differences between the agronomic parameters and the effectiveness of the treatments were established by an analysis of variance (one-way ANOVA) followed by Turkey's test of separation of means at the 5% threshold using STATISTICA 7.

3. RESULTS AND DISCUSSION

3.1 Cumulative numbers of different cabbage pests observed

Analysis of the data collected on the experimental plot enabled us to calculate the total number of individuals per species and per treatment for the two seasons (2023 and 2024). A total of 41508 pests were collected (Table 2). Seven different orders of pests were identified (Table 1) on the plot: pulmonates (slugs), Scolopendromorphs (millipedes), Homoptera (aphids), Orthoptera (locusts), Coleoptera (flea beetles), Diptera (white flies) and Lepidoptera (caterpillars). Our samples present a larger number of orders than those of Ouali-N'goran et al. (2014) who in their studies identified 4 main cabbage pests grouped into 4 orders, namely Homoptera (aphids), Lepidoptera (caterpillars), Diptera (cabbage maggot) and Orthoptera. The most representative individuals in our samples were aphids *Brevicoryne brassicae* (Linnaeus, 1758) with 34664 individuals (83%), followed by white flies Aleyrodes proletella (Linnaeus, 1758) with 4764 individuals (11%) and lepidopteran larvae, 688 individuals (3%) with a value of 994 individuals for *Plutella xylostella* (Linnaeus, 1758), 449 individuals for *Spodoptera exigua* (Hübner, 1808), 179 individuals for *pieris brassica* (Linnaeus, 1758) (Cabbage White) and 29 individuals for *Spodoptera littoralis* (Boisduval, 1833). The measurable economic losses caused by aphids are due to the diversity of their feeding behaviour.

Table 2: Diversity and proportion of cabbage pests collected for the two crop years

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	TRT1		TRT 2		TRT 3		TRT 4		TRT 5		TRT 6		TOTAL GENERAL	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Spodoptera E	0	13	3	9	1	11	9	64	13	25	81	220	**107**	**342**
Plutella X	7	23	19	26	44	64	10	86	21	37	420	237	**521**	**473**
Piéride	0	0	0	15	2	15	0	15	7	5	40	80	**49**	**130**
Spodoptera L	0	0	0	0	0	0	0	0	0	7	11	18	**11**	**18**
Puceron	1588	2710	3155	2489	1161	1161	1858	4861	607	347	6506	8221	**14875**	**19789**
Mouche B	455	310	463	340	437	490	385	362	376	188	444	514	**2560**	**2204**
Millepatte	0	4	3	4	0	0	0	22	4	5	5	27	**12**	**62**
Criquet	11	4	16	15	16	6	0	15	4	14	30	27	**32**	**81**
Altise	0	15	2	17	0	28	0	29	0	19	3	34	**77**	**142**
Amelide	1	0	11	2	5	0	1	4	2	0	12	12	**5**	**18**
TOTAL	**2062**	**3062**	**3672**	**2917**	**1666**	**1775**	**2263**	**5458**	**1034**	**647**	**7552**	**9390**	**18249**	**23259**

3.2 Diversity and abundance of lepidopteran larvae recorded in the experimental cabbage plot

The main pests, i.e. those causing the greatest losses in weight of apples in the field, were lepidopteran larvae (caterpillars). A total of four species of caterpillar pests were identified on the experimental plot: *Spodoptera exigua*, *pieris brassicae*, *Plutella xylostella* and *Spodoptera littoralis*. Table 2 shows that in 2023 and 2024, *Plutella xylostella* was the most abundant lepidopteran on cabbage plants, with an average ranging from 0.1 to 4 individuals and 0.31 to 8.05 respectively. Statistical analysis indicated that there was a significant difference between the different treatments with regard to *Plutella xylostella* (F= 2.49; P=0.00; F=0.000; P=19.13). These results are also in line with those presented by Charleston et al. (2005). We then had *Spodoptera exigua* (0.04 to 0.13 individuals) with a highly significant difference (F= 2.49; P=0.00). In 2024, *Spodoptera exigua* was more conspicuous, with a mean ranging from 0.12 to 3.33 individuals. The analyses also showed that there was a highly significant difference between the treatments (F=7.67; P=00000.1). These two species sometimes coexist, but at different frequencies.

Table 3: Average number of individuals per cabbage plant according to treatments crop year 2023

	Plutella X	*Piéride*	*Spodoptera E*	*Spodoptera L*	*Puceron*	*Mouche B*
T1	0,07b	0,00a	0,00b	0,00a	16,54b	4,73a
T2	0,19b	0,00a	0,03b	0,00a	32,86b	4,82a
T3	0,45b	0,02a	0,01b	0,00a	12,09b	4,55a
T4	0,1b	0,00a	0,09b	0,00a	19,35b	4,01a
T5	0,22b	0,07a	0,13b	0,00a	6,32b	3,9a
T6	4,37a	0,41a	0,84a	0,4a	67,77a	4,62a
F	24,96	0,0001	7,67	2,46	9,91	05
P	0,0001	0,19	0,0001	0,03	0,0001	0,7

Table 4: Average number of individuals per cabbage plant according to treatments crop year 2024.

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	Plutella X	*Piéride*	*Spodoptera E*	*Spodoptera L*	*Puceron*	*Mouche B*
T1	0,319a	0,00a	0,18a	0,00a	37,6389a	4,30ab
T2	0,35a	0,20ab	0,12a	0,00a	33,63a	4,59abc
T3	0,71a	0,16ab	0,12a	0,00a	12,90a	5,44bc
T4	1,16a	0,20ab	0,86a	0,00a	66,58ab	4,89abc
T5	0,52a	0,07ab	0,35a	0,00a	4,95a	2,68a
T6	8,05b	1,66b	3,88b	0,11a	114,18b	7,13c
F	19,13	0,9	11,07	2	5,54	4,98
P	0,000	0,032283	0,000	0,11	0,000057	0,000188

3.3 Average population dynamics of live Plutella xylostella and Spodoptera exigua larvae as a function of time and treatment.

In 2023, the Spodoptera exigua population size was less than one individual for treatments T1, T2, T3, T4, T5, over the period from 21 to 84 days, except for the control treatment which had a peak of 1.5 individuals on 63 days. As for Plutella xylostella, the same treatments show the same pattern, except that the control treatment shows an initial peak of 4 individuals on 42 days, followed by a second peak of 11 individuals on 84 days. This trend was also observed in 2024, i.e. the pest was present on days 21, 42 and 63. The control lot showed a strong attack by Spodoptera exigua on the 84th day, with an average of 10 individuals and an average of 6 individuals for Plutella xylostella

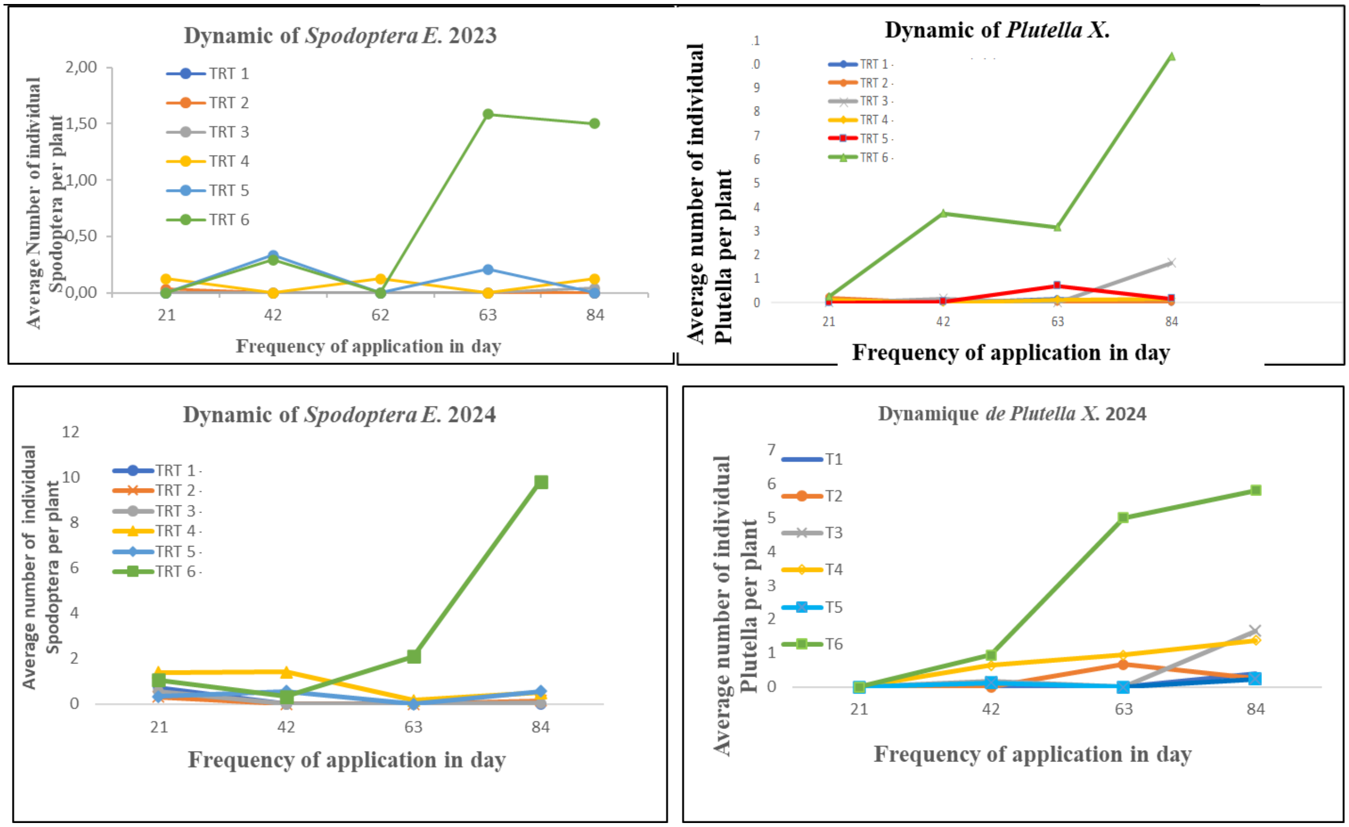

Figure 2: Evolution in average populations of Spodoptera E. and Plutella X. lava by treatment for the 2023 and 2024 crop years.

Figure 4: Harvest according to treatments and yield assessment in the experimental plot

3.5 Incidence and severity of cabbage diseases in the field

Observing cabbage diseases is essential for effective, preventive management of harvest losses. Cabbage is a plant that absorbs a lot of water, and when environmental conditions are favourable, the development of a strong fungal colony can be observed. The table above shows average values for the incidence and severity of cabbage diseases in the field. There were marked differences between the rates obtained in the control plots and those in the plots treated with insecticides or neem oil. The highest disease averages were obtained in cabbage plots that had not received any of these treatments. It can be seen that the neem oil treatments had a more effective effect on the appearance of diseases in the field. In fact, in the plots without any application (T6), attack levels remained very high, at around 60.87% for fusariosis and 12.73% for alternaria.

Table 5: Incidence and severity of cabbage diseases in the field

Trts	Inc. Alternariose	Inc. Fusariose	Sev. Alternariose	Sév. Fusariose
T1	0,00±0,00[a]	2,96±0,21[a]	0,00±0,00[a]	4,82±4,85[a]
T2	11,07±0,88[b]	0,00±0,00[b]	27,02±0,66[b]	0,00±0,00[b]
T3	0,00±0,00[a]	12,68±1,25[c]	0,00±0,00[a]	30,50±1,44[b]
T4	0,00±0,00[a]	6,33±0,55[d]	0,00±0,00[a]	17,93±0,32[c]
T5	0,00±0,00[a]	8,10±0,35[d]	0,00±0,00[a]	20,63±0,93[c]
T6	12,83±0,67[c]	23,67±1,55[e]	12,73±0,29[c]	60,87±0,42[d]
Df	5	5	5	5
F value	571,4	287,3	4365	320,2
Pr (>F)	0,001***	0,001***	0,001***	0,001***

***= Very high Significant; **=Very significant; *= Significant; NS= Not significant

Trts: treatment; Inc:Incidence; Sev: severity

Analysis of fungal diseases on cabbage leaves has enabled us to identify the pathogens responsible. Fungi are a common cause of plant disease and can cause significant losses in crops, including cabbage. The isolation of fungi in the laboratory was carried out in a controlled environment. The pure strains obtained belong to the species *Alternaria brassicae*, *Fusarium oxysporum* and *Aspergillus flavus*.

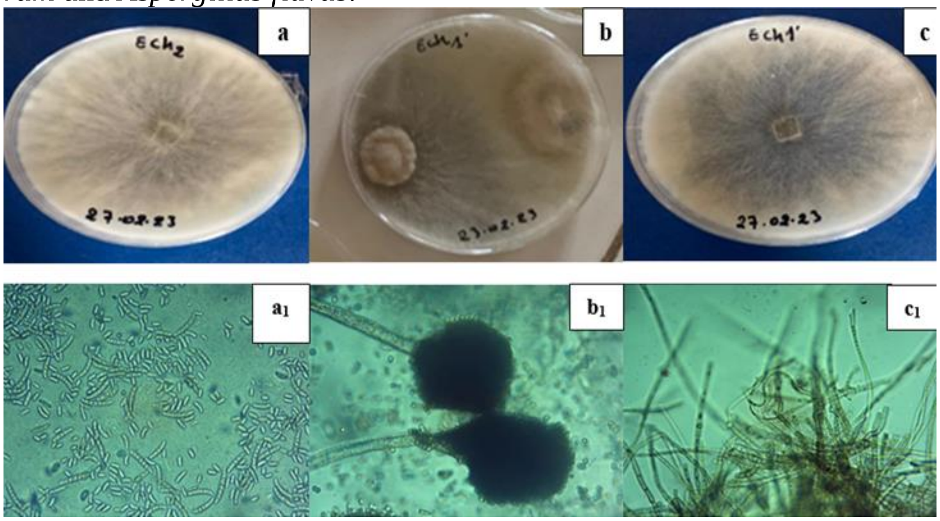

Figure 5: Fungal diseases developing on cabbage leaves (a and a1: Fusarium oxysporum, b and b1: Aspergillus flavus, c and c1: Alternaria brassicae

3.6. Impact of the different treatments on the conservation of cabbage apples one month after observation

The results show that the cabbage apples treated with chemical insecticides were the most affected by rot, which developed progressively after one month's observation, until it reached 100%, i.e. the total level of degradation. Apples treated with bio-insecticide showed a loss of 60%.

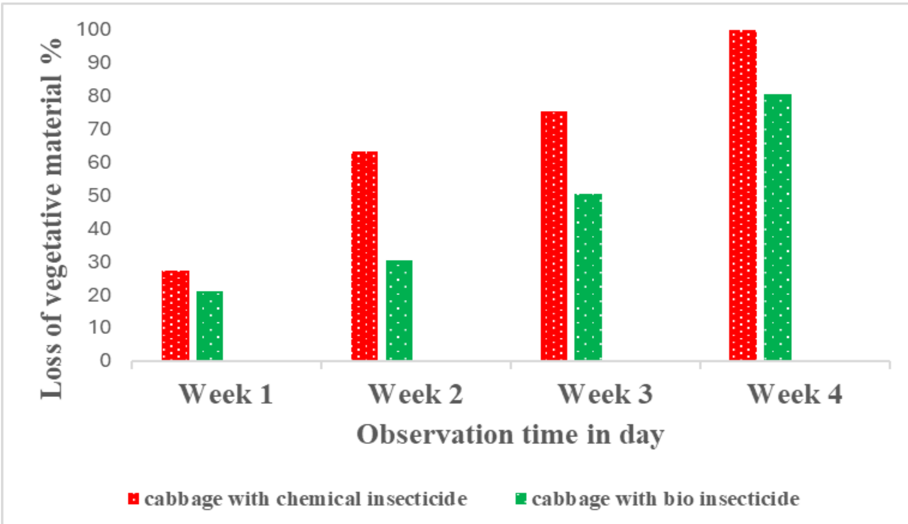

Figure 6: Degradation of cabbage apples as a function of the main treatments during one month's storage.

4. DISCUSSION

Market gardening is an important economic activity that contributes to food security and poverty reduction for rural households in Africa (Azonkpin et al. 2019). In Cameroon, as in many other West African countries, vegetable crops are subject to strong pest pressure, of which insects account for a significant proportion (Djomaha and Ghogomu, 2016). Note that, in 2023, a total of 18249 individuals were observed, compared with 23259 in 2024, for a total of 41508 specimens. Although these trials were conducted during the same periods for the two consecutive years, we note that the 2024 trial was more affected than the 2023 trial. This difference in trend could be explained by the low presence of insect pests on the surrounding crops or by the effects of climate change (temperature). Indeed, Kouassi et al. (2021) have shown that the period is a factor that may or may not favour the development of the main pests of apple cabbage. Some authors indicate that of the five main cabbage pests, Plutella xylostella is the most devastating and occurs in seven countries in East and Southern Africa (Tewary et al. 2005) and also in Central and West Africa (Djomaha and Ghogomu, 2016; Sotondji et al., 2022). These results corroborate those of Agboyi et al. (2009) who obtained the efficacy of neem seed extract on Plutella xylostella and an aphid species in cabbage crops in Togo. They invade and multiply rapidly, and rapidly damage field-grown plants, particularly foliage (Kaygm et al. 2008). For similar studies carried out in Côte d'Ivoire, Ouali et al. (2021) highlight the predominance of the Lepidoptera Plutella xylostella, Hellula undalis and Spodoptera littoralis. Our results also confirm this observation, as do others such as Sotondji et al. (2022) and Yao et al. (2022).

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With reference to the two main methods of protection, chemical insecticides and bio-insecticides, the results obtained show that Azadirachta indica juss oil was the best phytosanitary treatment product. It proved effective on the population of lepidopterans present in the plots (Plutella xylostella; Spodoptera exigua; pieris brassica and Spodoptera littoralis) and even other insect pests (Biao et al. 2018). This action resulted in a significant drop in the target population, which in turn reduced the level of nuisance to a low level compared with the control plot, which recorded significant losses. Azadirachtin, the main compound in neem seeds, has repellent and antiappetent properties against crop pests. These include crops such as cabbage, okra, sorghum, chilli and cotton (Sanou et al. 2018; Biao et al. 2018; Sane et al. 2018; Abdourahamane et al. 2019). This compound also stops larval development and blocks moulting in insects (Yarou et al. 2017; Cissokho et al. 2015). Amtul (2014) reported that Azadirachta indica juss contains compounds acting as inhibitors of the digestive enzyme alpha-amylase in the insect pest Tribolium castaneum (Coleoptera: Tenebrionidae). The advantages of pesticidal plants are their relatively rapid decomposition and low pollutant action (James et al. 2010). Under certain conditions, plant extracts can be as effective as conventional insecticides (Satondji et al. 2023). However, although chemical insecticide treatment is effective against cabbage pests, it does show a certain fragility, which may be linked to the resistance developed by the latter, as well as to environmental pollution, which is a cause for concern.

The treatments had an effect on the insect pest population at different frequencies and times. Studies by Yao et al (2022) showed that the population size of Plutella xylostella larvae was higher in T0 (control) and T3 (Eucalypthus leaf extracts), with a peak of 1.5 individuals on average at 79 DAS (Days After Semi) and 0.7 individuals at 73 DAS in T3. Our results show higher population sizes for these main pests in both collection years. The Neem oil treatment showed a population size of between 0 and 0.5 for the two species indicated, with a slight variation between 42 and 63 days, irrespective of the collection period. By observing the fluctuations in the different numbers of larvae after the treatments, we can see that the average numbers of P. xylostela and S. exigua on the treated plots decreased as the plants evolved physiologically.

By comparing the yield results we obtained with those of Kouassi et al. (2022), which indicates that the yield was 22.77 kg/ha for the chemical insecticide and 17.20 kg/ha with the Ocimum gratissimum-based bio insecticide, comparing our results with the latter, we note a positive difference in the yields of plots treated with botanical insecticides for the two campaigns (2023 and 2023). These results are in line with those of Mondedji et al. (2014) and Bia et al. (2008), who showed the efficacy of neem Azadirachta indica leaf extracts on certain cabbage insect pests in Togo and Benin. These two authors showed that plots treated with botanical insecticides gave better yields than plots treated with synthetic chemicals. Excessive treatments with synthetic insecticides are toxic to the pests' natural enemies, which means that the number of pests causing more damage to the crop increases (Sotondji et al. 2022). This clearly demonstrates that the use of botanical pesticides helps to protect the environment and control beneficials, while remaining effective on target insect pests (Slotkim et al. 2016). These accumulate in the various links in the food chain and cause damage to the ecosystem (Zaki et al. 2020; Sultana et al. 2024). Various species of pesticidal plants can be used as plant extracts or in combination with other crops to control pests. However, there is a growing need for environmentally friendly natural products to replace chemical pesticides with biopesticides. This experiment has shattered the myth that growing cabbage is an activity peculiar to the West, North-West and South-West regions, given

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their climate. We are now certain that cabbage can also be produced in the Centre region, and more specifically in Yaoundé, without the slightest difficulty.

Two fungal diseases have been identified Alternariose and Fusariose, in terms of incidence and disease severity of diseases could be explained by the fact that the insecticide treatment used helps to protect cabbage plants from insect damage and the stress caused by insect infestations makes them more vulnerable to fungal diseases. On plots treated with neem oil, cabbage plants were found to be less affected by these diseases in the field, which could be explained by the fact that neem oil acts as a fungicide on cabbage plants. Researchers Häseli and Weibel (2004) have shown the effectiveness of neem on diseases in cherry production. According to Pohe et al, 2013, neem leaf extracts and especially the seeds, which are richer in Azadirachtin, are capable of controlling both plant pests and diseases. It was found that plots treated with neem oil were less prone to these fungi, while control plots that had not received any treatment were more susceptible to fungal attack. Pohé and Agneroh (2013) showed that neem oil was more effective than Ridomil 66 WP in controlling brown pod rot in cocoa in Côte d'Ivoire.

In relation to degradation, Kouassi et al. (2022) showed that the use of biopesticides could improve fruit quality and post-harvest preservation. In other words, the absence of chemical molecules on apples slows down the process of material degradation. The biocidal action of plant extracts on fungi can be seen in the inhibition of sporulation or a reduction in the severity of the disease. By comparing the fungicidal effect of essential plant oils with that of conventional fungicides, it was found that the essential oil of X. aethiopica fruit strongly inhibited the mycelial growth of S. rolfsii, resulting in a considerable reduction in the incidence of the disease on treated tomato plants compared with untreated plants (Bi Bolou et al. 2015). Unlike bio-insecticides, synthetic pesticides can be degraded in the environment by abiotic or biotic processes, giving rise to potentially hazardous transformation products (Fenner et al. 2013). Contamination by the latter can have harmful effects on biodiversity, water quality, food safety and human health. Given the scale of the consequences, there is a growing need for natural, environmentally-friendly products to replace chemical pesticides.

5. CONCLUSION

The search for alternatives to chemical insecticides led us to test the effectiveness of neem oil, in comparison with a conventional chemical product, on the main insect pests and diseases of the cabbage crop. It is clear from this experiment that neem oil has a positive effect in controlling fungal diseases and cabbage pests. This pesticidal plant may be a promising alternative for managing bioaggressors in vegetable crops. However, the reduction in attack rates has led to a considerable increase in cabbage production. Induced yields are higher than or equal to those obtained with synthetic chemical insecticides, which correspond to average yields. Their application has also helped to improve the quality of cabbage apples, while protecting the health of consumers and the environment. Known for its therapeutic, medicinal and anti-parasitic uses, neem oil has multiple functions. Its insecticidal, ovicidal, larvicidal and antifungal properties make it a plant of interest to growers. Unfortunately, most of these pesticidal plants are little known, little cultivated and little disseminated. However, people need to be made aware of the advantages of using these plant-based pesticides to facilitate their use. Promoting these natural insecticide products could solve the current economic problems of importing synthetic pesticides, which remains a heavy financial burden for Africa in general and Cameroon in particular.

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