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RESEARCH ARTICLE

EFFECTS OF THE BIOPESTICIDE AND THE PEANUT VARIETY (ARACHIS HYPOGAEA L.) ON INSECT PESTS AND DISEASES OF THE SPECIES AT THE INRAN EXPERIMENTAL STATION IN DIFFA

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Abstract

The present study, conducted on the site of the National Institute for Agricultural Research of Niger (NIRA) in region the of Diffa (Niger), focused on the effects of some biopesticides and a chemical pesticides mixture. The objective is to compare the insecticidal and/or repellent effects of organic and chemical pesticides on groundnut pests and diseases. The biopesticides tested are neem almond juice, garlic juice, tobacco porridge and chili pepper juice at 10% each, and the chemical pesticide consisting of a mixture of fungicide and insecticide. In order to compare these effects with a baseline situation, controls where groundnut plants were not administered biopesticides or chemical pesticides were used. One trial with an experimental total randomisation design with 24 treatments and 3 replicates was conducted. The results showed that the chemical pesticide and neem juice were found to be more effective against groundnut pests and diseases. Other biopesticides, although not the best yield of pods and grains, have reduced the damage of pests and diseases to the crop. The ACP has shown that the V2P5, V3P1 and to a lesser extent V1P5 treatments are characterized by a good yield of pods, grain and biomass unlike the V1P0, V3P0, V4P0 and V2P0 treatments which are characterized by many leaves attacked by pests and yellowing and many rotten pods. In addition, the V2P0, V2P2, V2P3, V2P1 and V4P5 treatments are characterized by a lot of rotten pods, roots and crowns. The CAH suggested seven (7) groups. The G1 group is made up of controls characterized by pest and disease attacks, while the G6 and G7 groups mainly include the chemical pesticide and neem, which have been shown to be more effective. At the end of this study, we can therefore recommend the use of biopesticides to producers.

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Introduction:-

Niger, like other countries in the Sahel, has endured increased food shortages in recent decades. In order to achieve food self-sufficiency in the sub-region in general and in Niger in particular, a policy of priority agreement to cereal crops is recommended. This self-sufficiency takes into account all other food crops and cash crops, including groundnuts, which seem to be great interest to the population. Indeed, groundnuts are a multidirectional crop because they serve both as a source of food for the population and as a source of monetary income for producers (Thiam, 1989). Peanuts are a food rich in protein (30%) and lipids (50%). Its carbohydrate content amounts to about 7.5%. The peanut proteins found in most legumes are glycoproteins called leptins. They have the property of binding specifically to oligosaccharides (Bonhomme and Ndiaye, 1992). Groundnuts remains a plant with great potential for which it is imperative to develop and carry out research programs to achieve a better profitability of the sector in order to make it more attractive. The nutritional value of peanuts is undeniable, its richness in edible oil, various proteins, and its contribution to the fight against malnutrition have earned it widespread consumption in the country. Overall, the demand for groundnuts continues to grow. Exports, if supported by substantial production, could generate considerable revenues for the developing country. (Thiam, 1989).

However, this production encounters enormous constraints, among which we can note: attacks by insect pests and funguses, bacteria and viruses diseases. Thus, to improve yields and satisfy the ever-increasing market demand, the use of synthetic pesticides by producers is almost systematic (Kanda et al., 2013; Mondédji et al., 2015). Chemical pesticides are the first recourse for farmers because of their immediate effectiveness makes producers forget the health risks associated to their use (Ahouangninou et al., 2013). However, their harmful effects on humans and the environment and the resistance of pests and diseases to insecticides have been demonstrated (Assogba-Komlan et al., 2007; Houndété et al., 2010; Mondédji et al., 2015; Agboyi et al., 2016). Pesticides contain dangerous and toxic substances even at very low doses (Carlos, 2006). According to Gomgnimbou et al., (2009), their use is a source of health risks, water and soil pollution and the development of resistance in the targeted pests (Ouédraogo, 2004; Bass et al., 2015; Narayan et al., 2017). The effects of pesticides on the environment and health are not compatible with the sustainable exploitation of agro-ecosystems, as mentioned by several authors (Deguine and Ferron, 2004; Narayan et al., 2017).

Environmental pollution, on the other hand, results from the effects of overdose as well as from mismanagement (Kanda et al., 2013; Son et al., 2017). Thus, recently, several works have been carried out to propose alternative methods of protection, which are not only inexpensive but also respect environment. Biological control through the use of entomopathogens is a very promising alternative for integrated insect pest management (McGurire et al., 2005). In addition, in plant protection, the use of biopesticides is an alternative solution in the management of pests. The use of biopesticides such as botanical extracts and essential oils is known to be effective, biodegradable and poses no danger to the environment (Sanon et al., 2005; Rochefort et al., 2006; Salma and Jogen, 2011; Sarwar, 2015). Nowadays, several studies have evaluated the effectiveness of plant extracts in the management of insect pests (Gnago et al., 2010; Fayalo et al., 2014; Sane et al., 2018). It includes all methods that reduce the nuisance of pests, excluding chemical pesticides and control methods that directly reduce the populations of pests present. In the broad sense, biological control includes the varietal resistance of plants, the managements of pest habitats modification, the use of pheromones and growth inhibitors, natural enemies, the release of parasitoids, etc.

In the context of West Africa, the scientific literature shows that many plants of the West African flora have an enormous biocidal potential on a wide range of pests. Most of these plants are not cultivated, such as A. indica, probably the most widely used species as a pesticide plant. But like any other control method, the use of pesticide plants has advantages and limitations (Yarou et al.). To adopt an effective extension strategy, the search for scientific data on the identification of the most effective biopesticides remains essential. Also, Schmale et al. (2003) and Velten et al. (2008) find that it is possible to combine biological control and varietal resistance. It is in this innovative approach to research that the present work focused on the assessment of the effects of biopesticides on pests and parasitic diseases of crops is carried out. Among the biopesticides used are extracts based on neem derivatives (Azadirachta indica); tobacco (Nicotiana tabacum); chili pepper (Capsicum frutescens) and garlic (Allium sativum). It would be wise to compare the effects of the juice of spring rolls, which are widely used and recommended by studies, to other organic products such as tobacco porridge, chilli juice, garlic or, if necessary, to chemical pesticides known for their effectiveness in responding to peanut varieties.

MATERIAL AND METHODS:-

Presentation of the site

The present study was conducted in the urban commune of Diffa located in the extreme east of Niger (between the Sahelian and the Saharan zones) and is located between 10° 30' and 15°35' east longitude, 13°04' and 18°00' north latitude, on the site of the National Institute for Agricultural Research (NIRAN) as shown in Fig. 1.

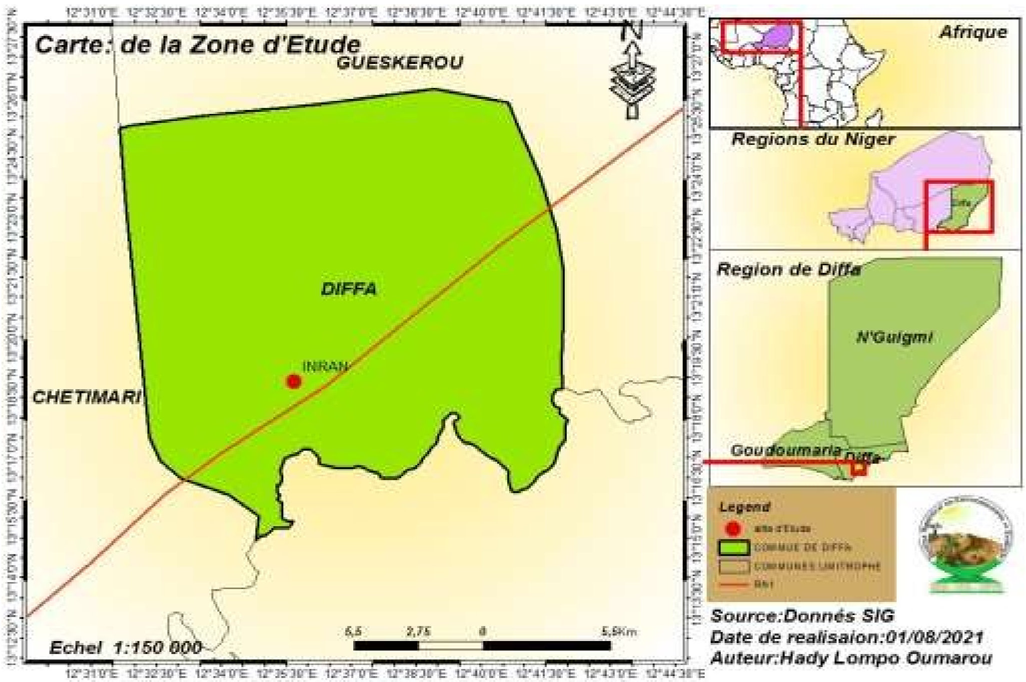


Fig. 1: Location of the experimental site

BIOLOGICAL MATERIAL:-

It is composed of:
Groundnut seeds: four varieties were used: samnut-24, JL24, 55-437, and ICIART.
Mature neem seeds collected and dried for the preparation of the juice;
Tobacco leaves for the preparation of porridge;
Dried chilli fruits for the preparation of juice;
Garlic for the preparation of juice.

EXPERIMENTAL DESIGN

In this study, two factors were studied:

Factor 1: effect of the pesticide with five (5) levels which are:

- P0: The control that does not receive any phytosanitary treatment;
- P1: Pesticide based on neem seeds at a dose of 10%;
- P2: Pesticide made from garlic cloves at a dose of 10%;
- P3: Pesticide based on tobacco porridge at a dose of 10%;
- P4: Pesticide based on chili pepper at a dose of 10% and;

- P5: A chemical pesticide prepared with mixture of fungicide and insecticide.

Factor 2: the groundnut variety with four (4) levels which are:

- V1: samnut-24;
- V2: JL-24;
- V3: 55-457 and;
- V4: ICIART.

As the site showed no apparent gradient, the total randomization device was used. The assignment of treatments to the experimental units is done by random selection. Each level of factor 1 is combined with each of the levels of factor 2. We will thus have 6*4 = 24 treatments which are:

✓ **V1P0: the control where the samnut-24 variety does not receive any phytosanitary treatment;**
V2P0: the control where the JL-24 variety does not receive any phytosanitary treatment;
V3P0: the control where variety 55-437 does not receive any phytosanitary treatment;
V4P0: the control where the ICIART variety does not receive any phytosanitary treatment

✓ **V1P1: the samnut-24 variety receives treatment with the juice of neem seeds at a dose of 10%;**
V1P2: the samnut-24 variety receives treatment with garlic clove juice at a dose of 10%;
V1P3: the samnut-24 variety is treated with tobacco porridge at a dose of 10%;
V1P4: the samnut-24 variety receives a treatment with chili juice at a dose of 10%;

✓ **V1P5: the samnut-24 variety receives a treatment with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB);**
V2P1: the JL-24 variety receives a treatment with the juice of neem seeds at a dose of 10%;
V2P2: the JL-24 variety receives treatment with the clove juice of garlic at a dose of 10%;
V2P3: the JL-24 variety is treated with tobacco porridge at a dose of 10%;
V2P4: the JL-24 variety receives a treatment with chili juice at a dose of 10%;

✓ **V2P5: the JL-24 variety receives a treatment with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB)**
V3P1: variety 55-437 is treated with neem seed juice at a dose of 10%;
V3P2: variety 55-437 is treated with garlic clove juice at a dose of 10;
V3P3: variety 55-437 is treated with tobacco porridge at a dose of 10%;
V3P4: variety 55-437 is treated with chili juice at a dose of 10%;

✓ **V3P5: variety 55-457 is treated with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB);**
V4P1: the ICIART variety is treated with the juice of neem seeds at a dose of 10%;
V4P2: the ICIART variety is treated with garlic clove juice at a dose of 10%;
V4P3: the ICIART variety is treated with tobacco porridge at a dose of 10%;
V4P4: the ICIART variety is treated with chilli juice at a dose of 10%;

✓ **V4P5: the ICIART variety is treated with a chemical pesticide (mixture of STRONG EMIRE and MANCOZEB).**

In total, three (3) replicates were used, i.e. 24x3 = 72 experimental units. The units measure 2mx2m = 4m² and the device measures 18mx16m=288m².

SOLUTION PREPARATION AND APPLICATION TECHNOLOGY

THE DIFFERENT SOLUTIONS USED IN THIS STUDY WERE PREPARED AS FOLLOWS:

Neem Almond Juice preparation

One of the most important advantages of neem is its insecticidal property. Gueye et al. (2011) reported the presence of more than 40 active substances with insecticidal properties including azadirachtin, salanine, nimbine, meliantriol and their analogues that affect the reproductive and nutritional capacities of many pest species. To have 1liter of an aqueous solution of 10% neem juice, it was necessary to dry and weigh 100g of neem almonds and 900g of water. The almonds weighed are pounded and mixed with the amount of water weighed for this purpose. According to the area to be treated (48m2), for each application he needed 120g of neem almonds for 1080g of water. The next day, before the treatment, a piece of white soap was taken which was pounded and then, two pinches of three fingers of the crushed soap was taken mixed with the aqueous solution. Then, the whole thing was stirred until the soap was completely melted. It is this final solution that was used as a biopesticide based on a 10% of neem almonds.

Preparation of the chilli juice

To prepare 1 liter of 10% chili juice you need 100g of chili fruits and 900g of water. Thus, to treat the area (48m2) 120g of dried chilli fruit and 1080g of water were needed. The fruits have been pounded and the powder wrapped in a cloth and then left to macerate in the quantity of water provided for this purpose and the container is kept closed for 24 hours. Then 2 to 3 pinches of soap powder (Marseille soap pillage) were soaked in the aqueous solution. 10% of aqueous solution of chili pepper is then obtained to treat the required area.

Preparation of the tobacco porridge

To prepare 1 liter of pesticide based on tobacco, it is necessary to crush 100g of dry tobacco leaves without making a powder and wrap it in a cloth then let it macerate in 900g of water, keep the container closed and in the shade for 24 hours. At the same time, soak 2 to 3 pinches of soap powder (Marseille soap) in the aqueous solution and leave it macerated for 24 hours. For the preparation of the amount of 10% solution needed to treat the 48m2 area, 120g of tobacco leaves and 1080g of water were used.

Preparation of the garlic porridge

For the preparation of the biopesticide based 10% garlic, 100g of garlic bulb and 900g of water are needed. The garlic bulbs are then pounded and wrapped in a cloth and left to macerate in water with 2 to 3 pinches of soap powder (Marseille soap). The container is kept closed for 24 hours. To prepare the amount of 10% solution needed to treat the 48m2 area, we will need 120g of tobacco leaves and 1080g of water.

The role of soap is to allow a good adhesion of the product with the aerial parts of the peanut. The pesticides were applied weekly with a 20 litre sprayer maintained by pressure.

Preparation of the chemical-based porridge

The porridge was prepared with a mixture of chemicals: a fungicide, Mancozeb 80% WP and an insecticide, EMIR FORT 104 EC, based on cypermethrin 72g/l and Acetamipride 32g/l. The fungicide acts on fungi and therefore on fungal diseases as the insecticide on pests. They were applied along with the biopesticides and according to the dose prescribed by the manufacturer.

THE PARAMETERS STUDIED

Groundnuts, although less attacked by insects and diseases than cowpeas, are facing attacks. The most common diseases of groundnuts are crown rot (young and adult) caused by aspergillus niger and sclerotium rolfsii, dry rot caused by macrophomina phaseolina, late and early leaf rot caused by cercospora arachidicola and phaeoisariopsis personata, pod rot caused by rhizoctonia solani and fusarium spp., the green rosette caused by peanut rosette virus and the clump caused by the clump virus. Groundnut pests include nematodes, caterpillars and aphids. An application of organic or chemical pesticides would make it possible to control these pests and diseases on groundnuts. The effectiveness of this control would result in a disappearance or, failing that, a decrease in attacks. Thus, during this study the following parameters were studied. These are: foliar attacks by pests;

leaves attacked by pests
Leaves attacked by yellowing;
Rotten pods;
Rotten roots;
Rotten snares;
Pod yield;
Grain yield;
Weight of 100 grains;
Biomass yield and;
Dry matter yield.

DATA COLLECTION METHODS:-

Observations relative to leaves were made every two days after pesticide application until the next application. At the same time, in addition after noting presence of pests on groundnut leaves, it was also mentioned that the leaves had been attacked. That was the same for the pods. The idea is that the toxicity of a pesticide should prevent pests landing on the parts of the plant that have undergone treatment. At harvest, the observations consisted mainly of counting the number of rotten pods, and weighing these pods and the grains that they contain.

Furthermore, it is appropriate to note the presence of parasitic diseases in order to measure the effectiveness of organic pesticides on fungi, bacteria and viruses. Each pathogen is associated with specific symptoms to one or more diseases. These symptoms will be used to determine the causative agents in the event of infection. The effectiveness of a bio-pesticide should allow the disappearance or reduction of symptoms attributable to the presence of germs. Observations were made in the central part of each experimental unit.

DATA ANALYSIS AND PROCESSING METHODS

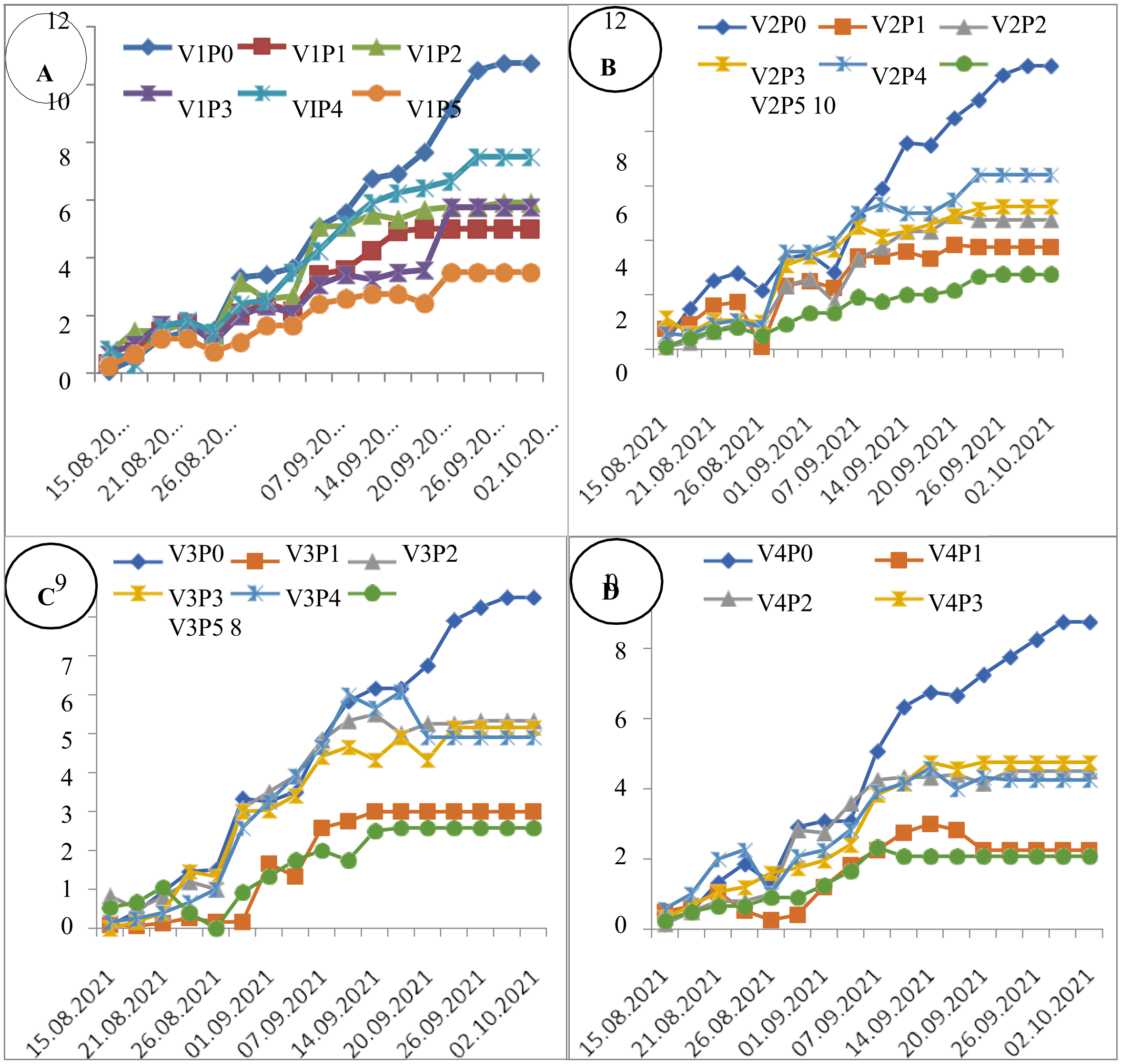
The data were submitted to the Excel table and the Minitab 18 software for statistical processing. ShapiroWilks and Levene tests were performed to check for normality and homogeneity of variances respectively before submitting them to analysis of variance (ANOVA). A Principal Component Analysis (PCA) was performed to find a link between treatments and the parameters studied and groupings with a hierarchical ascending classification (CAH) were made.

Results and Discussion:-

Results:-

Effects of treatments on the number of attacked leave

Groundnuts, as well as other legumes such as cowpeas, are attacked by pests, in this case caterpillars, grasshoppers, aphids, etc., which attack young leaves (Photo 1). Thus, the number of leaves attacked is an important parameter that testifies the degree of damage caused by these pests. The effectiveness of the treatments can occasion the reduction or even elimination of attacks on the leaves. Figure 2 shows the evolution of leaves attacks as a function of treatment and time. On all the curves, those of the controls (V1P0, V2P0, V3P0, V4P0) show that the damage changes much more over time. On the other hand, the curves for the chemical pesticide (V1P5, V2P5, V3P5 and V4P5) are below all the curves showing that the plants subjected to these treatments have suffered fewer attacks compared to the others. Indeed, Table 1 gives the effects of treatments on insect attacks on groundnut leaves. The analysis of this table shows that there is a statistically highly significant difference between the different treatments. Thus, the controls V1P0, V4P0, V2P0, V3P0 were more affected by insect attacks on the leaves as opposed to those subjected to the chemical pesticide (V1P5, V2P5, V3P5 and V4P5) and to a certain extent to neem juice at a dose of 10% (V3P1 and V4P1). Mixing chemical pesticides and neem juice at a dose of 10% had more effect on peanut leaves pests. However, the effects of neem juice were not effective against attacks on the leaves of V1 and V2 varieties. Tobacco porridge at the same dose, even if it did not have the same effectiveness as the first two, was more effective than garlic and chili juice.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V1P0
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V1P2
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Fig 2: Evolution of pest attacks on groundnut leaves as a function of treatments on varieties in a) V1: samnut-24; in b) V2: JL-24; in C) V3: 55-457 and in d) V4: ICIART

Photo 1: Grasshopper attacks in A) and caterpillar attacks in B) on groundnut leaves

Effects of treatments on yellowing of peanut leaves:-

The evolution of leaves yellowing is given in Figure 3. The analysis of this figure shows that the number of leaves affected by yellowing changes much more over time in the control (V1P0, V2P0, V3P0 and V4P0). For other treatments, the evolution of yellowing remains not only similar but tends towards a zero value synonymous as the disappearance of the disease. Photo 2 illustrates the yellowing of groundnut leaves at the site. Table 1 shows the effects of treatments on yellowing of groundnut leaves. Analysis of this table shows that there is a statistically significant difference between treatments. As a result, plants subjected to controls V1P0, V4P0, V2P0, V3P0 were more affected by yellowing as opposed to those subjected to the chemical pesticide (V1P5, V2P5, V3P5 and V4P5) and to some extent to neem juice at a dose of 10% (V3P1 and V4P1).

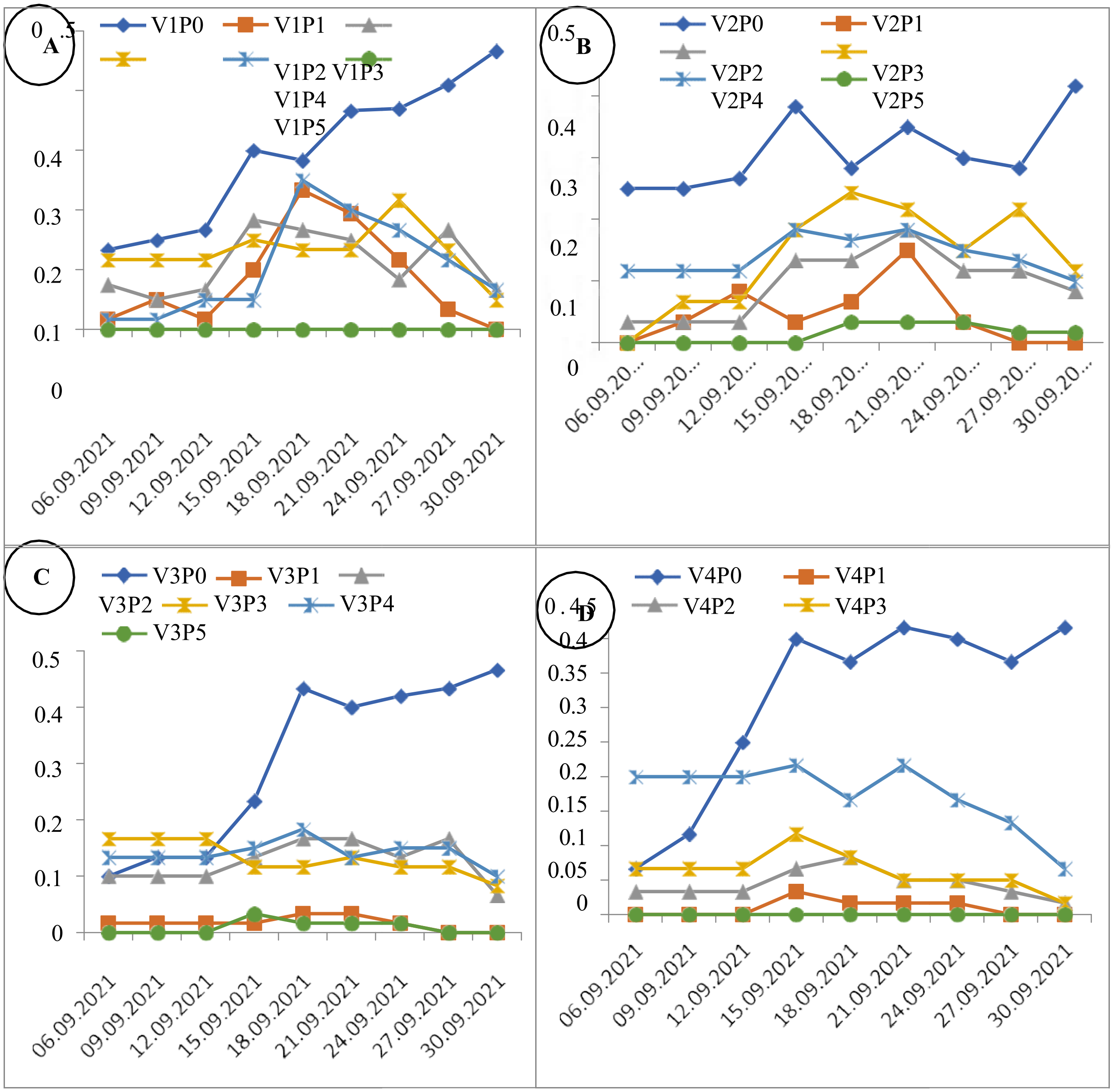


Figure 2: Evolution du jaunissement des feuilles d'arachide en fonction des traitements sur les variétés en a) V1 : samnut-24 ; en b) V2 : JL-24 ; en C) V3 : 55-457 et en d) V4 : ICIART

Photo 2: Yellowing of peanut leaves

Effect of Treatments on Root Rot in Groundnut Plants

Table 1 gives the average number of rotten roots according to the treatments. The analysis of this table shows that there is no statistically significant difference between the treatments at the 5% threshold. The treatments therefore had no effect on root rot.

Effect of Treatments on Groundnut Plant Crown Rot

The average number of rotten snares according to the treatments is given in Table 1. The analysis of this table shows that there is no statistically significant difference between the treatments at the 5% threshold. The treatments therefore had no effect on crown rot.

Effect of Treatments on Pod Rot in Groundnut Plants

Table 1 shows the effects of treatments on groundnut pod rot. The analysis of this table shows that there is a statistically highly significant difference between the different treatments at the 5% threshold. In fact, plants subjected to controls V1P0, V4P0, V2P0, V3P0 were more affected by the disease, as opposed to those subjected to the chemical pesticide (V1P5, V2P5, V3P5 and V4P5) and tobacco porridge at a dose of 10% (V1P3, V2P3, V3P3 and V4P3) and to a certain extent to neem juice at a dose of 10% (V2P1, V4P1). The mixture of chemical pesticides, tobacco porridge and neem juice at a dose of 10% had more effect on the rot of the peanut pods.

Table 1: Effects of Treatments on Mean Number of Pest Leaf Holes, Mean Number of Yellowed Leaves, and Number of Roots, Crown, and Rotting Pods

Treatment	Average number				
	Foliar attacks	Leaves attacked by yellowing	Rotten Pods	Rotten roots	Rotten snares
V1P0	21.13 ± 15.40^{a}	3.18 ± 1.56^{a}	8.67 ± 3.06^{ab}	1 ± 1^{a}	0.33 ± 0.57^{a}
V1P1	13.10 ± 8.59^{bcdef}	1.05 ± 1.26^{bcdefg}	4.00 ± 3.46^{b}	0.0 ± 0.00^{a}	0.66 ± 0.57^{a}
V1P2	15.71 ± 10.03^{abcde}	1.29 ± 0.96^{bcde}	6.33 ± 1.528^{b}	0.66 ± 0.57^{a}	0.33 ± 0.57^{a}
V1P3	12.44 ± 9.13^{bcdef}	1.36 ± 1.08^{bcde}	3.67 ± 2.08^{b}	0.33 ± 0.57^{a}	0.00 ± 0.0^{a}
VIP4	17.25 ± 12.41^{abcd}	1.10 ± 1.07^{bcdef}	7.000 ± 1^{ab}	0.33 ± 0.577^{a}	0.33 ± 0.57^{a}
V1P5	9.146 ± 6.011^{ef}	0 ± 0^{g}	3.33 ± 1.52^{b}	0.33 ± 0.577^{a}	0.33 ± 0.57^{a}
V2P0	21.19 ± 15.40^{a}	3.5 ± 1.19^{a}	13 ± 2^{a}	1.66 ± 0.577^{a}	1.00 ± 0.00^{a}
V2P1	11.71 ± 7.60^{def}	0.52 ± 0.73^{defg}	6 ± 2^{b}	0.66 ± 0.577^{a}	0.00 ± 0.00^{a}
V2P2	12.19 ± 7.75^{cdef}	1.07 ± 0.72^{bcdefg}	7.66 ± 1.52^{ab}	0.66 ± 1.155^{a}	0.66 ± 0.57^{a}
V2P3	12.83 ± 8.54^{bcdef}	1.65 ± 1.49^{bc}	4.66 ± 0.57^{b}	0.00 ± 0.00^{a}	0.66 ± 0.57^{a}
V2P4	15.13 ± 10.82^{abcdef}	1.60 ± 1.19^{bcd}	4.667 ± 1.15^{b}	0.33 ± 0.57^{a}	0.00 ± 0.00^{a}
V2P5	8.229 ± 5.340^{f}	0.14 ± 0.34^{fg}	4.333 ± 1.52^{b}	0.00 ± 0.000^{a}	0.33 ± 0.57^{a}
V3P0	18.82 ± 12.14^{abc}	3.354 ± 1.87^{a}	8.000 ± 1^{ab}	0.66 ± 0.57^{a}	0.6 ± 1.15^{a}
V3P1	9.18 ± 5.93^{ef}	0.19 ± 0.36^{fg}	4.33 ± 2.52^{b}	0.33 ± 0.57^{a}	0.00 ± 0.00^{a}
V3P2	13.98 ± 8.54^{bcdef}	1.43 ± 1.03^{bcde}	5.33 ± 2.08^{b}	0.33 ± 0.57^{a}	0.33 ± 0.57^{a}
V3P3	12.69 ± 8.84^{bcdef}	1.53 ± 0.78^{bcde}	4.333 ± 0.57^{b}	0.00 ± 0.00^{a}	0.33 ± 0.57^{a}
V3P4	14.27±10.89abcdef	1.6±1bcd	3.333±0.57b	0.33±0.57a	0.00±0.00a
V3P5	8.16±5.2f	0.09±0.27fg	6.000±1b	0.66±0.57a	0.00±0.00a
V4P0	19.14±13.16ab	3.59±2.05a	8.667±1.15ab	0.66±0.57a	0.66±0.57a
V4P1	8.33±5.53f	0.50±0.42efg	6.00±1.73b	0.33±0.57a	0.00±0.00a

V4P2	12.58±7.09bcdef	0.74±0.59cdefg	7.67±3.79ab	0.66±0.57a	0.00±0.00a
V4P3	11.60±8.07def	1.31±0.83bcde	3.333±1.528b	0.33±0.57a	0.00±0.0a
V4P4	13.500±6.3bcdef	2.01±0.97b	3.67±2.08b	0.33±0.577a	0.00±0.00a
V4P5	9.04±5.81ef	0±0g	5.00±3b	0.66±1.155a	1.00±0.00a
p-value	0.001	0.001	0.001	0.443	0.086

Averages followed by the same letters on the same column are not statistically different

Effect of Treatments on Peanut Pod Yield

Table 2 gives the average pod yield (in t/ha) of groundnuts, depending on the treatment. The analysis of this table shows that there is a statistically significant difference between the different treatments at the 5% threshold (p = 0.001). In fact, the treatments that had the best yields were V1P3, V1P5, V2P1, V2P3, V2P5, V3P1, V3P5, V4P1 and V4P2, while the V1P0 treatment had the lowest average pod yield.

Effect of Treatments on Peanut Grain Yield

The average yields (in t/ha) of groundnut varieties are shown in Table 2. The analysis of this table shows that there is a statistically significant difference between the different treatments at the 5% threshold (p = 0.001). The V1P3, V2P1, V2P5, V2P3 and V4P5 treatments had the best grain yields. In contrast, the V1P0 treatment and to some extent V2P0 and V3P2 had the lowest average grain yields.

Effect of Treatments on the Weight of One Hundred (100) Peanut Kernels

Table 2 shows the average weight of the hundred (100) grains (in g) of groundnuts, depending on the treatment. The analysis of this table shows that there is a statistically significant difference between the different treatments at the 5% threshold (p = 0.001). The treatments that had the best hundred weights were V2P1, V2P2, V2P3, V2P4 and V2P5 followed by V4P5. However, the V1P0, V3P0, V4P0 and V4P1 treatments had the lowest average hundred weights.

Effect of treatments on biomass yield

Table 2 shows the average quantity of biomass (in t/ha) as a function of treatments. The analysis of this table shows that there is no statistically significant difference between the treatments at the 5% threshold (p = 0.407).

Effect of treatments on dry matter quantity

The yield (in t/ha) in dry phytomass, as a function of treatments, is given in Table 2. The analysis of this table shows that there is no significant difference between treatments at the 5% threshold (p = 0.118).

Table 2: Average yield of pods, grain and weight of 100 grains by treatment Phytomass yield (t/ha)

Treatment	Average pod yield in t/ha	Average grain yield in t/ha	Average weight of 100 grains in g	Average biomass yield (t/ha)	Average dry matter yield in (t/ha)
V1P0	2.98±0.40[b]	1.50±0.23[c]	35.43±0.44[de]	7.56±2.9[a]	3.253±0.495a
V1P1	3.94±0.28[ab]	1.99±0.20[abc]	38.58±0.15[bcd]	11.62±3.96[a]	4.603±1.368[a]
V1P2	3.91±0.16[ab]	1.92±0.17[abc]	37.74±0.21[bcd]	8.67±3.61[a]	5.316±1.246[a]
V1P3	4.51±0.81[a]	2.250±0.436[a]	38.64±0.09[bcd]	9.607±1.439[a]	4.266±0.198[a]
VIP4	3.92±0.45[ab]	1.92±0.23[abc]	36.7±0.6[cde]	10.31±1.87[a]	4.125±0.183[a]
V1P5	4.33±0.42[a]	2.21±0.16[ab]	39.010±0.18[bcd]	10.21±2.71[a]	4.575±1.153[a]
V2P0	3.30±0.45[ab]	1.623±0.18[bc]	38.09±1.79[bcde]	6.56±2.93[a]	3.3±0.617[a]
V2P1	4.48±0.45[a]	2.260±0.20[a]	48.7800±0.11[a]	9.23±2.03[a]	3.909±0.46[a]
V2P2	4.07±0.27[ab]	2.07±0.11[abc]	45.64±2.48[a]	10.5±3.01[a]	4.284±0.449[a]
V2P3	4.50±0.43[a]	2.29±0.229[a]	48.30±1.15[a]	8.48±1.057[a]	3.769±0.948[a]
V2P4	3.87±0.08[ab]	2.07±0.07[abc]	45.283±1.30[a]	9.09±0.636[a]	4.575±1.1[a]
V2P5	4.43±0.06[a]	2.25±0.03[a]	48.56±1.99[a]	12.42±2.36[a]	5.484±0.855[a]
V3P0	3.57±0.53[ab]	1.70±0.28[abc]	34.02±1.97[e]	8.06±2.36[a]	4.172±0.314[a]
V3P1	4.51±0.65[a]	2.18±0.15[ab]	38.90±0.79[bcd]	13.21±4.14[a]	4.79±1.85[a]
V3P2	3.72±0.20[ab]	1.80±0.07[bc]	36.75±0.43[cde]	10.45±1.463[a]	4.003±0.191[a]
V3P3	3.65±0.42[ab]	1.81±0.23[abc]	39.47±0.12[bcd]	10.17±2.79[a]	3.8812±0.0744[a]
V3P4	3.45±0.16[ab]	1.79±0.07[abc]	37.82±0.43[bcde]	9.37±1.35[a]	3.488±0.212[a]
V3P5	4.17±0.48[a]	2.03±0.10[abc]	38.81±0.16[bcd]	10.02±3.76[a]	4.313±0.98[a]
V4P0	3.88±0.27[ab]	1.77±0.15[abc]	35.73±0.09[de]	8.06±2.32[a]	3.853±0.359[a]
V4P1	4.32±0.31[a]	2.09±0.24[abc]	40.37±1.21[de]	9.887±0.82[a]	4.266±0.388[a]
V4P2	4.28±0.35[a]	2.15±0.11[ab]	38.02±0.8[bcde]	11.76±3.27[a]	4.837±0.802[a]
V4P3	3.92±0.37[ab]	1.87±0.15[abc]	38.82±3.42[bcd]	10.92±3.18[a]	4.538±0.601[a]
V4P4	4.10±0.50[ab]	2.017±0.21[abc]	38.63±0.74[bcd]	9.79±2.16[a]	4.612±0.816[a]
V4P5	4.56±0.29[a]	2.307±0.227[a]	41.08±2.49[b]	10.683±1.014[a]	4.866±0.442[a]
p-value	**0.001**	**0.001**	**0.001**	**0.407**	**0.118**

Principal Component Analysis (PCA) and grouping by hierarchical ascending classification (HAC) of the treatments

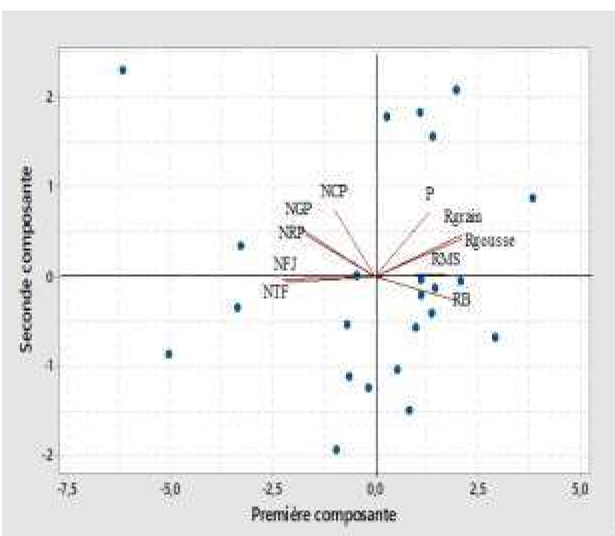
The data collected on the different parameters were subjected to the Principal Component Analysis PCA (Figure 3). The analysis of this figure shows that the first two (2) axes alone concentrate 73.4% of the inertia. This is enough to interpret the data. The analysis in Table 3 shows that the variables Rgousse (pod yield), Rgrain (grain yield) and RB (biomass yield) are positively correlated with axis 1 and therefore characterize this axis. On the other hand, it is negatively correlated with the variables NTF (Average Number of Leaves Attacked), NFJ (Average Number of Leaves Attacked by Yellowing) and NGP (Average Number of Rotten Pods).

The joint analysis of Table 3 and Figure 3 shows that the V2P5, V3P1 and to a lesser extent V1P5 treatments have a positive correlation with axis 1 and are therefore characterized by a good pod, grain and biomass yield unlike the V1P0, V3P0, V4P0 and V2P0 treatments. The latter are characterized by many leaves attacked by pests and yellowing and many rotten pods. In addition, the V2P0, V2P2, V2P3, V2P1 and V4P5 treatments are positively correlated with axis 2 and are therefore characterized by a lot of rotten pods, roots and crowns, despite a good grain yield and a high weight of the hundred seeds. The V3P4, V4P3 and to a lesser extent V3P3, V3P2 and V4P4 treatments have a negative correlation with axis 2. They are therefore characterized by few rotten pods, roots and crowns, but a low yield in grain and weight of the hundred seeds.

Figure 4 gives the ascending hierarchical classification (AC) of the treatments, with a similarity level of 56%. The analysis of this figure suggests seven (7) groups, numbered G1 to G7. The G1 group is made up of the V1P0, V3P0, and V4P0 treatments. As for the G2 group, it is made up only of V2P0. The G3 group is made up of the V1P1, V1P4, V3P2, V1P2, V2P4, V4P3 and V4P4 treatments. The V3P3 and V3P4 treatments form the G4 group while G5 is made up of V2P1 and V2P2. As for the G6 group, it consists of the V1P3, V1P5, V3P1, V3P5, V4P1, and V4P2 treatments. Finally, the G7 group is made up of V2P2, V4P5 and V2P5.

Table 3: Correlation between Treatments and Factor Axes

Variable	PC1	PC2
NTF	-0.383	-0.029
NFJ	-0.373	-0.042
NGP	-0.315	0.381
NRP	-0.287	0.331
NCP	-0.169	0.521
Rgousse	0.355	0.291
Rgrain	0.362	0.323
P	0.225	0.498
RB	0.335	-0.185
RMS	0.29	0.024



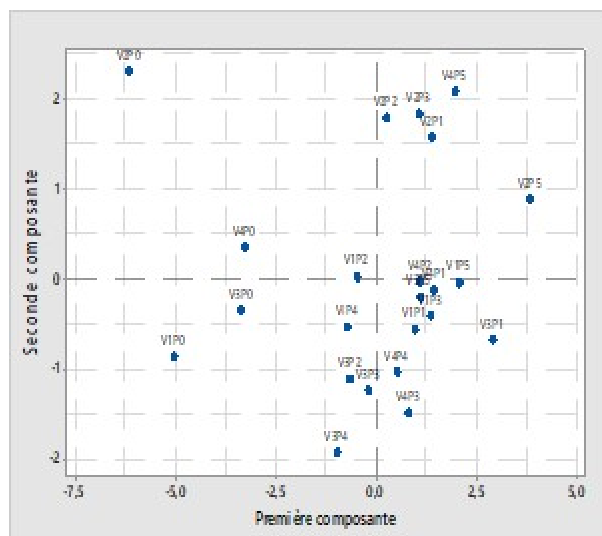
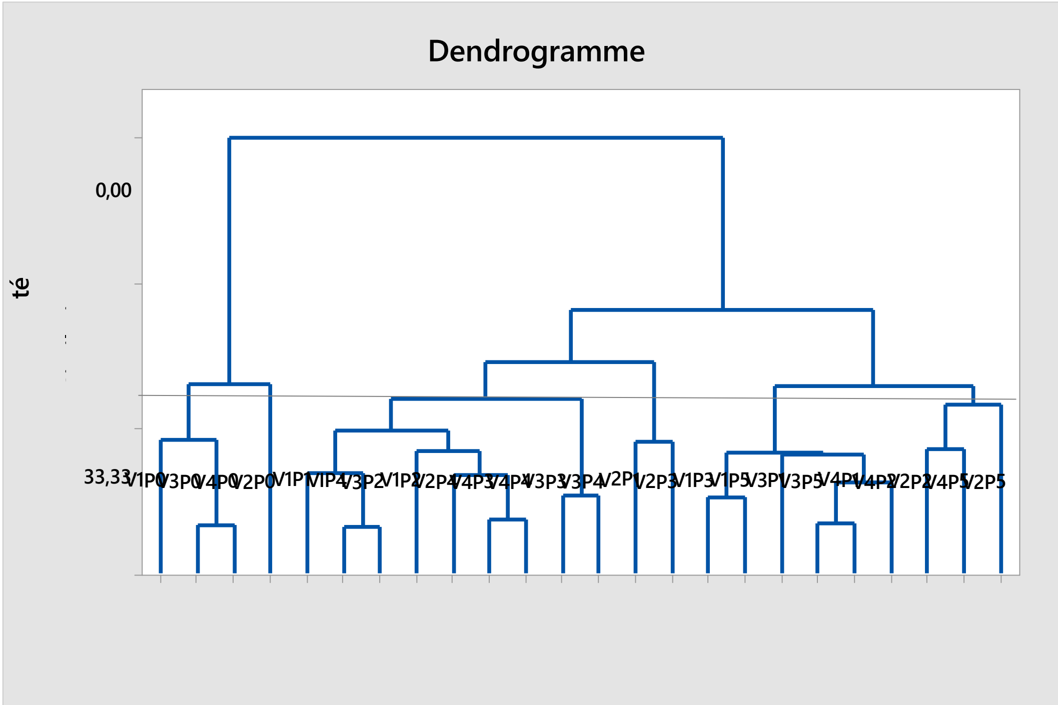


Fig. 3: Principal Component Analysis (PCA) Factor Design



Legend: NTF: Average number of leaves attacked; NFJ: Average number of leaves attacked by yellowing; NGP: Average number of rotten pods; NRP: Average number of rotten roots; NCP: Average number of rotten snares; Rgousse : Pod yield in t/ha; P: Weight of the 100 grains in g; Rgrain: Grain yield in t/ha; RB: Average biomass yield (t/ha); MSY: Average dry matter yield in (t/ha); V1P0: the control where the samnut-24 variety does not receive any phytosanitary treatment; V2P0: the control where the variety JL-24 does not receive any phytosanitary treatment; V3P0: the control where variety 55-437 does not receive any phytosanitary treatment; V4P0: the control where the ICIART variety does not receive any phytosanitary treatment; V1P1: the samnut-24 variety receives treatment with the juice of neem seeds at a dose of 10%; V1P2: the samnut-24 variety receives treatment with garlic clove juice at a dose of 10%; V1P3: the samnut-24 variety is treated with tobacco porridge at a dose of 10%; V1P4: the samnut-24 variety is treated with chili juice at a dose of 10%; V1P5: the samnut-24 variety is treated with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB); V2P1: the JL-24 variety is treated with the juice of neem seeds at a dose of 10%; V2P2: the JL-24 variety receives treatment with the clove juice of garlic at a dose of 10%; V2P3: the variety JL-24 receives treatment with tobacco porridge at a dose of 10%; V2P4: the JL-24 variety receives treatment with chili juice at a dose of 10%; V2P5: the JL-24 variety is treated with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB); V3P1: variety 55-437 is treated with the juice of neem seeds at a dose of 10%; V3P2: variety 55- 437 is treated with garlic clove juice at a dose of 10; V3P3: variety 55-437 is treated with tobacco porridge at a dose of 10%; V3P4: variety 55-437 receives treatment with chili juice at a dose of 10%; V3P5: variety 55-457 is treated with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB); V4P1: the ICIART variety is treated with the juice of neem seeds at a dose of 10%; V4P2: the ICIART variety receives treatment with garlic clove juice at a dose of 10%; V4P3: the ICIART variety is treated with tobacco porridge at a dose of 10%; V4P4: the ICIART variety is treated with 10% chilli juice; V4P5: the ICIART variety is treated with a chemical pesticide (mixture of EMIRE FORT and MANCOZEB).

DISCUSSION:-

The results of this study found that groundnut plants were exposed to various pest attacks at all stages of development, in particular during vegetative growth. The most pests present are defoliating caterpillars, grasshoppers, aphids, mites, beetles and thrips. These results corroborate those of Thiam (1989) who stipulate that the most important defoliating insects that are observed in abundance are lepidopteran larvae and beetles; as for the orthoptera, they are also present but not very abundant. According to this author, these defoliators had a high density between mid- August and mid-September. The results showed that there is a statistically highly significant difference between the different treatments at the 5% threshold. In fact, plants subjected to controls V1P0, V2P0, V3P0 and V4P0 were more affected by insect attacks on the leaves as opposed to those subjected to the chemical pesticide (V1P5, V2P5, V3P5 and V4P5) and neem juice (V1P1, V2P1, V3P1 and V4P1). The chemical pesticide and neem juice had more effects on peanut leaves pests. Indeed, according to Mouffok et al. (2008), neem seed extracts containing a mixture of more than 168 compounds consisting of a group of 7 related substances including azadirachtin A are widely considered to be the main compound with insecticidal properties of neem. According to the same authors, the application of neem extracts to insect larvae causes their death at different stages of their development, as well as malformations (reduced longevity and fecundity in adults.

These effects have been observed in several families of insects: lepidoptera (butterflies), dipterans (flies, horseflies, mosquitoes...), orthoptera (grasshoppers, locusts,...), hymenoptera (very weak for bees) and some species of aphids. This testifies to the effectiveness of neem extracts on pests. Also, according to several authors (Schmutterer 1990, Saxena 1997, Musabyimana et al. 2000; Musabyimana et al. 2001; Mondédji et al., 2015; Azandémè-Hounmalon et al., 2022; Abdourahamane et al., 2019; Zakari et al., 2016) products extracted from neem seeds have been shown to be effective against crop pests and nematodes. In addition, the V3 variety (55-457) gave the best results, regardless of the phytosanitary treatment considered. These results are in harmony with those reported by Adékambi et al., (2010), Tounou; al., (2011) and Gbenontin,. and Agbaka, 2016. According to these authors, the slow effects of organic pesticides on pests and diseases, their low persistence and the very limited spectrum of action, compared to that of synthetic products, are often considered a disadvantage by producers. Similar results have been reported by Rabo et al. (2021). Indeed, by studying the comparative effects of some biopesticides and a chemical pesticide (Cypermethrin 10 EC) on insect pests and parasitic diseases of cowpeas, these authors reported that biopesticides, even if they did not have the best results, were able to reduce the damage of pests and diseases on cowpea leaves, pods and inflorescences. Indeed, biopesticides, although of low persistence, manage to keep the pest population below the threshold of harmfulness.

This is confirmed by Amoabeng et al., (2014) who reported that under certain conditions, plant extracts can have an efficacy comparable to that of conventional insecticides. Although this effectiveness is not complete, it can nevertheless keep the pest population below the threshold and reduce the use of synthetic pesticides used on vegetables. In terms of pesticide residues, the sanitary quality of crops is thus improved, which can minimize the risk of poisoning the population. Several authors (Tounou et al., 2016; Harouna et al., 2019; Mondédji et al., 2014; Mondédji et al., 2015; Gnago et al., 2010 and Fayalo et al., 2014; Bambara et al., 2008) reported that botanical extracts significantly reduced the development of cowpea insect pests and in many cases (cases of neem and castor) the extracts resulted in toxicity effects similar to that induced by the synthetic chemical insecticide. Consistent results have been reported by Sane et al. (2018). These authors stipulate that azadirachtin A at 10 g/l was very effective on caterpillars (72% for carpophagi and 91% for leaf-eating insects) as was the chemical. However, the results on sucking stingers remain mixed (60% for Bemisia tabaci and 32% for Aphis gossypii). Neem oil extract formulated 1% (Azadirachtin A 10 g/l) can be used in integrated pest management of the main insect pests of cotton.

This study also focused on groundnut diseases. The results showed that the leaves of the groundnut are subject to some diseases such as yellowing of the leaves. Thus, the average number of leaves attacked by yellowing is statically significant between the different treatments. The treatments that had the greatest effect on the yellowing of the leaves were chemical pesticides, neem almond juice and to a lesser extent garlic juice. These results are in line with those of Ahmed and Boubaker (2018) who, by conducting a study on the effect of aqueous and ethalonic extracts of Rosemary on the growth of some phytopathogenic fungi, showed a significant antifungal effect of these extracts on three fungi (Penicillium sp, Aspergillus niger and Aspergillus flavus). Diseases have also concerned groundnut rots. Indeed, this study highlighted rots on pods, crowns and roots. However, the result was that the treatments had statistically significant effects only on the pod rot parameter. Thus, plants subjected to controls V1P0, V2P0, V3P0 and V4P0 were more affected in contrast to those subjected to the chemical pesticide (V1P5, V2P5, V3P5 and V4P5), tobacco porridge (V1P3, V2P3, V3P3 and V4P3) and neem juice especially in combination with varieties V2 and V4.

Indeed, the chemical pesticide, tobacco juice and neem juice had the best results. However, chili juice, even if it did not have the same effectiveness as the previous ones, was more effective than garlic porridge. Tobacco porridge is as effective on groundnut pod rot as the chemical pesticide. Thus, several conclusive studies have focused on the fungicidal properties of neem. The fungicidal properties of one of these neem formulations have also been studied on the diseases of some plants such as rose bushes (the white Microsphaera sp and black spots Diplocarpon rosae), lilac (white Microsphaera alni), geranium (grey mould Botrytis cinerea), tomatoes (stem canker), cucumbers (white ones) at the CRDH, on roses at the Montreal Botanical Garden, on strawberries (the white and grey mould Botrytis cinerea) and ginseng (Altenaria panax) on Île d'Orléans, grapevines (white Uncinula necator and downy mildew) on Agriculture and Agri-Food Canada farms in

Frelighsburg, Quebec and Summerland, British Columbia. As for garlic, it has powerful antimicrobial properties, effective against many fungal diseases (Bélanger and Musabyimana, 2005).

The treatments had effects on yield parameters such as pod yield, grain yield and hundred (100) seeds weight. However, they did not affect average biomass and dry phytomass yields. The highest pod yields were obtained by the V1P2, V1P5, V2P1, V2P3, V2P5, V3P1, V3P5, V4P1, V4P2 and V4P5 treatments. These results suggest that the pesticide is more important in pod yield than variety. Indeed, the chemical pesticide had the best yield in pods, followed by neem juice and to a lesser extent garlic juice. This is confirmed by the CPA, which states that the V2P5, V3P1, V1P5, V2P3, V2P1 and V4P5 treatments are characterized by a good yield of pods, grains, biomass and a high weight of 100 grains. Hierarchical ascending classification (HFC) grouping puts V2P2, V4P5, and V2P5 in group 7 and V1P3, V1P5, V3P1, V3P5, V4P1, and V4P2 in group

This corroborates the ACP's analyses. These results are in line with those reported by Rabo et al. (2021). In fact, the study of these authors has shown, with the ACP, that the yield is greater under chemical treatment than under biological treatment. Treatments with neem leaves juice, chilli juice and tobacco porridge, even if they haven't the best yield of pods and seeds, reduced pest and disease damage on cowpea leaves, pods and inflorescences. This could be explained by the fact that plant pesticides have a low persistence and a very limited spectrum action.

CONCLUSION

At the end of this study, which focused on the insecticidal and/or repellent effects of biopesticides and a chemical pesticide on groundnut pests and diseases, the results showed that the chemical pesticide and neem juice were more effective on groundnut pests and diseases. On the other hand, other biopesticides, even if they did not have the best yield of pods and grains, were able to reduce the damage of pests and diseases. The ACP has shown that the V2P5, V3P1 and to a lesser extent V1P5 treatments are characterized by a good yield of pods, grain and biomass unlike the V1P0, V3P0, V4P0 and V2P0 treatments which are characterized by many leaves attacked by pests and yellowing and many rotten pods. In addition, the V2P0, V2P2, V2P3, V2P1 and V4P5 treatments are characterized by a lot of rotten pods, roots and crowns. As for the CAH, it highlights seven (7) groups. The G1 group is made up of controls that have suffered more pest and disease attacks, while the G6 and G7 groups mainly include those based on chemical pesticides and neem, which have been shown to be more effective on groundnut pests and diseases. At the end of this study, we can therefore recommend to producers the use of biopesticides for agroecological management of groundnut pests and diseases.

BIBLIOGRAPHIC REFERENCE:-

1. Abdourahamane, H. M., Baoua, I., Lawali, S., Tamò, M., Amadou, L., Mahamane, S. et Pittendrigh, B. (2019). Essai comparatif de l'utilisation des extraits du Neem et du virus entomopathogène MaviNPV dans la gestion des insectes ravageurs du niébé en milieu paysan au Niger. Int. J. Biol. Chem. Sci. 13(2): 950-961. DOI: https://dx.doi.org/10.4314/ijbcs.v13i2.30
2. Adékambi, S. A., Adégbola, P.Y. & Arouna, A. (2010). Perception paysanne et adoption des biopesticides et/ou extraits botaniques en production maraichère au Bénin. In : Contributed Paper Presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 4843, 2899-2914
3. Agboyi, L.K., Ketoh, G. K., Martin, T., Glitho, I. A., Tamò, M. (2016). Pesticide resistance in Plutella xylostella(Lepidoptera: Plutellidae) populations from Togo and Benin. Int. J. Trop. Insect Sci., 36(4), 204-210.
4. Ahmed, D., Boubaker, K. I., (2018). Étude de l'effet des extraits aqueux et éthaloniques de Romarin sur la croissance de quelques champignons phytopathogènes, mémoire de fin d'études, Univer- sité de Bouira, 59 p.
5. Ahouangninou, C., Martin, T., Assogba, K. F., Simon, S., Djogbenou, L., Siddick, I., Pennetier, C,. Corbel, V., Fayomi, B. (2013). Using Aedes aegypti larvae to assess pesticide contamination of soil, groundwater and vegetables. British Biotechnology Journal, 3 (2) : 143-157.
6. Amoabeng, B.W., Gurr, G.M., Gitau, C.W., Stevenson, P. C., (2014). Cost:benefit analysis of botanical insecticide use in cabbage: implications for smallholder farmers in developing countries. Crop Prot., 57: 71-76.
7. Assogba-Komlan, F., Anihouvi, P., Achigan, E., Sikirou, R., Boko, A., Adje, C., Ahle, V., Vodouhe, R. et Assa, A. (2007). Pratiques culturales et teneur en éléments anti nutritionnels (nitrates et pesticides) du Solanum macrocarpumau sud du Bénin. Afr. J. Food Agric. Nutr. Dev., 7(4), 1-21.
8. Azandémè-Hounmalon, G. Y., Zandjanakou-Tachin, M., Ahouangninou, C., Mavo, O., Honfoga,
   i. J. (2022). Évaluation au champ de l'efficacité de trois pesticides dans le contrôle des ravageurs de la tomate (Solanum lycopersicum L.) au Sud Bénin. J.Anim.Plant Sci. 54 (2)
   ii. : 9932-9941 https://doi.org/10.35759/JAnmPlSci.v54-2.5

9. Bambara, D, et Tiemtoré, J. (2008). Efficacité biopesticide de Hyptis spicigera Lam., Azadirachta indica A. Juss. et Euphorbia balsamifera Ait. sur le niébé Vigna unguculata
   i. L. Walp. Tropicultura, 26(1): 53-55.
10. Bass, C., Denholm, I, Williamson, M. S, Nauen, R. (2015). The global status of insect resistance to neonicotinoid insecticides. Pesticide Biochemistry and Physiology, 121 : 78-87.
11. Bélanger, A. et Musabyimana, T. (2005). Le Neem contre les insectes et les maladies. Agriculture et Agroalimentaire Canada, Centre de recherche et développement en horticulture. Journées Horticoles 2005. 4p
12. Bonhomme, A. et Ndiaye, I. (1992). La problématique des iules en culture arachidière au Sénégal.
   i. ISRA, CNRA, Bambey, 5p.
13. Carlos J. S. P. (2006). « Exposition humaine aux pesticides: un facteur de risque pour le suicide au Brésil ». Vertigo-La revue en Science de l'Environnement ; 7-18.
14. Deguine, J. P. et Ferron, P. (2004). Protection des cultures et développement durable : bilan et perspectives. Le Courrier de l'Environnement de l'INRA (52) : 57-65. http://www7.inra.fr/dpenv/so.htm
15. Fayalo, G. D., Sokenou, H. F. D., Aboudou, M., Alavo, T. B. C. (2014). Effet de l'huile de colza sur les populations du puceron Aphis gossypii pour la protection du cotonnier. Int. J. Biol. Chem. Sci. 8 (6), 2508–2515.
16. Gbenontin, A. Y. C. et A. Agbaka, (2016). Evaluation de l'efficacité de l'huile de neem (Azadirachta indica A. Juss), Beauveria bassiana (Balsamo) Vuillemin (Hypocreales: Ophiocordycipitaceae) et leur combinaison pour la gestion de Megalurothrips sjostedtiTrydom (Thysanoptera: Thripidae) au laboratoire, EPAC/UAC.
17. Gnago, J. A., Danho, M., Atcham, A.T., Fofana, I. K., Kohou, A.G. (2010). Efficacité des extraits de neem (Azadirachta indica) et de papayer (Carica papaya) dans la lutte contre les insectes ravageurs du gombo (Abelmosehus esculentus) et du chou (Brassiea oleracea) en Côte d'Ivoire. Int. J. Biol. Chem. Sci. 4 (4), 953–966.
18. Godjo T. (2001). Revue des technologies existantes susceptible de transformer l‟arachide en huile et en Klui-klui. Communication présentée à l‟atelier scientifique post-récolte, Bohicon, les 26 et 27 juillet 2001
19. Gomgnimbou, A. P., Savadogo, P. W., Nianogo, A. J., & Millogo Rasolodimby, J. (2009). Usage des intrants chimiques dans un agrosystème tropical : Diagnostic du risque de pollution environnementale dans la région cotonnière de l'est du Burkina Faso. BASE
20. Guèye, M. (2011). Lutte contre les ravageurs des stocks de céréales et de légumineuses au Sénégal et en Afrique occidentale, Biotechnol. Agron. Soc. Environ. 15(1) : 183-194
21. Harouna, A. M., Ibrahim, B., Sitou L., Manuele T., Laouali A., Saadou M., Barry P. (2019). Essai comparatif de l'utilisation des extraits du Neem et du virus entomopathogène MaviNPV dans la gestion des insectes ravageurs du niébé en milieu paysan au Niger. Int. J. Biol. Chem. Sci., 13: 950-961.
22. Houndété, T. A., Kétoh, G. K., Hema, O. S. A., Brévaul,t T., Glitho, I. A., Martin, T. (2010). Insecticide resistance in field populations of Bemisia tabaci (Hemiptera: Aleyrodidae) in West Africa. Pest Management Science 66: 1181–1185. DOI:10.1002/ps.2008.
23. Kanda M., Djaneye-Boundjou, G., Wala, K., Gnandi, K., Batawila, K., Sanni, A., et Akpagana, K. (2013). Application des pesticides en agriculture maraichère au Togo. VertigO, 13(1), 4- 8.
24. McGurire, R., M, Ulloa, M., Young-Hoon, P., Hudson, N. 2005. Biological and molecular characteristic of Beauveria bassiana isolates from California Lygus Hesperus (Hemiptera: Miridae) populations. Biol. Control. 33: 307-314.
25. Mondedji, A. D., Nyamador, W. S., Amevoin, K., Ketoh, G. K., Glitho, I. A. (2014). Efficacité d'extraits de feuilles de neem Azadirachta indica (Sapindale) sur Plutella xylostel Plutellidae), Hellula (Lepidoptera: undalis (Lepidoptera: Pyralidae) et Lipaphis erysimi (Hemiptera : Aphididae) du chou Brassica oleracea (Brassicaceae) dans une approche « Champ Ecole Paysan» au sud du Togo. Int. J. Biol. Chem. Sci, 8(5): 2286-2295.
26. Mondedji, A.D., Nyamador, W.S., Amevoin, K., Adeoti, R., Abbey, G.A. Ketoh, G.K. and Glitho,
   i. I.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 maraichères au Sud du Togo. Int. J. Biol. Chem. Sci., 9, 98-107. https://doi.org/10.4314/ijbcs.v9i1.10
27. Mouffok, B., Raffy, E., Urruty, N. et Zicola, J. (2008). Le neem, un insecticide biologique efficace.
   i. Département génie biologique, Université Paul Sabatier. 15p
28. Musabyimana, T., Saxena R. C., Kairu EW, Ogol CPKO, Khan ZR 2000. Graines et tourteaux de neem en poudre pour la lutte contre le charançon de la banane, Cosmopolites sordidus et les nématodes parasites. Phytoparasitica 28:321–330
29. Musabyimana, T., Saxena, R. C. E., Kairu, W., Ogol, C. P. K., Khan, Z. R. (2001). Effects of neem seed derivatives on behavioral and physiological responses of the Cosmopolites sordidus (Coleoptera: Curculionidae). J. Eco. Entomol. 94, 449–454.
30. Narayan, S., Liew, Z., Bronstein, J. M, Ritz, B. (2017). Occupational pesticide use and Parkinson's disease in the Parkinson Environment Gene (PEG) study. Environment international, 107: 266-273. https://doi.org/10.1016/j.envint.2017.04. 010

31. Ouedraogo, J., Ouedraogo, E. et Nacro, H. B. (2004). Effet de l'interaction entre des modes de gestion de fertilité et la macrofaune sur la productivité du niébé et du sorgho en zone nord soudanienne du Burkina Faso. Int. J. Biol. Chem. Sci. 8(1): 104-114
32. Rabo, Y., Abdou, A. M., Abdou, L. et Mahamane, A. (2021). Effets comparés de quelques biopesticides et d'un pesticide chimique (cyperméthrine 10 EC) sur les insectes ravageurs et maladies parasitaires du Niébé, Vigna unguiculata (L.) Walp (Fabaceae). Rev. Mar. Sci. Agron. Vét. 9(4) : 710-717
33. Rochefort, S., Lalancette, R., Labbe, R., Brodeur, J. (2006). Recherche et développement de biopesticides et pesticides naturels à faible toxicité pour les organismes non ciblés lycopersicon) Caused by Ralstonia solanacearum in Benin. Plant Dis. 93 (5), 549 p.
34. Salma, M. and Jogen, C. K. (2011). A review on the use of biopesticides in insect pest management.
    a. Int. J. Sci. Adv. Technol. 1, 169–178.
35. Sane, B., Badiane, D., Gueye, M. T. et Faye, O. (2018). Évaluation de l'efficacité biologique d'extrait de neem (Azadirachta indica Juss.) comme alternatif aux pyréthrinoïdes pour le contrôle des principaux ravageurs du cotonnier (Gossypium hirsutum L.) au Sénégal. Int. J. Biol. Chem. Sci. 12(1): 157-167. DOI : https://dx.doi.org/10.4314/ijbcs.v12i1.12
36. Sanon, A., Dabire, L. C. B., Ouedraogo, A. P. et Huignard, J. (2005). Field occurrence of bruchid pests of cowpea and associated parasitoïds in sub humid zone of Burkina Faso: importance on the infestation of two cowpea varieties at harvest. Plant Pathol. J., 4 (1), 14–20.
37. Sarwar, M. (2015). Biopesticides: une ligne d'action efficace et respectueuse de l'environnement pour inhiber les insectes nuisibles. Int. J. Eng. Adv. Res. Technol. 1(2), 10–15.
38. Saxena, N. C. (1997). Saga of Participatory Forest Management in India. Bogor: CIFOR. 201 p https://doi.org/10.17528/cifor/000090
39. Schmale, I., Wäckers, F. L., Cardona, C., Dorn, S. (2003). Combining parasitoid and plant resistance for the control of Acanthoscelides obtectus in stored beans. Journal of Stored Product Research, 39, 401-411
40. Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, Azadirachta indica. Ann. Rev. EntomoI. 35, 271–297.
41. Son, D, Somda, I., Legreve, A, Schiffers, B. (2017). Pratiques phytosanitaires des producteurs de tomates du Burkina Faso et risques pour la santé et l'environnement. Cah. Agric. 26: 25005.
42. Thiam D. (1989). Contribution à l'étude d'une méthode de lutte chimique contre les arthropodesravageurs de l'arachide (ArachisHypogea,L.) au champ. Mémoire de fin d'études, diplôme d'ingénieur du développement rural. 77p
43. Tounou, A. K., Mawussi, Gbénonchi, A. S., Agboka, K., Gumedzoe, Y. M. D. and Sanda K. (2011). Bio-insecticidal effects of plant extracts and oil emulsions of Ricinus communisL. (Malpighiales: Euphorbiaceae) on the diamondback, Plutella xylostellaL. (Lepidoptera: Plutellidae) under laboratory and semi-field conditions. J. Appl. Biosci., 43: 2899 – 2914-
44. Velten, G., Rott, A. S., Conde Petit, B. J., Cardona, C., D. (2008). Improved bruchid management through favourable host plant traits and natural enemies. Biological Control, 47, 133-140
45. Yarou, B. B., Silvie, P., Komlan, F. A., Mensah, A., Alabi, T., Verheggen, F., Francis, F. (2017). Plantes pesticides et protection des cultures maraichères en Afrique de l'Ouest (synthèse bibliographique). Biotechnol. Agron. Soc. Environ. 21(4) :288-304
46. Zakari, A. H., Mahamadou, C. I., Hachimou, Z., Toudou, A. (2016). Efficacité de l'huile de Neem (Azadirachta indica) et de Bacillus thuringiensis (Biobit 2X) sur la dynamique la population de Bemisia tabaci (Gennadius 1889) et Helicoverpa armigera (Hubner, 1808) dans une plantation de tomate au Niger. Int. J. Biol. Chem. Sci 10(2): 497-505.
47. Abdourahamane, H. M., Baoua, I., Lawali, S., Tamò, M., Amadou, L., Mahamane, S. et Pittendrigh, B. (2019). Essai comparatif de l'utilisation des extraits du Neem et du virus entomopathogène MaviNPV dans la gestion des insectes ravageurs du niébé en milieu paysan au Niger. Int. J. Biol. Chem. Sci. 13(2): 950-961. DOI: https://dx.doi.org/10.4314/ijbcs.v13i2.30
48. Adékambi, S. A., Adégbola, P.Y. & Arouna, A. (2010). Perception paysanne et adoption des biopesticides et/ou extraits botaniques en production maraichère au Bénin. In : Contributed Paper Presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 4843, 2899-2914
49. Agboyi, L.K., Ketoh, G. K., Martin, T., Glitho, I. A., Tamò, M. (2016). Pesticide resistance in Plutella xylostella(Lepidoptera: Plutellidae) populations from Togo and Benin. Int. J. Trop. Insect Sci., 36(4), 204-210.
50. Ahmed, D., Boubaker, K. I., (2018). Étude de l'effet des extraits aqueux et éthaloniques de Romarin sur la croissance de quelques champignons phytopathogènes, mémoire de fin d'études, Univer- sité de Bouira, 59 p.
51. Ahouangninou, C., Martin, T., Assogba, K. F., Simon, S., Djogbenou, L., Siddick, I., Pennetier, C,. Corbel, V., Fayomi, B. (2013). Using Aedes aegypti larvae to assess pesticide contamination of soil, groundwater and vegetables. British Biotechnology Journal, 3 (2) : 143-157.

52. Amoabeng, B.W., Gurr, G.M., Gitau, C.W., Stevenson, P. C., (2014). Cost:benefit analysis of botanical insecticide use in cabbage: implications for smallholder farmers in developing countries. Crop Prot., 57: 71-76.
53. Assogba-Komlan, F., Anihouvi, P., Achigan, E., Sikirou, R., Boko, A., Adje, C., Ahle, V., Vodouhe, R. et Assa, A. (2007). Pratiques culturales et teneur en éléments anti nutritionnels (nitrates et pesticides) du Solanum macrocarpumau sud du Bénin. Afr. J. Food Agric. Nutr. Dev., 7(4), 1-21.
54. Azandémè-Hounmalon, G. Y., Zandjanakou-Tachin, M., Ahouangninou, C., Mavo, O., Honfoga,
    i. J. (2022). Évaluation au champ de l'efficacité de trois pesticides dans le contrôle des ravageurs de la tomate (Solanum lycopersicum L.) au Sud Bénin. J.Anim.Plant Sci. 54 (2)
    ii. : 9932-9941 https://doi.org/10.35759/JAnmPlSci.v54-2.5
55. Bambara, D, et Tiemtoré, J. (2008). Efficacité biopesticide de Hyptis spicigera Lam., Azadirachta indica A. Juss. et Euphorbia balsamifera Ait. sur le niébé Vigna unguculata
    i. L. Walp. Tropicultura, 26(1): 53-55.
56. Bass, C., Denholm, I, Williamson, M. S, Nauen, R. (2015). The global status of insect resistance to neonicotinoid insecticides. Pesticide Biochemistry and Physiology, 121 : 78-87.
57. Bélanger, A. et Musabyimana, T. (2005). Le Neem contre les insectes et les maladies. Agriculture et Agroalimentaire Canada, Centre de recherche et développement en horticulture. Journées Horticoles 2005. 4p
58. Bonhomme, A. et Ndiaye, I. (1992). La problématique des iules en culture arachidière au Sénégal.
    i. ISRA, CNRA, Bambey, 5p.
59. Carlos J. S. P. (2006). « Exposition humaine aux pesticides: un facteur de risque pour le suicide au Brésil ». Vertigo-La revue en Science de l'Environnement ; 7-18.
60. Deguine, J. P. et Ferron, P. (2004). Protection des cultures et développement durable : bilan et perspectives. Le Courrier de l'Environnement de l'INRA (52) : 57-65. http://www7.inra.fr/dpenv/so.htm
61. Fayalo, G. D., Sokenou, H. F. D., Aboudou, M., Alavo, T. B. C. (2014). Effet de l'huile de colza sur les populations du puceron Aphis gossypii pour la protection du cotonnier. Int. J. Biol. Chem. Sci. 8 (6), 2508–2515.
62. Gbenontin, A. Y. C. et A. Agbaka, (2016). Evaluation de l'efficacité de l'huile de neem (Azadirachta indica A. Juss), Beauveria bassiana (Balsamo) Vuillemin (Hypocreales: Ophiocordycipitaceae) et leur combinaison pour la gestion de Megalurothrips sjostedtiTrydom (Thysanoptera: Thripidae) au laboratoire, EPAC/UAC.
63. Gnago, J. A., Danho, M., Atcham, A.T., Fofana, I. K., Kohou, A.G. (2010). Efficacité des extraits de neem (Azadirachta indica) et de papayer (Carica papaya) dans la lutte contre les insectes ravageurs du gombo (Abelmosehus esculentus) et du chou (Brassiea oleracea) en Côte d'Ivoire. Int. J. Biol. Chem. Sci. 4 (4), 953–966.
64. Godjo T. (2001). Revue des technologies existantes susceptible de transformer l‟arachide en huile et en Klui-klui. Communication présentée à l‟atelier scientifique post-récolte, Bohicon, les 26 et 27 juillet 2001
65. Gomgnimbou, A. P., Savadogo, P. W., Nianogo, A. J., & Millogo Rasolodimby, J. (2009). Usage des intrants chimiques dans un agrosystème tropical : Diagnostic du risque de pollution environnementale dans la région cotonnière de l'est du Burkina Faso. BASE
66. Guèye, M. (2011). Lutte contre les ravageurs des stocks de céréales et de légumineuses au Sénégal et en Afrique occidentale, Biotechnol. Agron. Soc. Environ. 15(1) : 183-194
67. Harouna, A. M., Ibrahim, B., Sitou L., Manuele T., Laouali A., Saadou M., Barry P. (2019). Essai comparatif de l'utilisation des extraits du Neem et du virus entomopathogène MaviNPV dans la gestion des insectes ravageurs du niébé en milieu paysan au Niger. Int. J. Biol. Chem. Sci., 13: 950-961.
68. Houndété, T. A., Kétoh, G. K., Hema, O. S. A., Brévaul,t T., Glitho, I. A., Martin, T. (2010). Insecticide resistance in field populations of Bemisia tabaci (Hemiptera: Aleyrodidae) in West Africa. Pest Management Science 66: 1181–1185. DOI:10.1002/ps.2008.
69. Kanda M., Djaneye-Boundjou, G., Wala, K., Gnandi, K., Batawila, K., Sanni, A., et Akpagana, K. (2013). Application des pesticides en agriculture maraichère au Togo. VertigO, 13(1), 4- 8.
70. McGurire, R., M, Ulloa, M., Young-Hoon, P., Hudson, N. 2005. Biological and molecular characteristic of Beauveria bassiana isolates from California Lygus Hesperus (Hemiptera: Miridae) populations. Biol. Control. 33: 307-314.
71. Mondedji, A. D., Nyamador, W. S., Amevoin, K., Ketoh, G. K., Glitho, I. A. (2014). Efficacité d'extraits de feuilles de neem Azadirachta indica (Sapindale) sur Plutella xylostel Plutellidae), Hellula (Lepidoptera: undalis (Lepidoptera: Pyralidae) et Lipaphis erysimi (Hemiptera : Aphididae) du chou Brassica oleracea (Brassicaceae) dans une approche « Champ Ecole Paysan» au sud du Togo. Int. J. Biol. Chem. Sci, 8(5): 2286-2295.
72. Mondedji, A.D., Nyamador, W.S., Amevoin, K., Adeoti, R., Abbey, G.A. Ketoh, G.K. and Glitho,
    i. I.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 maraichères au Sud du Togo. Int. J. Biol. Chem. Sci., 9, 98-107. https://doi.org/10.4314/ijbcs.v9i1.10
73. Mouffok, B., Raffy, E., Urruty, N. et Zicola, J. (2008). Le neem, un insecticide biologique efficace.
    i. Département génie biologique, Université Paul Sabatier. 15p

74. Musabyimana, T., Saxena R. C., Kairu EW, Ogol CPKO, Khan ZR 2000. Graines et tourteaux de neem en poudre pour la lutte contre le charançon de la banane, Cosmopolites sordidus et les nématodes parasites. Phytoparasitica 28:321–330
75. Musabyimana, T., Saxena, R. C. E., Kairu, W., Ogol, C. P. K., Khan, Z. R. (2001). Effects of neem seed derivatives on behavioral and physiological responses of the Cosmopolites sordidus (Coleoptera: Curculionidae). J. Eco. Entomol. 94, 449–454.
76. Narayan, S., Liew, Z., Bronstein, J. M, Ritz, B. (2017). Occupational pesticide use and Parkinson's disease in the Parkinson Environment Gene (PEG) study. Environment international, 107: 266-273. https://doi.org/10.1016/j.envint.2017.04. 010
77. Ouedraogo, J., Ouedraogo, E. et Nacro, H. B. (2004). Effet de l'interaction entre des modes de gestion de fertilité et la macrofaune sur la productivité du niébé et du sorgho en zone nord soudanienne du Burkina Faso. Int. J. Biol. Chem. Sci. 8(1): 104-114
78. Rabo, Y., Abdou, A. M., Abdou, L. et Mahamane, A. (2021). Effets comparés de quelques biopesticides et d'un pesticide chimique (cyperméthrine 10 EC) sur les insectes ravageurs et maladies parasitaires du Niébé, Vigna unguiculata (L.) Walp (Fabaceae). Rev. Mar. Sci. Agron. Vét. 9(4) : 710-717
79. Rochefort, S., Lalancette, R., Labbe, R., Brodeur, J. (2006). Recherche et développement de biopesticides et pesticides naturels à faible toxicité pour les organismes non ciblés lycopersicon) Caused by Ralstonia solanacearum in Benin. Plant Dis. 93 (5), 549 p.
80. Salma, M. and Jogen, C. K. (2011). A review on the use of biopesticides in insect pest management.
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81. Sane, B., Badiane, D., Gueye, M. T. et Faye, O. (2018). Évaluation de l'efficacité biologique d'extrait de neem (Azadirachta indica Juss.) comme alternatif aux pyréthrinoïdes pour le contrôle des principaux ravageurs du cotonnier (Gossypium hirsutum L.) au Sénégal. Int. J. Biol. Chem. Sci. 12(1): 157-167. DOI : https://dx.doi.org/10.4314/ijbcs.v12i1.12
82. Sanon, A., Dabire, L. C. B., Ouedraogo, A. P. et Huignard, J. (2005). Field occurrence of bruchid pests of cowpea and associated parasitoïds in sub humid zone of Burkina Faso: importance on the infestation of two cowpea varieties at harvest. Plant Pathol. J., 4 (1), 14–20.
83. Sarwar, M. (2015). Biopesticides: une ligne d'action efficace et respectueuse de l'environnement pour inhiber les insectes nuisibles. Int. J. Eng. Adv. Res. Technol. 1(2), 10–15.
84. Saxena, N. C. (1997). Saga of Participatory Forest Management in India. Bogor: CIFOR. 201 p https://doi.org/10.17528/cifor/000090
85. Schmale, I., Wäckers, F. L., Cardona, C., Dorn, S. (2003). Combining parasitoid and plant resistance for the control of Acanthoscelides obtectus in stored beans. Journal of Stored Product Research, 39, 401-411
86. Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, Azadirachta indica. Ann. Rev. EntomoI. 35, 271–297.
87. Son, D, Somda, I., Legreve, A, Schiffers, B. (2017). Pratiques phytosanitaires des producteurs de tomates du Burkina Faso et risques pour la santé et l'environnement. Cah. Agric. 26: 25005.
88. Thiam D. (1989). Contribution à l'étude d'une méthode de lutte chimique contre les arthropodesravageurs de l'arachide (ArachisHypogea,L.) au champ. Mémoire de fin d'études, diplôme d'ingénieur du développement rural. 77p
89. Tounou, A. K., Mawussi, Gbénonchi, A. S., Agboka, K., Gumedzoe, Y. M. D. and Sanda K. (2011). Bio-insecticidal effects of plant extracts and oil emulsions of Ricinus communisL. (Malpighiales: Euphorbiaceae) on the diamondback, Plutella xylostellaL. (Lepidoptera: Plutellidae) under laboratory and semi-field conditions. J. Appl. Biosci., 43: 2899 – 2914-
90. Velten, G., Rott, A. S., Conde Petit, B. J., Cardona, C., D. (2008). Improved bruchid management through favourable host plant traits and natural enemies. Biological Control, 47, 133-140
91. Yarou, B. B., Silvie, P., Komlan, F. A., Mensah, A., Alabi, T., Verheggen, F., Francis, F. (2017). Plantes pesticides et protection des cultures maraichères en Afrique de l'Ouest (synthèse bibliographique). Biotechnol. Agron. Soc. Environ. 21(4) :288-304
92. Zakari, A. H., Mahamadou, C. I., Hachimou, Z., Toudou, A. (2016). Efficacité de l'huile de Neem (Azadirachta indica) et de Bacillus thuringiensis (Biobit 2X) sur la dynamique la population de Bemisia tabaci (Gennadius 1889) et Helicoverpa armigera (Hubner, 1808) dans une plantation de tomate au Niger. Int. J. Biol. Chem. Sci 10(2): 497-505.