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RESEARCH ARTICLE

STUDY OF THE EFFECT OF BIOPESTICIDES BASED ON WOOD ASH AND EUCALYPTUS ALBA ON APHIDS AND THE GROWTH OF PEPPERS (CAPSICUM ANNUM L.) IN DAKAR, SENEGAL.

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Abstract

The pepper plant (Capsicum annuum L.) is a vegetable crop that contributes to the socio-economic, food and medicinal development of populations. However, its production is currently facing new environmental challenges, particularly aphid attacks, which have a positive impact on yield. It is therefore necessary to study the effects of these attacks. The overall objective of this study is to contribute to the evaluation of the effect of wood ash and Eucalyptus alba-based biopesticides on aphids in a pepper crop. To do this, a Fisher block experimental design was adopted. The factor studied was the biopesticide product at three levels (wood ash, E. alba and the control) with three replicates. The parameters studied were the effect of the two biopesticides, the incidence of aphids, growth, development and production yield. The results of the experiment showed that Eucalyptusalba (T2) has a repellent effect on aphids and is more effective than wood ash (T1). In terms of average weight, production yields were higher with wood ash (T1), which obtained the highest fruit weight (37.00 g), followed by E. alba (T2) with an average of (35.70 g) and finally the control (T0), which had the lowest average of (35.05 g).

Introduction:-

The world population will reach 9.8 billion by 2050 (FAO, 2017). This, of course, is one of the major challenges that the international community will have to face in terms of food and nutritional needs. Global pepper production exceeded 24.7 million tonnes in 2005. China, Mexico, Turkey, Spain and the United States account for 72% of this production. China is by far the leading producer, with an average annual production of around 10 million tonnes, or 44.5% of total global production (FAO, 2005). In West Africa, this issue is even more problematic due to various stresses (cyclical droughts, salinisation and acidification) and the low uptake of innovation.

Agricultural technologies, including mechanisation and new plant material, but also poor agricultural practices (FAO, 2011). According to Moustier (2007), agriculture is a promising driver of economic growth and a vital source

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of income for resource-based producers in rural and peri-urban areas. The pepper (Capsicum annuum L.) is a vegetable plant native to tropical America, highly prized for its fruits, which are mainly consumed as vegetables (Tristan, 2004). It is a perennial plant in tropical environments belonging to the Solanaceae family, but is most often cultivated for its productivity. It is generally grown for its fruits, which are highly prized as vegetables and for their excellent nutritional and medicinal qualities (Pochard et al., 1992). Peppers remain one of the most widely cultivated crops across different continents. In total, 1.938,788 hectares worldwide are devoted to this crop, yielding 1.78 kilograms per square metre (FAO, 2016). Today, market gardening is subject to new environmental, economic, health and societal challenges that pose problems that cannot be ignored. The damage caused by pests and the negative economic impact on pepper production in Senegal are among the reasons why some producers are abandoning production or making intensive use of synthetic insecticides in production. Even with heavy applications of synthetic pesticides, farmers face obstacles in controlling these crop pests, and are thus unable to limit the damage they cause. At the same time, the risks of environmental pollution remain significant, even though the Eco-phyto 2018 plan aims to reduce pesticide use by half (Deguine J.P, 2008). Given the economic importance of peppers and the constraints on production linked to pests, producers have implemented a new alternative for the agroecological management of biological aggressors by promoting plant biodiversity at the level of cultivated plots. The overall objective of this study is to evaluate the effectiveness of biopesticides based on wood ash and E. alba on aphids in a pepper crop. Specifically, it will:

- Determine the effect of biopesticide treatments on aphids
- Observe the effect of treatments on pepper growth

Materials and Methods:-

Site presentation

Geo-administrative location

The trial was conducted during the 2024 dry season at the experimental station of the Plant Protection Directorate (DPV) in Dakar. The spatial and geographical location remains strategic. It is bordered to the east and west by the Mbao classified forest and the Coppée road, respectively, to the north by Yeumbeul, and to the south by the Atlantic Ocean and the municipality of Thiaroye/Mer. The site lies between longitudes 17°26' W and 16°15' W and latitudes 14° N and 15°56' N. This locality belongs to the Niayes zone, which is a fairly diverse horticultural production area.

Presentation of the structure

The Plant Protection Directorate (DPV), a structure of the Ministry of Agriculture, Food Sovereignty and Livestock (MASAE), located at Km 15, Route de Rufisque, is the central technical unit for plant health surveillance, control and protection. It is divided into several structures, which are: the Administrative and Financial Office (BAF), the Agricultural Warning Division (DAA), the Crop Protection Division (DDC), the Plant Health Legislation and Quarantine Division (DLQ), the Plant Health Training Centre (CFP), the Agricultural Surveillance and Warning Bases (BSA), and the Phytosanitary and Quality Control Posts (PCPQ). It also includes laboratories in nematology and phytopharmacy, phytopathology and malherbology, and agricultural zoology.

Biophysical Framework

Climate

The climate is tropical, similar to that of the southern Canary Islands, alternating between a long dry season from November to May and a warmer, humid and rainy season that lasts from approximately July to early October. A dry and rainy season, characterised by a long period of drought and a short rainy season. In fact, the sector experiences the Canary Islands' alternating climate.

Temperature

Average temperatures range between 24.7°C and 25°C, with lows of 20°C to 21.6°C and highs of up to 27.4°C and 30°C. The temperature range varies between 6.8°C and 7.3°C.

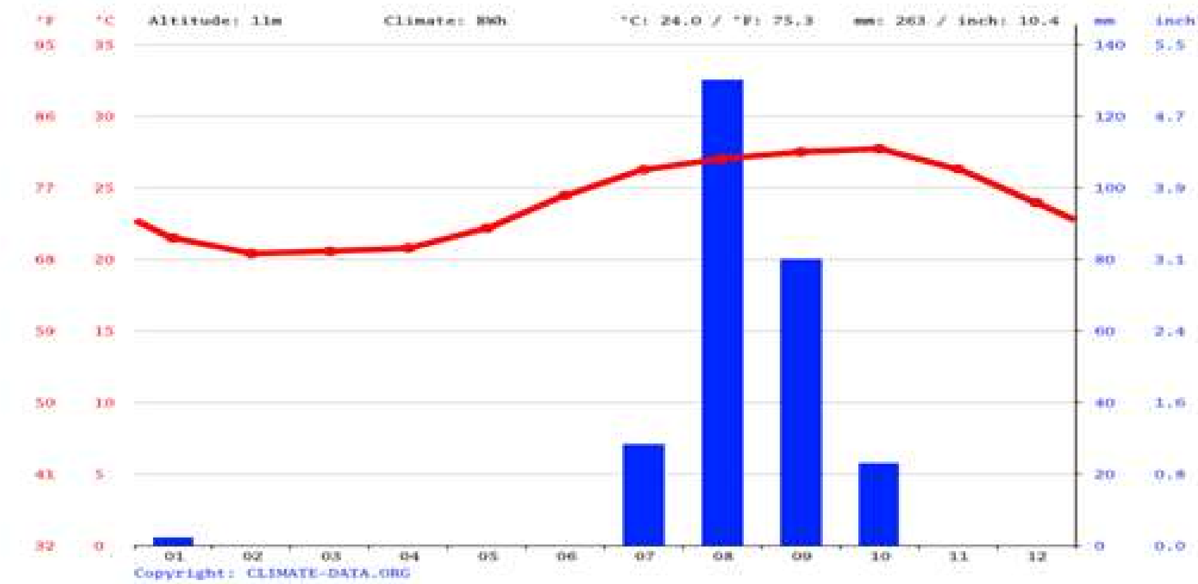

Figure 1: -Temperature assessment for Dakar in 2024 (source: climat-data.org).

Vegetation

The distribution of vegetation types can be explained by the topography of the environment, the diversity of soils, the proximity to the water table and water quality. Dry and wet forest formations contain tree species of Sudanese or Guinean origin. Protective afforestation is expanding rapidly. The choice is based mainly on species such as Eucalyptus camaldulensis. In addition to these new forest formations, there is vegetation in orchards, selected forest species such as mango trees, coconut trees, cashew trees and a strip of filao trees planted to protect the basins from dunes (Anonymous, 2004).

Photo 1:- Pepper seeds (a) Wood ash (c)Eucalyptus alba (b)

Technical equipment

This consists of all the tools used to carry out our field experiments. These technical tools include:

1. Tape measure, stakes, string and hammer to mark out the experimental plot;
2. Rake and spade used to prepare the ground and make the beds;
3. Wheelbarrow for spreading manure from the labels;
4. 11-litre watering cans and a hoe used for crop maintenance;
5. Blender, basin, bottle and pots used in the preparation of the aqueous extract solution from Eucalyptus alba leaves and wood ash;
6. 16-litre sprayer used for foliar fertilisation and phytosanitary treatments;
7. Scales used to weigh organic manure, eucalyptus leaves, ash and harvested pepper fruits;

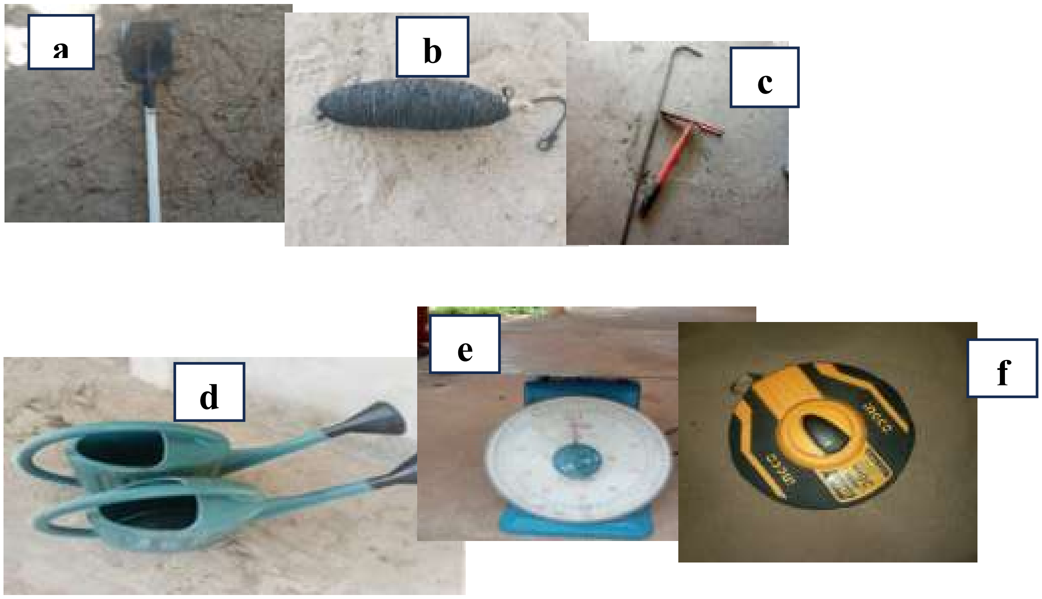

Photo 2:- Spade (a); string line (b); hoes (c); watering can (d); scales (e); tape measure (f)

Methods:-

Methodology is fundamental to any research process. It allows the essential steps and tools to be defined. In the context of this report, it revolves around:

Eucalyptusalba extraction method

1. The aqueous extraction of eucalyptus is carried out using freshly harvested leaves. After harvesting, the leaves are weighed, washed and then crushed. The resulting product is mixed with water and then filtered. 500 g of soap is cut up and added to the product, which is then placed in a 10-litre container. A small hole is made in the lid to allow air to escape:

2. Dosage and application periods
3. 1 kg of eucalyptus leaves in 5 litres of water plus 500 g of grated soap for 72 hours to obtain the finished product.
4. Application dose (T2): 1.5 litres of the finished product + 5 litres of water to be applied at 7-day intervals over an area of 13.5 m².

Photo 3:- Test tube (a); Eucalyptus leaves (b); Blender (c); maceration of leaves (d)

Method for obtaining wood ash

1. The ash is obtained after heating wood for cooking. Take 600 g and mix with 3 l of water for 24 hours, then filter through a sieve to obtain a product for treatment.
2. Leave the mixture to rest in the shade for 72 hours to obtain the finished product.
3. The mixture is filtered using a fine cloth.
4. Application dose (T1): 1.5 litres of the finished product + 3 litres of water to be applied over 7 days to an area of 13.5 m2.

Experimental setup

Our experimental setup is a completely randomised block or split block design, consisting of (three) 3 treatments and 3 blocks, giving a total of 9 treatments. The blocks are arranged lengthwise along the boards and are separated by main aisles of 1 m and secondary aisles of 0.5 m between the elementary plots; the length of a board is 3 m and the width is 1.5 m. The trial was conducted on a total experimental area of 60.5 m² with a length L = 11 m and a width l = 5.5 m (Figure 7).

T0: Control without application T1: Wood ash T2: Eucalyptusalba

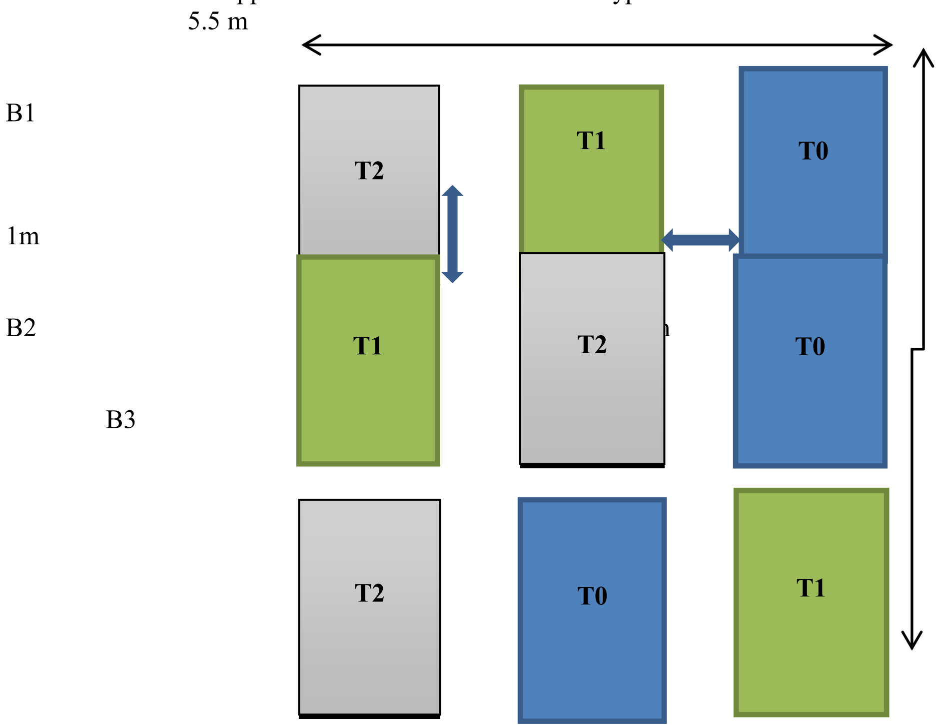

Figure 2: The experimental setup (Ficher block).

La parcelle élémentaire a une superficie de 4.5 m2. Elle est constituée de 3 lignes écarté de 0.60 m et les pieds sont distants de 0.50 m sur la ligne et disposés en quinconce. La densité de plantation est de dix-sept (17) plants par parcelle élémentaire, la méthode W a été utilisée pour faire un échantillonnage.

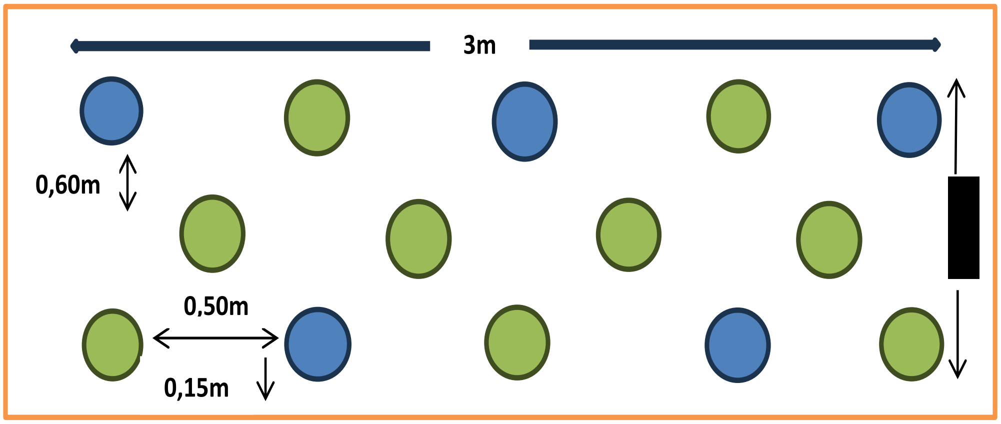

Figure 3: The elementary plot Diagram 1.
Observation plant

Conducting the trial
The trial was conducted according to the protocol designed by the Plant Protection Training Centre of the Plant Protection Directorate. The previous crop on the plot was cabbage.
Cultivation operations on the experimental plot
Cultivation operations are considered to be the chronological list of all activities carried out on the plot, from soil preparation to harvest.
Setting up the nurseries

The nursery was set up on 15 March 2024 in 105-hole trays filled with potting soil, used as a substrate, and sown with three seeds per hole. Germination was observed after 5 to 7 days with a germination rate of 100%. Thinning to one plant was carried out 15 days after sowing (DAS).

Photo 4:- Jarditropic potting soil.

Photo 5:- Pepper nursery.

Oil preparation
The basic beds were prepared on 20 April, with nine (9) beds measuring 4.5 m² each. We proceeded as follows:
1. Marking out and staking out the beds (3 m long by 1.5 m wide) in blocks of three (3) using the 3-4-5 method;
2. Pre-irrigation: thoroughly moistening the plot to facilitate subsequent operations, using at least 20 litres of water per square metre;
3. Shallow ploughing (10-15 cm) was carried out with a spade, which turned the soil to aerate and loosen it and break the development cycle of certain fungal diseases. Work was done to improve and maintain soil richness in accordance with the soil and climate requirements for pepper cultivation;
4. Construction of ridges to prevent runoff;
5. Raking to break up clods of earth and level the soil at the same time;
6. Application of basal fertiliser composed of organic matter (cow manure) at a rate of 9 kg and mineral fertiliser (10-10-20) at a rate of 180 g per 4.5 m² bed;
7. Digging: burying the base fertiliser to a depth of 25 cm;
8. Levelling the soil with a rake to create a good seedbed.

Acclimatisation
After a month and a half in the greenhouse, the plants are taken out of the shelter for acclimatisation and a foliar spray of an insecticide containing the active ingredients Lambda-cyhalothrin and acetamiprid is applied the day before transplanting to combat any attacks that the young plants may suffer; This is the first preventive treatment.

Transplanting
Two days before transplanting, pre-irrigation was carried out, with the recommended spacing per bed being 60 cm between rows and 50 cm between plants. Transplanting will be carried out in holes prepared for one plant per hole. Seventeen (17) plants were transplanted in a staggered pattern in each bed, for a total of one hundred and fifty-three (153) pepper plants for the experimental plot. Watering is done manually using watering cans, with 60 to 80 litres per bed per day. The young plants for the trial were transplanted on 30 April 2024.
Cultural maintenance

Weeding and hoeing
Weeding and hoeing will be carried out twice between each fertilisation 10 DTT (days after transplanting) and consists of weeding and at the same time loosening the surface crust of the soil using a hoe. This operation has other advantages such as aeration and water percolation.

Staking
Staking involves securing young plants to a support (stake) to enable them to grow properly and withstand wind. It also prevents the fruit from coming into contact with the ground and being damaged by insects and fungi.

Fertilisation
Fertiliser was applied in accordance with the DPV technical data sheets in terms of quantity and fractionation. As a base fertiliser, NPK 10-10-20 was used 5 days before transplanting at a rate of 3kg/m2, i.e. just after digging. Top dressing will be applied every 20 days in three instalments of 9 litres of neem leaves and 10 ml of Green OK each.

Pest control
We use biopesticides to control diseases and pests that are expected to occur in the experimental plot. A curative phytosanitary treatment plan was carried out using a 16-litre sprayer. Table 2 below summarises the different products used, their dosage and their application period (Table 1).
Tableau 1:- Phytosanitary treatment plan.

Number of treatments	Treatment code	Products used	Application dose	Amount of water used	Application period
1st treatment	T0	None (control)	-	-	-
	T1	Wood ash	1.5 l	3l	Every 7 days
	T2	Aqueous extract of Eucalyptus alba leaves	1.5 l	5l	
2nd treatment	T0	None (control)	-	-	-
	T1	Wood ash	1.5l	3l	Every 7 days
	T2	Aqueous extract of Eucalyptus alba leaves	1.5l	5l	
3rd treatment	T0	None (control)	-	-	-
	T1	Wood ash	1.5l	3l	Every 7 days
	T2	Aqueous extract of Eucalyptusalba leaves	1.5l	5l	

Harvesting
The first harvest took place 65 days after transplanting. It can be carried out when the fruits reach maturity and turn red, but they can also be harvested when they are green, manually with their stalks, when the fruits have not yet reached full maturity (Laumonier, R., 1979). Harvesting is carried out three (3) times, with one harvest every 15 days. The number of fruits per plant in each elementary plot was assessed, as well as the number of plants harvested, in order to determine the yield of each elementary plot. The fruits harvested in each elementary plot were weighed using a scale.

Agronomic observations
Observation sample
In each elementary plot, the W method was used to perform random sampling. A sample of nine (9) plants was observed for data collection. In fact, on the two (2) rows at each end, we sampled three (3) for the first, two (2) for the second and four (4) in the middle. All these plants will constitute the observation plants and are likely to change during another survey.

Agronomic parameters
The different agro-morphological variables observed are as follows:
Height
This was measured using a tape measure from the collar to the apex. Plant height measurements were taken on the 15th, 30th and 45th days after transplanting (DAT).
Length
This consists of measuring the vegetative development of the leaves of each plant on the 15th, 30th and 45th days after transplanting (DAT).
Parameters for observing aphids and their damage
To monitor the infestation rate of plants attacked by aphids and their development, we carried out direct visual counts using a pocket magnifying glass in the field and a binocular magnifying glass for the leaves collected. To assess the degree of aphid infestation, we used the scale established by (Rahmouni, 2019).
Aphid incidence (AI)

The number of plants infested by aphids was counted in order to calculate its incidence. The result obtained corresponds to the percentage of plants that have aphids in the vegetative development phase. The following formula is used to calculate the incidence:

IP (%) = (Number of plants attacked by aphids x 100) /Total number of plants

Data processing and statistical analysis

Microsoft Excel was used to enter and process the data. Analyses of variance (ANOVA) were performed to determine whether the differences observed were significant. For all analyses, the significance level was set at 5%. The graphs and dynamic cross-tabulation table were created using Microsoft Excel 2016.

Results:

Analysis of variance on all agronomic variables observed showed a significant difference on the experimental plot of a pepper crop.

Effect of biopesticides on the number of aphids

Figure 4 shows the variation in the number of aphids according to the treatments. The aphids encountered during the first observation were more numerous for T0 (control) and amounted to approximately 35. There were 22 T2 (E. alba) and 23 T1 (wood ash). Here, we can say that there was a significant negative effect with T1 and T2 compared to the control T0. For the second observation, the number of aphids is 47 for T0, 50 for T1 and 30 for T2. These results show that there is no significant reduction in aphids with T2 (E.alba) compared to treatments T1 and T0. At the last observation, with the application of treatments at the same dose, peppers treated with wood ash (T1) had fewer aphids with a significant difference compared to the controls (T0) and peppers treated with E. alba.

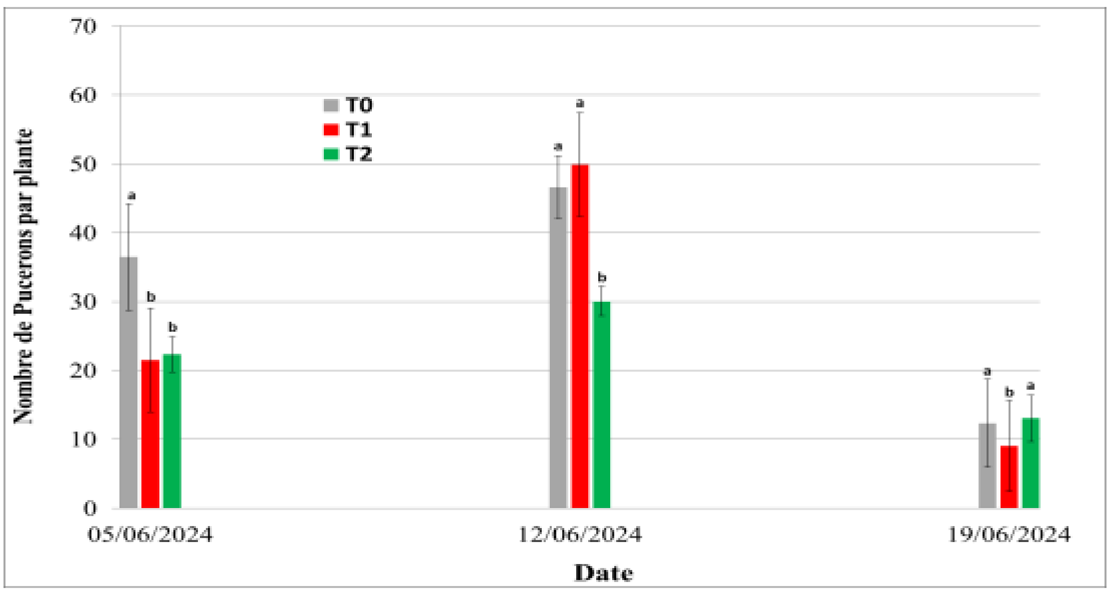

Figure 4: Effects of different treatments on the number of aphids.

Effects of treatments on plant growth in height and length

Effect of treatments on average plant height

The results obtained on the experimental plots show that there is no significant difference (P=0.552) in plant height according to the treatment. Biopesticides have no effect on the height of pepper plants (Table 2).

Tableau 2:- Variation de la hauteur des tiges suivant les traitements.

	Hauteur moyenne ± ES		
Modalités	20/05/2024	10/06/2024	30/06/2024
T0 (None control)	6.83 ± 0.880 a	11.58 ± 1.540 a	16.42 ± 1.992 a
T1 (Wood ash)	6.33 ± 1.135 a	12.10 ± 2.034 a	18.57 ± 3.021a
T2 (Eucalyptusalba)	7.80 ± 0.862 a	14.40 ± 1.808 a	22.17 ± 2.632 a
χ^2	67.45	67.45	253.58
d.f.	2	2	2
p-value-modality	= 0.502	= 0.502	= 0.282

Effect of treatments on average leaf length

The results obtained on the experimental plots show that there is no significant difference in leaf elongation depending on the treatment. Wood ash and E. alba have no effect on plant length (Table 3).Tableau 3:- Variation de la longueur des feuilles suivant les traitements.

	Longueur moyen ± ES		
Modalités	20/05/2024	10/06/2024	30/06/2024
T0 (None control)	1.91±0.214 a	3.45±0.422 a	5.06±1.992 a
T1 (Wood ash)	2.20±0.296 a	4.11±0.472 a	6.05±3.021 a
T2 (Eucalyptusalba)	2.38±0.303 a	4.33±0.512 a	7.28±2.632 a
χ^2	16.68	6.34	37
d.f.	2	2	2
p-value-modality	= 0.552	= 0.384	= 0.052

Results and Discussion:-

Discussion:-

The experiment on the effect of wood ash and Eucalyptus alba on aphids, plant growth, development, and pepper yield produced interesting and promising results. The results obtained in our study reveal that E. alba extract is bioactive against pepper aphids when applied as a foliar treatment, directly affecting viability rates.In our experimental plot, the results of the treatment's effects on the average height and length of the leaves show that these effects are not significant, with variation rates of 0.502 to 0.202 for the average height of stem growth and 0.552 to 0.052 for leaf development.

Thus, wood ash and Eucalyptus alba on the diameter and average weight of the fruits showed that the application of wood ash increased significantly. Indeed, the observation data suggest that E.alba extract could have a positive effect on the growth of pepper plants, increasing slightly from 49.42 cm for wood ash (T1) to 49.70 cm for Eucalyptus alba (T2).

Aphids are phytophagous insects, and all these piercing-sucking insects cause a lot of damage to vegetable crops, feeding on the sap (Leclant, 1982). The leaves of E. alba leaves have repellent and insecticidal properties against aphids, and their volatile compounds can kill aphids on contact or by inhalation (2001) according to K.A. Moore, J.R. Frazer and B.P. Hopper. Some studies have shown that it can be effective in repelling and killing aphids on other plants. Wood ash has no direct insecticidal properties. However, it can alter the pH of the soil, which can have an indirect impact on the aphid population. Alkaline soils may be less favourable to aphids than neutral or acidic soils.

The results in (T0) show that there is no significant difference between the first and second observations, with results tending to increase from 37% to 45% and then decrease by 12% at the end. Thus, wood ash treatments on these pests show a significant effect between the first and third observations, respectively, with incidence rates of incidence of 22% to 8%, unlike the second observation, where there is a non-significant effect with a rate of 50%, whereas there is a significant effect for the first and second observations with percentages of 23% and 30%. This contrasts with the last observation, where a reduction of 12.5% was seen, but there was no significant effect. Finally, the application of the treatment with E. alba leaf extract plays an important role in control systems, where aphids are present at a low rate compared to the control (T0). The effectiveness of E. alba and wood ash against aphids may vary depending on the aphid species, the severity of the infestation and environmental conditions.

Biocides have an effect on the aphids found in the experimental plot by reducing the number of aphids found, which tends to increase leaf and stem development. To evaluate the effectiveness of these biocides, we applied the treatments to the different blocks. The results of our study showed that biocides have highly significant effects in reducing the number of aphids. We note that after each treatment, the number of aphids was reduced by half in the T2 plots. In conclusion, we can say that E. alba extract is bioactive against pepper aphids when applied as a foliar treatment. Aqueous plant extracts currently play an important role in pest control systems. Their role in phytopharmaceutical research in certain countries around the world is well established (Lahlou, 2004). Researchers (Valdez V. S., 1994; Waayenberg; J. C., 1981) have shown that plant extracts have several intrinsic properties that allow them to be used in alternative strategies aimed at limiting the use of synthetic chemical pesticides against insect pests in market gardening. According to (Benramdan N., 2015; Bonnal A., 1981), aromatic plants act as repellents by emitting volatile substances (terpenes) that form a barrier preventing insects and other arthropods from coming into contact with the surface of the host. Further research is needed to confirm these results and to optimise the doses and methods of application of wood ash and Eucalyptus alba extract in pepper cultivation. It is also important to conduct studies on the impact of these products on other beneficial insects and on the biodiversity of agricultural ecosystems.

.Wood ash and E. alba were shown to significantly reduce aphid populations on pepper plants.
2. These products also had a positive effect on the growth, development, and yield of pepper plants.
Wood ash and E. alba are promising alternatives to chemical pesticides for pepper cultivation.

Conclusion:

In Senegal, market gardening plays an important role in the daily diet. Faced with ever-increasing demand, production levels remain low. Therefore, the search for alternatives to synthetic chemical insecticides led us to test the effectiveness of wood ash and E. alba on aphids in a pepper crop. Although E. alba and wood ash may have some repellent or indirect effect on aphids, there is insufficient evidence to conclude on their effectiveness in an experimental pepper plot. Further research is needed to assess the impact of these products on aphid populations and the positive effects on the growth and development of pepper crops.

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