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EFFECTS OF NEEM OIL AND PHYTO-EXTRACT OF LANTANA CAMARA ON SPODOPTERA FRUGIPERDA (LEPIDOPTERA-NOCTUIDAE), CORN PEST IN BANKIM, ADAMAWA-CAMEROON

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ABSTRACT

In sub-Saharan Africa, million people depend on maize for food. But the losses caused by Spodoptera frugiperda on maize amount to millions of dollars, and the chemical control costly and not eco-friendly. The purpose of this study was to evaluate the effectiveness of ethanolic extract of Lantana camara and neem oil (Azadirachta indica) in reducing crop damage in maize cultivation in Bankim. This was carried in a field experiment using a randomized complete blocks design with the following treatments; 0.5L.ha-1 and 1L.ha-1 of neem and 10% and 20% ethanolic extracts of L. camara replicated three times. Results show that neem oil treatments significantly reduced ($p< 0.05$) crop damage by S. frugiperda on the leaves of maize from 49th to 63rd day after sowing (DAS) compared to the control treatment. Neem oil at 1L.ha-1 had a significant effect on the incidence of S. frugiperda at the 35th and 49th DAS relative to the control treatment. Consequently, neem oil treatment produced yield (4137.33 kg.ha-1) higher than the control treatment (2812.66 kg.ha-1). Neem at 0.5L.ha-1 and 1L.ha-1 showed significant differences in the number of damaged ears compared to control. Ethanolic extracts of L. camara significantly ($p < 0.05$) reduced crop damage relative to the control, from the 49th to the 63rd DAS. On the incidence of damage and the percentage of damaged cobs, L. camara at 20% showed a significant difference on the 35th and 49th DAS. Consequently, the number of insects collected in the control plots during the experiment was higher relative to the treated plots. Neem oil at 1L.ha-1 showed reduced crop damage and the number of larvae of Fall Armyworm (FAW), thus increased the yield of maize.

Keywords: Spodoptera frugiperda, Neem oil, Lantana camara, Zea mays, bio control, Cameroon.

1. INTRODUCTION

Maize is one of the most important crops in tropical areas and, along with wheat and rice, is the main proportion of people's daily food intake [1]. In Cameroon, maize provides almost half of the calories consumed in rural and urban areas. It is mainly grown in the west and northwest of the country and has become a staple food in many areas. A majority of maize production in Cameroon is attributed to small-scale farmers and is a direct source of income for households [2]. Corn is eaten in the form of couscous, porridge, grilled, salad and soup. It is also used in animal feed and as a material in agricultural food industries. Agriculture in the sub-Saharan Africa is generally dependent on chemical pesticides that affect target and non-target organisms, causing environmental imbalances in ecosystem regulation. Also, there is need to exploit the rich floral biodiversity with plant species having pesticidal properties.

S. frugiperda caterpillar or the Fall Armworm attacks more than 80 plant species, causing damages to economically important cultivated cereals such as maize, rice and sorghum, as well as vegetable and cotton crops [3]. This caterpillar was first observed in Africa in Nigeria in January 2016, where larval stages caused significant damages [4]. It was detected in maize farms in the West Cameroon region by Tindo *et al*. [5].

Many botanical extracts or phyto-extracts of plants such as *Azadirachta indica*, *Milletia ferruginea, Croton macrostachyus, Phytolacea docendra, Jatropha curcas, Nicotina tabacum* and *Chrysanthemum cinerariifollium* have been used successfully to control insect pests [6,7]. Rioba and Stevenson [8] mentioned that the biological activities of some extracts included insecticidal, insectistatic, larvicidal, reduced growth and acute toxicity. By using seed cake extract of *A. indica*, Silva *et al*. [9] reported high larval mortality of the FAW. Neem oil contains at least 100 biologically active compounds, the most important being azadirachtin which appears to cause 90% of the effect on most pests [10]. Ethanolic extracts of *Argemone ochroleuca* caused FAW larval mortality due to a reduction in feeding and slowed larval growth [11]. The major set-back of neem-based sprays is the high photosensitivity of azadirachtin, which breaks down or isomerizes under sunlight; thus, neem has a low residual life under field conditions [12]. In a study by Abla *et al*. [13], aqueous extracts of *A. indica* have significantly reduced populations of *Plutella xylostella* and *Hellula undalis* on cabbage than Cydim Super, synthetic insecticide. In Ethiopia, work by Sisay *et al*. [14] on the FAW caterpillar of maize showed that untreated controls were more damaged compared to plants treated with botanical insecticide.

In India, 5 species of Hymenoptera parasitoids from FAW eggs was reported [15]. In Ethiopia from the total sample of FAW collected, three species of parasitoids larval emerged [14]. Some species of Dermaptera-Forficulidae, Coleoptera-Carabidae and Coccinellidae, Hymenoptera-Formicidae are natural enemies of *S. frugiperda*.

In general, botanical control is residue-free and safe for users and consumers. However, rigorous field testing needs to be done in the context of small holder farmers in Africa. Thus, the aim of this study was to test the effectiveness of neem oil and phyto-extracts of *L. camara* on field management of the FAW in maize production of small-scale farm holdings.

2. MATERIALS AND METHODS

2.1. Study Area

Bankim is located in the Adamawa Region, Division of Mayo Banyo (6-05'N and 11-29'E, altitude 737m) (Figure 1). The climate is of a humid and warm equatorial type with two main seasons (dry and wet), with an average temperature of 23ºC. The soils are sandy argilo silt, lateritic, ferralitic. The relief is strongly dominated by plains and hills. The vegetation of the zone was particularly dominated by *Tithonia diversifolia*, *Penissetum purpureum*, *Mimosa pudica*, and *Bidens pilosa*.

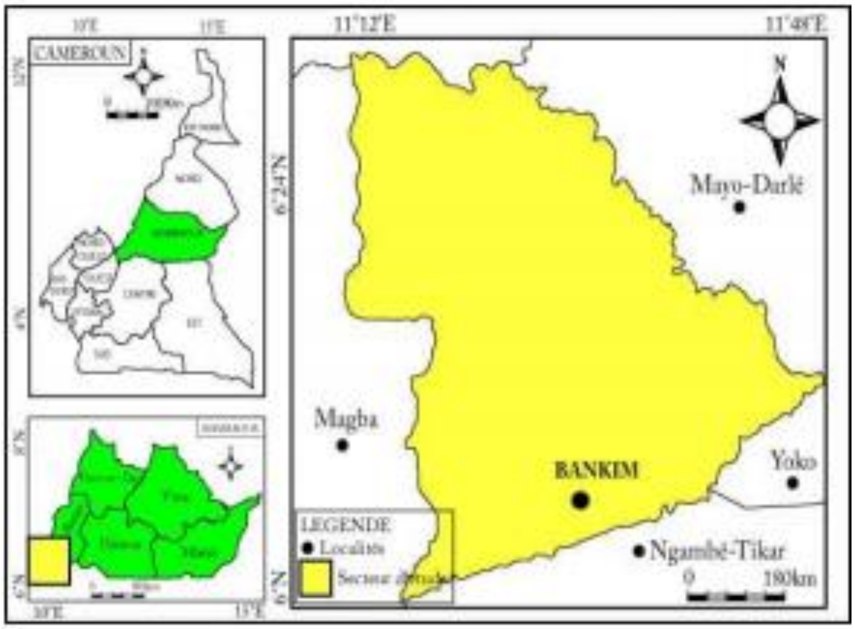

Figure 1: Location of Bankim

2.2. Materials

2.2.1. Plant Material

The plant material consisted of composite maize seed (CHC201) which the mostly cultivated by farmers in the area. Prior to the experiment, a seed germination test was performed using the sandwish method to obtain 89% germination rate.

2.2.2. Botanical Insecticides

Neem oil was purchased from a local market in the far north of Cameroon. The leaves of *L. camara* were collected from the surrounding villages of Bankim and extracted in the laboratory of the Plant Pathology and Agricultural Zoology Research Unit at the University of Dschang. These plants are reported to have pesticidal properties and are available in our environment [16, 17].

2.3. METHODS

2.3.1. Experimental Design

The experimental design was a randomized complete block with experimental units measuring 3.2 m^2. The treatments were repeated three times with a 0.5 m between blocks. Each experimental unit consisted of three seedling lines, and sowing was done at 80 cm between the lines and 50 cm between plants on the same line. Two seeds were sown per hole giving a total of 24 plants per experimental unit. A total of five treatments consisting of two doses of neem oil; N1: 0.5L.ha^{-1} and N2: 1L.ha^{-1}, Ethanolic extracts (10% and 20%) of *L. camara* and the control without any of the previous treatments were applied in this field experiment.

2.3.2. Land Preparation And Sowing

The field trial was carried out in December 2019 in a swampy area. One week before sowing, fowl droppings was applied as the base fertilizer at 5 tons.ha^{-1}. Two viable seeds of a maize were sown at a depth of 3-4 cm, at 80 cm between lines and 50 cm between plants giving a planting density of 50 plants ha^{-1}. Three weeks after germination, mineral fertilizer (NPK 20-10-10) was applied (150 $kg.ha^{-1}$). A second urea-based application at 100 $kg.ha^{-1}$ in a ring method was carried out 45 days after the first fertilizer application. Other farm management practices (weeding, mulching) were carried out as usual.

2.3.3. Preparation And Application Of Biopesticides

Solvent extraction was used to obtain 10% and 20% extracts of *L. camara*. Fresh leaves of *L. camara* harvested early in the morning and were properly washed in distilled water to get rid of microorganisms and dust particles. The cleaned leaves were subjected to air-drying for a period of two weeks. Dried leaves were crused in the laboratory and the powder used for solvent extraction. 100g of the dried powder was put into a beaker, 1L of 95% ethanol was added and the mixture was stored for two days. The mixture was then filtered and the resulting liquid was placed in a stainless-steel dish which was placed at 45°C to evaporate ethanol. After drying the powder obtained was used to prepare 10% and 20% by weighing 10g and 20g of the powder upon which 90ml and 80ml of distilled water were added, respectively. 10 ml of liquid soap was added to the ready-to-apply solution. Neem oil used in the experiment was extracted traditionally by producers in the Far North region of Cameroon. Two doses were prepared at a rate of $0.5l.ha^{-1}$ and $1l.ha^{-1}$. The interval between two treatments was 14 days following the recommendations of [18]. The firs treatment was carried out 21 days after sowing corresponding to the appearance of the first damage observed on the plants. Between treatment applications, the sprayer was thoroughly rinsed with clean water. Spraying was carried during the evening period to prevent overheating sun from distorting the chemistry of the extracts. The treatments were carried out using a 16-litre back spray (MATABI type) and spraying was done on both sides of the leaves and especially in the floral cone.

2.3.4. Data Collection

Data were collected weekly on 5 randomly selected plants in the middle of each experimental unit. Plant height, incidence and severity of FAW attack on the leaves, the number of insects captured and yield were among the variables measured during this study. The height of the sampled plants was measured using a measuring tape from the base to top of the longest leaf. The incidence (I) of FAW was calculated using the number of infested plants observed (Y) and the total number of plants (X) on experimental unit expressed in percentage as follows: ($I = Y/X * 100$). The rating scale defined by Notteghem *et al*. [19] was used for severity. This is a scale that ranges from 0 to 9 and is proportional to the damage observed on the leaf surface of a plant. The severity index is calculated according to the formula: **IS** = (ΣXi.Ni / 9 Nt) * 100, **IS**: Severity Index, **Xi**: Severity, **Ni**: Number of plants with severity i, **Nt**: Total number of plants observed, **9**: Highest score on the scale.

2.3.5. Insects Associated With Maize

Insects found on corn plants at the experimental site were captured and conserved in boxes containing 70% ethanol. These samples were taken to the laboratory where they were identified using available keys [20,21].

2.3.6. Yield Of Dry Corn Kernels

The maize cobs obtained were counted by treatment and seeded, then dried to constant weight on the sun for two weeks. Dry grain yield were calculated and extrapolated per hectare according to Guibert *et al*. [22]: Rdt (kg.ha^{-1}) = (10000m^2÷ SUE m^2) × PSG, where Rdt=yield, PSG =dry weight of grain collected per experimental unit, SUE = area in m^2 occupied by the sampled plans of the experimental unit.

2.3.7. Data Analysis

ANOVA in SPSS software was used and Turkey test used to separate the means at 5% probability level.

3. RESULTS

3.1. Evolution In Plant Height Over Time And Treatment

For all treatments, plant height kept increasing right up to 63rd DAS with the control treatment having the lowest height everytime in point. The two phyto-extracts of *L camara* showed the highest plant height.

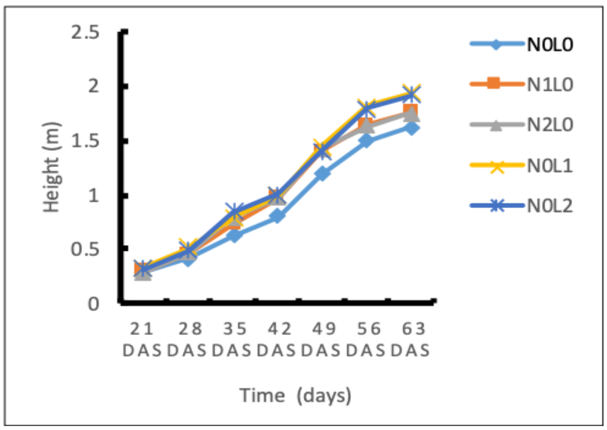

Figure 2: Evolution of plant height over time and treatments

The variance analysis shows that there is no significant difference (P > 0.05) between plant height and different treatments at the 21st, 28th and 49th DAS. Significant differences (P < 0.05) are observed between plant height and N0L2 at the 35th, 42nd DAS and 56th and 63rd for N0L1 (Table 2). The 2 doses of *L. camara* would have had a positive impact on plant growth during these periods, contrary to control.

Table 2: Averages of different plant heights for each treatment at different DAS.

Treatments	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS
N0L0	0.29a	0.41a	0.61a	0.79a	1.19a	1.5a	1.62a
N1L0	0.30a	0.46a	0.73ab	0.97ab	1.39a	1.64ab	1.76ab
N2L0	0.28a	0.47a	0.78ab	0.97ab	1.42a	1.62ab	1.73ab
N0L1	0.33a	0.51a	0.79ab	0.99b	1.44a	1.81b	1.93b
N0L2	0.32a	0.49a	0.83b	1.01b	1.39a	1.79ab	1.91ab

The numbers in the same column followed by the same letter are not significantly different at the 5% threshold.

3.2. Incidence Of Faw On Corn Leaves

The incidence was higher throughout the trial in control treatment as well as N0L1 treatment. Treatments N1L0, N2L0 and N0L2 showed a growing evolution from 21st to 42nd DAS. Subsequently, they dropped to the 49th DAS to remain almost constant until the 63rd DAS (Figure 3).

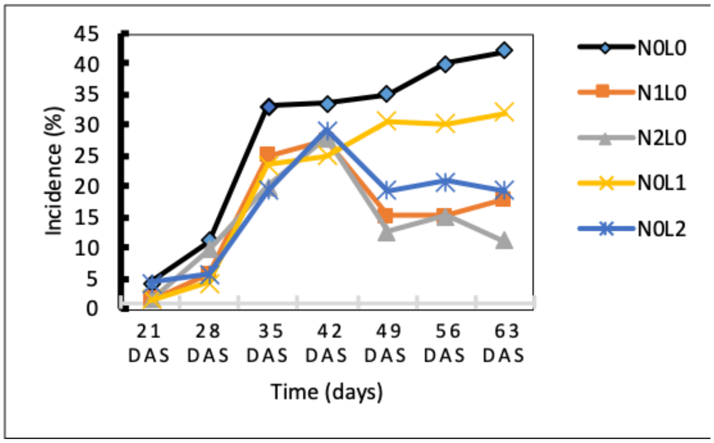

Figure 3: Evolution of the incidence of FAW on leaves

From the 21st, 28th, 42nd, 56th and 63rd DAS, no significant differences were observed between treatments ($P > 0.05$) and the incidence of FAW on corn leaves. Significant differences ($P < 0.05$) are obtained at the 35th and 49th DAS (Table 3). Indeed, in the 35th DAS, the neem shows a higher incidence compared to the control. Between the 35th and 49th DAS, the incidence of *L. camara* is greater compared to the control.
(Table 3).

Table 3: Averages of FAW incidence on plants for each treatment with different DAS.

Treatments	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS
N0L0	4.16a	11.11a	18.05a	29.16a	18.05ab	25.00a	31.94a
N1L0	1.38a	5.55a	36.11ab	33.33a	15.27ab	22.22a	20.83a
N2L0	1.38a	9.72a	31.94ab	27.77a	12.5a	15.27a	11.11a
N0L1	1.38a	4.16a	19.44a	25.00a	19.44ab	20.83a	19.44a
N0L2	4.16a	5.55a	43.05b	48.61a	34.72b	33.33a	31.94a

The numbers in the same column followed by the same letter are not significantly different at the 5% threshold.

3.3. Severity Of Faw On Leaves

Severity increased for N0L0 until the 49th DAS. The number of treatments based on 2 bio-pesticides increased until the 42nd DAS and then decreased to the 63rd in particular for the N2L0 treatment. The latter shows a considerable drop between the 42nd and 63rd. It remains almost constant for N1L0, N0L1 and N0L2 treatments (Figure 4).

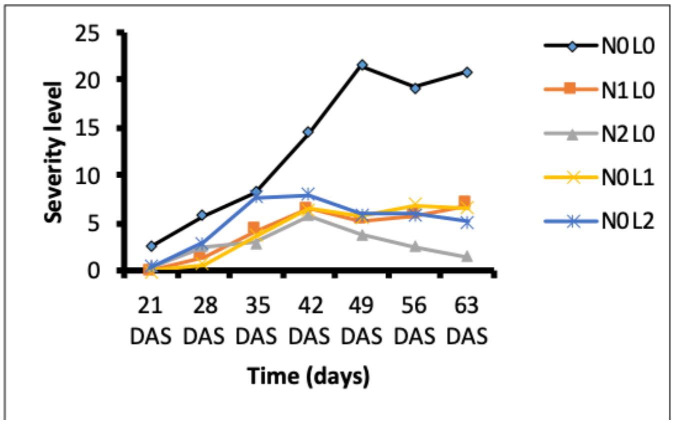

Figure 4: Evolution of severity

From the 21st to the 42nd DAS, no significant difference ($P > 0.05$) between severity and the different treatments. From the 49th to the 63rd DAS, there was a significant difference ($P < 0.05$) between the severity of FAW and the different treatments compared to the control (Table 4).

Table 4: FAW severity averages on leaves by treatment at different DAS

Treatments	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS
N0L0	2.55a	5.85a	8.18a	14.48a	21.59b	19.25b	20.85b
N1L0	0.00a	1.40a	4.14a	6.44a	5.29a	5.77a	6.92ab
N2L0	0.33a	2.55a	2.88a	5.77a	3.70a	2.48a	140a
N0L1	0.00a	0.66a	3.62a	6.51a	5.70a	6.85a	6.59a
N0L2	0.33a	2.96a	7.75a	7.92a	5.88a	5.88a	5.11a

The numbers in the same column followed by the same letter are not significantly different at the 5% threshold.

3.4. Insect's Orders Identified During The Trial

Lepidoptera has been strongly represented, the main pest subservient to corn belongs to this order. The number of FAW larvae collected on plots treated with N2L0 was lower and greater on N0L0 control plots. Hemiptera, Coleoptera, Dermaptera, Diptera and Orthoptera have also been identified. Some individuals of these orders are natural enemies of the FAW (Coleoptera-Coccinellidae, Dermaptera-Forficulidae, Hymenoptera-Formicidae and Vespidae). The number of beneficial insects was higher in the untreated plots. Neem would have a repulsive effect on the beneficial insect population in this study. *L. camara*, on the other hand, showed a fairly high activity of beneficial insects, especially at 42nd and 49th DAS. The use of *L. camara* extracts could be encouraged in integrated management systems against *S. frugiperda* and other maize pests.

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3.5. Dry Yield Of Corn Grains

The lowest yield is obtained with the control treatment (2812.6kg/ha), N2L0 gives the highest yield (4137.33 kg/ha). The yields in function of the treatments show significant differences (P<0.0001) with a confidence interval of 95% (Figure 5).

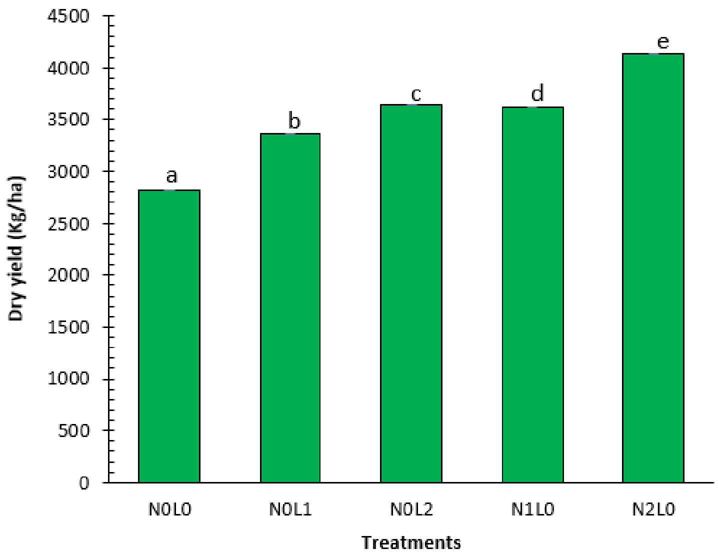

Figure 5: Dry yield corn grains based on treatments
P< 0.0001, confidence interval: 95%
The same letters do not show a significant difference at the level of P<0.0001

3.6. Number Of Grains Attacked Based On Treatments

Similarly, the most contaminated seeds come from untreated plots, followed by neem-treated plots at 0.5l.ha^{-1}. N0L2 treatment has the lowest rate of contamination (Figure 6).

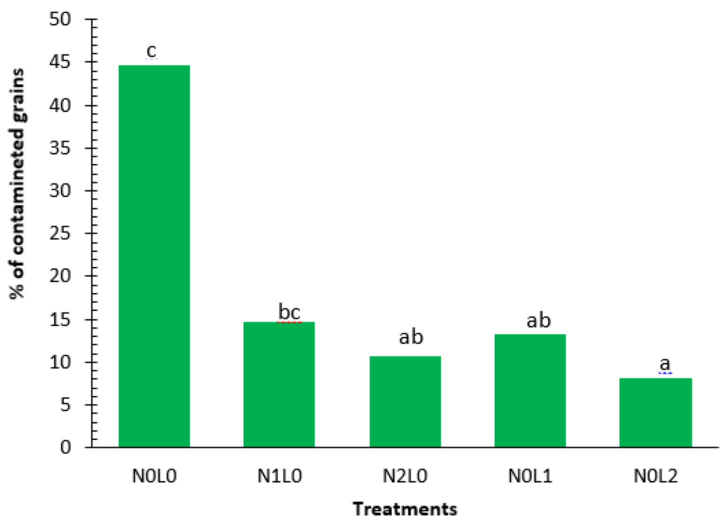

Figure 6: Percentage of grains attacked based on treatments
The same letters do not show a significant difference at the level of P<0.05

There is a significant difference ($P < 0.05$) between the % of attacked seeds and the N2L0 and N0L1, N0L2 treatments. N0L2 gave the least number of contaminated grains of 8.01%. The most contaminated ears are found on control plots N0L0 with an average of 44.81%.

4. DISCUSSION

4.1. Evolution Of Plant Height

The evolution of plant height as a function of time showed no significant difference ($P > 0.05$) between treatments at 21st, 28th and 49th DAS. The treatments did not affect plant height during these periods. However, significant differences ($P < 0.05$) were observed between plant height and the different treatments at 35th, 42nd, 56th and 63rd DAS. These results are contrary to those obtained by Tekou [23], who showed in his work that the neem-based treatments had no significant difference on maize plant height in Dschang, Cameroon.

4.2. Incidence Of Faw On Corn Leaves

From the 21st, 28th, 42nd 56th, and 63rd DAS, there was no significant difference ($P > 0.05$) between the incidence of FAW and the different treatments. Treated and control plots had similar incidence. But at the 35th and 49th DAS, significant differences ($P < 0.05$) were obtained. Neem showed greater efficacy on incidence than *L. camara*. According to Rioba and Stevenson [8], *A. indica* reduced *S. frugiperda* growth, increased development period, mortality, low egg laying, antifeedant activity, growth regulating activity, larvicidal. Work by Sane *et al*. [18] on cotton in Senegal found that Azadirachtin significantly reduced pest populations as well as their damage.

4.3. Severity Of Faw On Leaves

On days 21-42, there were no significant differences ($P > 0.05$) between severity and different treatments. In contrast, from day 49 to 63, there were significant differences ($P < 0.05$) between the different doses of neem and *L. camara* compared to the control. N2L0 and N0L2 treatments showed the most reduced damage. These results are similar to those obtained by Sisay *et al*. [14] who showed in their work an increase in mortality of FAW larvae consequently, a decrease in severity after application of neem and *L. camara* based extracts compared to the control in Ethiopia. Leaves perforated by FAW larvae were small in size as was the case with leaves perforated by the corn borer [24]. According to Socorro *et al*. [25], weekly application of 2% neem oil against *S. frugiperda* gave more than best protection when applied before pest infestations in Mexico.

4.4. Dry Yield Of Maize Grains

The neem oil and *L. camara* treatments gave the highest yields compared to the control, although they were not statistically different. N2L0 treatment gave the highest yield (4137.33kg/ha), as neem was found to significantly reduce the severity of FAW on leaves from 42 to 63 DAS, which would have had a beneficial effect on photosynthetic intensity, resulting in higher yield. According to Tekou [23], the neem-treated plots yielded the best compared to the control. The study of Siazemo and Simfukwe [26] showed that neem treatment had the highest maize yields of 4.9 t ha^{-1} followed by Cypermethrin with 4.7 t ha^{-1}, Chinaberry and Garlic with 4.3 t ha^{-1}. In Mexico, the treatment with 20.8% neem oil showed low defoliation, but yields were low at this high doses due to phytotoxicity [25].

4.5. Number Of Contaminated Seeds According To Treatments

The analysis of variance showed that there was a significant difference ($P < 0.05$) between contaminated seeds from treatments N2L0, N0L1, N0L2 and the control. The more contaminated the spikes, the more contaminated the seeds were. Sisay *et al*. [14] showed that plants treated with neem and *L. camara* had higher larvicidal activity compared to the control. Lepidoptera numbers were lower than Coleoptera numbers at N2L0 treatments. This shows that N2L0 is the optimal dose for FAW control.

4.6. Insect Orders Collected Per Treatment

The orders of insects collected are more important in the control plots than in the treated plots. This would be due to certain insect repellent properties of our two biopesticides. This same observation was made in Benin by Biao *et al*. [27] where plots treated with neem extracts had a low density of aphids compared to the control.

5. CONCLUSION

Plant height was greater with *L. camara* extracts than neem oil. Plots treated with neem extract (*A. indica*) at 1l.ha^{-1} showed a significant difference in incidence compared to the control at 49th DAS. *L. camara* at 20% showed statistically higher values of incidence compared to the control at 35th and 49th DAS. Neem oil at 1l.ha^{-1} and *L. camara* at 20% showed a significant decrease in the severity of fall armyworm damage from 49th to 63rd DAS compared to the control. Corn-infested insects belong to the order Coleoptera, Lepidoptera, Dermaptera, Diptera, Hemiptera and Hymenoptera. The plots treated with Neem oil at 1l.ha^{-1} gave the best yield followed by *L. camara* at 20% compared to the control with the lowest yields. The use of plant extracts as part of integrated pest management is recommended, especially since some Hymenoptera-Vespidae were identified in the treated plots.

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