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Eloi HOUESSOU,
Codjo Euloge TOGBE,
Jhonn LOGBO
Elisabeth ZANNOU-BOUKARI

Corresponding author: Eloi HOUESSOU1

1School of Horticulture and Green Spaces Management of National University of Agriculture BP 43, Kétou Bénin

2Faculty of Agronomic Sciences of University of Abomey-Calavi. 03 BP 2819 Jericho Cotonou Bénin,

Email : eloihouessou95@gmail.com

Tel: (+229) 96 25 73 15 / 95 98 02 27

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Research Article

Efficacy of neem extracts in the control of tomato insect pest *Helicoverpa armigera* in Southern Benin

Eloi HOUESSOU[1,2*], Codjo Euloge TOGBE[2], Jhonn LOGBO[1], Elisabeth ZANNOU-BOUKARI[2]

[1]School of Horticulture and Green Spaces Management of National University of Agriculture. BP 43, Ketou Benin.

[2]Faculty of Agronomic Sciences of University of Abomey-Calavi. 03 BP 2819 Jericho Cotonou Bénin.

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Abstract: *Helicoverpa armigera*, *Hübner*, 1808 (Lepidoptera: Noctuidae) is a major carpophagous insect pest of tomato in Benin. The damages by this insect pest and its resistance to most synthetic insecticides have necessitated the need for alternative methods to limit its damages on tomato. This study carried out in Toffo District in Southern Benin, aims to evaluate the effectiveness of neem extract (*Azadirachta indica Juss*.) on tomato (*Lycopersicon esculentum Mill*.) insect pest *Helicoverpa armigera*. Thus, two neem extract doses (1.5 l/ha and 2 l/ha) were compared to a chemical pesticide K-OPTIMAL (Lambda-cyhalothrin + Acetamiprid at a rate of 1 l/ha) in a randomized complete block design with four replications. The results indicated that neem extract has reduced tomato fruits infestation by *H. armigera* from 76.72 to 77.22%. The highest infestation reduction of this pest (81.26%) and the highest fruit yield (29.13 tons/ha) were observed in the plots treated with K-OPTIMAL. The yields obtained with neem extract (26.68 and 28.38 tons/ha respectively with 1.5 l/ha and 2 l/ha) were statistically lesser than tomato treated with K-OPTIMAL. However, neem extract allowed obtaining 33.86 to 42.39% yield profit compared to control plot. Neem extract showed its effectiveness to *H. armigera* control by reducing infestation rates and giving high tomato yield. The neem extract economic profit is lesser than chemical control. While the use of neem extract in agriculture protects environment, human and animal health.

Keys words: infestation rate, *Helicoverpa armigera*, neem extract, yield, Southern Benin.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.*)* is one of the most popular produced and extensively consumed vegetable crops in the world[1]. It can be eaten raw in salads or as an ingredient in many dishes, and in drinks[2]. Tomato has become an important cash and industrial crop in many parts of the world[3] not only because of its economic importance but also its nutritional value to human diet and subsequent importance in human health [4]. Tomato is rich in vitamins, minerals, sugars, essential amino acids, iron, dietary fibers and phosphorus[3]. It therefore serves as source of these nutrients when consumed. Tomato production can improve the livelihoods of small-scale producers by creating jobs and serving as source of income for both rural and periurban dwellers[5]. In Benin, tomato and black nightshade are the bests economic importance vegetables [6,7].

Unfortunately, tomato cultivation can be seriously affected by insect pests and diseases. A wide variety of insect pests attack tomato, despite the importance and opportunities that tomato offers. *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) is reported causing significant damages in particular on cotton, tomato and maize. Thus, in order to overcome the difficulties inducing by insects to tomato, chemical control is excessively used by the farmers. However, the result of a poor pesticide management is often environmental contamination and severing human health problems [8, 9]. Indeed, this has contributed to the environmental pollution through air or as residues in food. In order to support sustainable vegetable production, it is important to develop alternative methods of pest's control. Neem products, being practically no toxic to man and warm blooded animals and relatively harmless to natural insects, are very suitable for biological and integrated pest control programs[19]. However, none study approaches the efficacy of neem oil on the control of *Helicoverpa armigera,* a tomato major pest in Benin. Or tomato is an important commercial production in Benin. Reason why this study aims to evaluate the efficacy of neem extract on *Helicorverpa armigera*.

2. MATERIALS AND METHODS

2.1. Experimental sites: The experiment was carried out to determine the efficacy of neem oil in the control of *Helicoverpa armigera* on tomato in DAV AGROPASTOLE Farmer's field at Houegbo (north latitude 6°50'00'' and east longitude 2°04.9'00'') during june to december 2016 in Toffo District. It's placed in subequatorial climatic area, characterized by annual four seasons: two dries seasons (a high from mi-December to mi-March and a small from mi-July to August) and two rainy seasons (a high from mi-March to mi-July and a small from September to November). The average level of rainfall is 1100 mm for high season and 800 mm for small season. The monthly temperatures vary between 27°C and 31°C. The air relative humidy varies according to the months from 65% (January to March) to 97% (June to July).

2.2. Experimental design: The experiment was laid out in Randomized Complete Block Design with four treatments including a control with four replications. The plot size was 3 m × 3 m, plant to plant distance was 0.5 m and row to row distance was 0.80 m. The tomato variety under trial was Mongal F1, provided by BENIN SEEMENCES SARL. The treatments were applied to plots of 9 m2 (3 m * 3 m). Plants were spaced 0.5 m and 0.8 m within rows, resulting in a total of plants per plot. Seeds were bought at the market center

'BENIN SEMENCES SARL'. In total, 384 plants were transplanted in all plots. Plots were spaced 1.5m and 2.5m between blocs. Four treatments T0 = control, T1 = K- OPTIMAL at a rate of 1L/ha, T2 = neem oil at a rate of 1.5L/ha and T3 = neem oil at a rate of 2L/ha (Appendix 1) were used. T1 was replicated 2, 4 and 7 weeks after transplantation, T2 and T3 were repeated 2, 3, 4, 5, 6 and 7 weeks after transplantation of tomato young plants. The neem oil was bought at Biophyto at Allada.

2.3. Soil sterilization: 100 kg of soil was sterilized with traditional pot and mixed with 25 kg of poultry droppings for nursery installing.

2.4. Fertilization: Poultry droppings 0.5 tons/ha and AgroBio 0.5 tons/ha were used five days before transplantation and 0.5 tons/ha of poultry droppings and 1 tons /ha of AgroBio were applied a month after transplantation.

2.5. Data collection: Weekly scouting involved counting the numbers of damaged leaves, flowers, and bolls on 10 plants in each plot on centrals lines of the plots. The whole plant was examined, from bottom to top via the leaves, the flowers and the fruits. The numbers of the bollworms *H. armigera* were carefully counted on the leaves, flowers and fruits. The bracts of leaves, flowers and fruits were opened and examined and the number of larvae and nymphs were recorded and pooled for this pest. The number of damaged reproductive organs was determined by counting damaged squares, dropped or bollworm-infested leaves, flowers and fruits damaged by *H. armigera*. The treatments (Control T0, K-OPTIMAL T1: 1 l/ha, Neem oil T2: 1.5 l/ha and Neem oil T3: 2 l/ha) were applied when the threshold for this pest (see the Table S2) was reached. Tomato was harvested in an area of 2.2 m × 1 m delineated in the middle of each plot. Yields were estimated in kg per ha and per treatment. Statistical analysis and Data leaves, flowers and fruits damaged recorded at each plot were pooled together to perform the statistical analysis. The conversion $2\text{Arcsin}\sqrt{x}$, x= damage percentages; and Log 10[n+1], n= insects larvae number[11] have been done for normality homoscedasticity before data analysis. Analysis of variance (ANOVA) was performed using repeated measures with GLM procedure (SAS 9.2). Whenever the F-tests for fixed effects were found to be significant, a Tukey's test (a = 0.05) was performed for multiple comparisons among treatments.

3. RESULTS

3.1. Effects of neem oil on larval populations and damages of *H. armigera*: The average number of *H. armigera* larvae has been evaluated per plant by different treatments. The significant differences have been observed among treatments. However, the average number of *H. armigera* larvae per plant has been significantly reduced in treated plots in comparison to control plot during this study. The high average number of *H. armigera* larvae (2.43) has been obtained in control plots; but the low average numbers of *H. armigera* larvae (0.46) per plant have been observed by K-OPTIMAL followed by neem oil treatments (046 and 0.77). Analysis of variance pointed out that treatments showed a high significant influence (F-value = 84.54 and P-value < 0.0001) on the average number of *H. armigera* larvae per plant. But, the average number of *H. armigera* larvae per plant in K-OPTIMAL plots was similar to that observed in neem oil plots at 2 l/ha, see **Table 1**.

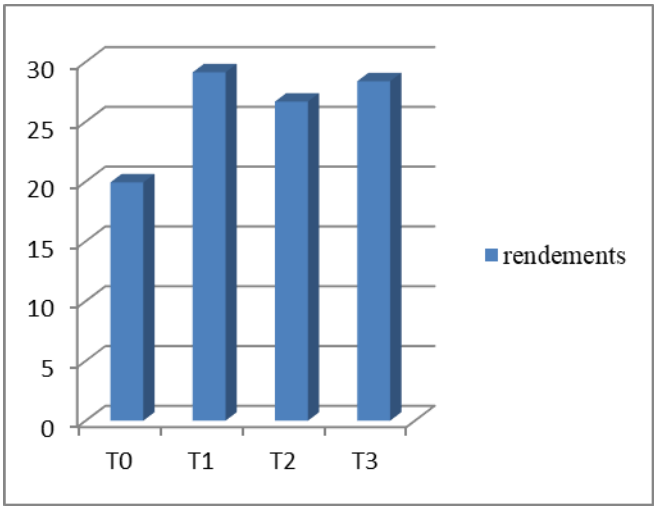
Table 1: Average of *H. armigera* larvae density and larvae infestation

TREATMENTS	AVERAGE OF LARVAE DENSITY + SD	INFESTATION ON FLOWERS + SD (%)	INFESTATION ON FRUITS + SD (%)
T0	2,43 ± 0.25 a (0,53)	7,06 ± 0,6 a (0,53)	63,56 ± 1,8 a (1,84)
T1	0,46 0,01c (0,16)	0,1 ± 0,2 c (0,19)	18,73 ± 2 c (0,89)
T2	0,77 ± 0,09 b (0,24)	2,4 ± 0,5 b (0,3)	23,27 ± 1,5 b (1)
T3	0,46 ± 0,10 c (0,16)	1,4 ± 0,4 c (0,23)	22,77 ± 2.5 c (0,89)
Probabilities	**P < 0,0001**	**p < 0,0001**	**p < 0,0001**

The average converted with 2Arcsin√x [11] (x represents percentage real values of des organs infested) for infestation the values followed by same letters are not significant different at 5%. The values into brackets in columns represent the means converted with Log10 (n+1) (Dagnelie, 1998) (n represents number real values of larvae) for larvae mean density. The values into brackets in columns represent

The assessment of infestation per plant on flowers and on fruits by treatments showed the significant differences among the treatments applied. But the high infestations on flowers and fruits of *H. armigera* have been obtained in control plots. The lowly infestations have been observed in K-OPTIMAL and neem oil treated plots. Analysis of variance indicated a significant high influence between the treatments F-value = 42.86 for flowers, F-value = 157.51 for fruits, P-value < 0.0001). None difference has been observed among K-OPTIMAL efficacy and neem oil efficacy at 2 l/ha on *H. armigera* infestation on tomato, see table 2. K-OPTIMAL and Neem oil respectively, reduced *H. armigera* infestation to 81.26% and from 76.72 à 77.22% in comparison to control.

3.2. Impacts of neem oil on tomato yield: The effects of treatments on tomato fruits have been estimated. The significant differences have been observed among treatments. While the yields significantly increased in treated plots by treatments in comparison to control plots. The lowly yields (19.93 tons/ha) were obtained in control plots; but the highly yields were observed in K-OPTIMAL and neem oil treated plots. K-OPTIMAL induced the highly yield (29.13 tons/ha) followed by neem oil (26.68 to 28.38 tons/ha). Analysis of variance showed a significant high influence among treatments (F-value = 216.49, P-value < 0.0001). None difference has been observed among K-OPTIMAL efficacy and neem oil efficacy at 2 l/ha on yields, see **Graph 1.**



Graph 1: Effects of treatments on tomato yield

3.2. Profitability of the Protection Systems: The costs of labour in the application of K-OPTIMAL and neem oil were different (**Table 2).** The labour costs of neem oil (bio-insecticide) were higher than those in the conventional treatments. The costs of inputs also differed, and these were highest under the bio-insecticide treatment than conventional treatment. The difference in input costs between conventional treatments and bio-insecticide treatments resulted from the variation in the amount of insecticides used, which depended on the number of times the threshold was reached. Profits per ha of the four tomato protection strategies were very different. The highest profit was obtained with K-OPTMAL, conventional treatment (1022.40 US$) followed by bio-insecticide (465.34 – 691.395 US$).

Table 2: Efficacy of neem oil at 2 l/ha on yields**,**

Treatments	**Yields (Kg/ha)**	**Labors (US$)**	**Inputs (US$)**	**Profit (US$)**
T0	19930	0	1048	-1391.67
T1	29130	25	1078	1022.40
T2	26682	1000	1093	465.34
T3	28380	1000	1108	691.395

The costs indicated above are the actual costs incurred by farmers in the experiment for the 2017 season. The price of 0.16 US$ per kg. 1US $ = 600 FCFA during the tomato harvest in December 2016. FCFA: Franc de la Communauté Franc d'Afrique Française

4.2. DISCUSSION

The perusal of the results reveal that neem oil and K-OPTMAL after their application, have performed better and these products have reduced significantly the average of *H. armigera* larvae density and damages on flowers and on fruits. However, the results on the basis of damaged flowers and fruits pointed out that neem oil (2 l/ha) and K-OPTIMAL obtained the similar results on the average of *H. armigera* larvae density and damages on flowers and fruits. As far as, neem oil and K-OPTIMAL increased significantly the tomato yields. Neem oil reduced *H. armigera* average larvae density from 0.46 to 0.77 per plant and its damages from 76.72 to 77.22% and K-OPTIMAL caused 0.46 per plant and 81.16% respectively *H. armigera* larvae density and damages reduction in comparison to control (2.43 larvae per plant and 63% infestation).

These results have been demonstrated by some authors like Traoré *et al*.[13] and El Shafiel et Abdelraheem[14],. Then, neem oil proved its efficacy in the *H. armigera* control on tomato increasing the yield. Neem oil and K-OPTIMAL allowed obtaining respectively yields gain from 33.8 to 42.39% and 46.16% regarding control. These results confirm Togbé *et al*.[15-17] results.

The efficacy of bio-insecticides was lower compared to that of synthetic insecticides used in conventional. This difference in yield can foster the reluctance of farmers to adopt the bio-insecticides. But the return to farmers who adopt them could be compensated if the real value of the bio-insecticides on the preservation of the environment was to be estimated, giving farmers a price incentive to grow organic tomato. Yield obtained from organic product (cotton) is far lower than conventional treatments [16]**.** Without such an incentive, farmers may not be motivated to adopt the bio-insecticides despite their relative advantages for the preservation of the environment compared to conventional tomato.

CONCLUSION

It can be concluded from this study that neem oil is effective and relatively safer choices for control of tomato fruit borer *Helicoverpa armigera* (Hubner). This Biopesticide constitutes an alternative method for crop sustainable agriculture and environmental protection.

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Corresponding author: Eloi HOUESSOU[1]

[1]School of Horticulture and Green Spaces Management of National University of Agriculture BP 43, Kétou Bénin

[2]Faculty of Agronomic Sciences of University of Abomey-Calavi. 03 BP 2819 Jericho Cotonou Bénin,

Email : eloihouessou95@gmail.com Tel: (+229) 96 25 73 15 / 95 98 02 27

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