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Performances Evaluation of Plant' Extracts and Standard Pesticides Sgainst Helicoverpa armigera and Bemisia tabaci of Tomato (Solanum lycopersicum L.)

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Abstract:- Helicoverpa armigera and Bemisia tabaci remain major insect pests of tomato in horticultural production areas of Mali; Producers prefer chemical control methods for their management, which were not often effective. The aim of this study was to improve tomato production system by using plants' extract. The experimental design was randomized Fischer block with three replications to compare performance of two plants' extract formula with Rapax and Lambda Master 2.5EC. Entomological observations and agronomic measurements were made on marked plants in the observation squares. The results reveal that the plant extracts gave similar efficiencies to the commercialized pesticides Lambda and rapax on Bemisia tabaci with percentages of efficiencies varying between 58.33% and 72.62%. Against Helicoverpa. armigera rapax, the formula 2 and 1 were poorly effective with less than 50% while Lambda offered a percentage of effectiveness ranging between 52 and 63%. The best yields were recorded with Formula 1 and 2 treatment (36.72 T/ha; 32.40 T/ha), respectively and (30.56 T/ha) for rapax. Results of variance have shown different significant effects level of pesticides applied on tomato yield ($p=0.001$ with $\alpha=0.05$). Therefore, this study recommends plants' extract as alternative to chemical control of Bemisia tabaci in tomato.

Keywords:- *Plant' extract; Helicoverpa armigera; Bemisia tabaci; Tomato, Katibougou*

I. INTRODUCTION

Solanum lycopersicum L was one of the important vegetable crops for economy growth of many countries due to the use of its fruit in daily dishes [1]. After potato, it was the most consumed vegetable in the world, either fresh or after processing. Tomato was also one of the most widespread crops in the world [2]. It was cultivated in all latitudes in a wide variety of conditions [3] . Tomato was the most consumed vegetable with a global production of 180,766,329 tons in the world, within 5,030,545 hectares [4]. Tomato production in Mali was 204,698 tons within 12,354 ha [4]. It is part of the daily diet and is grown throughout the country. The tomato value chain has been recognized by USAID-Mali as promising value chains which can contribute to accelerated economic growth and reduce poverty in Mali [5]. However, high parasitic pressure bias tomato production in agro-ecological areas of Mali. Among bio-aggressors, bollworm (*Helicoverpa armigera*) and whitefly (*Bemisia tabaci*) [6], [7]; *Helicoverpa armigera* and *Tuta absoluta* [8] represent a major threat in tomato crops. Farmers use a wide range of synthetic insecticides to manage these pests. In addition, these products can also kill non-target organisms by causing environmental imbalances in natural regulation. They lead to resistance in some species. According to [9], more than 500 species of insects and mites developed resistance to insecticides turning to increase pest problems, leading to economic losses [10]. Thus, in order to reduce the impact of synthetic chemicals on the environment, it appeared necessary to develop other less harmful strategies such as the use of bio-pesticides, agronomic control, biological control and recently, sustainable agro-ecological control to increase vegetable production specially, tomato production. In this perspective, the study on the efficacy of plant extracts on tomato pests was carried out on agricultural field of Rural Polytechnic Institute for Training and Applied Research (IPR/IFRA) of Katibougou in comparison with rapax (SC), a biological insecticide and lambda master 2.5 EC, a pyrethroid insecticide used in the management of vegetable crops pests for tomato production improvement through development and use of plant' extract.

II. METHODOLOGY

A. Study Area

Experimental trial was carried on field in agro-ecological conditions of IPR/IFRA of Katibougou over 12°56' N latitude, 7°37' W longitude, 326m altitude [10] with a leached tropical ferruginous, silty texture that was characterized by low nutrient content. The crop precedent for the plot was quinoa (*Chenopodium quinoa*).

B. Vegetable Inputs

Roma F1 variety of tomato was used for this study. It was a very vigorous variety and especially interesting for its resistance to tomato late blight. Its fruits grow in clusters, were elongated, fleshy and productive. Its flesh is tasty, firm and contains little water.

C. Plant' Extract Formulations and Reference Pesticides

The formulations were prepared from neem seed powder (N), vegetative apparatus of *Hyptis* sp (hyp), *Cissus quadrangularis* (Cis), Cactus (Cac), *Cassia nigricans* (Ca) and adhesives consisting of shea butter (Bk) and *Carapa procera* oil (Koby). These vegetative organs were all crushed and powdered for the preparation of the formulations, the methodology used was maceration. The two plant' extract formulas prepared for this study were:

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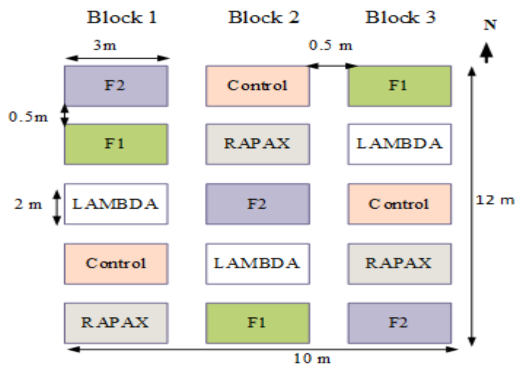
$F1 = N + hyp + Cis + koby + Bk$ (1)
$F2 = N + hyp + Cac + Ca + koby + Bk$ ..(2)

Rapax (SC) was a biological insecticide based on *Bacillus thuringiensis*. It was able to act on several insects, particularly lepidopterans. The recommended dose was 1 to 1.5L/ha. Lambda master 2.5EC, a pyrethroid based on Lambda-cyhalothrin 25g/l was effective against caterpillars, sucking pests of cotton, vegetable and cereal crops, cowpeas and peanuts.

D. Experimental Design

The experimental design was Fischer block with 5 treatments and 3 replicates. The size of elementary plot was 6m^2 (3m×2m). They were spaced by 0.5 m. There were three (3) blocks and each block measures 12m². They were separated by 0.5m walkways. The different treatments were control plot, treated plot with the lambda pesticide, treated plot with rapax pesticide, treated plot with extract Formula 1 (F1) and treated plot with extract Formula 2 (F2).



Fig,1. Field Experiment Plots

E. Carrying out the Trial

The nursery was installed on October 15, 2020. A board of 10m^2 was done, followed by a layer of 16kg of well-decomposed organic manure. The seeding was carried out in line in the grooves 15cm using rake and a wooden ruler at depth of 1cm. The furrows were then closed with a thin layer of soil and the board covered by straw. When the emergence was completed, the shade was removed to prevent the withering of the young plants. The soil layout consisted of cleaning the plot, ploughing followed by the making of 10 m long and 2 m wide boards. Each board received 16 kg of vermicompost as basic organic manure at the dose of 8T/ha. The young tomato plants were transplanted on November 30, 2020 at 0.40m over 0.60m spacing. The dead plants substitution was performed 2 days after transplanting. The cultural maintenance was mainly weeding, irrigation and plant tutoring.

F. Agronomic and Entomological Observations

The agronomic observations were focused on morphological aspects, particularly phenology (collar diameter, plant height, number of fruits and yield). All these measurements and observations were made on 9 marked plants taken along the 3 central lines of each treatment. Three observations were made at the 30th, 45th and 60th days after transplanting (DAT), respectively. The yield was calculated basing on fruits harvested per square of yield for all harvests. Entomological observations consisted of determining the number of pests and auxiliaries at all developmental stages on the plants from the observation squares of each treatment. These observations were done weekly. Changes in insect populations in treated and untreated plots were compared to determine the efficacy (Ep) of different pesticides and plant ‘extract using the Henderson & Tilton equation [11];[12]:

$$EP(\%) = \left[1 - \left(\frac{DTa}{DTb} \times \frac{DCb}{DCa}\right)\right] \times 100 \qquad (3)$$

, Where:
DTb and DCb = pest density before pesticide application in treated and control plots respectively;

DTa and DCa = pest density after pesticide application (chemical or organic) in treated and control plots respectively.

G. Statistical Analysis

Genstat 12th Edition software was used for morphological parameters and yield analysis. One-way ANOVA analysis was done to test the significant level of different parameters at Newman and Keuls test (5%) threshold. The graphical presentation of the results was done using Excel software.

III. RESULTS

A. Effect of Pesticides on Agronomic Parameters of Tomato

Results of variance show that collar diameter do not indicate any significant difference between treatments from 30th, 45th and 60th DAT, with 0.410; 0.223 and 0.403 respectively at threshold of α= 5%. However, the most vigorous plants were recorded at the level of F2 treatment with respectively 0.79; 1.01 and 1.13cm followed by F1 with respective root collar diameters of 0.77; 0.97; 1.11cm at three (3) observations. The shortest plants were recorded at the control plot with 0.56; 0.76 and 0.88cm high respectively on the three measurement dates.

The height of plants at different measurement dates (30th, 45th and 60th DAT) and variances analysis did not shown significant level of α = 5% with respectively P=0.969; 0.483 and 0.157 for various dates. Results show that plants’ control treatment (42.08; 62.80 and 57.90 cm) and Lambda (42.12; 62.70 and 71.20 cm) recorded the maximum sizes on the different measurement dates.

The smallest plants were obtained in the F1 treatment (with 37.46; 60.10 and 68.60 cm) during the three measurement dates. The first fruits were observed on plants treated with plants’ extract. However, results show that analysis of variance were not significant level during the three counting dates with respectively 0.461; 0.709 and 0.989 where α=0.5 threshold. On all three observation dates, the plants of the F2 treatment (with 1.46; 5.70 and 15.50 fruits per plant) and the F1 (0.17; 3.90 and 13.50 fruits per plant) offered the highest number of fruits

TABLE I. PLANT' EXTRACTS AND REFERENCE PESTICIDES EFFECT ON ROOT COLLAR DIAMETER, PLANT SIZE AND FRUIT NUMBER OF TOMATO

Treatments	**Root collar diameter (cm)**			**Plant size (cm)**			**Fruit number**		
	30DAT	***45DAT***	***60DAT***	***30DAT***	***45DAT***	***60DAT***	***30DAT***	***45DAT***	***60DAT***
Control	0.56	0.76	0.88	42.08	62.80	57.90	0.00	1.70	14.20
Lambda	0.58	0.80	1.03	42.12	62.70	71.20	0.00	1.70	12.20
Rapax	0.71	0.91	1.11	38.85	54.80	59.70	0.00	2.20	14.90
F1	0.77	0.97	1.11	37.46	60.10	68.60	0.17	3.90	13.50
F2	0.79	1.01	1.13	38.12	61.20	69.60	1.46	5.70	15.50
Average	***0.68***	***0.89***	***1.05***	***39.70***	***60.10***	***68.60***	***0.32***	***3.00***	***14.10***
Prob	***0.410***	***0.223***	***0.403***	***0.969***	***0.483***	***0.157***	***0.461***	***0.709***	***0.989***
CV	***6.60***	***7.20***	***0.90***	***14.00***	***3.60***	***4.10***	***173.20***	***86.50***	***13.40***

B. Effect of Pesticides on Tomato Yield

The results of the analysis of variance indicate that there was highly significant difference between effects of pesticides applied on tomato yield (p=0.001). Treatments average comparisons of Newman and Keuls was significant at 5% level with the following homogeneous classes: F1, F2 and rapax with respective yields 36.72; 32.40 and 30.56 T/ha; lambda (28.37 T/ha) and the control (25.37 T/ha).

TABLE II. TOMATO YIELD AVERAGE UNDER DIFFERENT PESTICIDE TREATMENTS

Treatments	**Yield Average (T/ha)**
Control	25.37 a
Lambda master 2.5EC	28.37 ab
Rapax	30.56 b
F1	32.40 b
F2	36.72 b
Average	30.40
Prob	0.001
CV	8.70

C. Phytophagous Insects Inventoried on Tomato

During entomological observations 8 insects' species were refereed by phytophagous group these species belong to 7 families distributed in 5 orders of which 3 known species were *Bemisia tabaci, Empoasca facialis, Helicoverpa armigera* (Table 3). among these pests, the most economically important were *Bemisia tabaci* and *Helicoverpa armigera.*

TABLE III. TYPES OF PESTS FOUND ON TOMATO

Order	**Family**	**Binomial name**
Homoptera	Aleurodidae	*Bemisia tabaci*
	Aphididae	*Aphis* sp.
	Cicadellidae	*Cicadelle* sp.
		Empoasca facialis
Lepidoptera	Noctuidae	*H. armigera*
Coleoptera	Chrysomelidae	*Chrysomele* sp.
Ephemeroptera	Ephemeridae	*?*
Thysanoptera	Thripidae	*Thrips* sp

D. Effect of Pesticides on the Evolution of Populations of Major Plant Pests

➢ *Evolution of Bemisia tabaci populations*

On the first observation date at 43rd DAT, *Bemisia tabaci* was observed in treatments with respective average densities of 17.96 individuals per plant (ipp) for the F1 treatment, 16.08 ipp for F2, 4 ipp for the lambda treatment; 3.22 ipp for rapax and 1.75 ipp for control. *Bemisia. tabaci* population densities showed a slight reduction across all treatments at the second observation date on DAR 37 with 14.04 ipp for F1 treatment; 16 ipp for F2; 0.67 ipp for lambda treatment; 1.33 ipp for rapax and 0.33 ipp for control. Agrochemical sprays on 43rd DAT provided a very strong reduction especially in F2 and F1 treatments on 3rd observation date with 3.21 ipp and 3.08 ipp respectively. Observations on 51st DAT saw the recording of population densities varying between 0.5 ipp for the control treatment and 2.87 ipp for F2. These densities were further reduced with the second phytosanitary treatment on 55th DAR with respectively 0.53 ipp for F1 treatment; 0.5 ipp for F2; 0.12 ipp for lambda treatment; 0.08 ipp for rapax and 0.25 ipp for control.

A slight increase in population density was observed after the second phytosanitary treatment at 58 DAT with densities ranging from 0.33 for control to 2.91 ipp for the F2 treatment. This increase was followed by a reduction of population densities at 72 DAT with respective densities of 0.12 individuals per plant (ipp) for F1 treatment, 0.25 ipp for F2, 0.07 ipp for lambda treatment, 0.05 ipp for rapax and 0.08 ipp for control. For all observations, the cumulative population density for the 7 entomological observations was respectively 39.4 ipp for F1 treatment; 41.44 ipp for F2; 6.08 ipp for lambda treatment; 5.8 ipp for rapax and 3.41 ipp for control. The results show that there were high significant difference between population density of the different treatments at the different observation dates with p=0.001 at the threshold α=0.05. Phytosanitaries treatment have reduced population density of *Bemisia tabaci* during the crop cycle.

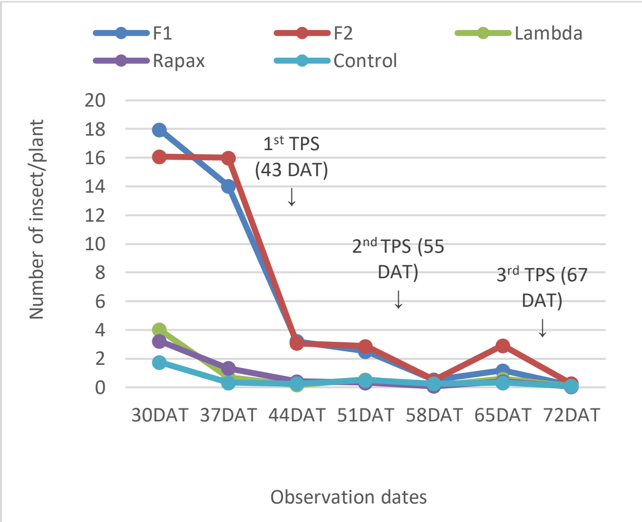


Fig. 2. Evolution of *Bemisia tabaci* populations on tomato under different phytosanitary treatments

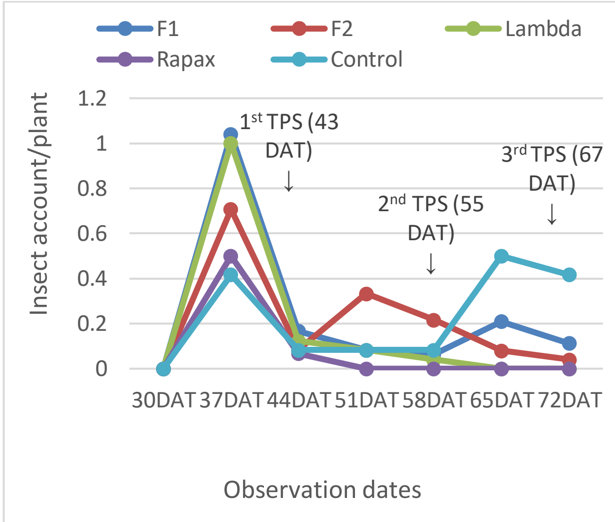


Fig.3. Evolution of *Helicoverpa armigera* populations on tomato under different phytosanitary treatments.

➢ *Helicoverpa armigera* population evolution

On the first observation date (30th DAT), *H. armigera* was not observed on the different treatments. It was during the second observation date (37th DAT) that *H. armigera* populations were observed with densities of 1.04 ipp for F1 treatment; 0.707 ipp for F2; 1.0 ipp for lambda treatment; 0.5 ipp for rapax and 0.417 ipp for control. Pesticide sprays on 43rd DAT reduced population densities at 44th DAT observation date at different treatments with population densities ranging from 0.067 ipp for rapax treatment to 0.167 ipp for F1. Observations on 51st DAT revealed population densities ranging from 0 ipp for rapax treatment to 0.083 ipp for the F1, lambda and control treatments and 0.333 ipp for F2 treatment. Phytosanitary second treatment at 55th DAT reduced densities at 58th DAT observations with 0.063 ipp for F1; 0.217 ipp for F2; 0.04 ipp for lambda treatment; 0 ipp for rapax and 0.25 ipp for control respectively. At 65th DAT population densities *of H. armigera* were 0.21 ipp for F1; 0.08 ipp for F2, and 0.5 ipp for control. The rapax and lambda treatments did not record *H. armigera* at 65 and 72 DAT. At the last observation date of 72th DAT, a reduction in densities was observed in F1 (0.113 ipp) and F2 (0.04 ipp) treatments and control (0.417 ipp). For all observations, the cumulative population density for the 7 entomological observations was respectively 1.563 ipp for F1 treatment; 1.42 ipp for F2; 1.246 ipp for lambda treatment; 0.567 ipp for rapax and 1.166 ipp for control. The results of statistical analysis show a highly significant difference between population density of different treatments at the different observation dates with p=0.002 at threshold α=0.05.

E. Efficacy of plant extracts on major pests of tomato

➢ *Comparative efficacy of plant protection products on Bemisia tabaci*

On *Bemisia tabaci*, during the first spraying at 43rd DAT, the pesticides lambda, rapax and formulations of plant extracts F2 and F1 have given percentages of 66.67%; 58.33%; 72.62% and 69.55% respectively. During the second spraying at 55th DAT the Ep were 54.32% for lambda, 50.00% for rapax; 65.43% for F2 and 57.54% for F1. At last treatment (67th DAR), the percentages efficacy were respectively 54.29% for lambda; 52.00% for rapax; 65.68% for F2 and 57.59% for F1. In all three applications, plants' extract treatments (F2 and F1) were more performant than synthetic products lambda and bio-pesticide rapax.

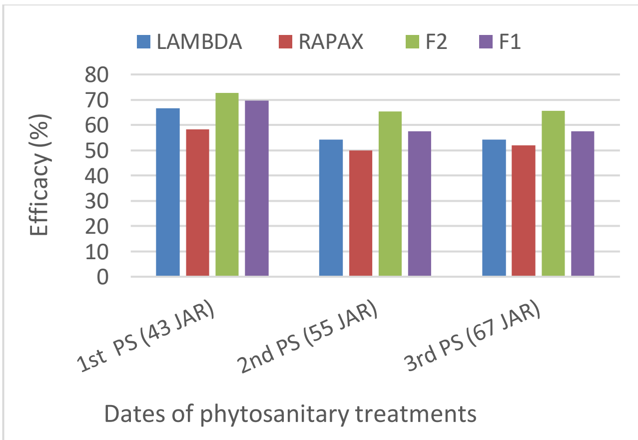


Fig. 4. Comparative efficacy of lambda, rapax and plant extracts on *Bemisia tabaci*

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- *Comparative efficacy of synthetic pesticides, bio-pesticides and plant extracts on H. armigera*

On *Helicoverpa armigera*, during the first phytosanitary treatment on the 43rd DAT, the different pesticides have given variable Ep, lambda (63.00%), rapax (33.33%) formulations of plants' extract F2 (41.04%) and F1 (19.87%). At the second phytosanitary treatment of 55th DAT the Eps' were about 52.00% for lambda; 35.00% for F2 and 24.00% for F1. In the last treatment *H. armigera* were absent from the plants of lambda and rapax treatments. However, the F2 and F1 formulations have given respective Ep of 40.00 and 35.24%. Overall, against *H. armigera*, the bio-based pesticides (rapax, F2 and F1) were not efficacy with Ep of less than 50%.

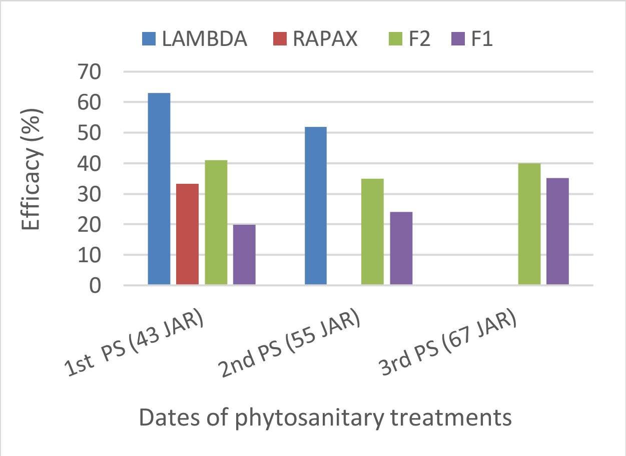

Fig.5. Comparative efficacy of lambda, rapax and plant extracts on *H. armigera*

IV. DISCUSSION

Seven families of insect pests (Aleurodidae, Aphididae, Cicadellidae, Noctuidae, Chrysomelidae, Ephemeridae, and Thripidae) were observed in tomato fields in the IPR/IFRA of Katibougou estate. These results were conform to those obtained in Benin [13], Nigeria [13], Ghana [15], Burkina Fasso [16] which have shown that tomato crop has a multitude of insect pests belonging to various families. *Bemisia tabaci* (Aleurodidae) and *Helicoverpa armigera* (Noctuidae) were the main potential pests of tomato crop on field. These results were in accordance with those of [17]. Against *B. tabaci* the plants' extract had variable percent efficacy (Ep) ranging from 57.54% to 72.62% compared to lambda (54.32 and 66.67%) and rapax (50 and 58.33%). According to [18], neem seed extract has medium efficacy on whiteflies, jassids and flea beetles. According to [18] work comparing plants' extract to conventional insecticides could show that some extracts can show the same efficacy as synthetic insecticides. Against *H. armigera* the percentage of efficiency of the extracts varied between 52 and 63% for lambda and 33.33% for rapax. These Ep were higher than those of the extracts, which ranged from 19.97 to 41%. According to [19], coprophagous caterpillars with an endocarpic diet (*H. armigera* and *Earias* sp) were less sensitive to botanical insecticides. These results corroborate those from [20] who showed that organic insecticides were found to be less efficacious than chemical pesticides in this case cypermethrin 10 EC on cowpea insects, *Vigna unguiculata*. According to Amoatey and Acquah [21] the combination of certain agricultural practices such as crop rotation, physical protection (anti-insect nets), the use of pesticide plants were likely to reduce significantly the pressure of bio-aggressors and the requirement of synthetic pesticides.

Plants' extract resulted in the highest fruit yields. Tomato yields from plants' extract treatments differed significantly from the commercial pesticide treatments (lambda and rapax) and control (p=0.001). These results corroborate those from [18] in which chemical recorded lowest cabbage yield and confirm the idea from [22] in which the use of some natural products in crop protection can increase yields in some cases, for a cost-benefit ratio similar to synthetic pesticides.

V. CONCLUSION AND RECOMMANDATIONS

The production of tomato in quantity and quality requires the control of bio-aggressors of the crop. For this management, the majority of farmers use chemical synthetic pesticides, which have harmful effects on humans and their environment. The comparative study of plants' extract with conventional pesticides Lambda and bio-pesticide Rapax was conducted as part of research for alternatives to chemical pesticides. The study revealed that *Bemisia tabaci* and *Helicoverpa armigera* were major insect pests met on tomato crop. The extracts have given similar efficiencies to the commercialized pesticides on whitefly of tomato with efficacy percentages varying between 58.33 and 72.62%. Against *Helicoverpa, armigera* extracts were fewer efficacies than pesticides (Lambda and rapax). For tomatoes yield, the effects of pesticides were significant (p=0.001 at 5% significance level) with the best yields recorded in the bio-pesticide treatments with respective yields of 36.72 T/ha for F1; 32.40 T/ha for F2, and 30.56 T/ha for rapax treatments. The results of the study attest that plants' extract can be an alternative solution in vegetable production contributing to the preservation of population and environmental health. Thus, the use of plants' extract constitutes a technology to be promoted, especially in farming environment as an alternative control against main insect pests and parasitic diseases of vegetable crops. To facilitate adoption of plants' extract uses against pests by producers, the state should support research and transfer of technology.

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REFERENCES

[1]. J. Dossou, I. Soulé, et M. Montcho, « Analyse économique de la production de purée de tomate », p. 8, 2006.
[2]. S. Naika, J. Jeude, M. Goffau, M. Hilmi, et B. Dam, *La culture de la tomate production, transformation et commercialisation*. 2020.

[3]. H. Laterrot, « Tomate - Production et données économiques de la tomate », 2013. http://ephytia.inra.fr/fr/C/4945/Tomate-Production-et-donnees-economiques-de-la-tomate (consulté le oct. 22, 2021).

[4]. FAO STAT, « Production mondiale de tomates par pays », *AtlasBig*, 2019. https://www.atlasbig.com/fr-fr/pays-par-production-de-tomates (consulté le oct. 21, 2021).

[5]. V. A. Kelly, J. Carpenter, T. Easterling, M. Kone, P. G. McCornick, et M. McGahuey, « Options pour la croissance économique du Mali à travers l'application des sciences et technologies à l'agriculture », No. 1093-2016-87807, 2005.

[6]. T.-X. Liu, « Life history of Eretmocerus melanoscutus (Hymenoptera: Aphelinidae) parasitizing nymphs of Bemisia tabaci biotype B (Homoptera: Aleyrodidae) », *Biological Control*, vol. 42, nº 1, p. 77-85, 2007.

[7]. N. S. Talekar, R. T. Opena, et P. Hanson, « Helicoverpa armigera management: a review of AVRDC's research on host plant resistance in tomato », *Crop Protection*, vol. 25, nº 5, p. 461-467, 2006.

[8]. M. Diatte, T. Brévault, D. Sall-Sy, et K. Diarra, « Des pratiques culturales influent sur les attaques de deux ravageurs de la tomate dans les Niayes au Sénégal », *International Journal of Biological and Chemical Sciences*, vol. 10, nº 2, p. 681-693, 2016.

[9]. P. Anjarwalla, S. Belmain, P. Sola, R. Jamnadass, et P. C. Stevenson, « Guide des plantes pesticides », *Optimisation des plantes pesticides: technologie, Innovation, sensibilisation et réseaux. World Agroforestry Centre (ICRAF). Nairobi, Kenya*, 2016.

[10]. IPR-IFRA, « Plan strategique de l'IPR/IFRA de Katibougou 2015-2020 version finale actualisée ». 2018.

[11]. C. F. Henderson et E. W. Tilton, « Tests with acaricides against the brown wheat mite », *Journal of economic entomology*, vol. 48, nº 2, p. 157-161, 1955.

[12]. O. D. Kpindou, A. Niassy, K. Badji, et C. Kooyman, «Application of mixtures of Metarhizium anisopliae var. acridum and cyhalothrin against the Senegalese grasshopper in Senegal», *International Journal of Tropical Insect Science*, vol. 28, nº 3, p. 136-143, 2008.

[13]. D. C. Choudourou, A. Agbaka, J. B. Adjakpa, R. E. Koutchika, et E. J. N. Adjalian, « Inventaire préliminaire de l'entomofaune des champs de tomates (Lycopersicon esculentum Mill) dans la Commune de Djakotomey au Bénin », *International Journal of Biological and Chemical Sciences*, vol. 6, nº4, p. 1798-1804, 2012.

[14]. D. M. Mailafiya, M. M. Degri, Y. T. Maina, U. N. Gadzama, et I. B. Galadima, «Preliminary studies on insect pest incidence on tomato in Bama, Borno State, Nigeria», *International Letters of Natural Sciences*, vol. 5, 2014.

[15]. E. S. K. Ofori *et al.*, «Preliminary studies of insect diversity and abundance on twelve accessions of tomato, Solanum lycopersicon L. grown in a coastal savannah agro ecological zone», *Journal of Agricultural Science*, vol. 6, nº8, p. 72, 2014.

[16]. D. Son *et al.*, « Détermination par piégeage de la diversité et de l'abondance des familles d'insectes associées à la culture de tomate (Solanum lycopersicum L.) au Burkina Faso », *Entomologie faunistique-Faunistic Entomology*, 2019.

[17]. L. Kansaye, A. K. Coulibaly, A. Sangaré, et A. Koné, « Influence de l'induction des composes volatiles des cultures associees dans la gestion des ravageurs : cas de la tomate et du chou », *Revue Malienne de Science et de Technologie*, nº22, p. 47-58, 2019.

[18]. J. A. Gnago, M. Danho, T. A. Agneroh, I. K. Fofana, et A. G. Kohou, « Efficacité des extraits de neem (Azadirachta indica) et de papayer (Carica papaya) dans la lutte contre les insectes ravageurs du gombo (Abelmoschus esculentus) et du chou (Brassica oleracea) en Côte d'Ivoire», *International Journal of Biological and Chemical Sciences*, vol. 4, nº 4, 2010.

[19]. G. Bonni, M. Adegnika, et A. Paraïso, « ravageurs du cotonnier au Bénin », *Tropicultura*, vol. 36, nº 4, p. 762-772, 2018.

[20]. R. Younoussou, « 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) », *Revue Marocaine des Sciences Agronomiques et Vétérinaires*, vol. 9, nº 4, 2021.

[21]. C. A. Amoatey et E. Acquah, « Basil (Ocimum basilicum) intercrop as a pest management tool in okra cultivation in the Accra Plains. », *Ghana Journal of Horticulture*, vol. 8, p. 65-70, 2010.

[22]. P. Silvie et P. Martin, « Les plantes pesticides au secours des cultures », 2017.