



The effect of pesticides and aqueous extracts of *Azadirachta indica* (A. Juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrididae) and *Helicoverpa armigera* (Hübner)(Lepidoptera: Noctuidae) found on tomato plants in Côte d'Ivoire.

Dohouonan Diabaté¹, Jean Ayekpa Gnago², Kouamé Koffi³, Yao Tano^{1,4}

¹ Laboratoire de Zoologie et Biologie animale, UFR Biosciences, University Félix HOUPHOUËT-BOIGNY (UFHB) Cocody- Abidjan, 22 BP 582 Abidjan 22 (225) Côte d'Ivoire

² Laboratoire de Zoologie Agricole et Entomologie, Institut National Polytechnique Félix HOUPHOUËT-BOIGNY (INPHB), BP 1313 Yamoussoukro, (225) Côte d'Ivoire

³ Agence Nationale d'Appui au Développement Rural (ANADER), BP 77 Bongouanou, Côte d'Ivoire

⁴ Université Nangui Abrogoua, 02 BP 801 Abidjan 02, (225) Côte d'Ivoire

Corresponding author: D. Diabaté: (225) 06 27 92 95; (225) 02 77 80 37; e-mail: diabdoh@yahoo.fr

Original submitted in on 18th June 2014. Published online at www.m.elewa.org on 31st August 2014. <http://dx.doi.org/10.4314/jab.v80i1.14>

ABSTRACT

Objective: The objective was to evaluate the effects of foliar application of *Jatropha* and neem aqueous extracts compared to a conventional insecticide treatment on the number of whitefly *Bemisia tabaci* (Gennadius) and bollworm *Helicoverpa armigera* (Hübner), yield of tomatoes in plots and the potentials of using any of these aqueous extracts to control these insect pests.

Methodology and results: the study was conducted in the region of Moronou (Bongouanou, Koffikro, CBC Kangandissou). The insecticides Décis 12 EC® and Cypercal 50 EC®, and neem and jatropha aqueous extract were used for tomato foliar treatment (neem and jatropha seeds 80 and 50g/L, neem leaves 67 g/L). The treatments of tomato plant plots with pesticides Decis® and Cypercal® showed similar yields of biopesticide made of neem and jatropha in Ahorosso (P=0.00), Bongouanou (P=0.07) and CBC Kangandissou (P=0.01) plots. All of these treatments reduced the number of *Bemisia tabaci* adults, reduced the number of *Helicoverpa armigera* larvae on tomato plants and increased number of fruits per plant, the fruit weight per plant and the yield.

Conclusion and application of findings: Statistical analysis shows that aqueous extract of jatropha and neem seed 80 g/L and 50 g/L, and of neem leaves 67 g/L are as effective as pesticides Décis® and Cypercal® on *Bemisia tabaci* and *Helicoverpa armigera*. Consequently, these biopesticides increased the number of fruits per plant and yield. This result should enable use of aqueous extract of neem and jatropha seed and of neem leaves to protect tomato plants against *Bemisia tabaci* and *Helicoverpa armigera* at farm.

Keywords: *Bemisia tabaci*; *Helicoverpa armigera*; tomato crop; aqueous extract; biocontrol

INTRODUCTION

The whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrididae) and bollworm *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) are key pests attacking many crops such as tomato (Talekar *et al.*, 2006; Liu, 2007). The whitefly *B. tabaci* is a pest with high economic impact of crops worldwide (Oliveira *et al.*, 2001; Liu, 2007). It comes to the fore of phytosanitary constraints of vegetables and other crops in tropical, subtropical and Mediterranean areas (Oliveira *et al.*, 2001; Simmons *et al.*, 2002). Its abundance and dynamics vary depending on the host plants and their stage of development, and on climatic factors (Simmons and Jackson, 2000). Indeed, the number of *B. tabaci* and the virus Tomato yellow leaf curl virus (TYLCV) that it inoculates in plants are high during the summer season (Stansly *et al.*, 2004). High temperatures of this season encourage their reproduction and migration on crops. From a taxonomic point of view, it is complex and comprises at least 24 subspecies morphologically indistinguishable but genetically distinct (Wang *et al.*, 2011). They are usually located on the underside of leaves of plants and transmit more than 110 viruses (Jones, 2003; Ben-Yakir, 2012). This whitefly transmitted to tomato TYLCV that is one of the most devastating pathogenic agents of tomato cultivated in tropical and subtropical regions of the world (Jones, 2003; Zhang *et al.*, 2004). The sucking of sap by larvae and adults of *B. tabaci* cause physiological disorders. This results in the early maturity, irregular coloration of tomato fruit and plant death (Ben-Yakir *et al.*, 2012). Thus, it affects the quality of fruits and decreases yields (Ben-Yakir *et al.*, 2012). The whitefly *B. tabaci* and bollworm *H. armigera* are important pests of vegetable crops. Moth *H. armigera* causes considerable yield losses by the destruction of leaf and fruit bodies (Zalucki *et al.*, 1986). Indeed, *H. armigera* larvae are polyphagous and can cause the destruction of 30% of untreated fruit of plants (Zalucki *et al.*, 1986; Walker and Cameron, 1990). The temperate climate whose average of daily temperature is 23.5 °C limits the development of *H. armigera* by two to three

generations per year. This limits the ability of *H. armigera* to reach damaging levels (Walker and Cameron, 1990). *H. armigera* damages are regularly distributed in the dry season, but much less, damage is localized at the top of the plant during the rainy season (Bouchard *et al.*, 1992). Farmers use large quantities of pesticides to protect their crops from *B. tabaci* and *H. armigera* damage and to increase yields. However, intensive use of chemical pesticides in its control has led to these pests developing resistance to the pesticides commonly used (Akbar *et al.*, 2011) and cause serious damage to natural enemies of these pests (Cui *et al.*, 2013). *H. armigera* adults are highly mobile and capable of migration and adaptation to their environment. Larvae may enter diapause optionally and develop resistance to insecticides (Torres-Villa *et al.*, 2002). Many studies have shown that most of the products used by farmers are persistent and accumulate in water, soil and air, but also in food (Harris *et al.*, 2001; Baglieri *et al.*, 2011). These pesticides cause neurological disorders to population resulting in neurodegenerative diseases such as Parkinson's disease and Alzheimer (Baldi *et al.*, 2003) and are endocrine disruptors (Oliva *et al.*, 2001). They are at the same time an ecological, environmental and sanitary threat. In Côte d'Ivoire, some areas have been the subject of several studies and helped to establish the state of contamination on populations and food (Mambo, 2001; Traoré *et al.*, 2002). Indeed, the analysis of groundwater samples in the areas of Buyo, Grand-Lahou, Yamoussoukro and Anyama showed the presence of pesticides in about 90% of the well water in areas where vegetable crops are practiced with total pesticides content up to 25.63 g/L (Traoré *et al.*, 2006). These average concentrations of key residues are beyond the standards or reference values recommended for drinking water, which are 0.1 mg/L for a separate active material and 0.5 mg/L for total active ingredients (WHO, 1994). In addition, studies by Traoré *et al.* (2003, 2008) showed the presence of organochlorine pesticides

respectively in fish in the southwest and in the cow milk of three agricultural zones of Côte d'Ivoire.

In Bongouanou, vegetable crops are grown near Ehuikro and Kabi dam whose water flows into the dam of Ehuikro. Furthermore, these farmers in majority use insecticides for cotton. In addition, each year the production of water by SODECI (Société de Distribution d'Eau en Côte d'Ivoire) Bongouanou is interrupted due to pollution. The population may be exposed to environmental and health problems. Thus, control of pests with the pesticides present numerous drawbacks. It is therefore paramount to find other alternatives to overcome these constraints. Numerous studies have demonstrated the efficacy of plant extracts on phytophagous pests. The toxicity of *J. curcas* seeds extract is attributed to several components, including saponins, lectins (curcin) (Li *et al.*, 2010), phytates, protease inhibitors, curcalonic acid and phorbol esters (Makkar *et al.*, 1997; 1998). The neem extracts contain active molecules such as azadirachtin, the Nimbin, the salanine and sterol (Schumutterer, 1990, Faye, 2010) and other substances, particularly saanine and méliantriol which have an effect on the biology of insects (Philogène, 1991). The extracts of *Melia*

azadirach L., *Azadirachta indica* A. Juss. affect the fertility and mortality of *B. tabaci* (Nardo *et al.*, 1997), soybean oil and cotton grains have also shown toxicity on *B. tabaci* (Butler *et al.*, 1988). Aqueous and ethanol extracts of *capsicum frutescens* have had negative effects on hatching, fertility and adult survival of *B. tabaci* (Bouchelta *et al.*, 2003). The ginger oil is a good repellent against silverleaf whitefly (Homoptera: Aleyrodidae) and its effectiveness increases with the concentrations (Zhang *et al.*, 2004). Leaves and roots extracts inhibit the growth of *Helicoverpa zea* (Boddie) (Aiyelaagbe and Gloer, 2008) and those obtained from the leaves of *J. gossypifolia* are toxic to *Spodoptera litura* second stages (F.) (Phowichit *et al.*, 2008). In searching for other products which are biodegradable and harmless to the environment, compatible with integrated pest management strategy, this study was conducted in the region of Moronou to compare the efficacy of aqueous neem seeds and leaves extracts, and of *jatropha* seeds to insecticides Décis® and Cypercal® commonly used in tomato crops to assess their effectiveness and applicability in large scale.

MATERIALS AND METHODS

Study area : Plots were established three localities (CBC Kangandissou, Ahorosso and Bongouanou) located in east-central Côte d'Ivoire in the region of Moronou between longitude 3° 40' and 4° 43' East and latitudes 6° 7' and 6° 55'.

Insects : *Bemisia tabaci* adults and *Helicoverpa armigera* larvae were counted on tomato plants (*Lycopersicon esculentum* Mill).

Plant Material and extraction

Plant Material: *Jatropha curcas* L. seeds were collected from Boundiali in the north of Côte d'Ivoire. Leaves and seeds of neem were collected from Bongouanou in the east central of Côte d'Ivoire. The neem (*Azadirachta indica* A. Juss) leaves were collected during daytime, were cleaned, washed with water and were grounded in a mortar to obtain a pasty content. *Jatropha* and neem seeds were dried under shade.

Extraction: For a better extraction of the active material 500 or 800 grams of neem seeds or *jatropha*

were cleaned, de-shelled and subsequently the kernels and hulls were separated manually.

The kernels were grounded to fine powders. The fine powders were placed in a bucket with 10 liters of water. The content was vigorously stirred every 2 hours. After 24 hours of soaking, the solution was filtered through a piece of fabric to retain the tissue and debris on the filter and the filtrate into a clean bucket. Then, the filtrate was poured into a spray can for the weekly treatment the plots. In severe attacks, additional applications are made (Anonymous, 2003). For extraction of active substance of neem leaves, the pasty content is weighed and introduced into a plastic bucket containing water at a dose of 1 kg in 15 liters of water. The mixture was vigorously stirred every two hours and for three days. After steeping, the solution was filtered through a clean cloth and the filtrate was used to spray the plots each week (N'Diaye and Seck, 1997; Padonou, 2008).

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

Pesticides: Pesticides used in this study were Cypercal® (50 EC, AF- CHEM SOFACO, Côte d'Ivoire) and Decis® (12 EC, AF- CHEM SOFACO, Côte d'Ivoire). The active ingredient of Cypercal 50 EC® and Decis 12 EC® respectively 50 g/L cypermethrin (C₂₂H₁₉C₁₂NO₃) and 12 g/L deltamethrin (C₂₂H₁₉Br₂NO₃). They belong to the family of synthetic pyrethroids and EC formulation. The recommended dose was 40 mL in 15 L of water to 400 m² for the Cypercal®. For Decis®, 50 mL of the product were added to 15 L of water to spray 500 m². These pesticides were foliar insecticides acting by contact and ingestion.

Treatments, experimental design and agronomic practices: Four varieties of tomato, tomato UC 82 of Italian origin, tomato UC 82 B of Dutch origin, tomato Roma VF of French origin and local tomato were used as the host plant of field tests. Tomato plants were transplanted in CBC Kangandissou plot in January 2013. This period is a dry season. However, Ahorosso and Bongouanou tomatoes plant were respectively transplanted on 9th June 2012 and on 24th June 2012, during rainy season (June, 2012). The experimental design was a fisher block with three replications in Ahorosso, Bongouanou and CBC Kangandissou. Each unit plot measuring 5 m on 1 m. Each elementary plot has 3 lines of plants spaced to 0.40 m. The lines are arranged in the direction of the length of parcels. In Ahorosso and CBC Kangandissou, the number of

treatments was reduced to 5 for the correct application of products by farmers. The tomato plants were planted in pairs in rows spaced 0.4 m and 0.8 m distance separating the grooves. Three trenches were one repetition. Nurseries were conducted on beds which were first disinfected by covering them with FURADAN 5G at a rate of 10 g/m² and fertilized with NPK at the rate of 10 g/m² five days before planting. A shade of a meter in height was constructed over the beds until the seed germination. Watering and treatment with fungicide Maneb® and weeding of nurseries were made. Transplanting was done on the beds, with a spacing of 40 cm between plants. This gives a density of 36 feet per repetition. After transplanting, dead plants were replaced and maintenance such as weeding, and irrigation were performed regularly. In Ahorosso and CBC Kangandissou, treatments applied to tomatoes to control *B. tabaci* and *H. armigera* were aqueous extracts of neem seeds (80 g/L) and jatropha (80 g/L), aqueous extracts of neem leaves 67g/L and insecticide Decis®. In Bongouanou, in addition to these treatments, the aqueous extracts of neem seeds (50 g/L) and jatropha seed (50 g/L), and pesticide Cypercal® were applied (Table 1). Insecticide sprayer was used for foliar applications in the field. The treatable area by biopesticide was 200 m². Only the control plots were not treated.

Table 1: Treatment of area of study

Treatment of area of study		
Ahorosso	Bongouanou	CBC Kangandissou
Aqueous neem seed extract 80g / L (T1)	Aqueous neem seed extract 80g / L (T1)	Aqueous neem seed extract 80g / L (T1)
-	Aqueous neem seed extract 50g / L (T5)	-
Aqueous extract of neem leaves 67g / L (T3)	Aqueous extract of neem leaves 67g / L (T3)	Aqueous extract of neem leaves 67g / L (T3)
Aqueous jatropha seed extract 80g / L (T2)	Aqueous jatropha seed extract 80g / L (T2)	Aqueous jatropha seed extract 80g / L (T2)
-	Aqueous jatropha seed extract 50g / L (T6)	-
Insecticide Décis 12EC® (T4)	Insecticide Décis 12EC® (T4)	Insecticide Décis 12EC® (T4)
-	Insecticide Cypercal 50 EC® (T7)	-

Field efficacy trials: Field efficacy trials were conducted to evaluate the biopesticides and insecticides. Untreated plants were used as controls. Adult *B. tabaci* and *H. armigera* larvae abundance was monitored weekly by selecting 30 plants per plot at random in Ahorosso (rural environment) and 12 plants

taken at random per plot in Bongouanou and CBC Kangandissou (experimental plots). Sampling took place between 6: 00 and 8: 00 weekly, three days after each treatment. In each case, the lower and upper faces of the leaves of the plants and the fruits of tomato were examined to be certain of the presence or absence of

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

insect pests. The number of each species was identified. The evaluation of production focuses on the total weight of mature fruit harvested per treatment, once a week until the end of the experiment. Thus, the yield (R) is estimated at the end of harvest by the formula: $R \text{ (kg / ha)} = P \text{ (kg)} \times 10\,000 / S \text{ (m}^2\text{)}$ where P is the total weight of ripe fruit harvested from a surface S.

RESULTS

Effect of treatments on *B. tabaci* adult abundance: The vegetative phase of Ahorosso and Bongouanou's tomatoes took place during the rainy season. Whole cycle of CBC Kangandissou tomatoes was made during the dry season. *B. tabaci* population of Ahorosso and Bongouanou are low compared to those of the CBC Kangandissou (Table 2). In Ahorosso, Bongouanou and CBC Kangandissou, the biopesticides made of neem and jatropha have similar efficiencies to pesticides commonly used by farmer to control *B. tabaci*. In Ahorosso (P=0.03) and CBC Kangandissou (P=0.00), the aqueous extracts of neem seeds 80g/L

Data analysis: For results, statistical treatments were performed. To do this, the data were entered in Excel. The data obtained were subjected to analysis of variance (ANOVA main effect) on the threshold of 5% and average discriminated with the Student-Newman-Keuls (SNK) using the STATISTICA software version 7.1 (2005).

and neem leaves 67g/L and aqueous extracts of Jatropha 80g /L and the pesticide Décis 12 EC® significantly reduced the number of *B. tabaci* on tomato plants compared to the control (untreated) (Table 2). In Bongouanou, the aqueous extracts of neem and jatropha seeds 80 g/L and 50 g/L, and neem leaves 67g/L applied to Bongouanou's plots of tomatoes have similar efficiencies to pesticides Décis® and Cypercal®. These products have significantly reduced the number of *B. tabaci* per plant compared to the control (P = 0.01) (Table 2).

Table 2: Average (± SD) of *Bemisia tabaci* adults per plant on tomatoes treated of aqueous extracts of neem, jatropha and insecticide Décis® and Cypercal® in three localities

Treatment	Concentration (g/L)	average of <i>Bemisia tabaci</i> adults per plant		
		Ahorosso	Bongouanou	CBC Kangandissou
		Rainy season		Dry season
Control (T0)	-	0.44b ± 0.02	0.26b ± 0.10	5.45b ± 2.31
Neem seeds (T1)	80	0.23a ± 0.01	0.11a ± 0.08	3.06a ± 2.03
Jatropha seeds (T2)	80	0.21a ± 0.02	0.13a ± 0.11	2.26a ± 1.23
Neem leaves (T3)	67	0.24a ± 0.02	0.14a ± 0.08	2.95a ± 0.93
Décis® (T4)	12	0.27a ± 0.07	0.16a ± 0.16	2.89a ± 1.09
Neem seeds (T5)	50	-	0.19a ± 0.12	-
Jatropha seeds (T6)	50	-	0.13a ± 0.10	-
Cypercal® (T7)	50	-	0.16a ± 0.15	-
P		0.03	0.01	0.00

Means followed by the same letter in a same column are not significantly different at P <0.05 level (Newman-Keuls test).

Effect of treatments on the abundance of *H. armigera* larvae and the number of tomato fruits attacked : In Ahorosso, aqueous extract made of neem seed 80 g/L was most effective against the larvae of *H. armigera*. Aqueous extracts of neem leaves 67g / L and jatropha seeds 80 g/L showed the same toxicity as insecticides Décis®. The aqueous extracts grain jatropha 80 g/L, neem leaves and Decis® have moderately reduced the number of *H. armigera* larvae

per plant compared to the control (P = 0.00). The number of *H. armigera* larvae per plant at the control plots was low (0.07). However, the number of fruits attacked by larvae per plant of tomato was high (2.95). All products tested have significantly reduced the number of fruits attacked by *H. armigera* larvae compared to T0 control (P = 0.01) (Table 3). In Bongouanou, the number of *H. armigera* larvae per plant was very low (control: 0.02 larvae). The aqueous

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

extracts of neem and jatropha , and insecticides Décis® and Cypercal® tested reduced significantly the number of larvae of *H. armigera* per plant. There is however a significant difference in the effectiveness of the products tested and the witness in number of larvae of *H. armigera* per plant ($P = 0.00$) and in the number of fruits attacked by the larvae of *H. armigera* per plant ($P= 0.03$). The biopesticides have the same effectiveness as the insecticides Décis® and Cypercal® on *H. armigera* larvae and the damage they cause (Table 3). In CBC Kangandissou, the number of

H. armigera larvae per plant was very low (control: 0.04 larvae). There are no significant differences between the products tested compared to the control ($P = 0.11$). However, biopesticides based on aqueous extracts of neem and jatropha seeds have the same effectiveness as the insecticides Décis® in the number of fruits per plant attacked. The effectiveness of different aqueous extracts of neem and jatropha and the Décis® is statistically different from that of the control ($P = 0.03$) (Table 3).

Table 3: Effects of aqueous extracts of neem, jatropha and insecticide Décis® on the number of *Helicoverpa armigera* larvae per plant and fruit damage per plant in Ahorosso, Bongouanou and CBC Kangandissou

Treatment	Ahorosso		Bongouanou		CBC Kangandissou	
	Rainy season		Rainy season		Dry season	
	Larvae per plant	Fruit damage per plant	Larvae per plant	Fruit damage per plant	Larvae per plant	Fruit damage per plant
T0	0.07c ± 0.03	2.95b ± 1.58	0.02b ± 0.02	1.56b ± 1.37	0.04 ± 0.05	2.94b ± 2.49
T1	0.02a ± 0.01	0.62a ± 0.08	0.00a ± 0.00	0.35a ± 0.30	0.01 ± 0.03	0.68a ± 0.47
T2	0.03b ± 0.01	0.77a ± 0.10	0.00a ± 0.00	0.35a ± 0.30	0.03 ± 0.05	0.99a ± 0.86
T3	0.04b ± 0.01	0.65a ± 0.07	0.00a ± 0.00	0.27a ± 0.24	0.03 ± 0.05	0.72a ± 0.38
T4	0.04b ± 0.01	0.78a ± 0.17	0.01a ± 0.00	0.32a ± 0.36	0.01 ± 0.02	0.46a ± 0.39
T5	-	-	0.00a ± 0.00	0.54a ± 0.59	-	-
T6	-	-	0.01a ± 0.00	0.36a ± 0.44	-	-
T7	-	-	0.00a ± 0.00	0.52a ± 0.84	-	-
P	0.00	0.01	0.00	0.03	0.11	0.03

T0: Control; T1: Neem seeds 80 g/L; T2: Jatropha seeds 80 g/L; T3: Neem leaves 67 g/L; T4: Décis®; T5: Neem seeds 50 g/L; T6: Jatropha seeds 50 g/L; T7: Cypercal®, Means followed by the same letter in a same column are not significantly different at $P < 0.05$ level (Newman-Keuls test).

Effect of treatments on the number of fruits per plant and fruits weight per plant : In Ahorosso, the number of fruits per plant, fruit weight per plant and yield of plots treated with aqueous extracts of neem seeds 80g/L, of neem leaves 67g/L and jatropha seeds 80g/L were statistically identical to those treated with the pesticide Décis®. However, there were significant differences between the treated plots and the control in the number of fruits per plant ($P = 0.01$), in weight of

fruits per plant ($P = 0.00$) and in yield ($P = 0.00$). The weakest yield were on the control, it value was 5330.88 kg/ha. Plots treated with aqueous extracts of jatropha seeds 80 g/L showed the number of fruits per plant (10.57), fruit weight per plant (399.95 g) and yield (9989.81 kg/ha) were higher compared to those obtained with aqueous extract of neem 80 g/L, leaves aqueous extract 67g/L and the pesticide Décis® (Table 4).

Table 4: Average yield (± SD) of tomatoes treated with aqueous extracts of neem, jatropha and insecticide Décis® and Cypercal® at Ahorosso

Treatment	Concentration (g/L)	Number of fruits per plant	Fruit weight per plant (g)	Yield (kg / ha)
Control (T0)	-	6.41b ± 0.61	213.46b ± 1.22	5330.88b ± 31.46
Neem seeds (T1)	80	9.44a ± 1,19	331.57a ± 26,60	8300.98a ± 645.97
Jatropha seeds (T2)	80	10.57a ± 1,70	399.95a ± 73,35	9989.81a ± 1844.07
Neem leaves (T3)	67	9.21a ± 1,14	321.70a ± 16,40	8044.46a ± 406.78

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

Décis (T4)	12	10.32a ± 1,76	342.08a ± 35,69	8600.95a ± 932.77
p		0.01	0.00	0.00

Means followed by the same letter in a same column are not significantly different at P <0.05 level (Newman-Keuls test).

In Bongouanou, there was no significant difference between the number of fruits per plant, fruit weight per plant and yield in plots treated with biopesticides based neem and jatropha, and pesticides Décis® and Cypercal®. However, these values are lower in the control plots (Table 5). In CBC Kangandissou, the number of fruit per plant was statistically identical in all treated plots with control plots (P = 0.23). However, this number was higher in plots treated with aqueous extracts of neem leaves 67g/L and aqueous extracts of *Jatropha* 80 g/L. These values are respectively 17.36 and 15.04 fruits per plant. There had significant

differences between treatment and control in fruit weight per plant (P = 0.00) and at yield (P = 0.01). In this locality, the weight of tomato fruits per plant and yield were respectively statistically identical in plots treated with different products. However, the number of fruit per plant and yield were higher in plots treated with aqueous extracts of neem leaves 67g/L (17.36fruits; 20944 kg / ha) and in those treated with *jatropha* extracts aqueous 80g/L (15.04 fruits; 18218.60 kg/ha). These values are lower in control plots (8.11 fruits; 6552.26 kg / ha) (Table 6).

Table 5: Average yield (±SD) of tomatoes treated with aqueous extracts of neem, *jatropha* and insecticide Décis® and Cypercal® in Bongouanou

Treatment	Concentration (g/L)	Number of fruits per plant	Fruit weight per plant (g)	Yield (kg / ha)
Control (T0)	-	5.26 ± 2.52	135.28 ± 125.06	3344.38 ± 3149.05
Neem seeds (T1)	80	7.47 ± 3.97	209.80 ± 138.23	5240.12 ± 3459.36
<i>Jatropha</i> seeds (T2)	80	8.56 ± 5.28	206.18 ± 95.78	5157.51 ± 2343.39
Neem leaves (T3)	67	6.37 ± 2.96	172.24 ± 81.62	4293.00 ± 2047.80
Décis (T4)	12	6.73 ± 3.34	170.13 ± 117.40	4266.10 ± 2923.44
Neem seeds (T5)	50	9.46 ± 6.98	215.52 ± 185.24	5384.47 ± 4633.86
<i>Jatropha</i> seeds (T6)	50	6.84 ± 5.75	168.40 ± 120.69	4206.21 ± 3019.70
Cypercal	50	5.05 ± 2.45	166.05 ± 108.30	4147.33 ± 2710.19
p		0.30	0.07	0.07

Table 6: Average yield (±SD) of tomatoes treated with aqueous extracts of neem, *jatropha* and insecticide Décis® and Cypercal® in CBC Kangandissou

Treatment	Concentration (g/L)	Number of fruits per plant	Fruit weight per plant (g)	Yield (kg / ha)
Control (T0)	-	8.11 ± 8.21	121.53b ± 107.28	6552.26b ± 3267.93
Neem seeds (T1)	80	11.89 ± 7,91	235.40a ± 114.80	14312.74a ± 5177.00
<i>Jatropha</i> seeds(T2)	80	15.04 ± 16.48	269.31a ± 138.39	18218.60a ± 11674.26
Neem leaves (T3)	67	17.36 ± 18.99	300.61a ± 40.29	20944a ± 10656.84
Décis (T4)	12	11.88 ± 8.31	263.33a ± 127.29	15835.70a ± 4468.47
p		0.23	0.00	0.01

Means followed by the same letter in a same column are not significantly different at P <0.05 level (Newman-Keuls test).

DISCUSSION

The study showed that the number of *B. tabaci* is low on tomato plant took place during the rainy season in Ahorosso and Bongouanou plots. The similar results were reported by Nunes et al.(2006) and N'Zi et al. (2010). According to these authors, adults of *B. tabaci* abandon weeds and neighboring host plants to colonize tomato plants during the dry season. Hilje (1995) and

N'Zi et al. (2010) showed that the period of rain disrupted the development of *B. tabaci* in causing the death of thousands of larvae and adults.

The foliage applications of *Jatropha* and neem aqueous extract have demonstrated a remarkable effect on *B. tabaci* and *H. armigera*. In fact, it reduces the number of *B. tabaci* adults and *H. armigera* larvae in tomato

plants and their damage. Consequently, yield increase. Similar results were reported by Nasiruddin *et al.* (1993) who demonstrated, that spraying of azadirachtin at low dose of 2 ppm onto barley seedlings infested *S. gregaria* nymphs protected the plant. Nardo *et al.* (1997), Rangarajan *et al.*, 2000 and Bouchelta *et al.*, 2005 reported that the substance in aqueous extracts of leaves and neem seeds inhibit the development of larvae, egg fertility and exerts repellent or toxic effect on *B. tabaci*. According to Viñuela *et al.* (2003), azadirachtin has effects similar to that of diflubenzuron (DIMILIN 25 WP, AgrEvo, Valencia, Spain) with similar actions in juvenile hormone blocking insect metamorphosis. It inhibits the growth that affects spawning (Ahmed *et al.*, 2001; Bruce *et al.*, 2004) and molting and larval development (Da Silva and Martinez, 2004; Islam *et al.*, 2007). Alice and Sujeetha (2008) showed that on rice, extracts of neem seeds and neem leaves inhibit the growth and development of *Sogatella furcifera* (Horvath) (Homoptera: Delphacidae). Senthil-Nathan *et al.* (2007) also reported that these extracts reduce the weight of nymphs of *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae) from 45 to 60%. Even low concentrations can effectively inhibit the growth and survival of *N. lugens*. Indeed, azadirachtin inhibit insect growth by preventing the synthesis of ecdysteroids, by inhibiting hormone blocking protothoracicotropic moulting and thus interrupts the reproductive cycle (Isman, 1997). Azadirachtin inhibit the ecdysone cascade modulate pathway, which result in the disorder of tissue remodeling in molting (Zhao *et al.*, 2014). According to Banerjee and Rembold (1992), azadirachtin cause accumulation of serotonin in the neuroendocrine organs, it seems definite that its interference with this neurotransmitter could be the

primary cause of inhibition of release of hormones responsible for growth and metamorphosis. In general, it affects the behavior of insects (Koul, 2004). Moreover, when the extract of neem is applied to plants, the active particles penetrate the different parts of the plant via the xylem, the phloem, and the proportion reaching the ground penetrates through the roots (Javed *et al.*, 2007). Furthermore, Javed *et al.* (2007) show that activity of 3% neem seed and leaves persist in the soil for 16 weeks. Cobbinah and Tuani (1992) demonstrated the negative effect of jatropha seed oil on survival and feeding rate of *Zonocerus variegatus* L. They also reported reduced damage by *Z. variegatus* to cassava foliage after treatment of jatropha seed extracts. It protects the plant against plant pests including insects and herbivores (Marshall *et al.*, 1985). Solsoloy and Solsoloy (2000) and Adebowale and Adedire (2006) showed that the jatropha products reduced significantly nesting insects at high concentrations and cause total mortality of eggs and larvae regardless concentration. According to these authors, the insecticides effects could be caused by sterols and terpene alcohols contained in jatropha product. Significant reduction in the number of *B. tabaci* and *H. armigera* by the application of biopesticides based on jatropha and neem in different localities would be related to the inhibition of oviposition exerted on insects. Bouchelta *et al.* (2005) showed that the extracts of saponins in *Capsicum frutescens* L. (Solanaceae) significantly reduce hatching eggs of *B. tabaci* compared to the control (1% ethanol). According to these authors, extracts of saponins affect more whitefly adult and the witness, the proportion of adult deaths is increasing with concentration.

CONCLUSION

The study show that the aqueous extracts of neem and jatropha are as effective as pesticides Décis® and Cypercal® on *B. tabaci* and *H. armigera* on farm. These

aqueous extracts of jatropha and neem can be integrated into a management program of *B. tabaci* and *H. armigera* in tomato crops.

ACKNOWLEDGEMENTS

This work was supported by ANADER (Agence National d'Appui pour le Développement Rural) Bongouanou/ Côte d'Ivoire.

REFERENCES

- Adebowale KO. and Adedire CO, 2006. Chemical composition and insecticidal properties of the underutilized *Jatropha curcas* seed oil. *Afri. J. Biotechnol.*, 5(10): 901-906.
- Ahmed KS, Yasui Y, Ichikawa T, 2001. Effects of neem oil on mating and oviposition behavior of Azuki bean weevil (*Challosobruchus chinensis* L). *Pakistan J. Bio. Sci.*, 4(11): 1371-1373.

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

- Aina S A, Banjo AD, Lawal OA, Jonathan K, 2009. Efficacy of some plant extracts on *Anopheles gambiae* larvae. *Acad. J. Entomol.*, 2(91): 31-35.
- Aiyelaagbe O O. and Gloer JB, 2008. Japodic acid, a novel aliphatic acid from *Jatropha podagrica* Hook. *Rec. Nat. Prod.*, 2: 100-106.
- Akbar SMD, Jayalakshmi SK, Sharma HC, Sreeramulu K, 2011. Characterization of dihydrolipoamide dehydrogenase from the mitochondria of *Helicoverpa armigera*, a pest resistant to insecticides. *Entomol. Res.*, 41: 221-228.
- Alice J. and Sujeetha RP, 2008. The biological and behavioral impact of some indigenous plant products on rice white backed plant hopper (WBPH) *Sogatella furcifera* (Horvath) (Homoptera: Delphacidae) in Plant products on WBPH biology and behavior. *Inde*, 1(2):193-196.
- Anonymous, 2003. Les savoirs traditionnels au profit de la lutte contre les maladies et ennemis des cultures. Ecole instrument de paix, Niger : 11 pp.
- Baglieri A, Gennari M, Arena M, Abbate C, 2011. The adsorption and degradation of chlorpyrifos-methyl, pendimethalin and metalaxyl in solid urban waste compost. *J. Environ. Sci. Health, Part B*. 46: 454-460.
- Baldi I, Lebaillly P, Mohammed-Brahim B, Letenneur L, Dartigues JF, Brochard P, 2003. Neurodegenerative diseases and exposure to pesticides in the elderly. *Am. J. Epidem.*, 157(5): 409-414.
- Banerjee S, Rembold H, 1992. Azadirachtin a interferes with control of serotonin pools in the Neuroendocrine System of Locusts [J]. *Naturwissenschaften*, 79: 81-84.
- Ben-Yakir DB, Antignus Y, Offir Y, Shahak Y, 2012. Colored shading nets impede insect invasion and decrease the incidences of insect-transmitted viral diseases in vegetable crops. *Entomol. Exp. Applic.*, 144: 249-257.
- Bouchard D, Ouedraogo A, Boivin G, 1992. Vertical distribution, spatial dispersion and sequential sampling plan for fruit damage by *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on tomato crop in Burkina Faso, *Trop. Pest Manag.*, 38(3): 250-253.
- Bouchelta A, Blenzar A, Beavougui AJP, Lakhli T, 2003. Étude de l'activité insecticide des extraits de *Capsicum frutescens* (Solanacées) sur *Bemisia tabaci* (Gennadius) (Homoptera : Aleyrodidae). *Rev. Méd. Pharm. Afr.*, 17: 19-28.
- Bouchelta A, Boughdad A, Blenzar A, 2005. Effets biocides des alcaloïdes, des saponines et des flavonoïdes extraits de *Capsicum frutescens* L. (Solanaceae) sur *Bemisia tabaci* (Gennadius) (Homoptera : Aleyrodidae). *Biotechnol. Agron. Soc. Environ.* 21-30.
- Bruce YA, Gounou S, Chabi-Olaye A, Smith H, Schulthess F, 2004. The effect neem (*Azadirachta indica* A. Juss) oil on oviposition development and reproductive potentials of *Sesamia calamistis* Hampson (Lepidoptera Noctuidae) and *Eldana saccharina* Walker (Lepidoptera Pyralidae). *Agric. Forest Entomol.*, 6:1-10.
- Butler GDJr, Coudriet DL, Henneberry TJ, 1988. Toxicity and repellency of soybean and cotton seed oil to the sweetpotato whitefly and the cotton aphid on cotton in greenhouse studies. *Southwest. Entomol.*, 13: 81-86.
- Cobbinah JR. and Tuani GK, 1992. Antifeedant effect of *Jatropha curcas* L. seed oil and extracts on the variegated grasshopper, *Zonocerus variegatus* L. (Orthoptera: Acrididae). *Journal of University of Science and Technology, Kumasi, Ghana*.
- Cui J, Li M-L, Yuan M-S, 2013. Semisynthesis of N-acyl homoserinelactone derivatives and the antifeedant activity against *Mythimna separate*. *J. Environ. Sci. Health, Part B* 48: 671-676.
- Da Silva FAC, Martinez SS, 2004. Effect of Neem Seed Oil Aqueous Solutions on Survival and Development of the Predator *Cycloneda sanguinea* (L.) (Coleoptera: Coccinellidae). *Neotrop. Entomol.*, 33(6):751-757.
- Faye M, 2010. Nouveau procédé de fractionnement de la graine de neem (*Azadirachta indica* A.JUSSI) Sénégalais : production d'un bio-pesticide d'huile et de tourteau. Thèse de doctorat de l'Université de Toulouse, France, 228 pp.
- Harris CA, Renfrew MJ, Woolridge MW, 2001. Assessing the risks of pesticide residues to consumers: recent and future developments. *Food Additives and Contaminants* 18(2):1124-1129.

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha curcas* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

- Hilje L, 1995. Aspectos bioecológicos de *Bemisia tabaci* en Mesoamérica. Manejo Integrado de Plagas (Costa Rica), 35 :46-54.
- Islam MD, Latif MA, Begum R, Razzaque MA, Akhtar Akhy A, 2007. Effect of neem oil on food consumption, growth and development of Jute hairy caterpillar, *Spilarctia obliqua* (Walker). *Int. J. Sustainable Agric. Technol.*, 3(4):1-5
- Isman MB, 1997. Neem and other botanical insecticides: barriers to commercialization. *Phytoparasitica* , 25(4): 339-44.
- Javed N, Gowen SR, Inam-ul-Haq, Abdullah K, Shahina F, 2007. Systemic and persistent effect of neem (*Azadirachta indica*) formulations against root-knot nematodes, *Meloidogyne javanica* and their storage life. *Crop prot.*, 26: 911-916.
- Jones DR, 2003. Plant viruses transmitted by whiteflies. *Eur. J. Plant. Pathol.* 109:195–219.
- Koul O, 2004. Neem: a global perspective: 1-19. In O. Koul and S. Wahab [eds.], *Neem: today and in the new millennium*. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Li C.-Y, Devappa RKJ-X., Lui J-MLv, Makkar HPS, Becker K, 2010. Toxicity of *Jatropha curcas* phorbol esters in mice. *Food Chem. Toxicol.*, 48: 620–5.
- Liu TX, 2007. Life history of *Eretmocerus melanoscutus* (Hymenoptera: Aphelinidae) parasitizing nymphs of *Bemisia tabaci* Biotype B (Homoptera: Aleyrodidae). *Biol. Control*, 42: 77-85.
- Makkar HPS, Aderibigde AO, Becker K, 1998. Comparative evaluation of non-toxic and toxic varieties of *Jatropha curcas* for chemical composition, digestibility, protein degradability and toxic factors. *Food Chem.*, 62(2): 207-215.
- Makkar HPS, Becker K, Sporer F, Wink M, 1997. Studies on nutritive potential and toxic constituents of different provenances of *Jatropha curcas*. *J. Agri. Food Chem.*, 45:3152-3157.
- Mambo V, Tidou A S, Ossey BY, Houenou P, 2001. Evaluation de l'état trophique du lac de Buyo (Côte d'Ivoire) : aspects physico-chimiques et biologiques, *J.Soc.Ouest-Afr. Chim.*, 11, pp 95-134.
- Marshall GT, Klocke JA, Lin L-J, Kinghorn AD, 1985. Effects of diterpene esters of tigliane, daphnane, and lathyrane types on pink bollworm, *Pectinophora gossypiella* saunders (Lepidoptera: gelechiidae). *J. Chem. Ecol.*, 11(2): 191-206.
- Nardo EAD, De Costa AS, Lorencao AL, 1997. *Melia azadirach* extract as an antifeedent to *Bemisia tabaci* (Homoptera: Aleyrodidae). *Florida Entomol.*, 80 (1): 92–94.
- Nasiruddin M. and Mordue (Luntz) AJ, 1993. The effect of azadirachtin on the midgut histology of the locusts, *Schistocerca gregaria* and *Locusta migratoria*. *Tissue Cell.* , 5:875-884.
- Nunes C, Lucas E, Coderre D, 2006. Parasitisme de *Bemisia tabaci* (Homoptera: Aleyrodidae) en cultures maraichères en tropique sec nicaraguayen. *Int. J. Trop. Insect Sci.*, 26 (1): 57-63.
- N'Diaye M. and Seck M, 1997. Effet de l'extrait aqueux des feuilles de neem (*azadirachta indica* Juss) sur la population de thrips et le rendement du niébe (*vigna unguiculata*), rapport de stage au Sénégal : 28 pp.
- N'zi JC, Kouamé C, N'Guetta ASP, Fondio L, Djidji AH, Sangaré A, 2010. Evolution des populations de *Bemisia tabaci* Genn. Selon les variétés de tomate (*solanum lycopersicum* L.) au Centre de la Côte d'Ivoire. *sciences & nature*, 7(1): 31-40.
- Okumu FO, Knols BGJ, Fillinger U, 2007. Larvicidal effects of a Neem (*Azadirachta indica*) oil formulation on the malaria vector *Anopheles gambiae*. *Malaria Journal*, 6:63-75.
- Oliva A, Spira A, Multigner L, 2001. Contribution of environmental factors to the risk of male infertility. *Human Reproduction* ,16(8):1768-1776.
- Oliveira MRV, Henneberry TJ, Anderson P, 2001. History, current status, and collaborative research projects for *Bemisia tabaci*. *Crop Prot.*, 20:709-723.
- Padonou S C, 2008. Analyse comparée du revenu et de sa distribution entre les producteurs de tomate utilisant les biopesticides et les pesticides chimiques en zone periurbain du Sud Benin. Mémoire de Diplôme d'ingénieur agronome, Université de Parakou : 8 p.
- Philogène BJR, 1991. L'utilisation des produits naturels dans la lutte contre les insectes : problèmes et perspectives. *La lutte antiacridienne*. AUPELF-UREF (ed.). Paris: 269-278 pp.

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

- Phowichit S, Buatippawan S, Bullangpoti V, 2008. Insecticidal activity of *Jatropha gossypifolia* L. (Euphorbiaceae) and *Cleome viscosa* L. (Capparidaceae) on *Spodoptera litura* (Lepidoptera: Noctuidae). Toxicity and carboxylesterase and glutathione-S-transferase activities studies. *Commun. Agric. Appl. Biol. Sci.*, 73: 611-619.
- Rangarajan A, Miller AR, Veilleux RE, 2000. Leptine glycoalkaloids reduce feeding by colorado potato beetle in diploid *Solanum* sp. Hybrids. *J.Am.Sc. Hortic. Sc.*, 125:689-93.
- Schmutterer H, 1990. Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. *Ann. Rev. Entomol.*, 35: 271-291.
- Senthil-Nathan S, Choi MY, Paik MY, Hong CH, Kim YSD, Kang SM, 2007. The toxic effects of neem extract and azadirachtin on BPH, *Nilaparvata lugens*(Stål) (Homoptera :Delphacidae). *Chemosphere*, 63(1):80-88.
- Simmons AM, Abd-Rabou S, Mccutcheon S, 2002. Incidence of Parasitoids and Parasitism of *Bemisia tabaci* (Homoptera: Aleyrodidae) in Numerous Crops. *Environ. Entomol.*, 31(6): 1030-1036.
- Simmons AM. and Jackson DM, 2000. Evaluation of foliar applied insecticides on abundance of parasitoids of *Bemisia argentifolii* (Homoptera: Aleyrodidae) in vegetables. *J. Entomol. Sci.*, 35: 1-8.
- Solsoloy AD. And Solsoloy, T.S., 2000. Insecticide resistance management in cotton in the Philippines. *Philippine J. Crop Sci.*, 25: p. 26.
- Stansly PA, Sánchez PA, Rodríguez JM, Canizares F, Nieto A, López Leyvad MJ. et al., 2004. Prospects for biological control of *Bemisia tabaci* (Homoptera, Aleyrodidae) in greenhouse tomatoes of southern Spain. *Crop Prot.*, 23: 701-712.
- Talekar NS, Opena RT, Hanson P, 2006. *Helicoverpa armigera* management: a review of AVRDC's research on host plant resistance in tomato. *Crop Prot.*, 25: 461-467.
- Torres-Vila LM, Rodriguez-Molina MC, Lacasa-Plasencia A, Bielza-Lino P, Rodriguez-del-Rincon A, 2002. Pyrethroid resistance of *Helicoverpa armigera* in Spain: current status and agroecological perspective. *Agric. Ecosyst. Environ.*, 93: 55-66.
- Traore K S, Mamadou K, Dembele A, Lafrance P, Banton O, Houenou P, 2002. Résidus de pesticides organochlorés dans le lait humain d'une zone agricole de Côte d'Ivoire, *J. Soc. Ouest-Afr. Chim.* 13, 99-109.
- Traore K S, Mamadou K, Dembele A, Lafrance P, Houenou P, 2003. Contamination des peuplements de poissons du lac de Buyo, *J. Soc. Ouest-Afr. Chim.*, 16,137-152.
- Traoré SK, Mamadou K, Dembélé A, Lafrance P, Mazellier P, Houenou P, 2006. Contamination de l'eau souterraine par les pesticides en régions agricoles en Côte d'Ivoire (centre, sud et sud- ouest). *J. Afr. Sci. Environ.*, 1: 1-9.
- Traoré S K, Dembele A, Mamadou K, Mambo V, Lafrance P, Bekro Y-A, Houenou P, 2008. Contrôle des pesticides organochlorés dans le lait et produits laitiers : Bioaccumulation et risques d'exposition. *Afr. Sci.*, 4(1): 87-98.
- Viñuela E, Medina P, Smagghe G, Budia F, 2003. Toxicity and absorption of azadirachtin, diflubenzuron, pyriproxyfen and tebufenozide after tropical application in predatory larvae of *Chrysoperla carnea* (Neuroptera: Chrysopidae). *Environ. Entomol.*, 32 (1) :196 - 203.
- Walker GP. and Cameron PJ, 1990. Pheromone trapping and field scouting for tomato fruitworm in tomatoes and sweet corn. *Proc. N.Z. Weed Pest Control Conf.*, 43: 17-20.
- Walter JF, 1999. Commercial experience with neem products. In: Hall FR, Menn JJ, editors. *Method in biotechnology*, 5: Biopesticides. Totowa, NJ: Humana Press. pp 155-70.
- Wang P, Sun DB, Qiu BL, Liu SS, 2011. The presence of six cryptic species of the whitefly *Bemisia tabaci* complex in China as revealed by crossing experiments. *Insect Sci.*, 18:67-77.
- WHO, 1994. Directive de qualité pour l'eau de boisson. Contrôle de l'eau de boisson destinée à l'approvisionnement des petites collectivités. Genève, Vol 3.
- Zalucki MP, Daghish G, Firempong S, Twine P, 1986. The biology and ecology of *Heliothis armigera* (Hübner) and *H.armigera* Wallenren (Lepidoptera: Noctuidae) in Australia: what do we know? *Australian Ecol.*, 34: 779-814.

Diabaté et al. J. Appl. Biosci. 2014. The effect of pesticides & aqueous extracts of *Azadirachta indica* (A.juss) and *Jatropha carcus* L. on *Bemisia tabaci* (Gennadius) and *Helicoverpa armigera* (Hübner) found on tomato plants in Cote d'Ivoire

Zhang W, McAuslan HJ, Schuster DJ, 2004. Repellency of Ginger Oil to *Bemisia argentifolii* (Homoptera: Aleyrodidae) on Tomato. *J. Econ. Entomol.*, 97(4):1310-13

Zhao J-c, Wu T-m, Liu L-h, Wang Y, He L, 2014. EcR-RNAi and azadirachtin treatments induced the abnormal proleg development in *Spodoptera litura*. *J. East China Normal University (Natural Science)*, 1: 133-141.