Agricultural Science Research Journal
ISSN 2026-6073
Mondedji et al , Volume (8) Issue (10): 174 – 181 October – 2018. RESEARCH PAPER

Evaluation of the effects of two botanical extracts on Lipaphis erysimi (Hemiptera: Aphididae) parasitic pressure on cabbage during the same period of two consecutive years in southern Togo

Mondédji A. Déla[1]*, Kasseney B. Dodji[1], Nyamador S. Wolali[1], Adéoti Razack[2], Abbey G. Abbevi[3], Amévoin Komina[1], Ketoh G. Koffivi[1] and Glitho I. Adolé[1]

[1]Laboratory of Applied Entomology (LEA), Faculty of Sciences, University of Lomé ; 01 PO BOX 1515 Lomé 01, Togo

[2]International Institute for Tropical Agriculture (IITA)- Bénin. 08 BP 0932 Tri postal Cotonou

[3]Advanced School of Agronomy (ESA), University of Lomé ; 01 PO BOX 1515 Lomé 01, Togo

* *Corresponding author: Fax :(+228) 22 21 85 95 ; Tel (+228) 90 10 93 17 ; E-mail : monedith14@gmail.com

Corresponding Author's

Mondédji A. Déla

Laboratory of Applied Entomology (LEA), Faculty of Sciences, University of Lomé ; 01 PO BOX 1515 Lomé 01, Togo

Email: monedith14@gmail.com

Abstract

***Lipaphis erysimi* (Kaltenbach, 1843) (Hemiptera: Aphididae) damages crucifers. Its control by botanical extracts is today an alternative to the use of chemical pesticides. The objective of this study is to evaluate the effects of leaf extracts of *Azadirachta indica* A. Juss. (Meliaceae) and *Carica papaya* Linnaeus (Caricaceae) compared to those of the chemical insecticide "Conquest Plus 388 EC" on *L. erysimi*'s parasitic pressure on cabbage during the same period of two consecutive years. The plots of cabbage were installed using randomized balanced complete blocks. The parasitic pressure of *L. erysimi* on cabbage varied with year. *A. indica* extract reduced parasitic pressure more than *C. papaya* extract. Conquest Plus 388 EC was more effective in reducing *L. erysimi* pressure. Although neem extract failed to reduce parasitic pressure by *L. erysimi* as well as the chemical pesticide, the use of neem leaf extract is an eco-friendly management method for this aphid.**

Key words: *Azadirachta indica* ; *Carica papaya* ; Conquest Plus 388 EC ; cabbage ; *Lipaphis erysimi* ; southern Togo.

Introduction

Total annual loss of agricultural production due to aphids is approximately 1.2 X 10^7 tons. This represents about 2% of the losses caused by all insect pests (Alavo, 2000). Damage caused by insects varied from year to year depending on the environment (vegetation, surrounding crops and climatic conditions). Cabbage *Brassica oleracea* L. (Brassicaceae) cultivation is an important income generating activity for small scale farmers providing quick cash income over short periods and contributing to food security in West Africa (James *et al*., 2010). However, production is constrained by a range of insect pests damages (Mondédji, 2010). In Togo, an important insect pest of *Brassica* crops is the aphid preceded by the diamondback moth, *Plutella xylostella* L. (Lepidoptera : Plutellidae) (Agboyi, 2009). The aphid is mustard aphid or turnip aphid *Lipaphis erysimi* (Kaltenbach, 1843) (Hemiptera: Aphididae) (Mondédji *et al*, 2016). This aphid has several host plants including crucifers like *B. oleracea*. The pest also poses serious problems in Asian countries and the USA

(Atwal and Dhaliwal, 2007; Biswas, 2008). Application of synthetic insecticides remains the most common control strategy against *L. erysimi* damage, even though this practice causes health and environmental problems (Toé *et al*., 2002; PAN-Africa, 2004; PAN-UK, 2005). Cabbage yield losses have been reported to exceed 30% despite frequent applications of synthetic insecticides (Agboyi *et al*., 2013) mainly organophosphates and pyrethroids (Mondédji *et al*., 2015; Agboyi *et al*., 2015).

Insecticidal properties of neem (*Azadirachta indica* A. Juss., Meliaceae) have traditionally been used in cultural practices for several thousand years (Philogène *et al*., 2003 ; Philogène *et al*., 2008). Neem compounds have various effects ranging from repellency to toxicity against a wide spectrum of insect pests including Orthoptera, Lepidoptera, Coleoptera, Diptera and Hemiptera (Schmutterer, 1990; Isman, 2006; Siddiqui *et al*., 2009; Degri *et al*., 2013; Mondédji *et al*., 2014; Shannag *et al*., 2014). These biological properties are controlled by different groups of compounds including limonoids and particularly azadirachtin present in neem seeds and considered the most active component responsible for both antifeedant and insecticidal effects (Isman, 2006). Neem-based insecticides have low environmental impact because of a rapid degradation in plants and soil (Isman, 2006) and have small effects on beneficial insects (Tang *et al*., 2002; Haseeb *et al*., 2004; Defago *et al*., 2011). Aqueous seed extracts are traditionally used in Malian cotton fields to fight Hemiptera pests and vectored pathogens (Boursier *et al*., 2011). Despite two fruition periods per year, their irregular availability limits the use of seed-based preparations. Interestingly, numerous active compounds including limonoids have also been found in neem leaves (Siddiqui *et al*., 2000 ; Afshan, 2002) whose extract was shown to exert insecticidal effects (Brunherotto *et al*., 2010; Egwurube *et al*., 2010).

Neem and papaya (*Carica papaya* L. (Caricaceae)) from Southeast Asia and tropical America respectively grow in many countries around the world including Togo (Klu, 2008). The choice of neem was made based on literature accounts but above all, on the habits of local gardeners. The choice of papaya is based on the habits of gardeners. In this scenario, botanical extracts based on neem and papaya preparations could provide an important new compound for *L. erysimi* management.

Because of insect damage variability and the potential of neem and papaya leaf-based preparations to control insect populations, our hypothesis was that these extracts affected *L. erysimi* parasitic pressure on cabbage during the same period of two consecutive years.

The objective of this study was to evaluate the effects of *A. indica* and *C. papaya* leaf extracts compared to those of the chemical pesticide “Conquest Plus 388 EC” on aphid parasitic pressure on cabbage during the same period in two consecutive years. The indicators used to evaluate extract effects were: infestation rate of cabbage plants, the area of cabbage leaf covered (covering) by *L. erysimi* and the yield of cabbage following treatment.

Materials and Methods

Materials and methods used (the study site, experimental plot arrangement, botanical extracts and chemical insecticide preparation and treatment of plots) are identical to those used by Mondédji *et al.* 2015.

Study site and experimental conditions

The study was carried out in Lomé (Southern Togo) with a tropical Guinean climate marked by two rainy seasons (April-July and September-October) separated by two dry seasons (August and November-March). Average monthly temperatures range from 25 to 29 °C during the year and average annual rainfall is around 932 mm. Mean annual relative humidity is about 82% and photoperiod is near 12 : 12 h LD.

Tests were conducted at an experimental station from mid-July to mid-October in 2005, at the agropastoral farm of the University of Lomé campus (6 ° 17'N and 1 ° 21'E). It was repeated from mid-July to mid-October in 2006. Mid-July to mid-October has short dry and short rainy seasons in southern Togo. This site is dominated by a man-made savanna with exotic plant species such as *A. indica*, *C. papaya*, *Hibiscus lunarifolius* Willd. (Malvaceae), *Senna siamea* (Lamarck) Irwin Barneby (Fabaceae), *Leucaena leucocephala* (Lamarck) de Wit (Mimosaceae), *Manguifera indica* Linnaeus (Anacarciaceae) and annual and seasonal crops (cassava, maize, cowpea, vegetables).

Experimental plot arrangement

A parcel of cabbage KK-Cross variety was installed using randomized balanced complete blocks. Three blocks (B1, B2 and B3) were made (Figure 1), each composed of eight elementary plots: one untreated elementary plot served as control (T0); one plot was treated with the chemical insecticide Conquest Plus 388 EC (C.P.); three elementary plots treated with different doses of neem leaf extract (N1, N2 and N3), and three treated with different doses of papaya leaf extract (P1, P2 and P3). In order to avoid contamination of an elementary plot by a product that is not intended for it during treatment, a distance of 1 m separated elementary plots and a distance of 2 m separated blocks. Each elementary plot (1.6 m × 6.8 m) contained four lines of plants with 17 cabbage plants per line. The spacing of the plants was 0.4 m on the lines and 0.4 m between lines (Figure 2).

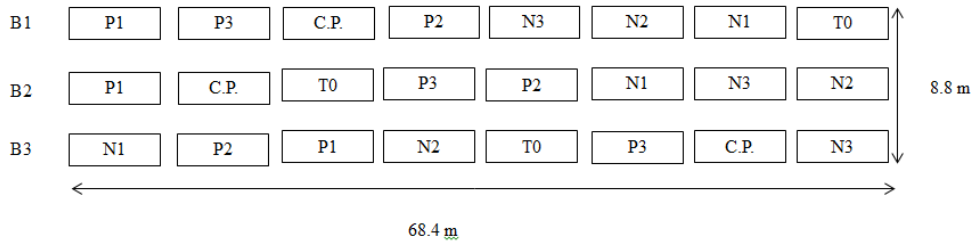

Figure 1: Experimental plot arrangement

B: Block; T0: Untreated plot (Control); C.P.: plot treated with chemical insecticide (Conquest Plus 388 EC); N1: plot treated with low dose of hydroethanolic neem leaf extract; N2: plot treated with medium dose of hydroethanolic neem leaf extract; N3: plot treated with high dose of hydroethanolic neem leaf extract; P1: plot treated with low dose of hydroethanolic papaya leaf extract ; P2: plot treated with medium dose of hydroethanolic papaya leaf extract ; P3: plot treated with high dose of hydroethanolic papaya leaf extract.

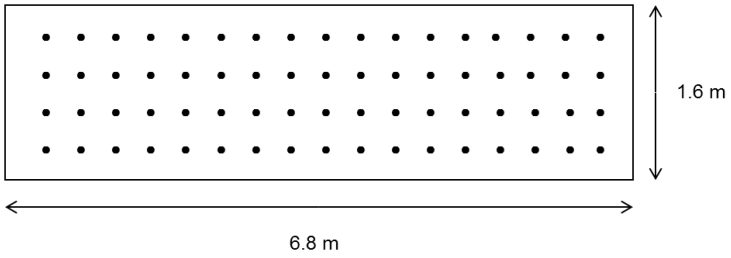

Figure 2: Arrangement of cabbage plants on plots (aligned points)

Preparation of botanical extracts

Fresh leaves of neem or papaya plants were collected on the domain of the University of Lomé. Extracts were obtained by soaking 1 kg of crushed fresh leaves in 1.5 l of 10% hydroethanol solution overnight at 25-30°C. After maceration for 12 hours under ambient conditions, the solution was filtered and the filtrate applied to the plots.

Preparation of chemical insecticide

The chemical insecticide was prepared by diluting 2 ml of Conquest Plus 388 EC in water to obtain 1500 ml of solution. Conquest Plus 388 EC is a ternary insecticide composed of 72 g/l Cypermethrin, 300 g/l Triazophos and 16 g/l Acetamiprid.

Treatment of plots

Treatments were done using an OSATU STAR 16 AGRO model with a maintained pressure backpack sprayer. Treatments of elementary plots were done once a week during six weeks (6 applications in total). The dose of chemical insecticide applied was 0.6 l of Emulsifiable Concentrate per hectare (or 460 l/ha of solution). Three doses of neem leaf extract (N1: 300 l/ha, N2: 600 l/ha and N3: 900 l/ha) and papaya leaf extract (P1: 300 l/ha, P2 : 600 l/ha and P3: 900 l/ha) were applied (Table 1). The control plots were untreated.

Table 1: Doses of extracts and synthetic pesticides applied

Treatment	Phytosanitary products used	Doses (l/ha)
T0	Untreated	0
CP	Conquest Plus	460
N1 or P1	Hydroethanolic neem or papaya (Low dose)	300
N2 or P2	Hydroethanolic neem or papaya (Medium dose)	600
N3 or P3	Hydroethanolic neem or papaya (High dose)	900

Cabbage plant observation for treatment effect evaluation

Observation was made the day after each application of treatment in different cabbage plots (every seven days). But treatment effect evaluation was done at the beginning of cabbage leaf imbrication (after three applications of treatment). The evaluation of a treatment effect was based on 30 plants in the middle of each elementary plot to avoid the bias associated with the edge effect.

Evaluation of treatment effect on infestation rate of cabbage plants by L. erysimi

A cabbage aphid-bearing plant was considered infested and was counted. The number of cabbage plants infested per plot for each treatment is given as a percentage.

Evaluation of treatment effects on the surface of cabbage covered by L. erysimi

The aphid covering was made by randomly selecting the 2nd or 3rd leaf from the apex of the plant. The lower and upper surfaces of the leaves were examined. The total area or surface (St) of the leaf and the surface occupied (So) by aphids were determined. The results were expressed in terms of covering (C).

$$C = \frac{So}{St} \times 100$$

Intervals were defined to determine the degree of attack of *L. erysimi* for each treatment. If:

- C <5%, species is rare
- 5% ≤ C <25%, species is common
- 25% ≤ C <50%, species is fairly abundant
- 50% ≤ C <75%, species is abundant
- C ≥ 75%, species is very abundant.

Evaluation of the effect of treatment on the yield of cabbage head

The yield data were obtained by weighing the harvested cabbage from the useful surfaces (area containing the plants observed in the middle) of the elementary plots. The results obtained were estimated per hectare.

Statistical analysis

Statistical analysis was performed using SPSS version 20.0. The comparisons of means were done using analysis of variance (ANOVA) followed by the Student Newman Keuls (SNK) comparison tests when ANOVA was significant at the 5% level.

Results

Evaluation of treatment effect on the infestation rate of cabbage plants by L. erysimi during the same period of two consecutive years

Infestation rate of cabbage plants by *L. erysimi* varied with year. It was lower in 2005 (4.44 to 37.78%) than in 2006 (6.67 to 100%). Similarly, treatment effect on the infestation rate varied by year, except for the synthetic insecticide (Conquest Plus 388 EC). Conquest Plus 388 EC was more effective in reducing infestation rate (4.44% in 2005 and 6.67% in 2006) than the high dose of neem extract (17.78 in 2005) followed by the other treatments of neem and papaya (31.11 to 37.78% in 2005 and 100% in 2006), similar to the control (32.22% in 2005 and 96.67% in 2006) ($F_{(15,47)}$ = 283,759, p = 0.000) (Figure 3).

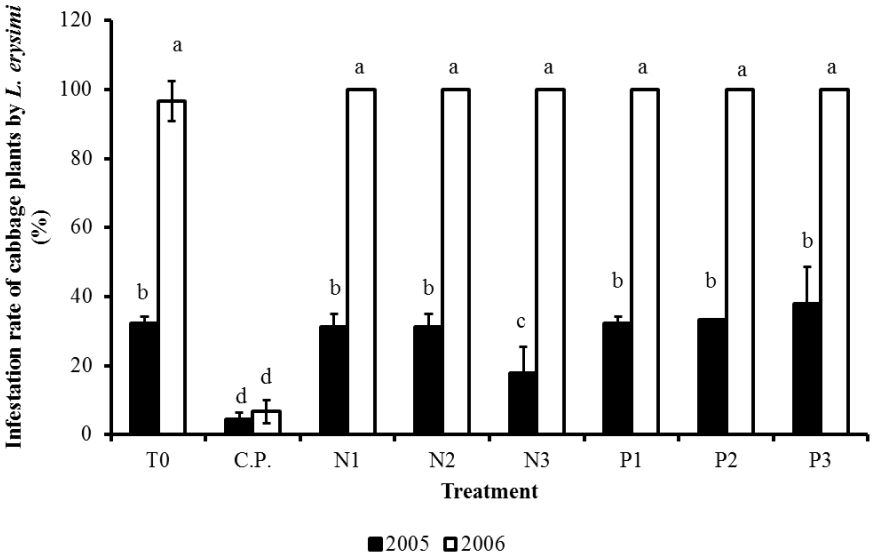

Figure 3: Average infestation rate of cabbage plants (X ± SD) by *L. erysimi* following treatment during the same period of two consecutive years

Letters at the top of the columns indicate statistically significant differences ($F_{(15, 47)}$ =283.759; p = 0.000).

T0: Untreated plot (Control); C.P.: plot treated with chemical insecticide (Conquest Plus 388 EC); N1: plot treated with low dose of hydroethanolic neem leaf extract; N2: plot treated with medium dose of hydroethanolic neem leaf extract; N3: plot treated with high dose of hydroethanolic neem leaf extract; P1: plot treated with low dose of hydroethanolic papaya leaf extract ; P2: plot treated with medium dose of hydroethanolic papaya leaf extract ; P3: plot treated with high dose of hydroethanolic papaya leaf extract.

Evaluation of treatment effect on the covering of L. erysimi population during the same period of two consecutive years

Covering of *L. erysimi* also varied by year. It was lower in 2005 than in 2006. In 2005, *L. erysimi* was identical for all treatments with covering ranging from 10.39% to 23.93% (10.39% ≤ C ≤ 23.93%) except for the chemical insecticide where the species was rare (C = 0.11%). The same pattern was observed in 2006, within plots treated with plant extracts except again for the chemical insecticide where the species was rare (C = 0.15%). But in the second year, the species was abundant for other treatments (56.77% ≤ C ≤ 67.75%). Thus treatment effect on *L. erysimi* covering also varied with year except for Conquest Plus 388 EC. In 2005, the effect of Conquest Plus 388 EC was very significant, followed by the effect of the three doses of neem, and by the three doses of papaya ($F_{(15,47)}$ = 168,239; P = 0.000). There was no significant difference between treatments with the three doses of papaya and the control. In 2006, only the chemical insecticide was very effective followed by medium and high doses of neem. But the papaya extract did not have a significant effect, (Figure 4).

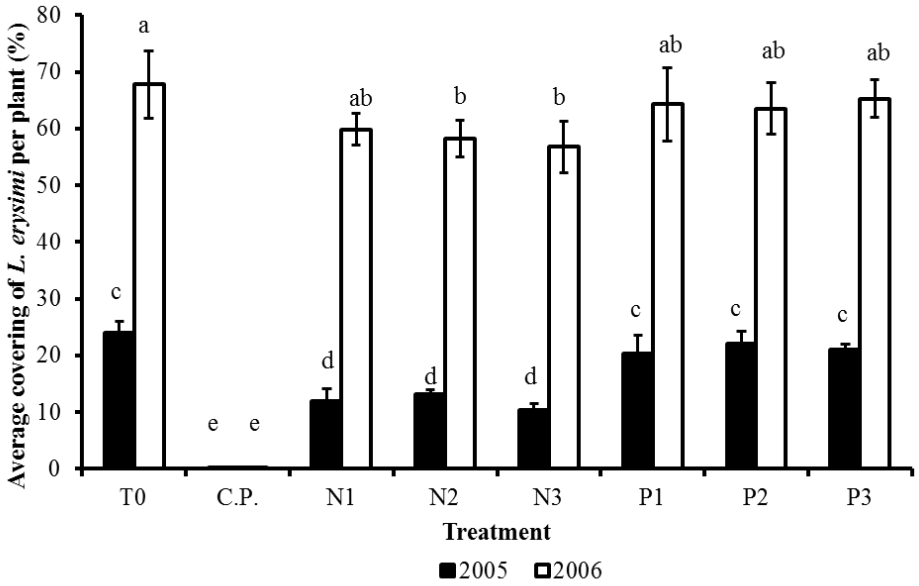

Figure 4: Covering rate (X ± SD) of *L. erysimi* per plant following treatment during the same period of two consecutive years
Letters at the top of the columns indicate statistically significant differences ($F_{(15, 47)}$ = 168.239; p = 0.000).
T0: Untreated plot (Control); C.P.: plot treated with chemical insecticide (Conquest Plus 388 EC); N1: plot treated with low dose of hydroethanolic neem leaf extract; N2: plot treated with medium dose of hydroethanolic neem leaf extract; N3: plot treated with high dose of hydroethanolic neem leaf extract; P1: plot treated with low dose of hydroethanolic papaya leaf extract ; P2: plot treated with medium dose of hydroethanolic papaya leaf extract ; P3: plot treated with high dose of hydroethanolic papaya leaf extract.

Evaluation of the effect of treatment on the yield of cabbage during the same period of two consecutive years

The mean yield of cabbage also varied with year. The effect of treatments on the yield of cabbage was greater in 2005 (13.00 ± 6.99 to 32.14 ± 24.11 t/ha) than in 2006 (0.35 ± 0.13 to 18.65 ± 7.61 t/ha). However, the medium dose of neem (32.14 ± 24.11 t/ha) and the low dose of papaya (31.65 ± 11.62 t/ha) in 2005 resulted in the best yields. There was no significant difference in treatment yields in 2006, but treatments were significantly different especially from those of the control (0.35 ± 0.13 t/ha). The effect of treatments on cabbage yield varied significantly with year ($F_{(15, 47)}$ = 3.855, p = 0.001) (Figure 5).

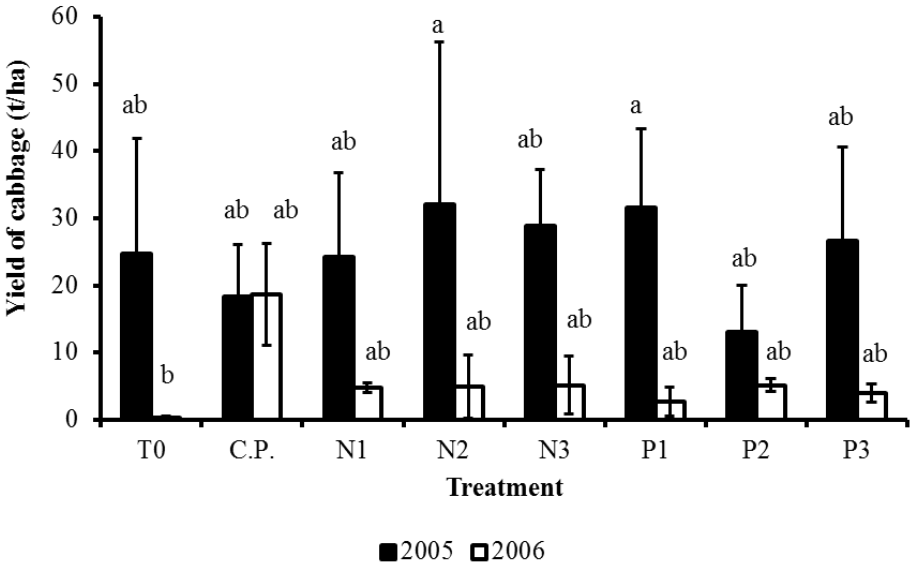

Figure 5: Yield of cabbage (X ± SD) following treatment during the same period of two consecutive years
Letters at the top of the columns indicate statistically significant differences ($F_{(15, 47)}$ =3.855; p = 0.001).
T0: Untreated plot (Control); C.P.: plot treated with chemical insecticide (Conquest Plus 388 EC); N1: plot treated with low dose of hydroethanolic neem leaf extract; N2: plot treated with medium dose of hydroethanolic neem leaf extract; N3: plot treated with high dose of hydroethanolic neem leaf extract; P1: plot treated with low dose of hydroethanolic papaya leaf extract ; P2: plot treated with medium dose of hydroethanolic papaya leaf extract ; P3: plot treated with high dose of hydroethanolic papaya leaf extract.

Discussion

Effects of extracts of neem and papaya leaves were evaluated on the parasitic pressure of the sap sucker *L. erysimi* on cabbage during the same period of two consecutive years (2005 and 2006) in southern Togo. A higher infestation rate of cabbage plants and a higher covering rate (abundance) of aphids were observed in 2006 than in 2005. Biswas (2013) studied the effectiveness of different doses of neem extract and a synthetic organic insecticide on mustard aphid at an experimental field during two consecutive years 2010-2011 and 2011-2012 in Bangladesh. He reported that a higher number of aphids was observed in 2012 than in 2011. Similar results were reported by Biswas (2008) in the same country. At low infestation, the high dose of neem extract is more effective than the other treatments (2005) except the chemical insecticide. On the other hand, botanical extracts had no effect on the rate of infestation when the parasitic pressure is high (2006). Neem extract reduced *L. erysimi* covering rate during the trials. Only the chemical insecticide was very effective followed by neem extract. In Bangladesh, Biswas (2013) reported that different doses (25g/l, 50g/l, 75g/l) of neem leaf extract reduced by 63.16 to 72.55% an aphid population numbering (78-100 aphids/plant) before treatment of mustard. But the chemical insecticide Malataf (Malathion 57EC) @ 2 ml/l caused the highest reduction in aphid population (93.75%).

High parasitic pressure of *L. erysimi* reduced the yield of cabbage heads. Bakhetia (1983) suggested that infestations of turnip aphid eventually would affect mustard seed yield and quality. We observed the same on cabbage. Infestations by turnip aphid affected cabbage yield and quality. When the parasitic pressure of *L. erysimi* was high, cabbage plants were affected and did not produce heads. Turnip aphid can attack various parts/ stages of crucifers by sucking plant juices and transmitting several kinds of viruses (Castle *et al.*, 1992). Yields obtained in 2005 were not significantly different. This was due to variations in yield for the same treatment of different blocks due to non-production of cabbage head by some plants. Yields obtained in 2006 also were not significantly different except for the control. The few cabbage heads obtained in 2006, were small with lower quality than those obtained in 2005. Indeed, in 2005, Conquest Plus 388 EC significantly reduced aphid parasitic pressure in terms of infestation rate (attacked plants) and covering, but did not produce the best yield. In 2006, the highest cabbage head yield (18.65 t/ha) was obtained with the chemical insecticide, less than 6 t/ha for other treatments and less than 1 t/ha for the control. The 2006 results corroborated those of Biswas (2013) who obtained the highest mustard seed yield of (1440 kg/ha) by using the chemical insecticide Malataf @ 2ml/l to treat mustard plots, and untreated plots produced a significantly lower seed yield (1150 kg/ha).

Conclusion

Neem extract in general and a high dose in particular reduced infestation rate and abundance (covering) of the insect. However, treatment effects were influenced by parasitic pressure. It did not appear to have a direct effect on cabbage yield regardless of the treatment applied. The effectiveness of different doses of neem and papaya leaf extracts revealed that the high dose of neem leaf extract performed better than other doses of neem extract and the three doses of papaya. Although

neem extract failed to reduce cabbage plant infestation by *L. erysimi* and aphid abundance as well as the chemical insecticide, the use of neem leaf extract was an eco-friendly management method of aphid and produces the best cabbage yield.

Acknowledgements

This study was conducted with support from the West and Central African Council for Agricultural Research and Development (CORAF/ WECARD) through Projet N°: Contrat FC/2003/27. Special thanks to Mr Tetevi WILSON-BAHUN, English teacher in University of Lomé for reviewing the manuscript.

References

Afshan F (2002). Studies on the chemical constituents of the leaves of *Azadirachta indica* (Neem). Thesis. University of Karachi, Karachi-Pakistan, 184 p.

Agboyi LKBA (2009). Vulnérabilité des agroécosystèmes maraîchers du Togo et essai de biocontrôle de deux ravageurs *Brevicoryne brassicae* et *Plutella xylostella* sur le chou à l'aide de *Beauveria bassiana* 5653 et de l'extrait aqueux d'amandes de graines de neem (*Azadirachta indica* A. Juss). Mémoire de D.E.A., Université de Lomé. 61 p.

Agboyi LK, Ketoh GK, Martin T, Glitho IA (2013). *Beauveria bassiana* 5653 could be an alternative to synthetic insecticides against *Plutella xylostella* in Togo, pp. 249–253. In Harnessing Pesticidal Plant Technologies for Improved Livelihoods. Proceedings of the First International Conference on Pesticidal Plants (ICPP) (edited by Ogendo J. O., Lukhoba C. W., Bett P. K. and Machocho A. K.). Egerton University, Kenya.

Agboyi LK, Djade KM, Ahadji-Dabla KM, Ketoh GK, Nuto Y, Glitho IA (2015). Vegetable production in Togo and potential impact of pesticides use practices on the Environment. International Journal of Biological and Chemical Sciences 9: 723–736.

Alavo TBC (2000). Investigations on the Entomopathogenic fungus *Verticillium lecanii (*Zimm.) Viegas (Moniliaceae,Hyphomycetes) for the biological control of Aphids (Aphididae, Homoptera). Verlag Dr. Koester: Berlin-Germany; 101. ISBN 3-89574-394-1. Verlag Dr. Koester Berlin, 101 p.

Atwal AS, Dhaliwal GS (Eds) (2007). Agricultural pest of South Asia and their management. Kalyni publishers, New Delhi, India. 487 pp.

Bakhetia DRC (1983). Losses in rape seed/mustard due to *Lipaphis erysimi* (Kaltenbach) in India : a literature study, pp. 1142-1147. Proceedings of the 6th International Rapeseed Conference Paris (France), 17-19 May 1983.

Biswas GC (2008). Efficacy of some plant matrerials against the mustard aphid, *Lipaphis erysimi* (Kalt.) Journal of the Asiatic Society of Bangladesh, Science 34 (1): 79-82.

Biswas GC (2013). Comparative effectiveness of neem extracts and synthetic organic insecticide against mustard aphid. Bangladesh Journal of Agricultural Research 38(2): 181-187.

Boursier CM., Bosco D, Coulibaly A, Negre M (2011). Are traditional neem extract preparations as efficient as a commercial formulation of azadirachtin A. Crop Protection. 30: 318-322.

Brunherotto R, Vendramim JD, Oriani MAD (2010). Effects of tomato genotypes and aqueous extracts of *Melia azedarach* leaves and *Azadirachta indica* seeds on *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Neotropical Entomology 39: 784-791.

Castle SJ, Perring TM, Farrar CA, Kishaba AN (1992). Field and laboratory study of watermelon mosaic virus 2 and zucchni yellow mosaic virus by various aphid species. Phytopathology 82: 235-240.

Defago MT, Dumon A, Avalos DS, Palacios SM, Valladares G (2011). Effects of *Melia azedarach* extract on *Cotesia ayerza*, parasitoid of the alfalfa defoliator *Colias lesbia*. Biological Control 57: 75-78.

Degri MM, Mailafiya DM, Wabekwa JW (2013). Efficacy of aqueous leaf extracts and synthetic insecticide on pod-sucking bugs infestation of cowpea (*Vigna unguiculata* (L.) Walp) in the Guinea Savanna Region of Nigeria. Advanced Entomology 1(2): 10-14.

Egwurube E, Magaji BT, Lawal (2010). Laboratory evaluation of neem (*Azadirachta indica*) seed and leaf powders for the control of khapra beetle, *Trogoderma granarium* (Coleoptera: Dermestidae) infesting groundnut. International Journal of Agriculture and Biology 12: 638-640.

Haseeb M, Liu TX, Jones WA (2004). Effects of selected insecticides on *Cotesia plutellae*, endoparasitoid of *Plutella xylostella*. Biological Control 49: 33-46.

Isman MB (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology 51: 45-66.

James B, Atcha-Ahowé C, Godonou I, Baimey H, Georgen G, Sikirou R, Toko M (Eds) (2010). Integrated Pest Management in Vegetable Production: A Guide for Extension Workers in West Africa. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 112 pp.

Klu K, (2008). Contribution à l'étude de l'envahissement de la flore forestière togolaise par les espèces végétales exotiques : cas du neem (*Azadirachta indica*). Mémoire de D.E.A., Université de Lomé, 61 p.

Mondédji AD (2010). Potentiel d'utilisation d'extraits de feuilles de Neem (*Azadirachta indica* A. Juss) et de papayer (*Carica papaya* L.) dans le contrôle des insectes ravageurs du chou (*Brassica oleracea* L.) en zones urbaines et périurbaines au sud du Togo. Thèse de doctorat, Université de Lomé, Togo, 195 p.

Mondédji AD, Ketoh GK, Amévoin K, Améline A, Giordanengo P, Glitho IA (2014). Evaluation of neem leaves-based preparations as insecticidal agents against the green peach aphid, *Myzus persicae* Sternorrhyncha : Aphididae). African Journal of Agricultural Research, 9(17): 1344-1352.

Mondédji AD, Nyamador WS, Amévoin K, Adéoti R, Abbey GA, Ketoh GK, Glitho IA (2015). Analyse de quelques aspects du système de production légumière et percepetion des producteurs de l'utilisation d'extraits botaniques dans la gestion des insectes ravageurs des cultures maraîchères au Sud du Togo. International Journal of Biological and Chemical Sciences, 9 (1): 98-107.

Mondédji AD, Kasseney BD, Nyamador WS, Abbey GA, Amévoin K, Ketoh GK, Glitho IA (2016). Effets d'extrait hydroéthanolique de feuilles de neem (*Azadirachta indica* A. Juss) sur *Plutella xylostella* (Lepidoptera : Plutellidae) et *Lipaphis erysimi* (Hemiptera : Aphididae) dans la production du chou au Sud du Togo. International Journal of Biological and Chemical. Sciences, 10 (4): 1666-1677.

Philogène BJR, Regnault-Roger C, Vincent C (2003). Produits phytosanitaires insecticides d'origine végétale: promesses d'hier et d'aujourd'hui. In *Biopesticides d'Origine Végétale*, Roger C, Philogène BJR, Vincent C (Eds). Lavoisier TEC & DOC : Paris; 1-15.

Philogène BJR, Regnault-Roger C, Vincent C (2008). Biopesticides d'origine végétale : bilan et perspectives. In :

Regnault-Roger C, Philogène BJR & Vincent C (Eds), Biopesticides d'origine végétale, 2e édition, Lavoisier Tec & doc, Paris, pp 1-24.
PAN-Africa, (2004). Les pesticides au Mali. 1ère édition. 40 p.
PAN-UK (2005). The list of lists: a catalogue of lists of pesticides identifying those associated with particular harmful health or environnemental impacts, 19 p.
Schmutterer H (1990). Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. Annual Revew of Entomology 35: 271-297.
Shannag HS, Capinera JL, Freihat NM (2014). Efficacy of different neem-based biopesticides against green peach aphid, *Myzus persicae* (Hemiptera: Aphididae). International Journal of Agricultural Policy and Research 2 (2): 061-068.
Siddiqui BS, Afshan F, Ghiasuddin FS, Naqvi SNH, Tariq RM (2000). Two insecticidal tetranortriterpenoids from *Azadirachta indica*. Phytochemistry 53: 371-376.
Siddiqui BS, Ali SK, Ali ST., Naqvi SNU, Tariq RM (2009). Variation of major limonoids in *Azadirachta indica* fruits at different ripening stages and toxicity against *Aedes aegypti*. Natural Product Communications 4: 473-476.
Tang YQ, Weathersbee AA, Mayer RT (2002). Effect of neem seed extract on the brown citrus aphid (Homoptera: Aphididae) and its parasitoid *Lysiphlebus testaceipes* (Hymenoptera:Aphidiidae). Environmental Entomology 31: 172-176.
Toé AM, Ouédraogo V, Guissou IP, Héma OS (2002). Contribution à la toxicologie agroindustrielle au Burkina Faso. Etude des intoxications d'agriculteurs par des pesticides en zone cotonnière du Mouhoun. Résultats, analyse et propositions de prise en charge du problème. *Revue de Médecine du Travail*, tome XXIX, numéro unique, pp. 59-64.