Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2023; 11(5): 106-111

Received: 02-07-2023
Accepted: 03-08-2023

Gatzaro Warapisse
Laboratory of Ecology and Ecotoxicology, Faculty of Sciences, University of Lomé, Togo

Mondédji Abla Déla
Laboratory of Ecology and Ecotoxicology, Faculty of Sciences, University of Lomé, Togo

Nyamador Seth Wolali
Laboratory of Ecology and Ecotoxicology, Faculty of Sciences, University of Lomé, Togo

Awia Atiyodi
Laboratory of Ecology and Ecotoxicology, Faculty of Sciences, University of Lomé, Togo

Ketoh Koffivi Guillaume
Laboratory of Ecology and Ecotoxicology, Faculty of Sciences, University of Lomé, Togo

Corresponding Author:
Mondédji Abla Déla
Laboratory of Ecology and Ecotoxicology, Faculty of Sciences, University of Lomé, Togo

Effects of associations of cabbage with *Mentha arvensis* L. and *Lippia alba* (Mill.) N. E. Brown on insect pests of Crucifera at an experimental station

Gatzaro Warapisse, Mondédji Abla Déla, Nyamador Seth Wolali, Awia Atiyodi and Ketoh Koffivi Guillaume

DOI: https://doi.org/10.22271/j.ento.2023.v11.i5b.9238

Abstract
Headed cabbage (*Brassica oleracea* L.) is a leafy vegetable facing enormous damage by insect pests. To deal with these insects, chemical control remains the main method used with its harmful consequences on the environment and human health. The objective of this study is to evaluate the effects of intercropping head cabbage with field mint (*Mentha arvensis* L.) and white verbena (*Lippia alba* (Mill.) N. E. Brown) on the main insect pests and cabbage yield. So, a trial was carried out at the Agronomic Experimentation Station of the University of Lomé using a device in complete randomized random blocks with 3 repetitions. Each block comprised seven elementary plots: (control (T0); cabbage plants surrounded by mint plants (Me); cabbage plants surrounded by white verbena plants (Ve); cabbage plant inserted in white verbena (Vi); cabbage plant interspersed among mint plants (Mi); cabbage plants interspersed with white verbena and mint plants (ViMi); cabbage plants surrounded by mint plants and white verbena (VeMe)). The insect pests identified were: *Plutella xylostella* L., *Spodoptera littoralis* Boisd., *Chrysodeixis acuta* Walker, *Hellula undalis* Fabricius, *Alpenus maculosa* Stoll., and *Lipaphis erysimi* Kalt. The crop associations presented low numbers of insect pests, and higher yields (1.38 to 2.31 t/ha) compared to the control (0.00 t/ha). The results of this study could inform an integrated program set up to fight insect pests of cabbage.

Keywords: Association of cultures, aromatic plants, *Brassica oleracea*, insect pests

Introduction
Globally, food insecurity remains one of the concerns caused by climate disruptions [2]. Agriculture tries to provide a solution to the food security program. It is an activity that contributes greatly to the socio-economic development of populations [10, 37] and employs more than 40% of the active population in the world [26]. In this sector, market gardening remains one of the most productive and profitable activities because it is less demanding in terms of investment costs, thus encouraging farmers to grow vegetables [29]. Vegetable growing contributes more than 33% of global agricultural production and employs 800 million people. The Brassicaceae family includes 3500 species in 350 genera and produces more than 70 million tons of this plant product worldwide [7, 11]. In Africa, vegetable crops appear to be one of the main components of urban and peri-urban agriculture that is important in the economic development of cities [15]. *Brassica* cultivation in Africa remains low with 5.8% of world production [7]. In Togo, urban and peri-urban market gardening is in full development, supplying fresh vegetables to the market in Lomé and other towns in the country [18]. In addition to vegetables produced for their tubers or fruits, leafy vegetables, especially cabbage, are widely grown [18, 28].

Cabbage cultivation is however subject to attack by multiple pests leading to a drop in yield [24]. This is especially the case of one of its main pests the diamondback moth *Plutella xylostella* L. (Lepidoptera: Plutellidae), whose damage sometimes causes up to a 90% loss [1, 17, 19, 32, 34] and *of Lipaphis erysimi* (Hemiptera: Aphididae) which can cause a 100% loss if no treatment is applied [27]. To reduce the populations of insect pests, market gardeners systematically resort to the use of synthetic chemical insecticides, often not intended for market gardening. However, the excessive use of synthetic pesticides leads to environmental contamination, development of resistance to bio-aggressors, destruction of beneficial species and bioaccumulation in organisms [3, 20, 33].

Among the methods used for managing bio-aggressors and for reducing the abusive use of synthetic pesticides in market gardening, plant association is an alternative that can be used and be promoted to growers [24]. This model of agriculture is based on efficient management of ecosystems and their biodiversity. Its advantages include the reduction of health problems, the constitution of a physical barrier against insect pests, the modification of the habitat and chemical environment or indirectly the stimulation of auxiliaries [16, 25, 30]. In some cases, it can induce improved soil fertility, diversification, abundance and activity of soil micro- and macro-organisms [13, 14, 16, 21, 30]. Plants that can be used in crop protection include so-called aromatic plants which do not form a clearly defined group of plants from a botanical point of view, but are often cultivated for the chemical properties of their organs that make them useful as food, as medicine and crop protection [36].

The general objective of this study is to evaluate the effects of cultivating cabbage in association with two aromatic plants on insect pests.

Specifically, these are:

- assess the effect of associations of cabbage with field mint (*Mentha arvensis* L.) and white verbena (*Lippia alba* (Mill.) N. E. Brown) on the abundance of insect pests of crucifers;
- evaluate the effect of associations of cabbage with *M. arvensis* and *L. alba* on cabbage yields.

Materials and Methods

Experimentation site

The trials were conducted at the Station d'Expérimentations Agronomique de Lomé "Lomé Agronomic Experiment Station" (SEAL) located on the Lomé University Campus in the Maritime Region in southern Togo (Fig.1) from July to September 2022. Its geographical coordinates are 6°17'62.58" north latitude and 1°21'12.72" east longitude (Figure 1). Rainfall varies on average between 800 mm and 1200 mm/year and temperatures between 24 °C and 32 °C [5]. The soil is ferralitic with a sandy-clayey texture [35].

Material

As a plant material, headed cabbage of the F1 Sultana variety purchased from the Togo Semences company, was cultivated. At maturity, the plant has a very firm head weighing about 1.5 kg. It has a development cycle of 60 to 70 days after transplanting. Cabbage has been associated with two aromatic plants (White verbena and field mint).

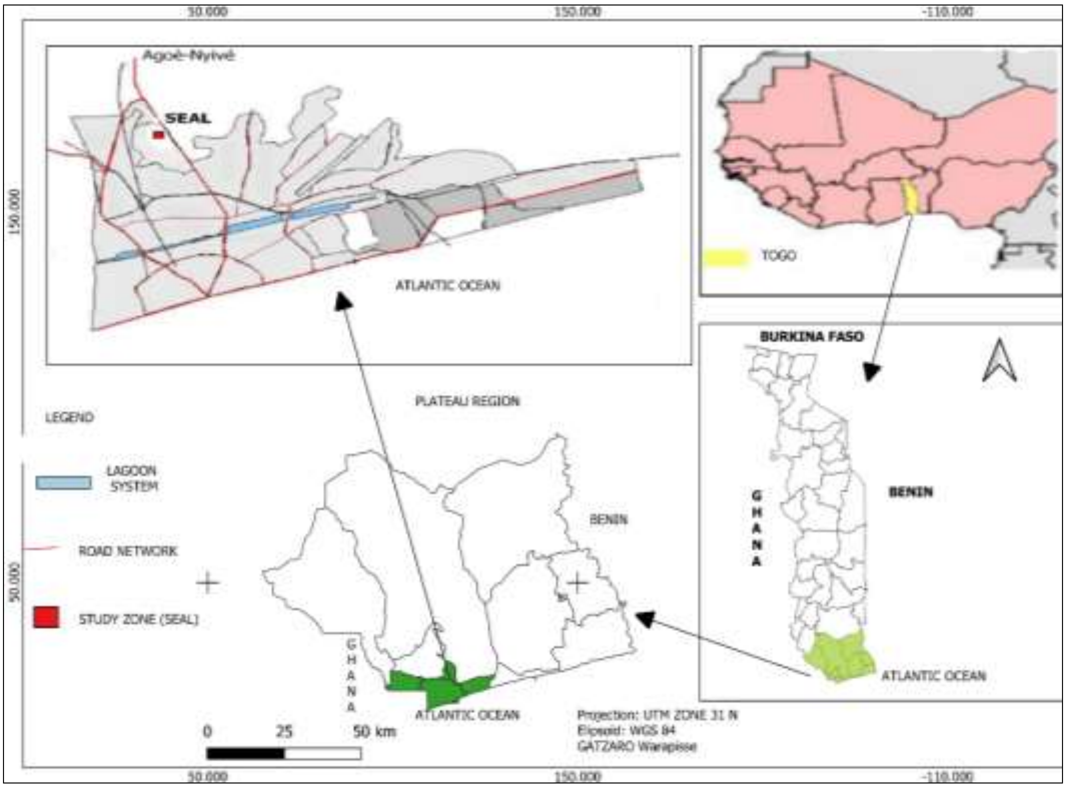

Fig 1: Map of Togo showing the locality where the experimental plot was installed

Experimental apparatus

Mint and verbena cuttings were planted 25 days before transplanting the cabbage. The experimental plot was subdivided into complete randomized random blocks, with 3 repetitions each containing seven elementary plots (treatments) : (control (T0); cabbage plants surrounded by mint plants (Me); cabbage plants surrounded by white verbena plants (Ve); cabbage plant inserted among white verbena (Vi); cabbage plant interspersed in mint plants (Mi); cabbage plants interspersed with white verbena and mint plants (ViMi); cabbage plants surrounded by mint plants and white verbena (VeMe)). In each block, each plot (1.6 m X 6.8 m) with an area of 10.88 m^2 is separated from the next plot by 0.5 m. The distance between blocks is 1 m. Each elementary plot is made up of four lines spaced 0.4 m apart. Each line contains 17 plants.

Entomofauna inventory

Observations consisted in counting each insect species on the lower and upper surfaces of the cabbage leaves. This was done once a week for 2 months. On each elementary plot, 30 cabbage plants were inspected. Some damage causing pests were captured in the larval stage and reared until the emergence of adults. They were then identified using the catalog of arthropods of vegetable crops in West and Central Africa, Mayotte and Reunion [8].

The inventory of aphids was done by randomly choosing the 2nd or 3rd leaves from the apex of the plant. The total leaf area and that occupied by aphids were determined. The results were expressed in terms of recovery R.

R = (area occupied by the aphid / total area) X 100 [31].

Intervals were delimited in order to appreciate the degree of attack of the species at the level of each treatment. If we have:

- $R < 5\%$, then the species is rare
- $5\% \leq R < 25\%$, then the species is uncommon
- $25\% \leq R < 50\%$, then the species is quite abundant
- $50\% \leq R < 75\%$, then the species is abundant
- $R \geq 75\%$, then the species is very abundant.

Cumulative number and abundance of Lepidoptera found on cabbage

Cumulative number (Ec)

Sum of the number of larvae of the Lepidoptera species found on the plants during monitoring.

$$Ec = \sum_{n=i} Ni = N1 + N2 \ldots\ldots + Nn$$

Abundance (A)

$$A = \frac{Ec}{Et} \times 100$$

Ec is the cumulative number of individuals of a species

Et is the total cumulative number of all Lepidoptera species.

Yield determination

Data on yields were obtained by weighing cabbage heads harvested from the elementary plots. The results were estimated in tons per hectare.

Statistical analysis of data

The data was entered on Microsoft Office Excel 2019 then imported into the Past software and processed. One-way analyses of variance (ANOVA, $p < 0.05$) were performed. The means were compared by the SNK test (Student-Newman-Keuls) at the probability threshold of 5%.

Results

Insect pests identified on cabbage

A total of six (6) species of pests have been identified, namely: *Plutella xylostella* L. (Lepidoptera: Plutellidae), *Lipaphis erysimi* Kalt. (Homoptera: Aphididae), *Spodoptera littoralis* Boisd. (Lepidoptera: Noctuidae), *Chrysodeixis acuta* Walker (Lepidoptera: Noctuidae), *Hellula undalis* Fabricius (Lepidoptera: Crambidae) and *Alpenus maculosa* Stoll (Lepidoptera: Erebidae).

Effects of crop associations on average coverage (X ± SD) and abundance of *L. erysimi*

The effect of the treatments on the populations of *L. erysimi* encountered was evaluated in terms of recovery. Statistical analyses revealed a significant difference between the control and the combined treatments ($F = 16.19$ and $P < 0.05$). The crop associations resulted in cabbage leaf cover by *L. erysimi* and lower aphid abundance levels than the control (Table 1).

Effects of crop associations on the cumulative number and abundance of Lepidoptera encountered in cabbage cultivation

The results of the observations on the elementary plots showed that *P. xylostella* was more abundant (80.70%) among the Lepidoptera with a cumulative number of 184 caterpillars followed by S. *littoralis* (8.33%) with a cumulative number of 19 caterpillars (Table 2). *C. acuta* was the least abundant species (4.82%) with a cumulative number of 11 caterpillars after *A. maculosa* (6.24%) which had a cumulative number of 14 caterpillars.

H. undalis being a borer, its count was not possible for fear of destroying the cabbage plants.

Table 1: Mean recovery (X ± SD) and abundance of *L. erysimi* depending on the treatment on cabbage

Treatments	Recovery (%)	Abundance level
T0	63.75±10.89 a	Abundant
Me	17.91±5.05 c	Uncommon
Ve	19.33±3.84 c	Uncommon
Vi	19.58±3.81 c	Uncommon
Mi	11.00±10.07 d	Uncommon
ViMi	23.16±8.22 b	Uncommon
VeMe	11.91±9.17 d	Uncommon

The averages followed by the same letter are not significantly different. T0: control; (Me): cabbage plants surrounded by mint plants; (Ve): cabbage plants surrounded by white verbena plants; (Vi): cabbage plants interspersed with white verbena plants; (Mi): cabbage plants interspersed in mint plants; (ViMi): cabbage plants interspersed among white verbena and mint plants; (VeMe): cabbage plants surrounded by white verbena and mint plants.

Table 2: Cumulative numbers and abundance of Lepidoptera encountered in cabbage cultivation

Species	Cumulative workforce	Plenty (%)
Plutella xylostella	184	80.7
Chrysodoxis acuta	11	4.82
Spodoptera littoralis	19	8.33
Alpenus maculosa	14	6.14

2.4. Effects of intercropping on cabbage yield

The plots with crop associations presented higher yields compared to the control which gave zero yield ($F = 3.22$ and $P < 0.05$). The average cabbage yield per treatment was 2.08±0.28 t/ha for the cabbage plant treatment surrounded by mint plants (Me); 1.85±1.04 t/ha for the cabbage plant treatment intercropped with the white verbena plants (Vi); 2.31±0.28t/ha for the cabbage plant treatment inserted among the mint plants (Mi); 1.62±0.76 t/ha on the cabbage plant treatment intercropped among the white verbena and mint (ViMi) plants; 1.85±0.28 t/ha for the cabbage plant treatment surrounded by mint plants and white verbena plants (VeMe) and 1.38±0.5 t/ha for treatment cabbage plants surrounded by white verbena plants (Ve) as Fig. 2 showed it.

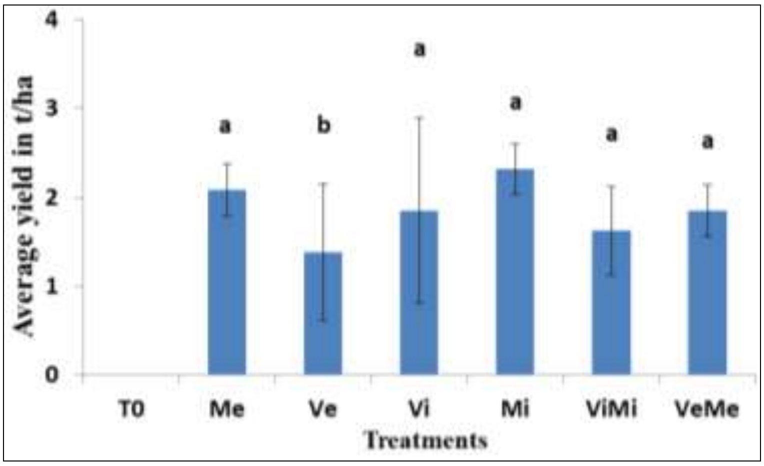

Fig 2: Effects of intercropping on cabbage yield

The columns surmounted by the same letter are not significantly different. T0: control; (Me): cabbage plants surrounded by mint plants; (Ve): cabbage plants surrounded by white verbena plants; (Vi): cabbage plants interspersed with white verbena plants; (Mi): cabbage plants interspersed among mint plants; (ViMi): cabbage plants interspersed with white verbena and mint plants; (VeMe): cabbage plants surrounded by white verbena and mint plants.

4. Discussion

The results of this study reveal that the insect pests identified were five lepidopterans and one homopteran. These insect pests have been causing damage to cabbage plants. This damage ranged from leaf perforation to total plant destruction. The aphid *L. erysimi* was identified in all treatments. Its presence in all treatments could be explained by the fact that each year, cabbage is grown at the same site. In addition, the culture covered the period of high *L. erysimi* pressure [27]. This homopteran infests cabbage plants early resulting in high cabbage leaf coverage, especially on the control. All treatments except the control treatment significantly reduced aphid colonies. Field mint and white verbena being aromatic plants, must have released volatile compounds which reduced the feeding and multiplication of *L. erysimi* on cabbage. Field mint essential oil contains more than 68.4% menthol. [12] It is known that white verbena essential oil contains mainly 38.1% carvone and 33.2% limonene [22]. Chemical compounds would have been released by these plants, preventing aphids from invading their host plant, and promoting low recoveries and higher yields.

P. xylostella was the most abundant pest among the Lepidoptera. This could be explained by the fact that *P. xylostella* is an exclusive pest of plant species belonging to the Brassicaceae family [24]. The caterpillar gnaws the leaves causing an almost complete defoliation of the plant in some cases [9]. The numbers of *P. xylostella* in our study were higher on the control plot than on the other plots where the associations were made. In addition, all the plants associated with cabbage made it possible to significantly reduce the populations of *P. xylostella*. This would be due to the fact that these associated plants would have emitted strong volatile compounds responsible for the insecticidal or repellent effects or even the disturbing smell of *P. xylostella* that prevented it from locating the host plant. Our results show that intercropping was most effective on *P. xylostella* numbers. Associations of cabbage plants with the aromatic plants tested would have the same effects on the other Lepidoptera (*S. littoralis*, *C. acuta*, *H. undalis* and *A. maculosa*) found on cabbage. Intercropping cabbage with non-host crops such as onion and tomato significantly reduced the numbers of *P. xylostella* populations on cabbage [4]. However, other authors have reported that the number of *P. xylostella* recorded on the treatment intercropped with cabbage and onion was not significantly different from that recorded on cabbage alone [6]. It should be noted that in their study the device used consists of two rows of cabbage intercalated with a row of onions; three rows of cabbage intercalated with a row of onions and four rows of cabbage intercalated with a row of onions.

The crop associations put in place increased the yield of headed cabbage compared with the control. This is due to the barrier created by the associated plants against insect pests. So, an increase in yield of 59 to 100% was recorded on the plots with crop associations compared with the control. Reducing the number of pests on intercropped cabbage resulted in an increase in yield from 11.03% to 50.1% [6]. However, other studies have reported a 15–24% reduction in cabbage yield when intercropped with clover because of nutrient competition between the two crops [23]. This means that the choice of non-host plants in an intercrop set up should be those species which can be grown and thrive under normal crop management practices and which do not compete with host crops or harbor pests. The control treatment where cabbage alone was grown, gave zero yield. This result would be due to the strong pressure of the aphid population during the season. This corroborates the results obtained (100% loss) at the same site by other authors during the same season in a previous year when no treatment was applied [27].

5. Conclusion

This study identified six insect pests on cabbage: *P. xylostella*, *C. acuta*, *S. littoralis*, *H. undalis*, *A. maculosa* and *L. erysimi*. The association of cabbage with mint and white verbena reduced the populations of insect pests and increased the yield of headed cabbage. The aphid *L. erysimi* was the most abundant pest on the plots and caused enormous damage, especially on the control plot. This aphid experienced a reduction in its numbers on all the plots of crop associations. Nevertheless, the treatments (Mi) (cabbage plant intercropped with mint plants) and (VeMe) (cabbage plants surrounded by mint and white verbena plants) resulted in a reduction in colonies of *L. erysimi* of the order of about 50% compared to the control treatment. The strong reduction of this pest and of *P. xylostella* among Lepidoptera resulted in a high yield on the plots with crop associations.

6. Conflict of interests

The authors have not declared any conflict of interests.

7. References

1. Akantétou PK. Contribution à l'étude d'un programme de lutte intégrée contre la teigne du chou : *Plutella xylostella* Schr. (Lepidoptera : Hyponomeutidae) : Mémoire de fin d'étude agronomique N° 90/05/PV. Université du Bénin, Lomé-Togo; c1990. p. 84.
2. Akpo AA. Evaluation de l'efficacité des extraits des plantes locales pour le contrôle des vecteurs du paludisme résistant aux pyréthrinoïdes au Bénin (Afrique de l'Ouest). Thèse de Doctorat de l'Université d'Abomey-Calavi; c2017. p. 253.
3. Anjarwalla P, Belmain S, Sola P, Jamnadass R, Stevenson PC. Guide des plantes pesticides. World Agroforestry Centre (ICRAF), Nairobi, Kenya; c2016. p. 74.
4. Asare-Bediako E, Addo-Quaye AA, Mohammed, A. Control of diamondback moth (*Plutella xylostella*) on cabbage (*Brassica oleracea* var capitata) using intercropping with non-host crops. American Journal of Food Technology. 2012;5:269-274.
5. Badameli A, Dubreuil V. Diagnostic du changement climatique au Togo à travers l'évolution de la température entre 1961 et 2010. In XXVIIIe Colloque de l'Association Internationale de Climatologie; c2015. p. 421-426.
6. Baidoo PK, Mochiah MB, Apusiga K. Onion as a pest control intercrop in organic cabbage (*Brassica oleracea*) production system in Ghana. Sustainable Agriculture Research. 2012;1(1):36-41.
7. Bojean A. Castor cultivation for chemical applications. Galileo/ONIDOL., France; c1991. p. 101.
8. Bordat D, Arvanitakis L. Arthropodes des cultures légumières d'Afrique de l'Ouest, centrale, Mayotte et Réunion; c2004. p. 291. ISBN 2-87614-593-6.
9. Capinera JL. Diamondback Moth, *Plutella xylostella* (Linnaeus) (Insecta: Lepidoptera: Plutellidae). EDIS, 1969 EENY-119/IN276, rev. 5/2000. DOI:10.32473/edis-in276-2000
10. Cervantes-Godoy D, Dewbre, J. Economic importance of agriculture for poverty reduction. Development; c2010. p. 23, 27. https://doi.org/10.1787/5kmmv9s20944-en
11. Cherry AJ, Osae M, Djegui D. Relative potency, yield and transmission of a Kenyan isolate of *Plutella xylostella* granulovirus in a population of diamondback moth from Benin, West Africa. In: Kirk AA, Bordat D, editors. Improving biocontrol of *Plutella xylostella*. Proceedings of the International Symposium, 21-24 October 2002. Montpellier, France; c2004. p. 158-162.
12. Diop SM, Gueye MT, Ndiaye EHB, Thiam A, Cissokho PS, Sanghare CH, *et al*. Activités antioxydante et insecticide d'huiles essentielles de *Mentha arvensis* L. du Sénégal. International Journal of Biological and Chemical Sciences. 2021;15:966-975. DOI: 10.4314/ijbcs.v15i3.10.
13. Duchene O, Vian JF, Celette F. Intercropping with legume for agroecological cropping systems: Complementarity and facilitation processes and the importance of soil microorganisms. A review. Agriculture, Ecosystems et Environment. 2017;240:148-161.
14. Ehrmann J, Ritz K. Plant: soil interactions in temperate multi-cropping production systems. Plant and Soil. 2014;376:1-29.
15. FAO. Growing greener cities in Africa. First status report on urban and Peri-urban horticulture in Africa. Roma: FAO; c2012.
16. Gaba S, Lescourret F, Boudsocq S, Enjalbert J, Hinsinger P, Journet EP, *et al*. Multiple cropping systems as drivers for providing multiple ecosystem services: From concepts to design. Agronomy for Sustainable Development. 2015;35:607-623. doi.org/10.1007/s13593-014-0272-z.
17. Iqbal M, Verkerk RHJ, Furlong MJ, Ong PJ, Syed AR, Wright DJ. Evidence for resistance to *Bacillus thuringiensis* (Bt) subsq. Kurstaki HD-1, Bt subsq. Aizawai and Abamectin in field populations of *Plutella xylostella* from Malaysia. Pesticide Science. 1996;139:1-8.
18. Kanda M, Akpavi S, Wala K, Djaneye-Boundjou G, Akpagana K. Diversité des espèces cultivées et contraintes à la production en agriculture maraîchère au Togo. International Journal of Biological and Chemical Sciences. 2014;8(1):115-127.
19. Kouassi AM, Ouali-N'Goran SWM, Akessé EN, Ehounou PG, Soro YR, Coulibaly A. Distribution of insects according to the phenological stages of apple cabbage *Brassica oleracea* var capitata (Brassicales: Brassicaceae) in Korhogo, northern Côte d'Ivoire. International Journal of Fauna and Biological Studies. 2019;6:43-49.
20. Kranthi KR, Jadhav D, Wanjari R, Kranrhi S, Russel D. Pyrethroid resistance and mechanisms of resistance in field strains of *Helicoverpa armigera* (Lepidoptera: Noctuidae). Journal of Economic Entomology. 2001;94:253-263.
21. Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios D. Annual intercrops: an alternative pathway for sustainable agriculture. Australian journal of crop science. 2011;5:396-410.
22. López MA, Stashenko EE, Fuentes JL. Chemical composition and antigenotoxic properties of *Lippia alba* essential oils. Genetics and Molecular Biology. 2011;34:479-488.
23. Lotz LAP, Groeneveld RMW, Theunissen J, Van Den Broek RCFM. Yield losses of white cabbage caused by the competition with clovers grown as cover crop. Netherland Journal of Agricultural Science. 1997;45(3):393-405.
24. Machiels L. Contribution à l'étude sur l'effet de l'association de l'armoise africaine (Artemisia afra j.) avec une culture de chou pomme; c2017. p. 89.
25. Malézieux E, Crozat Y, Dupraz C, Laurans M, Makowski D, Ozier-Lafontaine H, *et al.* Mixing plant species in cropping systems: concepts, tools and models. A review. Agronomy for Sustainable Development. 2009;29:43-62. doi.org/10.1051/agro:2007057.
26. Momagri. Chiffres-clés de l'Agriculture. 2016. http://www.momagri.org/FR/chiffres-cles-de-l agriculture/Avec-pres-de-40%25-de-la-population-active-mondiale-l'agriculture-est-le premier-pourvoyeur d'emplois-de-la-planete_1066.html, (20/06/2022).
27. Mondédji AD, Kasseney BD, Nyamador SW, Adéoti R, Abbey GA, Amévoin, *et al*. 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. Agricultural Science Research Journal. 2017;8:174-181. doi.org/10.4314/ijbcs.v10i4.18].

28. Mondédji AD, Nyamador SW, Amevoin K, Ketoh GK, Glitho IA. Efficacité d'extraits de feuilles de neem *Azadirachta indica* (Sapindale) sur *Plutella xylostella* (Lepidoptera : Plutellidae), *Hellula undalis* (Lepidoptera : Pyralidae) et *Lipaphis erysimi* (Hemiptera : Aphididae) du chou *Brassica oleracea* (Brassicaceae) da dans une approche « Champ Ecole Paysan» au sud du Togo. International Journal of Biological and Chemical Sciences. 2015;8(5):2286-2295.
29. Ntumba N, John TK, Muyasa EM, Bibich KA. Le maraîchage et l'accès aux facteurs de production dans le contexte socio-économique de Lubumbashi [The market gardening and the access to the factors of production in the context socioeconomic of Lubumbashi]. International Journal of Innovation and Applied Studies. 2015;13(3);527-537.
30. Ratnadass A, Fernandes P, Avelino J, Habib R. Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: A review. Agronomy for Sustainable Development. 2012;32:273-303.
31. Sotondji AF, Djihinto CA, Dannon AE, Sagbo MR, Kpindoui Douro OK, Chougourou CD, *et al*. Évaluation du baume de cajou et des huiles végétales pour la lutte contre les principaux insectes ravageurs du chou (*Brassica oleracea*) en milieu paysan au Sud du Bénin. 2022;20:104-117.
32. Talekar NS, Shelton AM. Biology, ecology and management of the Diamondback moth. Annual Revue of Entomology. 1993;38:275-301.
33. Tewary DK, Bhardwaj A, Shanker A. Pesticidal activities in five medicinal plants collected from mid hills of western Himalayas. Industrial Crops and Products. 2005;22:241-247.
34. Verkerk RHJ, Wright DG. Multitrophic interactions and management of the diamondback moth: A review. Bulletin of Entomological Research. 1996;86:205-216.
35. Worou SK, Ouest SC. Sols dominants du Togo: corrélation avec la Base de reference mondiale; c2002.
36. Xu Q, Hatt S, Lopes T, Zhang Y, Bodson B, Chen J, Francis F. A push–pull strategy to control aphids combines intercropping with semiochemical releases. Journal of Pest Science. 2018;91:93-103. doi.org/10.1007/s10340-017-0888-2
37. Yarou BB, Silvie P, Komlan FA, Mensah A, Alabi T, Verheggen F, *et al*. Plantes pesticides et protection des cultures maraichères en Afrique de l'Ouest (Synthèse bibliographique). 2017;21(4):288-304. doi.org/10.25518/1780-4507.16175