Acta
Entomology and Zoology

E-ISSN: 2708-0021
P-ISSN: 2708-0013
https://www.actajournal.com
AEZ 2023; 4(2): 25-30
Received: 20-04-2023
Accepted: 01-06-2023

Okrikata Emmanuel
Department of Biological Sciences, Federal Uiversity Wukari, Taraba State, Nigeria

Otabor Jane Itohan
Department of Biological Sciences, Federal Uiversity Wukari, Taraba State, Nigeria

Ugber Mwakyoga Abraham
Department of Biological Sciences, Federal Uiversity Wukari, Taraba State, Nigeria

Corresponding Author:
Okrikata Emmanuel
Department of Biological Sciences, Federal Uiversity Wukari, Taraba State, Nigeria

Impact of cashew (*Anacardium occidentale* L) and moringa (*Moringa oleifera* Lam) leaves-based biopesticides on major insect pests and predators associated with white-seed melon (*Cucumeropsis mannii* Naudin)

Okrikata Emmanuel, Otabor Jane Itohan and Ugber Mwakyoga Abraham

DOI: https://doi.org/10.33545/27080013.2023.v4.i2a.110

Abstract
We assessed the impact of cashew (*Anacardium occidentale* L.) and moringa (*Moringa oleifera* Lam.) leaves extracts on the insect pests and yield of white-seed melon (*Cucumeropsis mannii* Naudin) under field conditions in the late season of 2022. Concentrations (50%, 75%, and 100% v/v) of aqueous leaves extracts of *A. occidentale* and *M. oleifera* were utilised, with chlorpyriphos 20EC (Perfect killer®) and water serving as the positive and negative controls, respectively. Spraying began three weeks after germination and continued weekly for four weeks. Insect sampling was done weekly, six days after each spraying, to assess the effectiveness of each treatment. Pod and seed yields were recorded at harvest. We noted three major insect pests and two predators associated with the crop. The synthetic pesticide highly suppressed the major insect populations (pests and beneficial) by 90.6% to 100%. Plots treated with 100% v/v of *A. occidentale* (A_{100}) produced the highest pods (5.4 kg/m^2) and seed (116.2 g/m^2) yields. Plots treated with the synthetic pesticide yielded the lowest seed yield (53.6 g/m^2). There was no significant difference (p>0.05) in pod and seed yields among the treatments. The difference in the yields is thus due to random variations.

Keywords: *Aulacophora africana*, biopesticide, *Cheilomenes propinqua*, efficacy, egusi melon

Introduction

The white-seed melon (*Cucumeropsis mannii* Naudin) is a member of the Cucurbitaceae family which originates from West Africa. This melon is commonly known as "egusi," a term derived from the Yoruba language spoken in Nigeria. Data on global egusi melon production indicates that Nigeria is the highest producer, with commercial cultivation mainly in the southwest and north-central and less in the northeastern regions of Nigeria (FAO, 2018) [12]. It is cultivated twice annually, during the early planting season at the onset of rains (April to June) or during the late planting season (August to November). Intercropping egusi with other crops is a widely used agricultural land management technique that helps reduce water runoff, controls erosion, suppresses weeds, and enriches the soil with nutrients (Giwa and Akanbi, 2020) [14].

The white-seed melon/egusi melon is known for its high protein and oil content, and nutrient analysis reveals a fair amount of essential amino acids, fibre, carbohydrates, vitamins, minerals, and oils (Olajide *et al*., 2013; Jacob *et al*., 2015) [21, 15]. The oil, which constitutes about 50% of the melon, is rich in unsaturated fatty acids that improve cholesterol levels in the blood, thereby minimising the risk of heart disease (Eidangbe *et al*., 2010) [11]. Egusi melon is a significant part of the Nigerian delicacy consumed by different ethnic groups in the country, and the potential of egusi melon oil as a source of biodiesel has also been presented in an extensive review by Giwa and Akanbi, (2020) [14]. The benefits mentioned above of egusi make it an important food crop in Nigeria.

Despite the numerous benefits of egusi melon, its cultivation has been limited by insect pest infestations. While synthetic pesticides have been used for insect pest management, their ongoing use can lead to the production of resistant populations and pose hazards to humans and non-target organisms (Desneux *et al*., 2007) [10].

Hence, researchers continue to explore the potential of plant extracts and plant-based compounds to find insecticidal properties that can be used against various insect pests (Odeyemi *et al*., 2008) [17] and enhance yields. Extensive research has been conducted on two plant species; cashew (*Anacardium occidentale* L.) (Sapindales: Anacardiaceae) and moringa (*Moringa oleifera* Lam.) (Brassicales: Moringaceae), due to their nutritional and medicinal properties (Baptista *et al*., 2018; Gandji *et al*., 2018) [6, 13]. These plants have exhibited considerable potentials in effectively managing pests, specifically those affecting stored products (Buxton *et al*., 2017; Babatunde *et al*., 2021) [7, 5]. For instance, laboratory and field studies have demonstrated the efficacy of aqueous moringa extracts in controlling pests of cabbage and watermelon (Alao *et al*., 2018; Ogbonna *et al*., 2021) [2, 18]. The insecticidal properties of *M. oleifera* are likely attributed to the presence of various phytochemicals, such as catechol tannins, gallic tannins, steroids, tri-terpenoids, flavonoids, saponins, anthraquinones, alkaloids, and reducing sugars. These plant-produced compounds are a natural defence mechanism (Karar *et al*., 2021) [16]. Similarly, extracts from *A. occidentale*, such as cashew nut shell liquid, cashew seed powder, and extracts of cashew leaves, have been identified as valuable alternatives to synthetic pesticides. These extracts have proven effective in reducing the population of pests like *Callosobruchus maculatus*, *C. sibinnotatus*, and *Sitophilus oryzae* and inhibiting the emergence of larvae of pests such as *Anticarsia gemmatalis* and *Spodoptera frugiperda* (de Carvalho *et al*., 2019; Babatunde *et al*., 2021) [9, 5]. Moringa and cashew extracts are particularly beneficial as they pose no harm to humans, the environment, and beneficial arthropods like parasitoids, pollinators, and predators.

Although utilising *A. occidentale and M. oleifera* leaves and seed extracts in pest control is widespread, field-based data regarding their effectiveness as biopesticides are scarce. In order to delve deeper into the potential of *A. occidentale and M. oleifera* extracts as biopesticides, this study aims to assess the insecticidal properties of their aqueous leaf extracts. The evaluation will focus on their impact on pests, predators, and the overall yield of egusi melon plants.

Materials and Methods

Study area

The experiment was conducted at the Department of Biological Sciences Research Farm, Faculty of Pure and Applied Sciences, Federal University Wukari, Taraba State, Nigeria, during the late cropping season (September – November 2022). Geographically, Wukari is located in the Southern Guinea Savannah (Latitude 7°15'N - 7 ° 85'N and Longitude 9°47' E - 9 ° 78′ E). It has an annual rainfall of about 150 mm-200 mm with a mean temperature of 25 °C. The rain commences in April and terminates in October, while the dry season begins from November to March annually.

Plant materials used

The leaves of *A. occidentale* and *M. oleifera* were plucked at Federal University Wukari Research farm. It was authenticated at the Botany unit of the Department of Biological Sciences, Federal University Wukari, Taraba State. The plant species were selected for this study because farmers are familiar with their potential as pesticides and are abundant in the study area. The leaves were air-dried at room temperature for two weeks, ground to powder in a wooden mortar with a pestle, and stored in air-tight containers until needed for the experiment.

Experimental design and management

The experimental field was prepared by ploughing and harrowing it once. A total of twenty-four (24) plots were marked out for the experiment. The design employed was a Randomized Complete Block Design (RCBD) with eight treatments, including the control groups. The experiment was replicated three times. Each plot had dimensions of 3m by 2m, with a spacing of 1m between each plot. The seeds were planted with an inter-row spacing of 50cm and within-row spacing of 20cm, as per the method outlined by Olaniyi (2008) [22]. Cow dung was applied three weeks after sowing the melon seeds to ensure an even distribution of soil nutrients at a rate of 50 kg/ha (Olaniyi, 2008) [22]. Initially, two to four seeds were planted per hole, and after 14 days, thinning was performed to achieve one plant per stand. Weeding was carried out manually when needed.

Preparation of plant extracts

Two hundred grams (200g) of the crushed plant materials were individually weighed. Each weighed sample was placed into a 10-litre plastic bucket containing 1000 ml of water. The mixtures were left undisturbed for 24 hours. On the day of application, the mixtures were filtered using a muslin cloth, and the resulting liquid, referred to as the stock solution, was collected in a 5-litre plastic keg. The stock solution represented a concentration of 20% w/v. From the stock solution, 100ml of each plant extract was measured, and subsequently, three concentrations (50%, 75%, and 100% v/v) were prepared following the method outlined by Alao and Adebayo (2015) [1].

Treatment application

The synthetic insecticide [chlorpyriphos 20EC (Perfect killer®)] was applied according to the manufacturer's recommendation (2ml/l of water). Application of the treatments commenced three weeks after sowing, and this was carried out early in the morning with a 500ml capacity handheld sprayer at the rate of 100 ml/plot. A separate handheld sprayer was used for each treatment. Spraying was done weekly for four weeks, and observations were made six days after spraying (6DAS) (Alao and Adebayo, 2015) [1].

Data collection

Six days after each weekly treatment, population densities of predominant insects were determined through visual observation. The observations were conducted by randomly sampling of insects from the three central plant rows, following the methodology outlined by Tembo *et al*. (2018) [25]. Sampling took place early morning (about 7am) when the insects were relatively inactive (Alao and Adebayo, 2015) [1]. After three months of planting, the number of matured fruits per square meter was harvested, and their weight in kilogram (kg) was recorded. Following two weeks of fruit decay in the field, the seeds per square meter on each plot were separated from the decayed pulp, rinsed, dried, weighed and values were recorded in grams (g).

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using a randomised complete block design.

Significantly different means were separated with Duncan Multiple Range test at 5% probability. To normalise variances, the numbers of insects were square-root transformed. However, insecticide suppressive effect was calculated using formula adapted from Alao *et al.* (2022) [3] and Okrikata *et al*. (2022) [19]:

$$Suppressive\ (\%) = CA - TA/CA\ x\ 100$$

CA – The total number of the insect from the untreated plants
TA – The total number of the insect from the treated plants

Results

Table 1 displays the overall arthropod abundance in treatment plots, which were replicated three times. The data were collected one week after the application of treatments. In the field, two predator species and three pests were observed as the dominant insects associated with the plant. The results indicate that P (chlorpyriphos 20EC) achieved the highest insect suppressive impact of 100%. The treatments A_{100} and M_{100} suppressed the insect populations by 60.8% and 69.6%, respectively. Conversely, the treatment with the lowest suppressive value was A_{50}, which showed an efficacy of 39.1%.

Table 1: Impact of *A. occidentale* and *M. oleifera* leaves based biopesticide on the density of major insects associated with *C. mannii* one (1) week after treatment

Species	Order	Family	Status	Treatment							
				W	P	A_{50}	A_{75}	A_{100}	M_{50}	M_{75}	M_{100}
C. sulphurea	Coleoptera	Coccinellidae	Predator	2.33	0.00	1.67	1.33	0.00	0.33	0.00	0.33
L. vinula	Coleoptera	Chrysomelidae	Pest	1.67	0.00	0.33	0.33	0.67	1.33	0.67	0.67
A. africana	Coleoptera	Chrysomelidae	Pest	1.33	0.00	1.33	1.00	1.33	1.33	1.00	0.67
C. propinqua	Coleoptera	Coccinellidae	Predator	2.00	0.00	1.33	1.00	1.00	1.00	1.67	0.33
S. annulus	Hemiptera	Pentatomidae	Pest	0.33	0.00	0.00	0.67	0.00	0.00	0.33	0.33
Total				7.66	0.00	4.66	4.33	3.00	3.99	3.67	2.33
Suppressive (%)					100	39.1	43.5	60.8	47.9	52.1	69.6

A_{50}, A_{75} and A_{100} – *A. occidentale* extract at 50, 75 and 100% v/v, M_{50}, M_{75} and M_{100} - *M. oleifera* extract at 50, 75 and 100% v/v, P - Pesticide [chlorpyriphos 20EC (Perfect killer®)] (positive control), W - Water (negative control)

Table 2 indicates that P (chlorpyriphos 20EC) was the most insect suppressive treatment (90.1%). The treatments A_{100} and M_{100} suppressed the predominant insects by 47.7% and 52.4%, respectively. As also observed 1 week post-treatment, A_{50} was the least suppressive of the insects (14.1%).

Table 2: Impact of *A. occidentale* and *M. oleifera* leaves based biopesticide on the density of major insects associated with *C. mannii* two (2) week after treatment

Species	Order	Family	Status	Treatment							
				W	P	A_{50}	A_{75}	A_{100}	M_{50}	M_{75}	M_{100}
C. sulphurea	Coleoptera	Coccinellidae	Predator	2.00	0.00	1.67	0.67	0.33	2.00	0.33	0.67
L. vinula	Coleoptera	Chrysomelidae	Pest	1.00	0.33	0.67	1.33	1.33	0.67	0.33	1.00
A. africana	Coleoptera	Chrysomelidae	Pest	0.33	0.00	1.00	0.67	1.00	1.00	0.67	1.00
C. propinqua	Coleoptera	Coccinellidae	Predator	1.67	0.33	1.67	1.33	0.33	1.00	1.67	0.33
S. annulus	Hemiptera	Pentatomidae	Pest	2.00	0.00	1.00	0.67	0.67	0.00	1.00	0.33
Total				7.00	0.66	6.01	4.67	3.66	4.67	4.00	3.33
Suppressive (%)					90.6	14.1	33.3	47.7	33.3	42.9	52.4

A_{50}, A_{75} and A_{100} – *A. occidentale* extract at 50, 75 and 100% v/v, M_{50}, M_{75} and M_{100} - *M. oleifera* extract at 50, 75 and 100% v/v, P - Pesticide [chlorpyriphos 20EC (Perfect killer®)] (positive control), W - Water (negative control)

The results insect population data collected 3rd week pos-treatment as presented in Table 3 largely followed the previous trends. The synthetic insecticide, P (chlorpyriphos 20EC) was the most insect suppressive (96%). This was followed by the biopesticides, A_{100} and A_{75} which demonstrated 60.1% and 56% suppressive effect, respectively. The lowest suppressive value was obtained from plots treated with A_{50} and M_{75}, each with 44% impact.

Table 3: Impact of *A. occidentale* and *M. oleifera* leaves based biopesticide on the density of major insects associated with *C. mannii* three (3) week after treatment

Species	Order	Family	Status	Treatment							
				W	P	A_{50}	A_{75}	A_{100}	M_{50}	M_{75}	M_{100}
C. sulphurea	Coleoptera	Coccinellidae	Predator	1.67	0.33	1.67	1.67	1.00	1.33	1.00	1.33
L. vinula	Coleoptera	Chrysomelidae	Pest	2.67	0.00	1.67	0.00	0.00	1.00	0.67	1.67
A. africana	Coleoptera	Chrysomelidae	Pest	1.00	0.00	0.33	0.67	0.33	0.67	1.33	0.33
C. propinqua	Coleoptera	Coccinellidae	Predator	2.33	0.00	0.67	1.00	1.33	1.33	0.67	0.33
S. annulus	Hemiptera	Pentatomidae	Pest	0.67	0.00	0.33	0.33	0.67	0.67	1.00	0.67
Total				8.34	0.33	4.67	3.67	3.33	5.00	4.67	4.33
Suppressive (%)					96.0	44.0	56.0	60.1	40.1	44.0	48.1

A_{50}, A_{75} and A_{100} – *A. occidentale* extract at 50, 75 and 100% v/v, M_{50}, M_{75} and M_{100} - *M. oleifera* extract at 50, 75 and 100% v/v, P - Pesticide [chlorpyriphos 20EC (Perfect killer®)] (positive control), W - Water (negative control)

At 4 weeks post-treatment, P (Chlorpyriphos 20EC) remained the most suppressive (95.7%). Again, as in 3rd week post-treatment, A_{100} and M_{100} followed with 60.9% and 52.2% suppressive values, respectively. Also, M_{50}, maintained the least insect suppressive impact of 26.1% (Table 4).

Table 4: Impact of *A. occidentale* and *M. oleifera* leaves based biopesticide on the density of major insects associated with *C. mannii* four (4) week after treatment

Species	Order	Family	Status	Treatment							
				W	P	A_{50}	A_{75}	A_{100}	M_{50}	M_{75}	M_{100}
C. sulphurea	Coleoptera	Coccinellidae	Predator	2.00	0.00	1.00	0.67	0.33	2.00	0.67	1.00
L. vinula	Coleoptera	Chrysomelidae	Pest	1.33	0.33	1.33	1.00	0.67	0.67	0.33	0.67
A. africana	Coleoptera	Chrysomelidae	Pest	1.00	0.00	0.67	0.67	0.67	1.00	1.00	0.67
C. propinqua	Coleoptera	Coccinellidae	Predator	1.67	0.00	1.33	0.67	0.33	1.33	1.33	0.33
S. annulus	Hemiptera	Pentatomidae	Pest	1.67	0.00	1.00	1.00	1.00	0.67	1.00	1.00
Total				7.67	0.33	5.33	4.01	3.00	5.67	4.33	3.67
Suppressive (%)					95.7	30.5	47.7	60.9	26.1	43.5	52.2

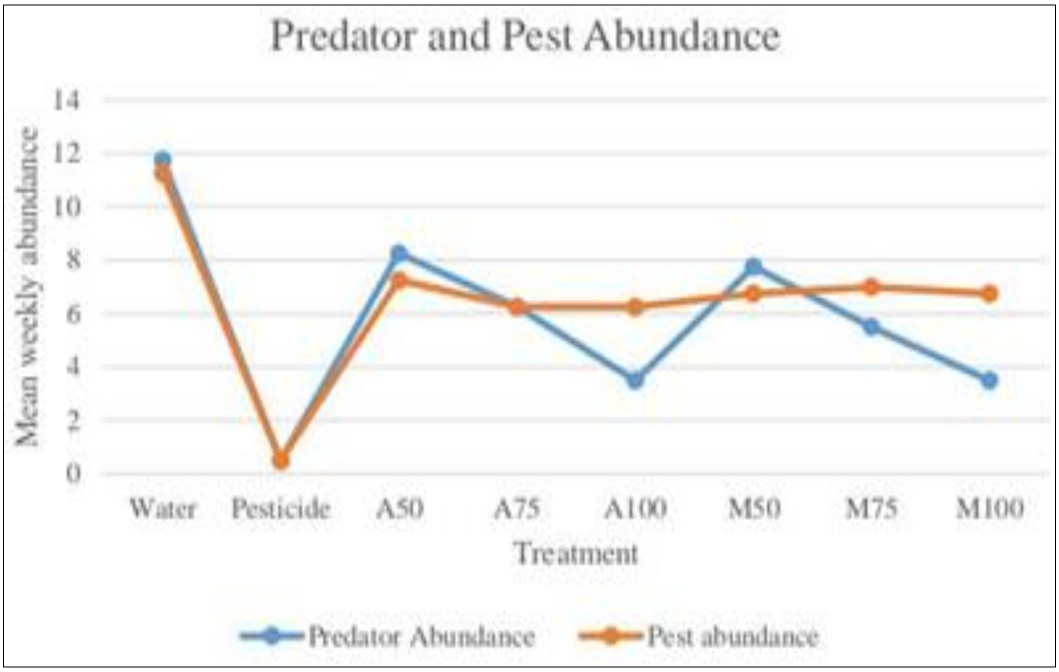
A_{50}, A_{75} and A_{100} – *A. occidentale* extract at 50, 75 and 100% v/v, M_{50}, M_{75} and M_{100} - *M. oleifera* extract at 50, 75 and 100% v/v, P - Pesticide [chlorpyriphos 20EC (Perfect killer®)] (positive control), W - Water (negative control)

Table 5 presents the average number of pests and predators collected for four weeks for each treatment and mean values of pod and seed yields. The results shows that the negative control plots (ie., plots treated with water) had significantly ($p<0.05$) the highest pest and predator abundance, while the positive control plots (ie., plots treated with chlorpyrifos) had significantly the least; which is only comparable with M_{100} treated plots in terms of predator abundance.

Among the plant based treated plots; those treated with A50 had the highest predator abundance and those treated with M_{100} had the least. With respect to pest populations; while A50 and A75 had the least values (5.7), M_{75} had the highest, 7.2.

The results also shows that differences in pod and seed yields among the treatments were due to random variation ($p>0.05$). However, plots treated with A100 had the highest pod yield (5.4 kg/m^2) and seed yield (116.3 g/m^2). Plots treated with A50 had the least pod yield (3.6 kg/m^2) and those treated with chlorpyrifos had the least seed yield (53.6 g/m^2).

Figure 1 shows the mean weekly fluctuations of the pests (*L. vinula*, *A. africana* and *S. annulus*) and predators (*C. sulphurea* and *C. propinqua*) populations' vis-à-vis the treatments applied. The fluctuations of pests and predators were observed to largely follow similar trends.



A_{50}, A_{75} and A_{100} – *A. occidentale* extract at 50, 75 and 100% v/v, M_{50}, M_{75} and M_{100} - *M. oleifera* extract at 50, 75 and, 100% v/v, P - Pesticide [chlorpyriphos 20EC (Perfect killer®)] (positive control), W - Water (negative control)

Fig 1: Effect of treatments on the mean weekly fluctuation of pests and predators

Discussion

In this study, we conducted research to evaluate the effectiveness of different concentrations of plant extracts on pest and predator abundance, as well as their impact on the yield of white-seed melon/egusi melon. Our findings revealed the presence of three major pests (*A. africa*, *L. vinula*, *S. Annulus*) and two key predators (*C. propinqua* and *C. sulphurea*) associated with crop. Interestingly, our results differed from a previous study by Alao *et al.* (2018) [2] which reported the presence of eight pests at various germination stages of the crop, with only *A. africa* being common in both studies. This variation in pest species could be attributed to differences in geographical locations and perhaps, planting times, as ecological factors such as environmental suitability and the abundance of competitor consumers or natural enemies can influence pest populations (Okrikata *et al*., 2019) [20].

Within the four weeks of treatment, the positive control (chlorpyriphos) suppressed the overall insect populations (pest and predators) by 90.1% to 100%. This result aligns with previous studies conducted by Tembo *et al*. (2018) [25] and Arshad *et al*. (2019) [4], which reported low abundance of pests and beneficial arthropods in plots treated with synthetic pesticides, while plots treated with plant extracts generally had higher numbers of pests and predators.

However, the untreated plots had higher pest and predator abundance than the biopesticide treated plots. This indicates that the biopesticide treatments have insect suppressive properties, both pest and predators. This buttresses the findings of Ogbonna *et al*. (2021) [27] which showed cabbage plants treated with moringa leaf extracts had reduced aphid infestation vis-a-vis untreated. A study conducted by Alao and Adebayo (2015) [1] showed a 50 - 62% reduction in watermelon pests when treated with moringa extract. The presence of phenols and flavonoids in moringa leaves accounts for their pesticidal properties, although the extraction medium and the preservation of bioactive compounds in the extract can influence efficacy (Vongsak *et al*., 2013) [26]. Additionally, *A. occidentale* contains phytochemicals such as phenolic acids, flavonoids, and tannins with pesticidal properties. These chemical compounds have been shown to act as antifeedants, repellents, biocides, or growth inhibitors against many insect species (Costa *et al*., 2020) [8].

Despite the higher pest abundance observed in crops treated with *A. occidentale and M. oleifera* compared to the synthetic control, the crop yields obtained from the plant extract treatments were comparable to those from the synthetic pesticide treatment. Furthermore, in our study, plots treated with A_{100} yielded the highest weight of pods and seed yield per square meter. These findings are consistent with reports by Osabutey *et al*. (2018) [23], who documented higher cabbage yields in plots treated with *Zanthoxylum zanthoxyloides* and A. *occidentale* extracts at a concentration of 6.7% w/v. Our result also aligns with the findings of Tembo *et al*. (2018) [25], who reported comparable yields from plots treated with synthetic pesticides and plant extracts. Similarly, Ogbonna *et al.* (2021) [27] reported that the plots treated with moringa extract resulted in a yield similar to that of synthetic pesticides. The similar yields across all treatments in our study may be attributed to the late planting season characterised by heavy rainfall, as egusi melon thrives in low to moderate rainfall conditions (Giwa and Akanbi, 2020) [14].

To further enhance our understanding, additional studies should be conducted to determine the action threshold for egusi pests instead of relying on fixed interval applications (Shah *et al*., 2019) [24]. Moreover, the duration of synthetic pesticide treatments should be reduced to minimise adverse effects on beneficial insects. Further research should also investigate the influence of abiotic factors on the efficacy of plant extracts.

Table 5: Treatment effect on the mean abundance of pest, predator and the resulting pod and seed yield

Treatment	Pest abundance	Predator abundance	Pod yield (kg/m^2)	Seed yield (g/m^2)
Water	11.3^c	12.0^e	4.7	94.0
Pesticide	0.3^a	0.7^a	4.1	53.6
A_{50}	6.8^b	8.2^d	3.6	88.8
A_{75}	5.7^b	6.7^{cd}	5.2	78.1
A_{100}	5.7^b	4.0^{bc}	5.4	116.3
M_{50}	7.0^b	7.2^d	4.5	72.5
M_{75}	7.2^b	5.3^{bcd}	4.1	92.5
M_{100}	6.7^b	3.5^{ab}	5.0	91.4
F-value	8.92	12.48	0.33	0.84
P-value	0.000	0.000	0.927	0.561

Means with the same superscript along a column are not significantly different at $p< 0.05$, A_{50}, A_{75} and A_{100} – *A. occidentale* extract at 50, 75 and 100% v/v, M_{50}, M_{75} and M_{100} - *M. oleifera* extract at 50, 75 and 100% v/v, P - Pesticide [chlorpyriphos 20EC (Perfect killer®)] (positive control), W - Water (negative control)

Conclusion

The synthetic pesticide, chlorpyrifos cumulatively suppressed insect populations (pest and predators) by 90.6 to 100%. Comparable values for *A. occidentale* and *M. oleifera* based biopesticide were 14.1 to 60.9% and 26.1 to 69.6%, respectively. Weekly fluctuation of pests and predators populations generally followed similar trend. Plots treated with A_{100} produced the highest pod and seed yields and the lowest seed yield was gotten from chlorpyrifos treated plots. Of interest however is that, the differences in pod and seed yields among the treatments were not significant. That differences in yields were not significant among the treatments may be attributed to heavy rainfall which characterized the late-planting seasons. We thus recommend that further studies be done to compare the performance of the biopesticide formulations in the early- and late-cropping seasons.

References

1. Alao FO, Adebayo TA. Comparative efficacy of *Tephrosia vogelii* and *Moringa oleifera* against insect pests of watermelon (*Citrullus lanatus* Thunb). International letters of natural sciences. 2015;36:71–78.
2. Alao FO, Adebayo TA, Olaniran AO. Bioefficacy of *Anacardium occidentale and Moringa oleifera* against insect pests of watermelon (*Citrullus lanatus* Thunb) and their effects on watermelon fatty acid profile. Acta Fytotechnica et Zootechnica. 2018;21(3):84-92.
3. Alao FO, Olaniran AO, Adebayo TA. Efficacy of selected plant extract mixtures on major field insect pests of watermelon (*Citrullus lanatus* Thunb). Journal

of Agriculture and Environmental Science Research. 2022;22:11-20.
4. Arshad M, Ullah MI, Çağatay NS, Abdullah A, Dikmen F, Kaya C, *et al*. Field evaluation of water plant extracts on sucking insect pests and their associated predators in transgenic *Bt* cotton. Egyptian Journal of Biological Pest Control. 2019;29(1):1-6.
5. Babatunde SF, Musa AK, Suleiman AF, Gambari LI. Effect of cashew (*Anacardium occidentale*) nut shell stored and fresh extracts on cowpea bruchid, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomelidae). Acta fytotechnica et Zootechnica. 2021;24(2):124-128.
6. Baptista A, Gonçalves RV, Bressan J, Pelúzio MDCG. Antioxidant and antimicrobial activities of crude extracts and fractions of cashew (*Anacardium occidentale* L.), cajui (*Anacardium microcarpum*), and pequi (*Caryocar brasiliense* C.): A systematic review. Oxidative Medicine and Cellular Longevity. 2018;2018:1-11.
7. Buxton T, Takahashi S, Niwata I, Owusu EO, Kim CS. Isolation and characterization of the insecticidal compounds in *Anacardium occidentale* (cashew nut) shell liquid against the rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae). Journal of entomology and zoology studies. 2017;5(2):1241-1246.
8. Costa AR, de Lima Silva JR, de Oliveira TJS, da Silva TG, Pereira PS, de Oliveira Borba EF, *et al*. Phytochemical profile of *Anacardium occidentale* L. (cashew tree) and the cytotoxic and toxicological evaluation of its bark and leaf extracts. South African Journal of Botany. 2020;135:355-364.
9. de Carvalho GHF, de Andrade MA, de Araújo CN, Santos ML, de Castro NA, Charneau S, *et al*. Larvicidal and pupicidal activities of eco-friendly phenolic lipid products from *Anacardium occidentale* nutshell against arbovirus vectors. Environmental Science and Pollution Research. 2019;26:5514-5523.
10. Desneux N, Decourtye A, Delpueoh JM. The sublethal effects of pesticides on beneficial arthropods. Annual Review of Entomology. 2007;52:81-106.
11. Eidangbe GO, Ojieh GC, Idonije BO, Oluba OM. Palm oil and egusi melon oil lower serum and liver lipid profile and improve antioxidant activity in rats fed a high fat diet. Journal of Food Technology. 2010;8(4):154-158.
12. FAO. FAOSTAT. FAO Statistics Division. www.faostat.org. 2018.
13. Gandji K, Chadare FJ, Idohou, R, Salako VK, Assogbadjo AE, Kakaï RG, *et al*. Status and utilisation of *Moringa oleifera* Lam: A review. African Crop Science Journal. 2018;26(1):137-156.
14. Giwa SO, Akanbi TO. A review on food uses and the prospect of egusi melon for biodiesel production. Bio Energy Research. 2020;13(4):1031-1045.
15. Jacob AG, Etong DI, Tijjani A. Proximate, mineral and anti-nutritional compositions of melon (*Citrullus lanatus*) seeds. British Journal of Research. 2015;2(5):142-151.
16. Karar ME, Alsunaydi F, Albusaymi S, Alotaibi S. A new mobile application of agricultural pest’s recognition using deep learning in cloud computing system. Alexandria Engineering Journal. 2021;60:4423–4432.
17. Odeyemi OO, Masika P, Afolayan AJ. A review of the use of phytochemicals for insect pest control. African Plant Protection. 2008;14(1):1-7.
18. Kaur S. Nutritional value and value-addition in Drumstick-A review. Int. J Agric. Food Sci. 2021;3(2):36-41.
DOI: 10.33545/2664844X.2021.v3.i2a.55
19. Okrikata E**,** Agere H, Olusesan AI, Malu SP, Ahmad M. Neem plus garlic oils biopesticide formulation: Safe and efficient in watermelon pest management. Agriculture Conspectus Scietificus. 2022;87(3):231-243.
20. Okrikata E, Ogunwolu EO, Ukwela MU. Efficiency and economic viability of neem seed oil emulsion and cyper-diforce® insecticides in watermelon production within the Nigerian Southern Guinea Savanna Zone. Journal of Crop Protection. 2019;8(1):81-101.
21. Olajide OA, Aderogba MA, Fiebich BL. Mechanisms of anti-inflammatory property of *Anacardium occidentale* stem bark: Inhibition of NF-κB and MAPK signaling in the microglia. Journal of Ethnopharmacology. 2013;145:42-49.
22. Olaniyi JO. Growth and seed yield response of Egusi melon to nitrogen and phosphorus fertilizers application. American-Eurasian Journal of Sustainable Agriculture. 2008;2(3):255-260.
23. Osabutey AF, Eziah V, Buxton T, Owusu EO. Evaluating the insecticidal potential of aqueous plant extracts from *Zanthoxylum zanthoxyloides* and *Anacardium occidentale* against insect pest complexes of cabbage in an open field experiment. International Journal of Agricultural Science Research. 2018;7(3):18-27.
24. Shah FM, Razaq M, Ali Q, Shad SA, Aslam M, Hardy IC. Field evaluation of synthetic and neem-derived alternative insecticides in developing action thresholds against cauliflower pests. Scientific reports. 2019;9(1):1-13.
25. Tembo Y, Mkindi AG, Mkenda PA, Mpumi N, Mwanauta R, Stevenson PC, *et al*. Pesticidal plant extracts improve yield and reduce insect pests on legume crops without harming beneficial arthropods. Frontiers in Plant Science. 2018;9:14-25.
26. Vongsak B, Sithisarn P, Mangmool S, Thongpraditchote S, Wongkrajang Y, Gritsanapan W. Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. Industrial crops and products. 2013;44:566-571.
27. Ogbonna CU, Okonkwo NJ, Nwankwo EN, Alo MN, Egbuche CM, Ezemuoka LC, *et al*. Aqueous extract of *Moringa oleifera* leaf in the management of insect pest of cabbage plant both in the laboratory and field. International Journal of Entomology Research. 2021;6(2):88-98.