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Original Paper

Bioefficacy of *Moringa oleifera* and *Anacardium occidentale* against insect pests of watermelon (*Citrullus lanatus* Thumb) and their effects on watermelon fatty acid profile

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This experiment was carried out at Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeriaduring the late and early planting seasons of 2011 and 2012 to determine the efficacy of *Moringa oleifera* (L) and *Anacardium occidentale* (L) extracts on major insect pests of pests of watermelon and their effects on fatty acid compound of watermelon. This experiment was arranged in a randomized complete block design and each treatment was replicated three times. Each of the plant extracts was applied at three different concentrations (5, 10 and 20% v/v). Gas chromatography was used to determine the level of fatty acid composition of the harvested watermelon. The results showed that the applied plant extracts exhibited insecticidal action against *Aulocophora africana* (Weise) and *Dacus cucurbitae*(Coquillet), with *M. oleifera* proved to be more effective than *A. occidentale* extracts in the control of the observed insects. Although, none of the plant extracts significantly(P >0.05) performed better than synthetic insecticide (Lambdacyhalothrin) against the studied insects during the raining season fruits obtained from extracts treated-plots had higher number of fatty acid compounds than those of the synthetic insecticide treated-plots. Therefore, the use of botanical extracts in the management of insect pests of watermelon improved the fatty acid contents of watermelon fruit.

Keywords: *Moringa oleifera*, *Anacardium occidentale, Aulocophora africana*, *Dacus cucurbitae*, Lambdacyhalothrin, watermelon

1 Introduction

Watermelon (*Citrullus lanatus* Thumb) belongs to the Cucurbitacea family which includes about 118 genera and 825 species (Dane, 2007). It originated from Kalahari and Sahara deserts in Africa (Schippers, 2000) and now found in Tropical and subtropical climates worldwide. It has been reportedly cultivated for a long time in Africa and in the middle East and Egypt (Huh, 2008).

According to Schippers (2000), the fruit reportedly contains 95% water, 5 mg Carbohydrate, 8 mg Calcium, 0.64 g vitamins, 9 mg Phosphorous and 8 mg ascorbic acid per 100 g of edible portion. It has highest Lycopene, content among fresh fruits and vegetables, containing 60% more Lycopene than tomato. Lycopene has been reported to prevent heart attack and certain cancers (Perkins-Veazie, 2001). Rind of watermelon contains an important natural compound called Citrulline, an amino acid that is required by human body. Citrulline is found in high concentration in liver and is involved with athletic ability and functioning of immune system (Perkins-Veazie, 2001). Also, it is a good source of fiber which is important for keeping digestive tract operating properly by preventing constipation, hemorrhoids and diverticular disease

Cultivation of watermelon in Nigeria especially in Southern part of the country is low due to the high level of insect infestations during early season (Alao et al., 2015). Insect pests such as, *Aulocophora africana*, *Zonocerus variegatus*, *Phylothreta cruciferae*, *Dacus cucurbitae* etc. have been implicated to cause various degree of damage to this crop (Olaifa, 1987). Also, most of these insects are responsible for the transmission of diseases (Webb, 2010).

In order to obtain high fruit yield, protection of this crop against aforementioned insects is highly necessary. In developing countries, farmers apply synthetic insecticides to combat the insect pest attack of watermelon. Synthetic insecticides have quick action against the insect pest infestation but they are not easily degraded in the environment thereby resulting into environmental

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pollution (Isman, 2006). Some of these insects have been reported to develop resistance to the application of synthetic insecticides. Consumers as well as farmers are not saved from the use of synthetic insecticides. In view of these facts, alternatives to the use of synthetic insecticide should be initiated and such alternatives must be affordable, effective and environmentally friendly (Isman, 2008).

Several research works have been conducted on the use of plant secondary metabolites, which have been found to be effective against insect pests of some crops (Adebayo, 2003; Akhtare et al., 2008; Olaniran et al., 2013; Alao, 2015) *Moringa oleifera* also known as Horseradish tree, is a pan-tropical species that is known by such regional names as benzolive, drumstick tree, kelor, marango, saijhan and sajna (Fashey, 2005). *M. oleifera* can be grown in a variety of soil conditions preferring well-drained sandy or loamy soil that is slightly alkaline (Abdul, 2007; Anjorin et al., 2010). The main constituents of Moringa plant are oleic, palmitic and stearic acid, saponins, glycoside, gum, protein, vitamins A (8855iuper 100g), B1, B2, B3, C, Minerals: calcium, iron, phosphorus, magnesium (Mitta et al. 2007, Anjorin et al., 2010, Mehta et al., 2011). The medicinal effect of the plant was ascribed to their possession of anti-oxidants, which are known to suppress formation of reactive oxygen species and free radicals (Sofidiya et al., 2006; Ogbunugafor et al., 2011). It is a good source of nectar used by the honey bees for production of honey (Babarinde, 2009). Its insecticidal potentials against many insect pests have been reported by several authors (Babarinde et al., 2011; Ashfaq and Ashfaq, 2012; Santos et al., 2018). Cashew nut shell liquid (CNSL) contains a high proportion of phenolic compound, Anarcadic acid and Cardole (Oparaeke et al., 2005; Olotuah and Ofuya, 2010; Mukhopadyay et al.,2010). Ethanolic extract of cashew nut shell liquid was effective as synthetic insecticide (Cymbush) against field insect pests of cowpea (Olotuah and Ofuya, 2010). In addition to that insecticidal activities on stored insect pests have also been documented. For instance, Oparaeke and Bunmi (2006) observed that cashew nut shell caused 100% mortality of *Callosobruchus subannotatus* within 48 hours pot application.

However, most of these researchers did not consider the impacts of botanical insecticides on the nutritional contents of their particular studied crops. This has become necessary because the some crops are capable of absorbing the foreign materials into their body system which could generate a reaction on the phytochemical compounds inherent in the plant part. Therefore, this research was carried out to evaluate the insecticidal efficacy of *Moringa oleifera* and *A. occidentale* and their impact on the fatty acid compound of watermelon fruits.

2 Material and methods

2.1 Study site

The field experiment was conducted in the cropping season of 2013 and 2014 at Ladoke Akintola University of Technology (LAUTECH) Teaching and Research Farm, Ogbomoso, Nigeria. This region is on longitude 4° 3' E and latitude 10° 5' N. The region can be described as humid tropical falls in Southern Guinea Savannah of Nigeria.

2.2 Experimental design and management

The experimental land was ploughed and harrowed once. There were four treatments and each of the treatment was replicated three times in a Randomized Complete Block Design (RCBD). The plot size was 3 m by 3 m and each plot had four plant rows. Poultry manure was applied at 10 t/ha to all treated and untreated plots to ensure uniform distribution of the soil nutrients. This was done prior to the sowing of the watermelon seeds. The test crop was watermelon (variety Baby sugar). Two to four seeds were sown per hole which was later thinned after 14 days to achieve one plant per stand. Weeding was done manually.

2.3 Preparation of plant extracts

The leaves of *M. oleifera* and *A. occidentale* were air-dried for two days and each of the plant material was crushed separately with mortar and pestle. Five hundred grams (500 g) of the crushed plant materials were weighed separately with sensitive scale after which each of the paste was put into a separate 10-litre plastic buckets containing 1000 ml of water. The soaked materials were allowed to stay overnight. The filtration was done with muslin cloth and filtrates collected were stored in a 5-litre plastic keg as stock solution. One litre of each of the plant extracts was measured out from the stock solution of which three concentrations (5, 10 and 20%) were calculated (Alao and Adebayo, 2016).

2.4 Treatment application

Application of the treatment commenced three weeks after planting and this was done early in the morning with 2-litre capacity hand held sprayer. Each of the concentrations of the plant extracts and synthetic insecticide were further diluted with 1,000 ml of clean water to achieve the same spraying volume. Untreated plots were sprayed with ordinary water and synthetic insecticide was applied at 400 ml per ha. Spraying was done at seven- day intervals and four- weekly observations were made.

2.5 Data collection and analysis

Population densities of adult *Phyllotreta cruciferae*, *Aulocophora africana*, *Diabrotica undecimpunctata* and *D. cucurbitea* were made by visual observation and this was done a day after each weekly treatment. Random sampling of the insects was done from the two middle plant rows. This was done early in the morning when they were relatively inactive (Alao and Adebayo, 2016).

Data were also collected on matured fruit damaged, defoliated flowers and young fruit damaged using the method described by Alao and Adebayo (2016).

Three months after planting, the matured fruits were harvested and weighed on the field with manual scale in kilogram (kg) which was later calculated in ton per hectare (t/ha). Collected data were subjected to analysis of variance (ANOVA) and significant means were separated using Ducan multiple range text at 5% probability.

2.6 Extraction of fatty acid compounds

The fatty acid methyl esters were extracted thrice from the mixture with redistilled n-hexane. A 50 mg portion of the extracted oil (extracted with n-hexane boiling point of 40–60 °C using Soxhlet apparatus). The sample collected was esterified for five minutes at 95 °C with 3.4 ml of the 0.5 M KOH in dry methanol. The mixture was neutralized by using 0.7 M HCL and 3 ml of 14% boron triflouride in methanol. The mixture was heated for 5 minutes at the temperature of 90 °C to achieve complete methylation process. The content was concentrated to 10 ml for gas chromatography analysis and 1 µl was injected into the injection port of GC. The fatty acids were identified by comparing their retention times with those of standards. The content of the fatty acids was expressed as percentage of total fatty acids.

2.7 Quantification of fatty acid compounds

Presence of fatty acid in the treated and untreated watermelon fruit was determined with the aid of gas chromatography with column dimensions 30 m × 0.25 mm × 0.25 µm, column type Agilent 19091-433HP-5MS 5% phenyl methyl silox. The Machine model was 7890A GC system, 5675C Inert MSD with triple Axis detector. GC-MS conditions were ion source temperature (EI), 250 °C. interface temperature; 300 °C, pressure; 16.2 psia, out time, 1.8 mm, lµl injector in Split mode with split ratio 1:50 with injection temperature of 300 °C the column temperature started at 100 °C for 1min and changed to 200 °C at the rate of 4 °C per min, the temperature was raised to 230 °C at the rate of 2 °C per min and the temperature was then raised to 280 °C at the rat of 8 °C per min and held for 15 min and helium as a carrier gas. The total elution was 62.25 min. This was done at University of Ilorin Kwara state, Nigeria. MS Solution software provided by supplier was used to control the system and to acquire the data; Identification of the compounds was carried-out by comparing the mass spectra obtained with those of the standard mass spectra from NIST library (NIST, 2005).

3 Results and discussion

3.1 Effect of botanical extracts and synthetic insecticides on Dacus cucurbitae populations

The results presented in Table 1 shows that the two tested plant extracts had the same insecticidal effects at 1 week after treatment (WAT) but there were not significantly effective as Lambdacyhalothrin in both planting seasons. Similar result was obtained at 2 WAT during early season. Application of *M. oleifra* at 20% v/v significantly performed better than other tested concentrations at 3 WAT. Although *A. occidentale* extract at 20% v/v was not aseffective as *M. oleifera* at the same rate. The latter significantly controlled *D. cucurbitae* than 10 and 5% v/v at 3 WAT during early season. *A. occidentale* sprayed at 5 and 10% v/v failed to control *D. cucurbitae* when compared with populations of *D. cucurbitae* observed on the unsprayed plots in the early season.

Applied plant extracts at 20% v/v significantly proved effective in the control of *D. cucurbitae* compared

Table 1 Population of *Dacus cucurbitae* on watermelon plots treated with botanical extracts and synthetic insecticide

		Weeks After treatment (Early Season)				Weeks After treatment (Late Season)			
Treatments	Rate	1	2	3	4	1	2	3	4
Lambdacyalothrin		1.4^{b}	1.0^{b}	0.7c	0.7c	1.0^{a}	0.7^{b}	0.7c	0.7^{b}
Control		2.2^{ab}	2.5^{a}	2.3^{a}	2.4^{a}	1.7^{a}	1.7^{a}	1.8^{a}	1.7^{a}
Moringa oleifera	5	2.1^{ab}	2.1^{a}	1.9^{ab}	1.9^{ab}	1.2^{a}	1.4^{a}	1.2^{ab}c	1.4^{ab}
	10	2.0^{ab}	2.2^{a}	1.9^{ab}	1.9^{ab}	1.2^{a}	1.3^{ab}	1.0c	1.3^{ab}
	20	2.0^{ab}	2.1^{a}	1.6^{b}	0.7c	1.2^{a}	1.2^{ab}	0.9c	1.0^{ab}
Anacardium occidentale	5	2.3^{a}	2.2^{a}	2.4^{a}	2.0^{ab}	1.4^{a}	1.4^{a}	1.7^{ab}	1.7^{a}
	10	2.0^{ab}	2.2^{a}	2.3^{a}	1.9^{ab}	1.4^{a}	1.5^{a}	1.3^{ab}c	1.4^{ab}
	20	2.1^{ab}	2.3^{a}	2.1^{ab}	1.7^{b}	1.3^{a}	1.3^{ab}	1.1^{b}c	1.3^{ab}

Means with the same superscript along the column are not significantly different at 5% probability using DMRT

Table 2 Population of Aulocophora africanaon watermelon plots treated with botanical extracts and synthetic insecticide

Treatments	Rate	Weeks After treatment (Early Season)				Weeks After treatment (Late Season)			
		1	2	3	4	1	2	3	4
Lambdacyalothrin		1.9^{b}	1.4^{c}	1.0^{d}	0.7^{e}	1.2^{b}	1.0^{b}	0.7^{d}	0.7^{b}
Control		2.6^{a}	2.8^{a}	2.5^{a}	2.2^{a}	2.0^{a}	2.3^{a}	2.3^{a}	1.5^{ab}
Moringa oleifera	5	2.2^{ab}	2.3^{ab}	1.9^{abc}	1.3^{cd}	1.7^{ab}	1.8^{ab}	1.5^{bcd}	1.2^{ab}
	10	2.2^{ab}	1.9^{abc}	1.4^{cd}	1.0^{de}	1.6^{ab}	1.8^{ab}	1.1^{cd}	1.0^{ab}
	20	1.9^{ab}	1.9^{bc}	1.3^{cd}	0.9^{de}	1.5^{ab}	1.6^{ab}	1.0^{cd}	0.7^{b}
Anacardium occidentale	5	2.4^{ab}	2.3^{ab}	2.1^{ab}	1.9^{ab}	2.0^{a}	2.0^{a}	2.0^{ab}	1.8^{a}
	10	2.4^{ab}	2.3^{ab}	2.1^{ab}	1.7^{bc}	1.9^{a}	2.0^{a}	1.9^{ab}	1.6^{ab}
	20	2.2^{ab}	2.1^{abc}	1.7^{bcd}	1.3^{cd}	1.8^{ab}	1.9^{ab}	1.7^{abc}	1.2^{ab}

Means with the same superscript along the column are not significantly different at 5% probability using DMRT

Table 3 Effect of botanical extracts and synthetic insecticide on Yield

Treatments	Rate	Yield Parameters (Early Season)					Yield Parameters (Late Season)				
		yield (t/ha)	fruit damage (%)	aborted fruit (%)	defoliated flower (%)	defoliated leave (%)	yield (t/ha)	fruit damage (%)	aborted fruit (%)	defoliated flower (%)	defoliated leave (%)
Lambdacyalothrin		34.0^{a}	17.4^{e}	17.2^{f}	8.4^{c}	13.8^{d}	25.6^{a}	8.4^{c}	13.8^{d}	3.8^{c}	8.9^{c}
Control		8.11^{c}	45.4^{a}	49.5^{a}	38.8^{a}	34.0^{a}	12.0^{c}	38.8^{a}	33.8^{a}	33.9^{a}	43.0^{a}
Moringa oleifera	5	13.9^{c}	36.6^{bc}	33.3^{cde}	23.1^{bc}	24.7^{bc}	17.2^{bc}	23.1^{bc}	24.7^{bc}	28.7^{ab}	30.8^{ab}
	10	18.8^{bc}	31.9^{cd}	31.7^{de}	20.5^{bc}	22.8^{c}	18.6^{abc}	20.5^{bc}	22.8^{c}	24.6^{ab}	28.1^{abc}
	20	26.8^{ab}	30.5^{d}	27.2^{e}	18.9^{bc}	22.3^{c}	22.0^{ab}	18.9^{bc}	22.3^{c}	18.9^{b}	21.1^{bc}
Anacardium occidentale	5	10.8^{c}	40.9^{ab}	42.8^{ab}	25.3^{ab}	31.8^{ab}	13.4^{c}	25.3^{ab}	31.8^{ab}	29.4^{ab}	40.8^{ab}
	10	14.3^{bc}	37.3^{bc}	39.3^{bc}	26.2^{ab}	25.5^{abc}	14.8^{c}	26.2^{ab}	25.5^{abc}	27.0^{ab}	35.2^{ab}
	20	20.7^{bc}	33.7^{cd}	35.2^{cd}	21.5^{bc}	25.6^{abc}	18.8^{abc}	21.5^{bc}	25.6^{abc}	24.2^{ab}	31.0^{ab}

Means with the same superscript(s) along the column are not significantly different at 5% probability using DMRT.

with other concentrations and *A. occidentale* (5, 10 and 20%) during early planting season at 4 WAT. In the early planting season, *M. oleifera* sprayed at 20% v/v competed effectively with Lambdacyhalothrin in the control of *D. cucurbitae*. All the applied plant extracts had significant efficacy when compared with control except *A. occidentale* applied at 5% v/v.

3.2 Effect of botanical extracts and synthetic insecticide on *Aulocophora africana* populations

The result presented in Table 2 shows that the tested plant extracts had the same significant insecticidal effects on *A. africana* irrespective of their concentrations at 1 WAT during early season. During the late planting season, *M. oleifera* had significantly higher effect than *A. occidentale* on *A. africana* except the plots treated with *A. occidentale* at 20% v/v. However, *A. occidentale* applied at 5 and 10% v/v did not exhibit insecticidal action during late planting season at 1 WAT.

The plots treated with *M. oleifera* at 20% v/v had the least *A. africana* population compared with other tested concentrations and *A. occidentale* during early planting season at 2 WAT. No significant difference was detected between the efficacy of *A. occidentale* applied at 5 and 10% v/v in both planting seasons at 2 WAT. At 3 WAT, plots sprayed with *A. occidentale* at 5 and 10% v/v had highest infestations when compared with *M. oleifera* (5, 10 and 20% v/v) and *A. occidentale* at 20% v/v but all the applied plant extracts exhibited insecticidal action against *A. africana* when compared with the control in both seasons. Plots treated with *M. oleifera* at 10 and 20% v/v had significantly lower *A. africana* population than plots treated with *A. occidentale* (5, 10 and 20% v/v) and *M. oleifera* treated with 5% v/v during early planting season at 4 WAP. However, during late planting season applied *A. occidentale* at 10 and 20% v/v had the same insecticidal potential with *M. oleifera* at 5% and 10% v/v.

3.3 Effect of botanical extracts and synthetic insecticide on watermelon agronomic parameters

Table 3 shows that pants sprayed with *M. oleifera* had significantly highest yield (26.8 and 22 t/ha respectively) in the both planting seasons when compared with other plant extracts tested concentrations and unsprayed plants (8.11 and 12.0 t/ha, respectively). No significant difference was observed in the yield obtained in *M. oleifera* treated plants at 10% v/v and *A. occidentale* treated plots at 10 and 20% v/v during early planting season but during late planting season, the obtained yield was significantly higher in *M. oleifera* treated plants than what was obtained in the plots treated with *A. occidentale*. However, yield obtained in the unsprayed plants (12.0 t/ha) was significantly the same as that of plots sprayed with *A. occidentale* at 5 and 10% v/v (13.4 and 14.8 t/ha respectively).

The least percentage of fruit damaged was recorded in Lambdacyhalothrin sprayed plants (8.4%) compared with applied treatments and unsprayed plants which had significant highest damaged fruit (38.8%) during late planting season. The result obtained in the early planting season follows the same trend as in the case of late planting season. Among the tested concentrations (5, 10 and 20% v/v), plots treated with *M. oleifera* at 20% had the lowest percentage fruit damaged during early planting season; but during late planting season, plots treated with *A. occidentale* and *M. oleifera* highest concentration had the least fruit damaged (21.5 and 18.9% respectively).

In respect to aborted fruit, untreated plants had highest percentage of aborted fruits in both seasons followed by the plots sprayed with the least plant extracts concentrations. *M. oleifera* extracts performed better in the prevention of aborted fruits than *A. occidentale*. None of these plant extracts exhibited higher level of prevention of abortion of young fruits as obtained in Lambdacyhalothrin- treated plants.

Number of defoliated flower observed in the Lambdacyhalothrin statistically compared to other treated plants and untreated plants during both planting seasons. Plants sprayed with *M. oleifera* at 20% v/v had the least defoliated flower in both planting seasons when compared with other plant extracts concentrations.

M. oleifera applied at 10% v/v competed effectively with *M. oleifera* at 20% v/v in respect to number of defoliated leaves. *M. oleifera* was more effective in the protection of leaves from being defoliated compared with *A. occidentale*.

Table 4 shows the effects of insecticides application on different unsaturated/saturated fatty acid compounds on watermelon fruits. Three fatty acid were observed in the synthetic insecticide Lambdacyhalothrin-treated fruits, which were Heptadecanoic acid, Nonadecanoic acid and Heneicosanic acid. However, five fatty acid Pentadecanoic, Heptadecanoic, Nonadecanoic, Heneicosanoic and Tricosanoic acids were detected in the fruits obtained from the plots treated with plant extracts and untreated fruits. Among the fatty acid, Heptadecanoic acid had highest percentage composition whereas Tricosanoic had the least composition in *A. occidentals* and untreated watermelon fruits but Pentadecanoic acid had the least composition in *M. oleifera*-treated fruits.

This experiment demonstrates the effectiveness of *M. oleifera* and *A. occidentale* in the control of *D. cucurbitae* and *A. africana*. Meanwhile, there was variation in

Table 4 Fatty acids profile of watermelon fruits obtained from plots treated with botanical extracts and synthetic pesticide

Source	Peak	Retention time RT	Compound Name	Chemical formula	% Composition
Lambdacyhalothrin	1-Absent				
	2	16.099	Heptadecanoic acid, methylester	$C_{18}H_{36}O_2$	55.1
	3	21.722	Nonadecanoic acid, methylester	$C_{20}H_{40}O_2$	15.9
	4	26.855	Heneicosanoic acid, methylester	$C_{22}H_{44}O_2$	30
	5-Absent				
Control	1	10.091	Pentadecanoic acid, methylester	$C_{16}H_{32}O_2$	5.12
	2	16.093	Heptadecanoic acid, methylester	$C_{18}H_{36}O_2$	57.7
	3	21.729	Nonadecanoic acid, methylester	$C_{20}H_{40}O_2$	15.4
	4	26.873	Heneicosanoic acid, methylester	$C_{22}H_{44}O_2$	20.2
	5	31.561	Tricosanioc acid, methylester	$C_{24}H_{48}O_2$	4.66
Moringa oleifera	1	10.11	Pentadecanoic acid, methylester	$C_{16}H_{32}O_2$	2.41
	2	16.098	Heptadecanoic acid, methylester	$C_{18}H_{36}O_2$	42.8
	3	21.72	Nonadecanoic acid, methylester	$C_{20}H_{40}O_2$	9.09
	4	26.87	Heneicosanoic acid, methylester	$C_{22}H_{44}O_2$	16.1
	5	31.567	Tricosanioc acid, methylester	$C_{24}H_{48}O_2$	8.79
Anacardium occidentale	1	10.091	Pentadecanoic acid, methylester	$C_{16}H_{32}O_2$	7.68
	2	16.089	Heptadecanoic acid, methylester	$C_{18}H_{36}O_2$	57.5
	3	21.733	Nonadecanoic acid, methylester	$C_{20}H_{40}O_2$	15.1
	4	26.881	Heneicosanoic acid, methylester	$C_{22}H_{44}O_2$	15.1
	5	31.572	Tricosanioc acid, methylester	$C_{24}H_{48}O_2$	4.62

the efficacy of the tested plant extracts against the observed insects. During the early planting *M. oleifera* had higher efficacy (57%) against the observed insects than *A. occidentale* which had 43% efficacy. This is an indication that *M. oleifera* exhibited higher insecticidal potential than *A. occidentale*. This observation is in line with earlier report by Alao (2015) who reported that *A. occidentale* extracts had the least insecticidal potential when compared with other selected plant extracts against insect pests of watermelon.

There was a significant reduction in the level of insect infestation in the plots treated with plant extracts compared with unsprayed plots. This suggests that the observed insects were susceptible to Quercetin and Kampeferol (Pace-Asciak et al., 1995) derived from *M. oleifera* and Anacardic acid and Cardanols (Rehm and Espig, 1991) which have been reported as insecticidal compounds in cashew nut extract. None of the applied plant extracts proved to be effective as the synthetic insecticide (Lambdacyhalothrin) during early planting season. This could be attributed to photo-stability of synthetic insecticide and environmental factors such as wind, sunlight and temperature which reduced the insecticidal potential of the plant based-insecticides (Eileen and Sydney, 2013). Meanwhile, the tested plant extracts compete effectively with Lambdacyhalothrin in the control of *A. africana* and *D. cucurbitae* in the late planting season this might have been due to low infestation rate of the target insects. Also, variation in the chemical composition of the plant extracts used due to seasons and weather factors can be another factor. Studies have shown that the variations in the secondary metabolites of botanicals occur in respect to age, locations and seasons and collection time (Isman, 2006; Usman et al., 2017). The efficacy of each of the tested plant extracts depended on the rate of application (Alao et al., 2011). These data suggest that the higher applied concentration exerted lower level of insect infestation. This observation concurs with earlier reports by Seljasen and Meadow (2005) and Alao and Adebayo (2015) who reported that the applied plant extracts acted in a dose- dependent manner in the control of insect pests.

The ultimate aim of every poor-resource farmers is high yield (Adebayo, 2003). However, the major factor militating against fruit yield is the insect infestation which affects both physiological and morphological structure of the target crop (Alao et al., 2016). *D. cucurbitae* has been implicated for the premature falling of young fruits and damage of matured ones (Dihllion et al., 2005). Therefore, the low yield obtained in the unsprayed plants clearly showed that the rate of insect infestation was higher in unprotected plants than protected plots. Lambdacyhalothrin-treated plants had low insect infestations with corresponding higher yield than botanical treated plants.

Fatty acids are widely occurring in natural fats and dietary oils and theyplay an important role as nutritious substances and metabolites in living organisms (Cakir, 2004). It was observed that application of Lambdacyhalothrin resulted into reduction in fatty acid composition of watermelon despite the fact that it had the highest yield of watermelon fruits. Meanwhile, plant extracts treated fruits were very rich in fatty acids. This implies that botanical insecticides had positive impact in the fatty acid profile of watermelon fruits when compared with Lambdachyalothrin. Polyunsaturated fatty acids have been described as the major nutritional contents which responsible for the proper functioning of the brain, eyes and entire nervous system. Although, uncontrolled intake of dietary lipids constitute a major health risk factor (Ntsomboh-Ntsefong 2016). Meanwhile, significant variation detected among the treated fruits revealed that the applied plant extracts and synthetic insecticide were absorbed from the soil and translocated to other part of the plant thereby impacting negatively or positively in the nutritional content of watermelon fruits.

4 Conclusions

The results indicate that the applied treatements were observed into the plant physiological systems and influenced the chemical composition of the treated plants. Lambdacyhalothrin controlled the target insects but decreased the fatty acid composition whereas botanical insecticide exhibited insecticidal action on the major insect pests and also improved the fatty acid profile of the treated watermelon fruits, It shows the potentials of the botanical insecticide on the improvement of the health of the consumers. Also, the safety of the environment through the use of plant extracts is assured. Therefore, the use of secondary metabolites of botanical origin in the pest control schemes should be encouraged among the rural farmers.

References

ABDUL, D.A.S. (2007) *Economic importance of Moringa oleifera in Tafa Local Government Area of Niger State. NDE project.* Kaduna: Federal College of Forestry Mechanization.

ADEBAYO, T.A. (2003) *Efficacy of mixture formulations of synthetic and botanical insecticides in the control of insect pests of okra and cowpea: Ph.D. Thesis.* Ogbomosho: Ladoke Akintola University of Technology.

AKHTAR, Y., YEOUNG, V.R. and ISMAN, M.B. (2008) Comparative bioactivity of selected extracts from Meliaceac and some commercial botanical insecticides against two noctuid caterpillar. *Trichoplusia* and *Pseudaletiaunipuncta*. *Phytochemistry Reviews*, vol. 7, pp. 77–88.

AKHTAR Y. and ISMAN, M.B. (2004) Comparative growth inhibitory and antifeedant effects of plant extracts and pure allelochemicals on four phytophagous insect species. *Journal of Applied Entomology,* vol. 128, pp. 32–38.

ALAO, F.O. (2009) *Insecticidal principle of allellochems derived from Tephrosia vogelli and petiverian alliacea on post flowering insect pests of cowpea: M. Tech Dissertation.* Ogbomoso: Ladoke Akintola University of Technology.

ALAO, F.O. (2015) *Effects of plant extracts in the control of field insect pests associated with watermelon: Ph.D. thesis.* Ogbomosho: Ladoke Akintola University of Technology.

ALAO, F. O. and ADEBAYO, T. A. (2015) Comparative efficacy of *Tephrosia vogelii* and *Moringa oleifera* against insect pests of watermelon (*Citrulus lanatus* Thumb). *International letters of natural sciences,* vol. 36, pp. 71–78.

ALAO, F.O. et al. (2016) Population density of insect pests associated with watermelon (*Citrullus lanatus* Thumb) in southern guinea savanna zone, Ogbomoso. *Journal of Entomology and Zoology Studies,* vol. 4, no. 4, pp. 257–260.

ALAVANJA, et al. (2004) Health effects of chronic pesticide exposure: cancer and neurotoxicity. *Annual Review of Public Health,* vol. 25, p. 155.

ALLWOOD, A.J. et al. (1999). Host plant record of fruit flies (*Diptera*; *Tephritidae*) in southeast Asia. *The Raffles Bulletin in zoology supplies,* vol. 7, 92 p.

ANJORIN, T.B. et al. (2010) Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. International. *Journal of Agriculture and Biology,* vol. 12, pp. 431–434.

ANJORIN, T.S. et al. (2010) Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. *International Journal of Agriculture Biology,* vol. 12, pp. 431–434.

ASOGWA, E.U. et al. (2007) Evaluation of cashew nut shell liquid (CNSL) as a potential natural insecticide against termites (soldiers and workers Castes). *Research Journal of Applied Sciences,* vol. 2, no. 9, pp. 939–942.

BABARINDE, S.A. (2009) Tree bees use – *Moringa oleifera*. *Bees for Development Journal,* vol. 92, p. 11.

BABARINDE, S.A. et al. (2011) Bioactivity of *Piper guineense* Schum. & Thonn seed and *Moringa oleifera* Lam. leaf powder against *Trogoderma granarium* Everts (Coleoptera: Dermestidae). *Archives of Phytopathology and Plant Protection,* vol. 44, no. 3, pp. 298–306.

CAKIR, A. (2004) Essential oil and fatty acid composition of the fruits of *Hippophae rhamnoides* L. (Sea Buckthorn) and *Myrtus communis* L. from Turkey. *Biochem. System. Ecol.,* vol. 32, pp. 809–816.

BAMISHAIYE, E.I. et al. (2011) Proximate and Phytochemical composition of *Moringa oleifera* leaves at three stages of maturation. *Advance Journal of Food Science and Technology,* vol. 3, no. 4, pp. 233–237.

DANE, F. and LIU, J. (2007) Diversity and origin of cultivated and Citron type watermelon (*Citrullus lanatus*). *Genet Resour Crop Evol,* vol. 54, pp. 1255–1265.

DE LIMA, S.G. et al. (2008) Effects of immature cashew nut-shell liquid (*Anacardium occidentale*) against oxidative damage in *Saccharomyces cerevisiae* and inhibition of acetylcholinesterase activity. *Genetics and Molecular Research,* vol. 7, no. 3, pp. 806–818.

DENT, D. (1991) *Yield loss assessment.* In: Insect pest management. Wiltshire: C.A.B. International, Redwood Press.

DERKE, E.C. and DEHNE, H.W. (2004) Safeguarding Production losses in major crops and the role of crop protection. *Crop Protection.* vol. 23, pp. 275–285.

DHILLION, M.K., et al. (2005) The melon fruits fly, *Bactrocera cucurbitae*: a review of its biology and management. *Journal of Insects Science,* vol. 5, p. 40.

FASHEY, J.W. (2005) *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. *Trees Life J.,* no. 1, p. 5.

EILEEN, A.B. and SYDNEY, G.P.B. (2013) Natural products for managing landscaping and garden pests in Florida. EDIS.

GICHIMU, B.M. et al. (2009) Morphological characterization of some wild andcultivated watermelon (Citrullus sp.) accession in Kenya. *ARPN Journal of Agricultural and Biological Science,* vol. 4, pp. 1990–6145.

HASYIM, A. et al. (2008) Population fluctuation of the adult males of the fruits fly, *Bactrocera tau* Walker (*Diptera*: *Tephritidae*) in passion fruit orchards in relation to abiotic factors and sanitation. *Indones*. *J. Agric. Sci*., vol. 9, no. 1, pp. 29–33.

INDRA, P.S. and KAMINI, V. (2003). *Control of flea beetle, Phyllotreta nemorum L. (Coleoptera: Chrysomelidae) using locally available natural resources.* Tribhuvan: Central Department of Zoology, Tribhuan University, Kathmandu, Nepal.

ISMAN, M.B. (2006) Botanical insecticides, deterrents and repellents in modern agriculture and increasingly regulated world. *Annual Review of Entomology,*vol. 51, pp. 45–66.

ISMAN, M.B. (2008) Perspective Botanical Insecticides: for richer for poorer. *Pest Management Science,* vol. 64, pp. 8–11.

KHAN M, et al. (2007) Effect of Neem leaf dust and a commercial formulation of a neem compound on the longevity, fecundity and ovarian development of the melon fly, *Bactrocera cucurbitae* (Coquillet) and the oriental fruit fly, *Bactrocera dorsalis* (Hendel) (*Diptera*: *Tephritidae*). *Pakistan Journal of Biological Sciences,* vol. 10, pp. 3656–3661.

MUKHOPADHYAY, et al. (2010) Larvicidal properties of cashew nut shell liquid (*Anarcardium occidentale* L.) on immature stages of two mosquito species. *Journal of Vector Borne Disease*, vol. 47, pp. 257–260.

MITTAL, M., et al. (2007) Pharmacognostical and phytochemical investigation of antidiabetic activity of *Moringa oleifera* Lam leaf. *Ind. Pharm.,* vol. 6, pp. 70–72.

OBERLIES, et al. (1997) Structure activity relationships of diverse *Annonacers acetogenins* against multidrug resistant human mammary *adennocarcinnoma. Journal medical chemistry*, vol. 40, pp. 2012–2106.

OGBUNUGAFOR, H.A. et al. (2011) Physic-chemical and antioxidant properties of *Moringa oleifera* seed oil. *Pakistan Journal of Nutrition,* vol. 1, no. 5, pp. 409–414.

OLAIFA, J.I. and ADEBAYO, T.A. (2003) Procedure for evaluation of toxicity and dosage and plant based pesticides. *Journal of Annals of Agriculture Sciences,* vol. 3, no. 2, pp. 31–37.

OLANIRAN, et al. (2013) Control of foliage pests of roselle (*Hibscus sabdariffa* L.) using plant extracts of *Tephrosia vogelii* and *Azardiractha indica* in Ogbomoso Nigeria. *Transnational Journal of Science and Technology,* vol. 3, no. 6, pp. 51–62.

OLOTUAH, O.F.and OFUYA, T.I. (2010) Comparative protection of cowpea, *Vigna unguiculata* L.) Walpers against field insect pests using cashew nut shell liquid and Cypermethrin (Cymbush). *Pakistan Journal of Nutrition,* vol. 9, no. 2, pp. 158–161.

OPARAEKE, A.M., Bunmi (2006) Insecticidal potential of cashew (*Anacardium occidentale* L.) for control of the beetle, *Callosobruchus subinnotatus* (Pic) (*Bruchidae*) on bambara groundnut (*voandzeis subterranean* L.). Verde *Archives of Phytopathology and Plant Protection,* vol. 39, no. 4, pp. 247–251.

PERKINS-VEAZIE, J. (2001) *In search of High Lycophene watermelon.* Washington: USDA-ARS, South Central Agric. Research Centre Lane.

PRABHU, K. and MURUGAN, A. (2011) Larvicidal and repellent potential of *Moringa oleifera* against malarial vector, *Anopheles stephensi* Liston (Insecta: *Diptera*: Culicidae). *Asian Pac. J. Trop. Biomed.,* pp. 124–129.

NAVA-DIAZ, et al. (2000) Organismos association a chirmoyo (A. Chermola M:Il) *Agrociencia*, vol. 34, pp. 217–226.

REHM, S. and ESPIG, G. (1991) *The cultivated plants of the tropics and subtropics.* Munchen: Verlag Josef Margraf, Weikersheim.

SCHIPPERS, R.R. (2000) African indigenous vegetable. In: An *overview of the cultivated species Chatthan,* pp. 56–60.

SELJASEN, R., and MEADOW, R. (2006) Effect of neem on oviposition and egg and larval development of *Mamestra brassicae* L: Dose response, residential activity. Repellent effect and systemic activity in cabbage plants. *Crop Protection,* vol. 25, pp. 238–345.

SINGH, R.N, and SARATCHANDRA, B. (2005) The development of botanical products with special refrence to seri-ecosyetem. *Caspain Journal Environmental Science*, vol. 3, no. 1, pp. 1–8.

SINGH, R.N, and SARATCHANDRA, B. (2002) An integrated Approach in the Pest Management in the sericulture. *International Journal Industries Entomology*, no. 5, pp. 141–151.

SOFIDIYA, M.O. et al. (2006) Free-radical scavenging activity of some Nigerian medicinal plant extracts. *Pakistan Journal of Biological Science*, vol. 9, no. 1, pp. 1438–1441.

WEEMS, H.V. and HEPPNER, J.B. (2001) *Melon fruit fly, Bactrocera cucurbitae Coquillet (Insecta: Diptera:Tephritidae)*. Florida Department of Agriculture and consumer Services, Division of plant industry and T.R. Fasulo, University of Florida. University of Florida publication EENY-199.

WHEELER, D. and ISMAN, M.B. (2001) Antifeedant and toxic activity of *Trichilia americana* extracts against the larvae of Spodoptera litura. *Entomologia Experimentals Applicata*, vol. 98, p. 9.