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RESEARCH ARTICLE

Evaluation of Botanical Insecticides against flea beetles *Podagrica sjostedti* and *Podagrica uniforma* of okra

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Abstract

Field trials were conducted during 2012 and 2013 cropping season to assess the efficacy of aqueous extract of leaves and bulb of some botanicals for the control of two species of flea beetles (*Podagrica sjostedti* and *Podagrica uniforma*), important destructive pests of okra, in Southern Guinea Savannah, Nigeria. Okra variety NHV47-4 was used for the study. The treatments consisted of leaf extracts of neem (*Azadirachta indica*) and pawpaw (*Carica papaya*), and bulb extract of onion (*Allium cepa*) and untreated control. The experiment was laid out in a Randomized Complete Block Design and replicated three times. Data were collected on abundance of insects a day before botanical application and for the three consecutive days after spraying of insecticides. Yield parameters data collected were number of fruits, weight of fruit and yield of fruits. The results showed that all the extracts of the three botanicals significantly ($P < 0.05$) reduced the population of the two flea beetles with the least percent efficacy of 56.4% and the highest 83.8%. However, pawpaw leaf extract had highest significant effect ($P < 0.05$) in reducing the population of the beetles. The order of effectiveness in decreasing sequence was found to be pawpaw leaf extract > neem leaf extract > onion bulb extract. Onion bulb extract showed a moderate level of effectiveness with (63.9%; 56.4%) and (75.6%; 71.1%) on *P. uniforma* and *P. sjostedti* in 2012 and 2013 respectively. Pawpaw leaf extract showed the highest level of effectiveness with (79.7%; 81.5%) and (76.5%; 83.8%) on *P. uniforma* and *P. sjostedti* in 2012 and 2013 respectively. Higher yield, higher number of fruits and improved fruits' weight of okra on treated plots indicated the efficacy of these botanicals. However, the effectiveness of neem leaf extract is comparable to pawpaw leaf extract.

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INTRODUCTION

Okra (*Abelmoschus esculentus*) is an important vegetable in Nigeria and in many countries of the world. It is grown for its immature edible pods which are consumed as vegetable. Okra fruit contains proteins, carbohydrates and vitamins A, B, C, minerals, iron and iodine but it is low in sodium, saturated fat and cholesterol (Lamont, 1999; Owolarafe and Shotonde, 2004), and plays a vital role in human diet. Okra mucilage is used for glace paper production and also a confectionary use (Akinyele and Temikotan, 2007). It has medical application as a plasma replacement or blood volume expander (Adetuyi *et al*., 2008; Kumar *et al*., 2010). Okra is being cultivated by farmers in Nigeria and the cropping system usually adopted mostly is mixed cropping, although sole cropping still exist in some farms. It can be grown on a wide range of soils but prefers well-drained sandy loam with pH 6 – 7 and a high content of organic matter give high yield (Akanbi *et al*., 2010; Akande *et al*., 2010).

One of the limiting factors in okra production is the damage caused by insect pests. The incidence patterns of insect pests are observed to be common in all phonologies of the crop and the insect pests that attack it are also common

among other members of the family Malvaceae. Some of the insect pests that attack okra include *Podagrica species*, whiteflies (attack this crop at the vegetative stage, feed effectively on the sap), *Zonocerus variegatus*, okra red mite, cotton stainer, cotton bollworm and cotton shield bug are found causing significant yield reduction (Ewete 1983; Kumar *et al*., 2010). Out of the insect pests of okra listed above, *Podagrica species* happened to be the most destructive insect pests of okra (Egwuatu, 1982). *Podagrica species* are responsible for heavy leaf defoliation (Odebiyi 1980) and cause economic damage (Ewete *et al*., 1996). These insects transmit the okra mosaic virus, causing significant yield losses of about 20 – 50% (Fajinmi and Fajinmi, 2010). There is need to control these insect pests due to their destructive activities so as to improve okra yield and quality. The common control measures has been the use of synthetic insecticides due to their swift action in eradicating the pests, their use is being discouraged due to associated human and environmental problems such as pest resistance to insecticides, environmental pollution, high cost of purchase, non-availability as well as hazards to farmers (Akob and Ewete, 2007). These drawbacks have necessitated the need for sustainable alternatives that are easily biodegradable, environmentally friendly and safe (Ewete *et al*., 1996). The challenge of finding a good alternative to replace these conventional insecticides has led to bio-prospecting for plant with natural insecticidal potency. Therefore, this study was conducted to evaluate the efficacy of the extracts of three readily available plants namely: pawpaw leaves, neem leaves and onion bulbs on two flea beetles, *Podagrica sjostedti* and *P. uniformis*, important insect pests of okra.

MATERIALS AND METHODS

The experiment was carried out at Teaching and Research Farms of Kwara State University, Malete, Kwara State, Nigeria (Longitude 04° 44′E and Latitude 08° 71′N, elevation: 365m above sea level) during the wet season of 2012 and 2013. The region is located in hot humid tropical falls in Southern Guinea Savanna of Nigeria with a mean temperature of 27°C and annual rainfall of 1314 mm. The textural class of the soil is loamy sand with pH of 6.5.

Preparation of Botanicals

The plant materials screened for insecticidal properties were *Azadirachta indica* (neem) leaves, *Allium cepa* (onion bulb) and *Carica papaya* (pawpaw) leaves. The preparation of neem leaf extracts was modified from the method of Aderolu *et al* (2012). Five (5) kg of fresh neem leaves were collected from neem tree, thoroughly cleaned from debris and other foreign materials. Neem leaves were chopped into smaller pieces and put inside a 50 litres capacity container filled with 40 litres of water and placed under shade and allow the active components to leach into the solution. The solution was stirred every three days interval for two weeks when it is assumed that the active component would have been completely released. The leaves were sieved out of the solution using muslin cloth and the extract was collected and stored in a clean container with a good tight lid ready for use. This concentrated solution was tagged neem leaf extract (NLE) and was further diluted at ratio of 1:1 with water during the field application. Two hundred grammes of onion were mixed with 1 litre of water and ground with a blender to obtain onion juice. This juice was thoroughly mixed with additional 1 litre of water. The mixture was then sieved using muslin cloth to obtain a uniform onion bulb extract (OBE). Papaya leaf extract was modified from the method of Mochiah *et al*., (2011). One hundred grammes of pawpaw leaves were collected and ground using wooden mortar and pestle. 1 litre of water was added and allowed to stay for 24 hours. I litre of water was later added to the solution which was sieved to obtain a uniform pawpaw leaf extract (PLE). 10 ml of liquid soap was added to the onion bulb extract (OBE), neem leaf extract (NLE) and pawpaw leaf extract (PLE) to improve their delivery and allow them to stick to the surface of the leaves of the okra plants (i.e. acts as surfactants). The spraying of the botanicals was done early in the morning and the application rate used was 1200 L/ha.

Field experiment

NHV47-4 okra variety collected at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria was used for the experiment. The treatments consisted of aqueous extract of three plant materials/botanicals namely: neem leaves, pawpaw leaves and onion bulbs, and an untreated control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. The experimental site was cleared, packed and seed beds prepared before planting was done. The experimental site was 11.5 m × 15 m (172.5 m^2) this cover an area of 12 plots, each plot measured 2.5 m × 2.5 m separated by 1m each between plots and between replicates. Each plot comprised of 36 okra stands, weeding was done manually at regular interval and organic fertilizer (un-amended compost) soured from Aleshinloye Fertilizer Plant, Ibadan, Nigeria was incorporated into the soil a week before planting at the rate of 100kgN/ha. The use of organic fertilizer was intentional as to avoid the use of inorganic fertilizer in the course of the experiment to make it organic farming.

Estimation of the flea beetles (*Podagrica sjostedti* and *P. uniforma*) was randomly done from the six okra stands in the two middle rows. This sampling commenced at 3 weeks after planting (WAP), it was done before treatments were applied and for three consecutive days after spraying (DAS). Yield data collected include number of fruits, weight of fruits and yield of okra fruits. The data collected were analyzed using analysis of variance (ANOVA) and

means when significant were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability. The reduction percentage of insect population was calculated using Henderson-Tilton's formula (Henderson-Tilton, 1955):

% Efficacy = $(1 - T_1/C_1 \times C_2/T_2) \times 100$

Where: T_1= infestation in the treated plot before treatment application

T_2= infestation in the treated plot after treatment application

C_1= infestation in the control plot before treatment application

C_2= infestation in the control plot after treatment application

The population of insect pests in each of the treatments was used as yardstick for insecticide efficacy, the higher population of flea beetles represent lower efficacy and vice versa.

RESULTS

The results showed that the three botanical insecticides have significant effect on the population of *Podagrica uniforma* and *P. sjostedti* in the two cropping seasons. The mean numbers of *P. sjostedti* and *P. uniforma* in response to the weekly application of botanicals presented in Table 1 and 2 showed a reduction in Podagrica population in the two seasons. In 2012 planting season, there was significant reduction ($P < 0.05$) in the population of the two beetles at one day after spray compared to the control. The same trend was recorded at 2 and 3 days after spray in each week. There was no significant difference ($P > 0.05$) among the three treatments - neem leaf extract, pawpaw leaf extract and onion bulb extract in reducing the population of the two beetles in this cropping season. The same trend was observed in 2013 cropping season, as there was significant reduction ($P < 0.05$) in the mean number of the two beetles as a result of the three botanicals applied compared to the untreated control. The population of *P. sjostedti* was significantly higher than that of *P. uniforma*. *P. sjostedti* found was on the average of 15insects/plant while that of *P. uniforma* was on the average of 5 insects/plant on the untreated control (Table 1 and 2). The percent reduction of the three botanical insecticides against *P. sjostedti* and *P. uniforma* on okra are presented in Table 3 and 4. In 2012 cropping season, there was no significant difference ($P > 0.05$) in percent reduction over pre-treatment during the first spray among the three treatments at 1, 2 and 3 days after spray in the case of *P. sjostedti*. From second spray to the last spray application, there observed decrease in percent reduction of *P. sjostedti* on okra treated with onion bulb extract from 1 – 2 days after spray in the two seasons (Table 3 and 4). In 2012, at 1 day after spray, 76.9% reduction was recorded it decreased to 68.3% at 3 day after spray. During the third spray, it decreased from 86.6% to 70.6%, the same trend was recorded in 2013 also. The percent reduction value with pawpaw leaf extract and neem leaf extract also decreased from 1 day after spray to 3 day after spray but the reduction was lower than what was recorded in plot treated with onion bulb extract. During the second spray, the percent reduction in plot treated with pawpaw leaf extract decreased from 89.3% to 65% unlike what was obtained in plot treated with neem leaf extract which reduce to 42% from 76.8%, during the third spray plot treated with neem leaf extract decreased to 46.7% from 73.3% while there was no reduction on plot treated with pawpaw leaf extract at 3 day after spray. Although, the decrease in percent reduction was observed in all treatments application from 1 day after spray to 3 day after spray, it was more severe in neem leaf extract and onion bulb extract application in both seasons. The same trend was also observed on the effect of the botanicals on *P. uniforma* population in both seasons. After 3 day after spray, plot treated with pawpaw leaf extract had the highest value of percent reduction except in 2012 during the 1stspray where percent reduction in the plot treated with neem leaf extract was higher than that of pawpaw leaf extract. The percent reduction value recorded on plot treated with pawpaw leaf extract at 3 day after spray ranged from lowest 72.1% to the highest 83.3% in 2012. In 2013, at 3 day after spray, it ranged from the lowest 65% to the highest 88.3%. The percent reduction value observed in the case of onion bulb extract decreased also in both seasons and it was lower than the value obtained in the plot treated with pawpaw leaf extract and neem leaf extract.

The overall percent efficacy of the treatments on *P. sjostedti* in 2012 showed that there was no significant difference ($P > 0.05$) between the treatments, the lowest recorded in onion bulb extract – 75.65%, followed by pawpaw leaf extract – 76.5% and the highest 78.8% was recorded in neem leaf extract. There was no significant difference on the overall percent efficacy of the botanical insecticides on *P. uniforma* in 2012, with highest value recorded on plot treated with pawpaw leaf extract – 79.7% followed by that of neem leaf extract – 71.6% and the least 63.9% recorded on plot treated with onion bulb extract. In the 2012 cropping season, plot treated with onion bulb extract had the lowest overall percent reduction of flea beetle with 63.9% reduction of *P. uniforma* and 75.6% reduction of *P. sjostedti*. In 2013, there was significant difference ($P < 0.05$) in the overall percent reduction of flea beetle. Pawpaw leaf extract gave the highest percent reduction of 81.5%and 83.3% of *P. uniforma* and *P. sjostedti* respectively. This was followed by neem leaf extract with 57.2% and 78.1% on *P. uniforma* and *P. sjostedti* respectively. There was significant difference ($P < 0.05$) between the percent reduction of the flea beetle between

pawpaw leaf extract and onion bulb extract in 2013. Pawpaw leaf extract significantly reduced *P. uniforma* than neem leaf extract and onion bulb extract, but there was no significant reduction ($P > 0.05$) on *P. sjostedti* between pawpaw leaf extract (83.8%) and neem leaf extract (78.1%), but percent efficacy for pawpaw leaf extract (83.8%) was significantly better ($P < 0.05$) than what was obtained on the plot treated with onion bulb extract (71.1%) on *P. sjostedti* in 2013.

The effect of botanical insecticides on fresh fruit weight is presented in Table 5. There was no significant difference ($P > 0.05$) between the treated and untreated plot in 2012. In 2013, there was significant difference ($P < 0.05$) between the fruit weight of the treated plot (highest being 14.83g, lowest being 14.73g) and untreated control (11.63g). In 2013, there was no significant difference ($P > 0.05$) in fruit weight between the three treated plots. With regards to the number of fruits recorded, in both cropping seasons, there was significant difference ($P < 0.05$) between the treated and untreated plots (Table 6). In relation to yield, in 2012, the plot treated with pawpaw leaf extract gave the highest yield (168.97 kg/ha) but was not significantly different from the yield obtained from the plots treated with neem leaf extract (132.43 kg/ha) and onion bulb extract (148.3 kg/ha) (Table 7).The yield obtained from plot treated with pawpaw leaf extract was significantly higher ($P < 0.05$) than the one obtained from untreated control (91.43 kg/ha). In 2013, there was significant difference ($P < 0.05$) in yield between the treated and untreated plots. The yield obtained from the plot treated with pawpaw leaf extract gave the highest yield of 210.83 kg/ha, followed by the plot treated with neem leaf extract and onion bulb extract which gave the yield of 204.3 kg/ha and 198.3 kg/ha respectively, these three yield were not significantly different from one another ($P > 0.05$), but are significantly higher ($P < 0.05$) than the untreated control (145.07 kg/ha).

Table1: Mean number of *P. sjostedti* in response to weekly application of botanicals

2012																
	Week 1				Week 2				Week 3				Week 4			
	CBS	DAS			CBS	DAS			CBS	DAS			CBS	DAS		
Treatment		1	2	3		1	2	3		1	2	3		1	2	3
Neem leaf extract	16^a	5^b	3^b	3^b	13^a	2^b	3^b	6^b	18^a	2^b	4^b	4^b	16^a	3^b	5^b	4^b
Pawpaw leaf extract	15^a	4^b	2^b	2^b	12^a	3^b	4^b	3^b	8^b	2^b	2^b	2^b	6^b	2^b	1^b	1^b
Onion bulb extract	19^a	4^b	5^b	5^b	13^a	3^b	5^b	5^b	17^a	2^b	3^b	5^b	12^a	1^b	3^b	5^b
Control	18^a	17^a	19^a	16^a	14^a	14^a	18^a	17^a	16^a	14^a	15^a	16^a	14^a	17^a	12^a	17^a
2013																
	Week 1				Week 2				Week 3				Week 4			
	CBS	DAS			CBS	DAS			CBS	DAS			CBS	DAS		
Treatment		1	2	3		1	2	3		1	2	3		1	2	3
Neem leaf extract	12^a	3^b	2^b	3^b	12^a	1^b	4^b	3^b	13^a	2^b	2^b	4^b	11^a	1^b	4^b	3^b
Pawpaw leaf extract	15^a	2^b	3^b	2^b	10^a	1^b	2^b	3^b	16^a	1^b	2^b	1^b	10^a	1^b	2^b	2^b
Onion bulb extract	17^a	4^b	5^b	5^b	12^a	2^b	4^b	4^b	10^a	2^b	3^b	5^b	14^a	1^b	3^b	5^b
Control	14^a	12^a	15^a	14^a	15^a	14^a	15^a	13^a	14^a	17^a	13^a	15^a	14^a	15^a	14^a	16^a

Means followed by the same letter and within the same column are not significantly different ($P < 0.05$, DMRT)
KEY: CBS = Count before spray; DAS = Day after spray

Table2: Mean number of *P. uniforma* in response to weekly application of botanicals

2012																
Treatment	Week 1				Week 2				Week 3				Week 4			
	CBS	DAS			CBS	DAS			CBS	DAS			CBS	DAS		
		1	2	3		1	2	3		1	2	3		1	2	3
Neem leaf extract	6a	2b	1b	2b	7a	1b	1b	3ab	5a	1b	2b	3ab	6a	1b	2b	2b
Pawpaw leaf extract	5a	2b	2b	1.95b	8a	0.95b	1b	1b	5a	1b	1b	2b	6a	0.5b	1b	1b
Onion bulb extract	6a	2b	3ab	3b	5a	2b	2b	3ab	5a	1b	1b	3ab	7a	1b	2b	3b

Control	5a	6a	5ab	7a	7a	6a	5a	6a	6a	7a	8a	6a	6a	8a	6a	7a
2013																
Treatment	Week 1				Week 2				Week 3				Week 4			
	CBS	DAS			CBS	DAS			CBS	DAS			CBS	DAS		
		1	2	3		1	2	3		1	2	3		1	2	3
Neem leaf extract	5a	1b	3b	3ab	6a	1b	2b	2b	5a	2b	2ab	4a	6a	1b	2ab	3b
Pawpaw leaf extract	7a	0.5b	2b	2b	5a	0.5b	1b	1b	4a	1b	0.5b	1a	7a	0.25b	1b	1bc
Onion bulb extract	7a	1b	2b	3ab	5a	1b	2b	2b	5a	1b	3ab	4a	5a	1b	2ab	3b
Control	6a	5a	7a	6a	7a	5a	4a	4a	4a	6a	4a	6a	6a	5a	4a	6a

Means followed by the same letter and within the same column are not significantly different ($P < 0.05$, DMRT)
KEY: CBS = Count before spray; DAS = Day after spray

Table 3: Percent reduction of three different botanical insecticides against *Podagrica sjostedti* on okra

	2012				2013			
Treatment	1DAS	2DAS	3DAS	Mean	1DAS	2DAS	3DAS	Mean
First spray								
Neem leaf extract	65.9a	82.2a	79.9a	76.0a	71.0b	84.5a	75.1b	77.0ab
Pawpaw leaf extract	71.1a	73.3a	85.0a	76.7a	84.5a	81.4a	85.0a	83.5a
Onion bulb extract	77.6a	75.0a	70.3a	74.3a	72.6b	72.7b	70.7b	72.0b
Second spray								
Neem leaf extract	84.6a	82.1a	82.0a	82.9a	91.1a	66.7b	75.0a	77.6a
Pawpaw leaf extract	74.9a	74.0a	79.4a	76.1ab	89.3a	80.0a	65.0ab	78.1a
Onion bulb extract	76.9a	70.1b	68.3b	71.8b	78.6a	60.0b	53.8b	64.1a
Third spray								
Neem leaf extract	87.3a	76.3a	77.8a	80.5a	87.3ab	83.4a	71.2b	80.5ab
Pawpaw leaf extract	71.4b	73.3a	75.0a	73.2a	94.9a	85.5a	94.2a	91.5a
Onion bulb extract	86.6a	81.2a	70.6a	79.5a	83.5b	67.7b	53.3c	68.2b
Fourth spray								
Neem leaf extract	84.6ab	63.5b	79.4a	75.8a	91.5a	63.7b	76.2a	77.1a
Pawpaw leaf extract	72.6b	80.6a	86.3a	79.8a	90.7a	80.0a	75.5a	82.1a
Onion bulb extract	93.2a	71.0ab	66.0b	76.7a	93.3a	78.6a	68.8a	80.2a
Overall percent efficacy								
		2012				2013		
Neem leaf extract		78.8a				78.1ab		
Pawpaw leaf extract		76.5a				83.8a		
Onion bulb extract		75.6a				71.1b		

Values followed by the same letter and within the same column are not significantly different ($P < 0.05$, DMRT)

Table 3: Percent reduction of three different botanical insecticides against *Podagrica uniforma* on okra

	2012				2013			
Treatment	1DAS	2DAS	3DAS	Mean	1DAS	2DAS	3DAS	Mean
First spray								
Neem leaf extract	72.3a	83.4a	76.2a	77.3a	76.0b	49.6b	40.0c	55.2b
Pawpaw leaf extract	66.7a	60b	72.1a	66.3a	91.4a	75.4a	71.3a	79.4a
Onion bulb extract	72.3a	50b	64.4a	62.0a	82.8a	75.4a	57.0b	71.7a

Second spray								
Neem leaf extract	83.3a	80.0a	40.0b	67.8ab	76.8a	42.0b	42.0b	53.6b
Pawpaw leaf extract	86.1a	82.5a	85.4a	84.6a	86.0a	65.0a	65.0a	72.0a
Onion bulb extract	53.3b	44.0b	30.0b	42.4b	72.0a	30.0b	30.0b	44.0b
Third spray								
Neem leaf extract	88.3a	70.0b	40.0b	66.1a	73.3a	60.0b	46.7b	60.0b
Pawpaw leaf extract	88.3a	85.0a	60.0a	77.8a	88.3a	87.5a	88.3a	88.0a
Onion bulb extract	88.3a	85.0a	40.0b	71.1a	88.6a	40.0b	46.7b	58.4b
Fourth spray								
Neem leaf extract	87.5a	66.7a	71.4ab	75.2a	80.0a	50.0b	50.0b	60.0b
Pawpaw leaf extract	93.8a	88.3a	88.3a	90.1a	95.7a	78.0a	85.7a	86.5a
Onion bulb extract	89.3a	87.1a	63.1b	79.8a	76.0a	40.0	40.0b	52.0b
Overall percent efficacy								
		2012				2013		
Neem leaf extract		71.6a				57.2b		
Pawpaw leaf extract		79.7a				81.5a		
Onion bulb extract		63.9a				56.4b		

Values followed by the same letter and within the same column are not significantly different ($P < 0.05$, DMRT)

Table 5: The effect of botanicals on mean weight of okra fruits

	2012	2013
Treatment	Weight of Fruits (g)	Weight of Fruits (g)
Neem leaf extract	9.47a	14.83a
Pawpaw leaf extract	10.57a	14.83a
Onion bulb extract	10.80a	14.73a
Control	10.73a	11.63b

Means followed by the same letter(s) within the same column are not significantly different ($P < 0.05$, DMRT)

Table 6: The effect of botanicals on number of okra fruits

	2012	2013
Treatment	Number of Fruits	Number of Fruits
Neem leaf extract	14.30a	13.83a
Pawpaw leaf extract	15.87a	14.30a
Onion bulb extract	13.53a	13.43a
Control	9.47b	11.47b

Means followed by the same letter(s) within the same column are not significantly different ($P < 0.05$, DMRT)

Table 7: The effect of botanicals on yield of okra fruits

	2012	2013
Treatment	Yield of Okra Fruits (kg/ha)	Yield of Okra Fruits(kg/ha)
Neem leaf extract	132.43ab	204.30a
Pawpaw leaf extract	168.97a	210.83a
Onion bulb extract	148.30ab	198.30a
Control	91.43b	145.07b

Means followed by the same letter(s) within the same column are not significantly different ($P < 0.05$, DMRT)

DISCUSSION

The efficacy of three different botanical insecticides – neem leaf extract, pawpaw leaf extract and onion bulb extract for the control of two flea beetles (*P. sjostedti* and *P. uniforma*) on okra was evaluated during the main cropping season of 2012 and 2013. The result showed that all botanicals greatly reduced the population of the two flea beetles in the two cropping seasons. The three botanicals possessed great level of insecticidal properties in effectively reducing the population of flea beetle. The percent reduction over pre-treatment was higher with pawpaw leaf extract and neem leaf extract followed by onion bulb extract. Pawpaw leaf extract was highly effective with 83.8% and 81.5%, and 76.5% and 79.7% reduction of *P. sjostedti* and *P. uniforma* population in 2013 and 2012 respectively. This was closely followed by neem leaf extract with 78.1% and 57.2%, and 78.8% and 71.6% reduction of *P. sjostedti* and *P. uniforma* population in 2013 and 2012 respectively. These findings can partially be compared with what Aderolu *et al*., (2012) discovered that neem leaf and modified neem leaf extract decrease significantly *Hymenia recurvalis* population by 42% on Amaranthus. Similar result by Adamu and Yashim, (2011), showed that neem seed extracts sprayed resulted in the highest significant reduction of head bug's population per panicle on sorghum. This reduction in pest population could be as a result of azadirachtin that is present in neem plant which elongate development in insect and sometimes deform the insect. The use of azadirachtin based insecticide however is unstable, it easily gets degraded in the environment, and this necessitates its application at short interval of times. Neem leaves contain insect controlling substances primarily azadirachtin A and B, Salannin and Meliantriol which have repellent effects, and Nimbin/Nimbidin which have antiviral effect (Zuber, 1996; Stoll, 2000). These pesticidal properties the neem plant possessed and its mode of action as systemic and stomach poison could be the reason why it effectively reduced the population of flea beetle in the two seasons. Ndor *et al*., (2012), observed that pawpaw aqueous leaf extract performed better than bush tea and moringa extracts in reducing population of insect pests attacking watermelon and that plots treated with pawpaw leaf extract had lowest mean number of perforated leaves. Figueroa-Brito *et al*., (2011), also confirmed the effectiveness of different species of pawpaw seed extracts in controlling larvae of *Spodoptera frugiperda* with percentage mortality ranged from 50 – 73.6%. The higher percent reduction of flea beetle recorded due to the effect of pawpaw leaf extract could be as a result of the active component of pawpaw leaf. It contains an albuminous enzyme – papain and an alkaloid carpine which are repellent, insecticidal and fungicidal in action (Stoll, 2000). Onion bulb extract proved to be effective as bio-pesticide with overall percentage reduction ranging between 56.4 and 75.6% in the two seasons. Stoll (2000), also observed extract of onion bulbs to be effective against leaf eating insect pests. To support the findings of this work, Chimanikire (1994), opined that onion bulb extract was effective against ants and grubs, these attest to the finding from this work that onion bulb is also an effective bio-pesticide most importantly as repellent.

The impact of these plant extracts on yield components could be felt on the significant yield differences observed among the treatments in comparison with the control. The extracts of the three plants used proved to have significant effect on the yield parameters tested. Yield is dependent on the abiotic and biotic factors of which insect pest infestation is an important factor that influence the yield, this could be a reason why the yield obtained from the untreated plot was significantly lower than what was obtained in the treated plot, attesting to the fact that pest problem is a population problem, the higher the number of insect pests found on an economic crop, the higher the level of damage caused. Our findings is in agreement with Aderolu *et al*., (2012), who observed that neem leaf extract, modified neem leaf extract and wood ash enhance better yield of Amaranthus in comparison with the untreated control. Mochiah *et al*., 2011, also observed that vegetables in which botanicals were applied produced the highest mean fruit weight and fruit numbers of okra and egg plant, supporting what was discovered in this work as the fruit weight and numbers of okra treated with the botanicals were found to be significantly higher than the fruit weight and number of the untreated plot. This could be as a result of high level of population of flea beetles in the untreated plots that defoliated larger proportion of the leaf surface thereby inhibiting cell multiplication, amino acid synthesis and energy formation which invariably inhibit photosynthetic ability of the plant, its products thereby not easily translocated to the sinks (Eifedeyi and Remison, 2010).

In conlusion, it was observed that *P. sjostedti* are more abundant than *P. uniforma* in the two cropping season. The plant extracts could successfully serve as the best option in pest management considering their effectiveness in reducing the population of flea beetles which translate to better yield. These botanicals are effective, eco-friendly, cheap, readily available and do not pose any threat to the users. It is due to these reasons that pawpaw leaf extract, neem leaf extract and onion bulb extract are recommended in that order for the management of insect pests. There is need to investigate further on effectiveness of combine application of these botanicals on pests that attack crops to reduce total reliance on synthetic pesticides.

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