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Phytochemical composition and insecticidal potentials of some plant aqueous extracts in suppressing *Podagrica* spp. (Coleoptera: Chrysomelidae) infestation on Okra (*Abelmoschus esculentus* L. Moench)

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Abstract: Foliar application of 25% w/v crude aqueous extracts of *Calotrophus procera* (Aiton) W.T. Aiton, *Canarium schweinfurthii* (Engl.) and *Bryscocarpus coccineus* (Schum. & Thonn.) were evaluated for their insecticidal activity in reducing *Podagrica* infestation on okra. Results showed that the plants extracts significantly suppress *Podagrica* spp. infestation and protect okra plant from severe leaves defoliation, with *C. schweinfurthii* (21.67 and 20.14) and *B. coccineus* (23.07 and 24.55) showing promising insecticidal activity for both cropping seasons. The yield attributes from okra sprayed with Lambda cyhalothrin did not differ significantly compared to those sprayed with botanical insecticide despite having highest yield attributes. Qualitative phytochemical screening revealed the presence of Triterpenoids, Steroids, Flavonoids, Phlobatanins, Saponins, Tannins, Cardiac glycoside and Anthraquinones. Alkaloids and Anthraquinones were not detected in *C. procera* and *C. schweinfurthii* while Triterpenoids and Phlobatanins were absent in *C. schweinfurthii.* The presence of these phytochemicals indicates that the plants possess insecticidal properties responsible for significant reduction in *Podagrica* spp. infestation, severity of leaves damaged and improved okra yields. Performance of the treatments is rated in the following order: Lambda cyhalothrin > *B. coccineus* > *C. schweinfurthii* > *C. procera,* with *B. coccineus* and *C. schweinfurthii* having similar treatment means in all the parameters evaluated. In light of the foregoing, crude extracts of *B. coccineus* and *C. schweinfurthii* could be utilized as suitable alternative to synthetic insecticide in sustainable okra production.

1. Introduction

Okra (*Abelmoschus esculentus* L. Moench) is an important fruit vegetable crop in the diets of most people in the tropics and subtropical countries. It is grown mainly for its freshly immature pods and ranks fourth worldwide after pepper, tomato and onion on the basis of land area, production and value.

Despite the great demand for okra due to its nutritional and economic importance, okra production is being hampered by array of insect pest infestation resulting in poor yield and low market value. Different growth stages of okra are generally attacked by different insect pests (Adesina and Afolabi, 2014; Kedar *et al*., 2014) and *Podagrica* species (Coleoptera: Chrysomelidae) is one of the most prevalent and damaging insect pests considered as major constraint to cultivation of okra which defoliate or damage the plant leaves and flowers; thereby results in reduction of the photosynthetic capability of the crop (Odebiyi, 1980). The insects equally act as vectors in transmitting mosaic viral diseases and ultimately reduce yield (Fasunwon and Banjo, 2010), mainly if control measures are not undertaken. Important yield losses of 20-50% are reported in Nigerian and Ghana (Obeng-Ofori and Sackey, 2003; Ahmed *et al*., 2007; Fajinmi and Fajinmi, 2010).

Currently, synthetic insecticide is being used across the globe to control agriculturally important insect pests due to their quick action and lasting effect (Alao *et al*., 2011). The failure of synthetic insecticides to ensure total insect pest control due to development of resistant and resurgence and couple with increasing concern over environmental pollution, carcinogenic effect and destruction of beneficiary insects (Isman, 2008), level of pesticide residues in food had compelled the scientific community to explore the abandoned and neglected traditional and indigenous products that are cheap, environmental safe and easily biodegradable products as alternatives to synthetic insecticides for tackling agricultural insect pests (Antonio, 2009; Alao *et al*., 2011; Aetiba and Osekre, 2016).

Presently, in many parts of the world, attention has been focused on the utilization of plant products that possess both medicinal and aromatic properties which are abound in various agro-ecological zones of the world as novel chemotherapeutants in plant protection (Dubey *et al*., 2010). The popularity of botanical pesticides is once again increasing and some plant products either in crude form or by processing into different formulations are being used globally as green pesticides (Dubey *et al*., 2008).

The shortcomings associated with the use of synthetic chemicals, necessitated the idea of developing effective, cheap and easily biodegradable alternative products. Therefore, this study aims to screen and report the efficacy of aqueous extracts of *Calotrophus procera* (Ait.) Ait*., Canarium schweinfurthii* (Engl.) and *Bryscocarpus coccineus* (Shum and Thonn.) in suppressing flea beetles *Podagrica* spp. (Coleoptera: Chrysomelidae) infestation on okra.

2. Materials and Methods

Experimental location, designs and treatments

The study was carried out on 168 m^2 area of land manually cleared and prepared at the Teaching and Research Farm, Rufus Giwa Polytechnic (RUGIPO), Owo, Ondo State located in South Western Nigeria and lies on latitude 7° 12’ N and longitude 7° 35’ E. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental land was divided into 4 blocks of 4x4 m to produce a total of 12 plots. The plot size was 2x1.5 m with 0.5 m between plots and 1x1 m between blocks to prevent pesticide drift and inter-plot interference, respectively.

An early maturity okra cultivar (NH-47) obtained from Ondo state Agricultural Development Project (ADP), Akure, Ondo State, Nigeria was sown with two to three seeds per hole at a depth of 2-3 cm and spaced 50x60 cm and later thinned to one plant per stand. Weeding was carried out manually as at when due to ensure clean plots free from weed competition.

The treatments applied were 25% w/v *B. coccineus, C. schweinfurthii, C. procera* and 0.8 L/ha synthetic insecticide (Lambda cyhalothrin) as control. Application of treatments commenced four weeks after planting (WAP) with a 2-litre capacity hand-held sprayer. The spraying was carried out weekly till fruiting early in the morning to avoid photo decomposition and drifting of the extracts. Synthetic insecticide was applied every two weeks.

Collection and preparation of plant extracts

Leaves of *B. coccineus* and *C. schweinfurthii* were collected from Owo, Ondo state, Nigeria and *C. procera* were collected from Ogbagi Akoko Ondo State, Nigeria (7° 35’ N, 5° 43’ E) at full blooming and 25 kg were weighed separately using electronic balance (Table 1). Thereafter, the weighed plants were washed with water to remove dirt or other contaminants and each of the plant materials was pounded separately in a mortar into a fine soft paste form. The

Table 1 - Plant materials used for the experiment

Scientific name	Common name	Family	Part used
Calotropis procera	Giant swallow wort or Milkweed	Asclepiadaceae	leaves
Canarium schweinfurthii	African elemi or canarium	Burseraceae	leaves
Byrsocarpus coccineus	Short-pod	Connaraceae	leaves

paste (crushed plant leaves) was then put into a 10-litre plastic bucket and the appropriate volume of distilled water added to make a 25% w/v crude aqueous extract solution (25% w/v represents an extract made with 25 g of crushed plant leaves per every 100 ml of water). The pastes were soaked overnight (approximately 14 hours) in a covered bucket with occasional stirring and filtered using muslin cloth with the filtrates stored in a 10 L keg in a cool dry place till use.

Phytochemical screening

The qualitative phytochemical tests were performed on the crude aqueous extract to detect the presence of bioactive secondary metabolites in tested plant materials using standard laboratory methods following the procedure described by Odebiyi and Sofowora, 1978; Sofowora, 1982; Williamson *et al.,* 1996; Banso and Ngbede, 2006; Ngbede *et al*., 2008.

Data collection and statistical analysis

All data were collected from five plants randomly tagged per treatment in the two middle rows of each plot. Leaves damage index was determined by visual counting of the number of holes caused by the insect feeding activities. While insect count for estimation of the population densities of *P. uniformis* and *P. sjostedti* was made 4 WAP between the hours 6-7 AM when the insects are still inactive through visual counting. The fruits were harvested two months after planting (MAP), when the fruits were still fresh at the interval of 4 days. Weighing balance was used to determine the weight of the fruits and the fruits length measured using ruler. Data collected were analyzed by analysis of variance (ANOVA) using Gester Version 1.2, insect count were subjected to square root (y =√) transformation before analysis to normalize the data. Significant treatment means were compared using Tukey test at 5% probability.

3. Results

Podagrica spp. population before application of some plant aqueous extracts

Table 2 shows *Podagrica spp.* population on okra before the application of the aqueous plant extracts treatments. The results showed that the insect populations were not significantly different. The population ranges between 4.07-4.93/plant for 2015 cropping season and 4.10-4.98/plant for 2016 cropping season.

Table 2 - *Podagrica* spp. population before application of some plant aqueous extracts

Treatments	Insect population	
	2015	2016
C. procera	4.07±0.77 a	4.98±0.15 a
C. schweinfurthii	4.08±0.66 a	4.46±0.34 a
B. coccineus	4.27±0.38 a	4.10±0.07 a
Lambda cyhalothrin	4.93±0.66 a	4.47±0.28 a

Treatments with the same letter in column are not statistically significant different from each other.

Toxicity effect of some plant aqueous extracts in suppressing Podagrica spp. infestation

The utilization of plant aqueous extracts to suppress *Podagrica* spp. infestation on okra was presented in Tables 3 and 4 for 2015 and 2016 cropping season, respectively. Application of the various treat-

Table 3 - Toxicity effect some plant aqueous extracts in suppressing *Podagrica* spp. infestation 2015

Treatments	4 WAP		5 WAP		6 WAP		7 WAP		8 WAP		9 WAP	
	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
C. procera	2.93±1.86 a	0.33±0.31 ab	0.80±0.60 ab	0.87±1.17 a	1.80±1.51 a	3.27±1.36 b	1.33±1.03 a	0.67±0.12 a	0.20±0.20 b	0.60±0.35 a	0.33±0.31 a	0.80±0.31 ab
C. schweinfurthii	1.13±1.14 ab	0.07±0.12 c	0.27±0.23 c	0.07±0.12 b	0.37±0.35 b	1.13±0.70 a	0.27±0.35 ab	0.20±0.35 a	0.00	0.53±0.61 a	0.18±0.12 a	0.73±0.51 ab
B. coccineus	1.40±1.22 ab	0.6±0.87 a	1.0±1.40 a	0.40±0.53 a	0.22±0.06 b	0.47±0.53 a	0.4±0.69 ab	0.80±1.22 a	0.82±1.05 a	0.6±0.53 a	0.8±1.22 a	0.93±0.52 a
Lambda cyhalothrin	0.13±0.23 c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00a	0.00

WAP = Weeks after planting; DAS = Days after spray.
Treatments with the same letters in columns are not statistically significant different from each other.

Table 4 - Toxicity effect some plant aqueous extracts in suppressing *Podagrica* spp. infestation 2016

Treatments	4 WAP		5 WAP		6 WAP		7WAP		8 WAP		9 WAP	
	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS
C. procera	2.05±0.62 a	0.73±0.31 a	0.98±0.56 a	0.53±1.04 a	1.18±1.51 a	1.02±0.16 a	0.88±1.06 a	0.63±0.14 b	0.42±0.20 b	0.6±0.35 a	0.55±0.24 a	0.56±0.31 a
C. schweinfurthii	1.89±0.14 ab	0.28±1.52 b	0.67±0.23 a	0.18±0.32 a	0.37±0.35 ab	0.63±1.08 a	0.41±0.05 ab	0.4±0.33 a	0.20±0.07 b	0.53±0.61 a	0.17±0.16 b	0.41±1.61 a
B. coccineus	1.44±0.21 ab	0.92±0.87 a	0.82±1.03 a	0.46±1.07 a	0.08±0.11 b	0.82±0.12 a	0.2±0.09 ab	0.87±0.22 a	1.0±0.35 a	0.6±0.53 a	0.46±1.42 a	0.57±0.25 a
Lambda cyhalothrin	0.10±0.23 c	0.22±1.61 b	0.00	0.00	0.00	0.00	0.00	0.00a	0.00	12:00	0.00	0.00

WAP = Weeks after Planting; DAS = Days after spray.
Treatments with the same letters in columns are not statistically significant different from each other.

ments resulted in significant reduction in the insect population, while synthetic insecticides completely suppressed the insect pest infestation. The results clearly indicate that insect population reduced in relation to the number of spraying regimes, with the exception of okra plants sprayed with *C. procera* aqueous extract, which slightly increased or resurgence at 6 WAP for both seasons and 3 days after spraying (DAS) at 7 WAP in 2015 cropping season only. In 2015 non-significant difference was observed at 3 DAS and 7 DAS in all the treatments at 7, 8 and 9 WAP, while in 2016 non-significant difference was recorded 7 DAS at 6, 8 and 9 WAP in 2016 cropping season, respectively.

The insecticidal activity of the aqueous plant extracts treatments is rated in the following decreasing order: *B. coccineus* > *C. schweinfurthii* > *C. procera,* with *B. coccineus* and *C. schweinfurthii* having similar treatment means which is not significantly different in most instances but significantly differ compared to *C. procera* in both seasons.

Toxicity effect of some plant aqueous extracts on okra yield attributes

The yield of okra plant in response to various plant aqueous extracts evaluated in reducing *Podagrica* spp. infestation was presented in Table 5. From the results, fruit weight and fruit diameter were not significantly different in both cropping seasons for all the treatments sprayed on the okra against *Podagrica* spp. infestation. Also non-significant difference equally observed between okra plants sprayed with *B. coccineus* and *C. schweinfurthii* compared to Lambda cyhalothrin for number of harvested fruit and fruit lengths for both seasons except for *C. schweinfurthii* in 2015 season. Although, there was significant difference in the number of harvested fruits and fruit lengths between okra sprayed with *B. coccineus*, *C. schweinfurthii* and Lambda cyhalothrin compared to *C. procera* in both seasons. The yield attribute performance of the treatments is rated in the following decreasing order: Lambda cyhalothrin > *B. coccineus* > *C. schweinfurthii* > *C. procera,* with *B. coccineus* and *C. schweinfurthii* having similar treatment means.

Effects of plants aqueous extracts on severity of leaves damage on Okra by Podagrica spp.

The utilization of plants aqueous extract on severity of leaves damage on Okra (*A. esculentus L.*) by *Podagrica spp.* was presented in Table 6. Significant

Table 5 - Toxicity effect some plant aqueous extracts okra yield attributes

Parameters	*C. procera*		*C. schweinfurthii*		*B. coccineus*		Lambda cyhalothrin	
	2015	2016	2015	2016	2015	2016	2015	2016
Number of pod	3.75±1.13 b	3.98 ±0.19 b	4.69±1.59 a	4.51±1.79 a	4.75±1.79 a	4.93±2.41 a	5.12±0.84 a	5.45±1.79 a
Fruit length	3.02±0.88 ab	3.47±1.66 ab	3.93±2.71 ab	4.00±1.34 a	4.12±1.76 a	4.70±0.28 a	4.83±2.02 a	4.67±1.17 a
Fruit weight	0.08±0.06 a	0.05±0.02 a	0.05±0.03 a	0.09±0.11 a	0.05±0.06 a	0.07±0.12 a	0.04±0.03 a	0.06±0.02 a
Diameter	5.51±1.89 a	4.80±0.43 a	4.9±1.45 a	4.64±0.93 a	4.44±1.72 a	4.03±1.06 a	4.72±0.69 a	4.46±0.82 a

Treatments with the same letters in columns are not statistically significant different from each other.

Table 6 - Effects of plants aqueous extracts on severity of leaves damage on Okra by *Podagrica* spp.

Severity of leaf damage	*C. procera*		*C. schweinfurthii*		*B. coccineus*		Lambda cyhalothrin	
	2015	2016	2015	2016	2015	2016	2015	2016
4 WAP	3.47±1.08 e	4.51±0.71 e	4.73±0.43 e	4.02±0.66 b	3.40 ±1.83 c	3.27±1.10 d	1.67±0.76 a	1.44 ±0.83 a
5 WAP	6.27±0.73 e	8.12±2.46 e	5.82±1.18 e	6.83±0.37 b	4.00±1.95 c	4.17±1.38 d	3.20 ±1.51 a	4.27 ±0.73 a
6 WAP	12.23±1.09 d	12. 85±2.03 d	9.50±1.76 d	8.91±1.92 b	10.53±1.68 b	11.48±2.06 c	4.07 ±0.69 a	4.23 ±1.09 a
7 WAP	19.93±1.93 c	20.14±1.17 c	11.97±0.86 c	13.25±1.81 ab	16.27 ±2.68 ab	17.04±1.39 b	4.07 ±0.39 a	4.93 ±2.93 a
8 WAP	29.60±1.55 b	26.92±2.41 b	15.53±1.78 b	17.09±2.01 a	20.67±2.61 a	19.85±2.14 ab	4.80 ±1.70 a	5.60 ±1.55 a
9 WAP	32.20±0.66 a	33.32±1.82 a	21.67±2.90 a	20.14±1.26 a	23.07±1.32 a	24.55±2.82 a	5.20 ±1.30 a	6.33 ±1.75 a

Treatments with the same letters in columns are not statistically significant different from each other.

difference was not recorded between okra plant sprayed with the extracts at 4, 5, 6, 8 and 9 WAP. However, there was significant difference in the severity of leaves recorded at 7 WAP. Significant difference was also recorded between *C. procera* and chemical insect controlled okra but *C. schweinfurthii* and *B. coccineus* were not statistically significant from each other. The highest severity was recorded at 9 WAP followed by 7 WAP which could be due to lack of rainfall in these periods.

Severity of leaves damage by *Podagrica* spp. is presented in Table 6. The least percentage leaves defoliation was observed from the plants treated with synthetic insecticide and *C. procera* treated plant recorded highest percentage of defoliation among the botanical insecticides. *C. schweinfurthii* and *B. coccineus* showed significantly promising effect in reducing severity of leaves damage. However, all botanical treated okra plants prevented the leaves from being severely defoliated as all the plants suffered below 33.32% defoliation at 9 WAP. In general term, leaves damage increased with the increasing age of okra plants.

Phytochemical screening

The result of phytochemical screening of crude leaf extracts revealed the presence of Triterpenoids, Steroids, Flavonoids, Phlobatanins, Saponins, Tannins, Cardiac glycoside and Anthraquinones in the plants (Table 7). Alkaloids and Anthraquinones were not detected in both *C. procera* and *C. schweinfurthii* while Triterpenoids and Phlobatanins were absent in *C. schweinfurthii.* The presence of these bioactive compounds in the plant materials is an indication that it may have some insecticidal potential against agriculturally important insect pest.

Table 7 - Phytochemical screening of crude aqueous extract of *C. procera*, *C. schweinfurthii* and *B. coccineus*

Chemical constituents	*Calotrophus procera*	*Canarium schweinfurthii*	*Bryscocarpus coccineus*
Alkaloids	-	-	+
Terpenoids	+	-	+
Flavonoids	+	+	+
Anthraquinones	-	-	+
Tannins	+	+	+
Phlobatanins	+	-	+
Saponins	+	+	+
Cardiac glycosides	+	+	+
Steroids	+	+	+

+ = Present, - = absent.

4. Discussion and Conclusions

Plants are rich sources of natural substances that can be utilized in the development of environmentally safe methods for insect pests control as veritable alternative to synthetic insecticide (Sadek, 2003**).** Moreover, growing awareness of health and environmental issues accompanied by the intensive use of chemical inputs has led to increased concerns and the need for alternate forms of crop protection in the world (Adesina, 2013).

The crude aqueous extracts evaluated in this study have been reported to contain insecticidal, termiticidal, antifeedant, ovacidal and larvacidal properties (Ahmed, 1993; Shaaya *et al*., 1977; David, 1989; Jahan *et al*., 1991; Abayeh *et al*., 1999; Abbassi *et al.*, 2003; Umsalama *et al*., 2006; Bakavathiappan *et al*., 2012; Katunku *et al.*, 2014; Nagawa *et al*., 2015; Okoli *et al*., 2016). The result of the study showed that the crude plant extracts were able to reduce insect population, but not significantly, compared to the synthetic insecticide, but were able to show some suppressing effect on the rate of feeding of the insects as the severity of the leaves damaged by the insects was not enough to cause significant reduction in yield compared to results obtained from okra plants sprayed with chemical.

The target insects are notorious for leaves defoliation owing to their biting and chewing mouthparts resulting in reduction of photosynthetic ability of the infested plants which invariably affect the plant growth and yield (Dent, 1999). The aqueous extracts were not effective at first two weeks of application. Synthetic insecticide recorded a higher efficacy compared to aqueous extract. This might be as a result of active ingredients of aqueous extracts being easily volatilized especially in the sun, thereby leading to their limited efficacy (Ware, 2000) and the delayed effect of aqueous extracts is reported to be one of the major problems of botanical insecticides (Oparaeke, 2006; Isman, 2008).

Since the beetles live and feed on the vegetative parts, any chemical that shows a remarkable efficacy against them must have contact toxicity, repellent or anti-feeding action. Several authors have reported that, the deleterious effects of crude plant extracts on insects are manifested in several ways, including toxicity (Hiremath *et al*., 1997) and feeding inhibition (Klepzig and Schlyter, 1999; Wheeler and Isman, 2001). Thus, reducing the level of beetle infestation and increasing okra pod carrying capacity; this confirmed the earlier report of Thirumalai *et al*. (2003)

who observed the effective reduction of mite population with application of neem seed kernel extract.

The reduction in *Podagrica* beetle population and increase in yield caused by the plant extracts treatment was comparable with those caused by synthetic insecticide. This supports the findings of Katunku *et al*. (2014) and those of Yusuf and Mohammed (2009) who reported that *C. schweinfurthii* and *Monordica balsamina* powder treatments were as effective as and comparable to permethrin and pirimiphos methyl in suppressing *C. maculatus* population and growth in cowpea storage.

The high rate of *Podagrica spp.* population reduction on exposure to the aqueous extracts treatments may be attributed to the chemical composition of the products. Plant extracts often consist of complex mixtures of bioactive constituents which may act as antifeedants, disturb insect growth, development and inhibit oviposition (Gerard and Ruf, 1991; Emimal Victoria, 2010). Thus, suggesting that most of the secondary metabolites such as terpenoids and alkaloids can be used as active insecticidal compounds that could be an effective alternative to synthetic insecticides for insect pest management. The toxicity of alkaloids was reported by Abbassi *et al.* (2003) and David (1989) reported that tannic acid acts as toxin and feeding deterrent to insects. Bernhoft (2010) reported that saponnins is found to affect the respiratory system of insects and causes emetic effect due to their detergent action. In the same vein, Philip *et al.* (2009) reported that plant products have repellent properties and toxic effect on the heart muscles in insects. Frazier (1986) reported that antifeedants can be found amongst all major classes of secondary metabolites (alkaloids, flavonoids, terpenoids and phenolics). Plant metabolites may produce toxic effects if ingested leading to rejection of the host plant (Russel and Lane, 1993)**.**

The utilization of *C. schweinfurthii* and *B. coccineus* aqueous extracts had positive toxicity impact in decreasing the rate of *Podagrica spp.* infestation and also increased the yield of okra plant thus could serve as alternative to synthetic insecticide to protect okra plant against *Podagrica* spp. infestation to maximize the yield and income of the resource poor farmers.

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