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Bioefficacy of *Petiveria alliacea* and *Annona squamosa* against *Podagrica* species of Roselle (*Hibiscus sabdariffa* Linn)

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Abstract
Control of major insect pests of crops with plant based insecticides has been widely considered as another source of environmental protection. These experiments were conducted during the major planting season of 2015 and 2016 to evaluate the efficacy of *Petiveria alliacea* (L.) and *Annona squamosa* (L.) in the control of *Podagrica sjostedti* (J.) and *P. uniformis* (J.) which are the major leave feeding beetles of Roselle. The plant materials were extracted with Ethanol and the paste was formulated with black Soap, Texapol, Nitrosol and Salt. This field experiment was set up in a randomized complete block design and each treatment was replicated three times. Application of the plant extracts was done early in the morning. Data collection was based on insect population densities, defoliated leaves and calyx yield. The result showed that the tested plant extracts had significant control of the observed insects when compared with the level of insect infestations in the untreated plants. *A. squamosa* leaves had the same insecticidal efficacy with the seeds against the studied insects. The calyx yield obtained from botanical insecticide treated plants was 50% higher than that of treated plants but 25% lower than that of Lambdachyalothrin sprayed plants. Therefore, the two plant extracts can be used in the management of insect pests of roselle in organic farming system

Keywords: *Podagrica sjsotedtii*, *Podagrica uniformis*, roselle, *Petiveria alliacea*, *Annona squamosa*, lambda cyhalothrin

Introduction

Roselle, *Hibiscus sabdariffa* (Linn) called roselle belongs to the family Malvaceae and is one of the common flower plants grown in the tropics and subtropics especially in India, East Indies, Nigeria and South America [1, 6]. However, Benin, Sudan, Cote D'Ivoire, Ghana, Niger, Burkina Faso and Nigeria were reported as major areas of Roselle cultivation in Africa [25]. The most economical part of roselle is the calyx which is obtained by removing the petals of the flower from its capsule containing the seeds. They are used as valuable food products; wine, jelly, beverages, jam, colour and flavour ingredients [17, 27]. Non-food products include the pharmaceutical use of flower and fruits to treat cases of bronchitis and cough, hypertension, diarrhoea and many other diseases [7, 12]. The calyx is high in calcium, niacin, riboflavin and iron. It contains three and nine times more vitamin C than blackcurrant (*Ribes nigrum* L) and citrus (*Citrus sinesis* L) fruit respectively [17]. In Nigeria, the leaves are used in making soup as well as salad while red calyces are used as tea after adding sugar which is locally known as Zobo. In recent years, cultivation of roselle has gained wide acceptability among Nigeria farmers due to its medicinal importance.

In spite of aforementioned numerous benefits of this crop, its production in Nigeria especially in southern part of this country is at subsistence level because farmers rarely cultivate more than one acre of land. There is a ready local market for this crop which supposes to be an incentive for increased production. However, insect pest infestations such as *Anomis erosa*, *Cosmophila erosa*, *Dysdercus cingulatus*, *D. poecilus*, *Bemisia tabaci*, Cotton aphid, *Podagrica* spp etc. are the major militating factor in the cultivation of roselle. *Podarica* spp and *Zonocerus variegatus* have been described as dominant insect pests in western part of Nigeria [24, 9]. Meanwhile, different insect pests have been reported from various agro ecological zones for instance *Podarica* spp and *Zonocerus variegatus* have been described as dominant leaf feeding insect pests in Western part of Nigeria [24]. According to Fasunwon and Banjo [11], *Podagrica* species attack the lamina of the foliage and matured leaves of the okra plant which result in reduction of the photosynthetic ability of the crop leaves. This insect is also responsible for transmission of mosaic virus, this infection could result to 20 - 50% yield reduction [11].

Due to the destructive potential of the aforementioned insect pests, control becomes imperative. The use of synthetic insecticides has become a common practice in developing countries due to their quick effectiveness [5] but most of these synthetic insecticides have been implicated to have caused environmental hazard, insect pest resistance and resurgence and some have been proved as carcinogenic. These problems have led to resuscitation of the old idea of using plant extracts [3]. Botanical insecticides are naturally occurring chemicals extracted from plants and are available as an alternative to synthetic chemical formulations but they are not necessary less toxic to humans [16].

Annona squamosa is commonly known as Sitaphal, Sweetsop, and Custard Apple, is a native of West Indies and is cultivated throughout India, mainly for its edible fruit. Leatemia and Isman [18] reported that plant parts of some species of this family have been used traditionally as insecticides. Powdered seeds and leaves of *Annona* have been used traditionally to treat head and body lice [23] antimicrobial and insecticidal activities have already been reported in leaves, stems and seeds of this plant species [22].

Therefore, this experiment was conducted to evaluate the efficacy of *A. squamosa* and *P. alliacea* in the control of major field insect pests of reselle

Materials and Methods

Study Site: The field experiment was conducted in the cropping season of 2015 and 2016 at Ladoke Akintola University of Technology (LAUTECH) Teaching and Research Farm, Ogbomoso, Oyo state. This region is on longitude $4^{0}3$'E and latitude $10^{0}5$'N. The region can be described as humid tropical falls in Southern Guinea Savannah of Nigeria.

Experimental Design and Management

Experimental land were ploughed and harrowed once. Fifteen plots were arranged and demarcated in a Randomized Completed Block Design with three replicates. The plot size was 3 m x 3 m with a planting space of 1 m x 1 m between and within the plant rows respectively. Four seeds of Roselle (Red calyx) were planted per hole which was later thinned to one plant per stand after two weeks of planting. Manual weeding was done fortnightly.

Formulation of Botanical insecticides

The roots of *P. allieacea*, leaves and seeds of *A. squamosa* were washed separately to remove sand, dust and chemical contaminants, the plant extract were air dried to reduce the moisture content. Each of the plant was crushed with electric blender and it was later soaked in a 10- littre bucket for 12 hours. Ethanol were used as extracting agents, this was done separately. Filtration was done with muslin cloth and filtrate collected was stored in a 10-litre keg. Each of the filtrate was loaded into the steam water bath for 24hours in other to evaporate the solvents. The paste collected was stored separately in a refrigerator which was used as an active ingredient in the formulation of botanical insecticide.

The 33.3% of active ingredient (paste) was separately diluted with adjuvant substances such as Texapon (11.11%), Nitrosol (22.22%), Salt (22.22%) and Black soap (11.11%). Hence the mixture was equivalent to 100 ml. the unsprayed plots and synthetic insecticide Karate (Lambdachyalothrin, Syngenta) which was treated at 0.5 ml per plot were included for comparison. Each concentration of both synthetic and botanical insecticides was diluted with 1000 ml of water to achieve the same spraying volume. This formulation is in line with already establisbed procedures by Olaniran *et al*., 2016

Treatment Application

One hundred of the formulated solution (100 ml) was measured from stock solution which was later diluted with 900 ml of water. Application was done with hand-held sprayer (2-litre capacity) and ensured it had contact with target crop as well as insect pests. The spraying was done early in the morning to avoid photo degradation of the extracts. Some plots were left unsprayed to serve as control. Four -weekly application was done at seven days interval

Data Collection

Data were collected on insect population densities and collections were done early in the morning by visual observation. The morphological data collected were based on numbers of plant heights, percentage defoliated leaves, damaged fruit per plot and yield was calculated in kg/ha which was later converted to ton per hectare (t/ha).

Results

Table 1: Effect of botanical insecticide on *Podagrica uniformis* population.

Treatments		Weeks After Treatment			
	1	2	3	4	Efficacy (%)
P. allaicea extract	1.05ab	1.93bc	1.58bc	1.76a	31.15
A. squamosa	1.05ab	2.90a	2.30ab	1.65a	13.94
Karate	0.88b	1.65c	0.88c	0.88a	53.27
A. squamosa seed extract	1.05ab	2.72ab	1.64bc	2.12a	17.97
Control	1.56ab	3.07a	2.44a	2.11a	-

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

The result presented in table 1 showed the effect of insecticides on *P. uniformis*. Although there was no significant difference ($P<0.05$) between the botanical insecticides treated plants and unprotectected plants but untreated plants had higer *P. uinformis* infestation at 1 week after treatment (WAT). Meanwhile, plant extracts treated plants had lower *P. uniformis* attack than unprotected plants at 2 WAT. Among the botanical treated plants, *P. alliacea* had higher insecticidal efficacy than *A. squamosa* treated plants. Meanwhile, lower *P. uniformis* population density was observed in *A. squamos*a seed extracts sprayed plants compared with *A. squamosa* leaves extracts treated plants at 2 WAT.

At 3WAT, *P. alliacea* and *A. squamosa* seed extracts exhibited the same insecticidal control on *P. uniformis*. However, *A. squamosa* seed extracts performed better than *A.*

squamosa leaves extracts. Though there was no significant difference ($P<0.05$) between the protected and and unsprayed plants but unsprayed plants and *A. squamosa* leaves extracts were heavily attacked by *P. uniformis* at 4WAT.

Generally, *P. alliacea* proved to be more effective against *P. uniformis* (31.15%) followed by *A. squamosa* seed extracts (17.97%) while *A. squamosa* had the least insecticidal efficacy though synthetic insecticide (Lambdacialotrina) had highest control (53. 3%) of *P. uniformis*.

Table 2: Shows effect of botanical insecticide on *Podagrica sjostedii* population.

Treatments	Weeks After Treatment				
	1	2	3	4	Efficacy (%)
P. allaicea extract	1.38a	1.46b	1.94ab	3.28a	20.69
A. squamosa	1.17ab	1.56b	1.86ab	3.24b	21.03
Karate	0.71b	0.88c	1.35b	0.88c	64.12
A. squamosa seed extract	1.05ab	1.46b	1.39b	3.18b	22.90
Control	1.44a	2.04a	2.46a	3.93a	-

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

The result presented in table 2 showed that application of *P. alliacea* significantly ($P<0.05$) failed to control *P. sjostedti* when compared with control at 1WAT. *A. squamosa* leaves and seeds extracts had the same insecticidal control of *P. sjostedti* at 1WAT. All the treated plants had lower *P. sjostedti* infestations compared with untreated plants (2WAT). There was no significant difference ($P<0.05$) in the level of *P. sjostedti* infestations among the tested plant extracts at 2WAT. There was no significant difference in the level of *P. sjostedti* infestations among the tested plant extracts at 2WAT. Applied *A. squamosa* seed extracts compete effectively with synthetic insecticide (Lambda cyhalothrin) against *P. sjostedti* at 3AWT. *A. squamosa* seed and leave extracts proved more effective in the control of *P. sjostedti* than *P. alliacea* at 4WAT.

Table 3: Shows effect of botanical insecticides on yield (t/ha)

Treatments	Yield (t/ha)
P. allaicea	19.87ab
A. squamosa leaf	20.64ab
Karate	33.16a
A. squamosa seed extract	20.73ab
Control	10.47b

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

Table 3 showed that synthetic insecticide treated plants had highest calyx yield (33.2 t/ha). *A.squamosa* seed and leaves extracts had the same significant calyx yield. The calyx yield obtained from *P. alliacea* sprayed plants was comparable with to that of unprotected plants

Table 4: Shows the effect of botanical insecticides on defoliated leaves (%)

Treatments	Week After Planting	
	4	6
P. allaicea extract	54.92a	28.95b
A. squamosa (leaf)	54.43a	35.57ab
Karate	0.85b	29.16b
A. squamosa (seed)	37.31ab	39.64ab
Control	72.66a	45.85a

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

In respect to defoliated leaves, plants sprayed with Lambda cyalothrin had the least defoliated leaves (0.88%). Among the botanical treated plants, *A. squamosa* seed extracts effectively protected the roselle leaves from leave eating beetles and unsprayed plants. At 6 week after planting, the level of leaves defoliation in the *P. alliacea* was statistically comparable with that of Lambda cyhalothrin treated plants which had 29.2%. Untreated plants had highest defoliated leaves (45.9%)

Discussion

Management of insect pests through the use of plant secondary metabolites can be described as another means of environmental protection. This experiment demonstrated that plant extracts can be used to control the menace of pre-flowering insect pests of roselle. *P. sjostedti* and *P. uniformis* were observed during the active growing plant stage of roselle responsible for leaves defoliation. *P. alliacea* and *A. squamosa* were evaluated against these dominant insect pests of the target plants. It was observed that the tested plants exhibited insecticidal effects on the two major pre-flowering insect pests when compared with the level of insect pests attack on the untreated plants. This observation is in line with the earlier report by Olaniran *et al.*, [23] who reported that *T.vogelii* and *Azardirachta indica* had insecticidal control of *Podagrica* species and *Zonocerus variegatus*.

The insecticidal potential of *P. alliacea* can be attributed to the insecticidal compound Dibenzyl Trisulfide [25]. Anonnain and squamocin [19] have been reported as the active insecticidal compound of *A. squamosa* but the seeds were observed to have had the highest active ingredients. Meanwhile, the result revealed that there was no significant difference in the effectiveness of *A. squamosa* seed and leaves extracts despite the fact that *A. squamosa* seed extracts have more active insecticidal compounds than the leaves [16].

The data suggest that there was variation in the efficacy of each tested plant extracts in respect to the observed insects. *P. alliacea* had 31.2% efficacy (Table1) against *P. uniformis* whereas *A. squamosa* seed extracts had 18% and *A. squamosa* leave extracts had 14% control. Meanwhile, *A. squamosa* seed and leave extracts had 22% and 21% efficacy respectively against *P. sjostdtii* but *P. alliacea* had 20.7% control. This showed that the observed insects responded differently to insecticidal compounds obtained from each plant extracts. Many studies have reported that closely related species can differ markedly in susceptibility to the same plant extracts or pure allele chemical [15, 2]

It was observed that the level of infestations of the target insects corresponds to defoliation of leaves. Synthetic insecticide treated plants which had the least insect infestations had lower defoliation leaves whereas unprotected plants had highest leave defolilated (45-72.2%). This result showed that the plant extracts proved effective in the management of leave-eating beetles.

The yield which is the ultimate goal of farmers can be drastically affected with the level of insect pest attack depending on the level of infestations [8]. Yield obtained from unsprayed plants was considerably low when compared with Lambda cyhalothrin and plant extract treated plants. This observation suggests that yield loss corresponding to the level of insect pest infestation thereby, defoliation of leaves by the insect resulted to low calyse yield. However, the level of defoliation of the leaves by the *Podagrica* species decreased as the maturity of the leaves increased. The synthetic insecticide which produced the highest yield constitutes the environmental hazard such as environmental pollution, insect resistance and resurgence and most of these insecticides are carcinogenic [16]. Despite inadequacy of plant extracts in the protection of crops against insect infestations when compared with synthetic insecticides, the environment is better protected since botanical insecticides have been found to be ecological and environmentally friendly [4].

In conclusion, use of botanical insecticides has been reported to have gained advantage over syntethetic insecticides through quick decomposition and protect the food through contamination and safety of life is granteed. This is an indication that the tested plant extracts is scientifically accepted in the cultivation of rossele especially in the organic farming. However, these plant extracts are medicinal and the possibility of constituting environmental hazard when mistakenly consumed by the farmers during the course of spraying will be minimal. Further research will be carried out to evaluate the effects of the tested plants extracts on the nutritional contents of calyses

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