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Evaluation of Oil Extracts from Three Indigenous Botanicals against Field Pest of *Solanum* Species

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Authors' contributions

This work was carried out in collaboration among all authors. Author OA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TIO, MOO and JEI managed the analyses of the study. Author SKA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Oil extract of three plant insecticides, *Acalypha godseffiana, Annona muricata and Petiveria alliaceae* were evaluated as protectant against field pest of three major *Solanum* species cultivated in Nigeria. The experimental design was laid out in a completely randomized block design with each treatment replicated three times. The results indicated low level in severity of shoot damage among *Solanum macrocarpon* bio-pesticide treated plants and their interactions. Higher fruit damage severity (13.93%) was reflected in untreated *S. macrocarpon* interactions. Findings from the study reflected a coefficient of determination (R^2) = 0.18 between plant oil treatments and fruit yield of eggplant species, which implies that 18% of the variance in fruit yield of eggplant species can be attributed to the plant oil treatments. Further screening of the active components of the botanicals for insecticidal potency is hereby recommended.

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1. INTRODUCTION

The Solanum species, "eggplant" are part of the major fruit and leaf vegetable crops cultivated in Nigeria. The need to enhance dietary and nutritional diversity necessitates the inclusion of nutrient rich indigenous fruit and vegetables such as eggplant in daily diet by the general populace in Nigeria, and are consumed in different forms according to individual culture. The glabrous leaves of *Solanum macrocarpon* is cooked like spinach while its large fruits are cooked in stews with meat and other vegetables [1]. In a similar vein, mature ripe fruits of *S. melongena* are cooked with stew and serve with yam in South-Western Nigeria [2].

A major biotic production constraint of eggplant on the field is insect pest infestation, which include; *Daraba laisalis* (eggplant fruit and shoot borer), *Euzophera villora* (stem borer), *Spodoptera littoralis* (leafworm) and *Tetranychus spp* (mites) [3]. However, the use of chemical pesticides have been adopted over the decades in the control of eggplant pests by small, medium and large scale producers in many developing countries [4]. Chemical pesticides are effective, rarely available and affordable to farmers, and there is appreciable danger of abuse, death of beneficial insects and non-target fauna, toxic chemical resistance development as well as limited shelf life of dust formulations [5]. Consequent of the growing concern for environmental safety and numerous undesirable side effects on the use of pesticide in the cropping system, it has become pertinent to develop pesticides of plant origin which are affordable, bio-degradable and non-toxic with low mammalian toxicity and eco-friendly [6,7,8]. Therefore, researchers have shifted toward the use of plant materials as they were believed to contain myriads of chemicals that could be insecticidal in nature, while many of them have proven to be highly medicinal and ecofriendly [9, 10, 11].

Acalypha godseffinana (Muell Arg) is a medicinal plant proven to have anti-malarial and anti-fungi efficacy while research on its insecticidal efficacy on seeds and grains proven against grain weevils (Ikewuchi et al., 2011;6). *Annona muricata* (L.), commonly known as soursop is a fruit bearing tree widely distributed throughout tropical and subtropical parts of the world, including Nigeria. Its fruits are usually eaten raw, medicinal and have been reported as anticancer agent, anticonvulsant, anti-arthritic etc. [12]. *Petiveria alliacea* (L.) is a perennial shrub in the family Phytolaccaceae. It has commonly been used in folk medicine and various preparations made from this plant are considered to have anti-inflammatory, antimicrobial, antispasmodic, diuretic, and stimulant effects, among others [13].

It is against the backdrop of the bioactivity of these plants that this study therefore, evaluated oil extract of *A.godseffiana, A.muricata and P.alliacea* as protectant against field insect pest of *Solanum* species.

2. MATERIALS AND METHODS

2.1 Study Site and the Experimental Layout

2.1.1 Study area

The field experiment was carried out at the Teaching and Research Farm of the The Federal University of Technology Akure (7^o 18 28 608" N; 5^o7 21 438" E), within the rainforest zone of Southwest Nigeria in the main cropping season of 2017. The annual rainfall recorded at the site was 1383mm and bimodal in pattern.

2.1.2 Collection of seed and plant materials

Seeds of the *Solanum* species; *S. melongena*, *S. macrocarpon* and *S. aethiopicum* were collected from the Seed Genebank of the National Centre for Genetic Resources and Biotechnology (NACGRAB) Ibadan, Nigeria. The bio pesticides plants, *A. muricata* and *P. alliaceae* were collected from the Field Genebank of NACGRAB, Ibadan (07^o 23 11 3"N, 3^o 50 25 0"E), while fresh leaves of *A. godseffiana* were collected from the Botanical Garden, Teaching and Research Farm of the Federal University of Technology, Akure (07^o18 24 4"N, 5^o 21 7 "E).The identity of the plant samples was confirmed at the Herbarium Unit of the NACGRAB.

2.1.3 Extraction of plant oils

Leaves of *P. alliacea* and *A. godseffiana* were washed under running tap water to remove the surface pollutants .The leaves were air dried under shade at room temperature (27± 2ºC) for 4-5 days and milled separately into fine powder with the aid of 1 mm Thomas ® milling machine. Physiological mature fruits of *A. muricata* were cut longitudinally and the black seed removed with the aid of a sharp knife. The mucilage covering of the seeds was removed manually and seeds air dried for 4-5 days before milling into fine power. The organic extraction from the plant materials was carried out following Association of Official Analytical Chemist [14] procedures. 500 g sample of the powdered materials was macerated at room temperature (27±2ºC) in 500 ml of 99% ethanol (BDH®) for 48hrs and then filtered with Whatman Filter paper (9 mm).The solvent was evaporated by using a rotary evaporator (Resona Technics®) .The resulting extract slurry was air dried to remove traces of the solvents .The oil obtained was kept in reagent bottles and stored in a deep freezer at 4ºC until needed.

2.2 Experimental Procedure

The experimental design was factorial, 3 x 5 x 3, laid out in randomized completely block design. The factors were eggplant species (3), plant oils (3), rate of treatments (5), 0.1, 0.5, 0.9, Cypermethrin 10EC (250 ml/ha) and control=0 positive control. Seedlings were raised in black colour germination trays (0.55 m x 0.27 m x 0.06 m) filled with top soil rich in organic matter. Emerged seedlings at 4-6 leaves stage were transplanted 5 weeks after sowing (WAS) into the plots by dibbling at a spacing of 0.75 m x 0.25 m, on 2 m x1 m per plot replicated three times respectively. The total size of the experimental plot was 75 m x 4.7 m; 352.5 m^2. Fertilizer application of NPK 15: 15: 15 was applied at the rate of 125 kg/ha 10 days after transplanting. The experimental plots were subjected to natural pest infestation during the period of evaluation. The leaf damage on the treated and untreated plots were assessed on a scale of 0-4 as described by Niles [15]. Shoot damage and fruit borer infestation was calculated using the percentage of the shoot and fruit damage as a result of pest infestation;

$$\%\,Shoot\ damage = \frac{number\ of\ \ stand\ with\ shoot\ damage}{total\ no\ of\ stand\ in\ a\ plot} \times \frac{100}{1}$$

$$\%\,Fruit\ damage = \frac{weight\ of\ the\ infested\ fruits}{total\ weight\ of\ fruits\ harvested} \times \frac{100}{1}$$

2.3 Data Analysis

Descriptor for eggplant developed by the International Board for Plant Genetic Resources [16] was used for scoring of the quantitative traits. Data on days to 50% flowering, leave damage , height of plant at flowering, % shoot damage, % fruit infestation and fruit yield were collected from five randomly selected plant per plot and subjected to analysis of variance (ANOVA) using the general linear model [17]. Statistically significant means were separated using Tukey post hoc test at 5% probability level.

3. RESULT

3.1 Influence of Plant Oils and Cypermethrin on Plant Growth and Yield Attributes of the Eggplant Species

Result from the study shows that there was insignificant difference ($p > 0.05$) in the effect of plant oils on the height of the eggplant at flowering (Table 1). However, significant differences ($p < 0.05$) existed on days to 50% flowering, shoot damage, fruit yield, leaf damage and fruit infestation among the eggplant species. Days to 50% flowering of eggplant treated with *A. godseffiana* (106.33 days), *P.alliacea* (108.07) oil extracts and Cypermethrin (107.33 days) recorded the highest days to 50% flowering which was significantly different ($p < 0.05$) from the control (103.44 days). No statistically detectable shoot damage was noticeable among eggplant without plant oil treatment and Cypermethrin while significant difference existed with *A. godseffiana* (8.50%) and *A. muricata* (8.70%) treated plants. Lowest leaf damage (11.11%) was recorded with Cypermethrin in contrast to *A. godseffiana* (23.19%) treated plants and the control (22.22%). Cypermethin (633.68 g) and the control (271.08 g) reflects the significantly highest and lowest fruit yield respectively. Similarly, Cypermethrin treated eggplant had fruit damage (0.22%) which was significantly lower than other treatments applications.

3.2 Efficacy of Plant Oil Rates on Growth and Yield Parameters of the Eggplant Species

Table 2 shows that plant height of eggplant species at flowering was not significantly ($p > 0.05$) altered by the different rate of plant oil treatments. The result shows that rate of plant oils significantly ($p \leq 0.05$) reflected on days to 50% flowering, shoot damage, fruit yield, leaf damage and fruit infestation of the eggplant species. Eggplant without oil treatments (103.44 days) flowers earlier than plants treated with Cypermethrin (107.33 days) and 0.9 ml oil treated eggplant (108.04 days). Inadvertently, eggplant with positive control (Cypermethrin) and the control recorded no shoot damage which differs significantly from other treatments. Leaf (11%) and fruit damage (0%) was reduced on Cypermethrin treated eggplant when compared to the control with the highest leaf (22%) and fruit damage (12%). Eggplant treated with Cypermethrin (633.68 g) and control (271.08 g) recorded the highest and lowest fruit yield respectively.

3.3 Influence of eggplant species and plant oils treatment on growth and fruit yield of indices of the eggplant

Significant interactions occurred amongst the plant oils and eggplant species on days to 50% flowering, fruit yield and plant height at flowering of eggplant while no significant difference ($p > 0.05$) was observed for leaf damage (Table 3). Analysis of the interaction effect between *S.melongena* and Cypermethrin (122.33 days) had the highest days to flowering which differs significantly from other treatment interactions except interaction between *S. melongena* and *P.alliacea* (120.89 days). *S.macrocarpon* and Cypermethrin (962.27 g) and *S.macrocarpon* and control (236.23 g) recorded the highest and lowest fruit yield respectively. *S.melongena* and *A. godseffiana* (36.44 cm) interaction had the highest plant height at flowering while *S.macrocarpon* and Cypermethrin (14.59 cm) had the lowest plant height at flowering. All *S.macrocarpon*, *S.melongena* and *S.aethiopicum* interaction with Cypermethrin and no oil treatment recorded no shoot damage which differs significantly from *S.aethiopicum* and *A.muricata* (18.89%) interaction. While interaction between *S.macrocarpon* with Cypermethrin application (0.13%) and *S.macrocarpon* and control (13.93%) recorded the lowest and highest fruit damage respectively.

3.4 Linear Regression Analysis Between Insecticidal Plant Oil and Fruit Yield

The degree of plant oils applied to fruit yield of eggplant was found to be correlated (r) = 0.42 and coefficient of determination (R^2) = 0.18. This implies that 18% of the variance in fruit yield of eggplant can be attributed to the plant oil treatments (Table 4). Table 5 shows the multi-linear regression model between plant oil and fruit yield of eggplant. The result reveals that eggplant species and plant oils treatments have negative coefficient, thus, negatively predicts fruit yield of eggplant. Therefore, taking treated eggplant species constant at zero (0), fruit yield of eggplant will be 7.92g. Thus, a unit change or increase in eggplant species with plant oil treatments will lead to -2.40, -4.61 and 1.09 unit change or increases in fruit yield change of eggplant respectively.

Table 1. Effect of plant oil extracts on some growth parameters and infestation of the eggplant

Botanicals	Days to flowering	Shoot Damage	Fruit yield (g)	Leaf Damage	Plant Height at Flowering (cm)	Fruit Infestation
A.godseffiana	106.33a	8.50a	614.72ab	23.19a	31.02a	5.05b
A.muricata	105.70ab	8.70a	367.78bc	19.44ab	26.86a	4.50b
P.alliacea	108.07ab	7.28ab	387.94abc	19.44ab	25.91a	3.28bc
Cypermethrin	107.33a	0.00b	633.68a	11.11b	25.66a	0.22c
Control	103.44b	0.00b	271.08c	22.22a	30.96a	11.98a

Means followed by the same letter(s) within the same column are not significantly (p >0.05) different from each other using Tukey post hoc test

Table 2. Effect of plant oil extracts rates on some growth parameters and infestation of eggplant species

Rate	Days to flowering	Shoot damage	Fruit yield (g)	Leaf damage	Plant Height at flowering(cm)	Fruit infestation(%)
0.1ml	104.96ab	0.06ab	483.12abc	0.22a	26.52a	0.05b
0.5ml	107.11ab	0.11a	534.22ab	0.20ab	27.76a	0.03bc
0.9ml	108.04a	0.07ab	353.09bc	0.19ab	29.51a	0.05b
Cypermethrin	107.33a	0.00b	633.68a	0.11b	25.66a	0.00c
Control	103.44b	0.00b	271.08c	0.22a	30.96a	0.12a

Means followed by the same letters within the same column are not significantly (p > 0.05) different from each other using Tukey post hoc test

Table 3. Interactive effect between species and plant oil on some eggplant growth parameters and pest infestation

Species	Botanicals	Days to flowering	Shoot Damage	Fruit yield (g)	Leaf Damage	Plant height at flowering(cm)	Fruit Infestation
S.melongena	*A.godseffiana*	119.11ab	11.22ab	672.97abc	16.67a	36.44a	5.91a-d
	A.muricata	116.89ab	7.22ab	401.08bc	11.11a	30.98abc	2.27cd
	P.alliacea	120.89a	6.30ab	467.56abc	11.11a	28.36a-d	4.15cd
	Cypermethrin	122.33a	0.00b	466.97abc	8.33a	29.42abc	0.23cd
	Control	113.33bc	0.00b	362.50bc	16.67a	35.98a	8.67abc
S.macrocarpon	*A.godseffiana*	92.33f	0.00b	808.47ab	22.33a	22.28a-d	4.16cd
	A.muricata	96.44ef	0.00b	500.79abc	16.67a	20.26bcd	7.45a-d
	P.alliacea	95.00f	0.00b	435.21abc	16.67a	18.64cd	3.22cd
	Cypermethrin	95.00def	0.00b	962.27a	8.33a	14.59d	0.13d
	Control	92.33f	0.00b	236.23c	25.00a	26.07a-d	13.93a
S.aethiopicum	*A.godseffiana*	103.44cde	14.28ab	362.72bc	30.56a	34.33ab	5.09bcd
	A.muricata	105.22cd	18.89a	201.46c	30.56a	29.35abc	3.78cd
	P.alliacea	105.44c	15.56ab	261.04c	30.56a	30.73abc	2.47cd
	Cypermethrin	104.67cd	0.00b	471.80abc	16.67a	32.97abc	0.30cd
	Control	104.67d	0.00b	214.50b	0.25ab	30.83abc	13.34ab

Means followed by the same letter(s) within the same column are not significantly (p > 0.05) different from each other using Tukey post hoc test

Table 4. Model of Fit between plant oils and fruit yield

R	R Square	Adjusted R Squared	Std. Error of the Estimate
0.42	0.18	0.16	339.18

Table 5. Multi-linear regression model between plant oil and fruit yield

Model	Unstandardized Coefficients		T	Sig	VIF
	B	Std. Error			
(Constant)	895.0	113.0	7.92	0.000	
Species	-86.0	35.8	-2.40	0.018	1.00
Plant oil	-95.2	20.6	-4.61	0.000	1.00
Rate	-39.0	35.8	-1.09	0.277	1.00

Table 6. Correlation matrix between rate of plant oil, growth, pest infestation and fruit yield of eggplant

	Plant oil treatments	Days to flowering	Shoot damage	Fruit yield	Leaf damage	Plant height at flowering
Days to flowering	0.125					
Shoot damage	-0.014	0.108				
Fruit yield	-0.365**	-0.157	0.019			
Leaf damage	-0.256*	-0.270**	0.253**	0.092		
Plant height at harvest	-0.223*	0.325**	0.201*	0.215*	0.188*	
Fruit infestation	-0.582**	-0.197*	0.003	0.398**	0.211*	0.163

3.5 Relationship between Rate of Plant Oils and Plant Growth, Pest Infestation of the Eggplant Species

Table 6 shows the correlation matrix between plant oil treatments, days to 50% flowering, shoot damage, fruit yield, leaf damage, plant height at flowering and fruit infestation of the eggplant species. Result shows that plant oil treatments is correlated with fruit yield (r = -0.365, $p \le 0.01$), leaf damage (r = -0.256, $p \le 0.05$), plant height at flowering (r = -0.223, p ≤ 0.05) and fruit infestation (r = -0.582, $p \le 0.01$). Days to flowering is correlated with leaf damage (r = -0.270, p ≤ 0.01), plant height at flowering (r = 0.325, $p \le 0.01$) and fruit infestation (r = -0.197 $p \le 0.05$). Shoot damage is correlated with leaf damage (r = 0.253, $p \le 0.01$) and plant height at flowering (r = 0.201, $P \le 0.05$). Fruit yield is correlated with plant height at flowering (r = 0.215, $P \le 0.05$) and fruit infestation (r = 0.398, $p \le 0.01$). Leaf damage is correlated with plant height at flowering (r = 0.188, $p \le 0.05$) and fruit infestation (r = 0.211, $p \le 0.05$).

4. DISCUSSION

This result from this study has clearly demonstrated that oil extract from the three medicinal plants provided some level of protection against the field insect pest of *Solanum* species in comparison with Cypermethrin 2.5 EC at 250 ml/ha in terms of sustenance of some growth parameters and fruit yield indices . Result from the study also revealed low level of shoot and leaf damage in plant oil treatments application on *S. macrocarpon*. This could presumably be attributed to the significant level of alkaloids present in the species acting as antifeedant for the larvae of the pest (18). Furthermore, fruit infestation of the eggplant species range between 0.22 to 22%, shoot damage between 0 to 11% and leaf damage between 11 to 22% respectively with the Cypermethrin treated eggplant recording the lowest value. Interactive treatments of *S.macrocarpon* with Cypermetrin application (0.13%) and *S.macrocarpon* and control (13.93%) recorded the lowest and highest fruit damage respectively. The lower fruit damage severity observed is in contrast to 40 - 80% severity findings of Mainali [19] and [20]. The lower rate of fruit infestation severity among the treated eggplant species could probably be as a result of intercropping adopted in experimental design which subtly agreed with the works of [21] and [22]. In a similar vein, Tooker and Frank [23], demonstrated increased plant diversity improved insect pest management via bottom –up and top down mechanisms. The observed field protective activity of the plant oils is not dose dependent as higher rate of the oil (0.9 ml) is as effective as the lower rate (0.1 ml, 0.5 ml) in comparison to the Cypermethrin 2.5 EC. The efficacy of pulverized leaves of *Annona squamosa*, a closely related species to *A. muricata* as a seed protectant against stored grain pest, *Tribolium castaneum* has been previously reported by Anita et al., [24]. *P.alliacea* oil extract compared favourably with the other two botanicals as a field protectant, this agrees with the findings of Adebayo et al., [25] and Cruz-Estrada et al., (2013) on crude extract and ethanolic extract of the plants as both insecticidal and larvicidal to field pest of cowpea, and eggs and larvae of *Bemisia tabaci* respectively. The study also reflected a coefficient of determination (R^2=0.18) between plant oil treatments and fruit yield which indicated that 18% of the variance in fruit yield of the eggplant species is attributed to the oil treatments received.

5. CONCLUSION

Solanum species are important group of crops with great economic potentials among smallholder farmers and other producers in Nigeria and other countries in Sub-Sahara Africa. The production of these crops is prone to depredation by perilous pest which lowers the yield, produce quality as well as the processing quality. This study proved the efficacy of the oil extract of *A. godseffiana, A. muricata and P. alliacea* as field protectant in the management of the field pest of *Solanum* species. These innovative products solution can as well be deployed in the management of field pest of other Solanaceous crops such as tomato, potato, peppers etc. Findings from this research work has led credence to the need for the continuous utilization and deployment of botanicals products in our cropping system for enhance yield and sustained food production. The study recommends further biochemical screening of the bio pesticides plants to ascertain the active components of insecticidal interests.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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