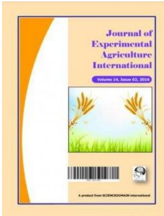

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Evaluation of the Insecticidal Potential of Six Plants Leaves Powders against *Acanthoscelides obtectus* Say on Stored *Phaseolus vulgaris* L.

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Authors' contributions

This work was carried out in collaboration among all authors. Author AIN designed the study, performed the statistical analysis and wrote the protocol. Author AAJM wrote the first draft of the manuscript and managed the literature searches. Authors VBO and PAA managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Most plant powders possess insecticidal properties and can be used to control insect pests on stored products. This study was conducted to evaluate insecticidal properties of *Solanum melongena*, *Parkia biglobosa. Ipomoea batatas*, *Colocasia esculenta*, *Tridax procumbens* and *Terminalia catappa* against *Acanthoscelides obtectus* Say, an insect pest of stored *Phaseolus vulgaris* L. The leaves powder of these plants were assessed for aduticidal and reproduction inhibition potential as well as effect on seed weight in a completely randomized design at three treatment concentrations of 0.5%, 1.0%, 1.5% and 0 as the control. All the test plants investigated exhibited insecticidal activity against *A. obtectus*. Results showed a trend of variation in adult *A.*

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obtectus mortality according to post-treatment days and plants powder concentrations. Results analysis revealed that at 14 days after treatment, *T. catappa* at 1.5% had the highest significant (P=0.05) mortality of 40.21±0.71[i]. This was followed by *S. melongena* which had a similar effect of 39.41± 0.52[i] at the same concentration (1.5%). The least significant mortality was observed in the control. At 0.5% *T. procumbens*, 0.5% *Parkia biglobosa*, 1.0% *I. batatas* and 1.0% *C. esculenta*, leaves powder had comparable effects. It was observed that the control had the highest number of progeny emergence of 181.33 ± 0.88[g] after six weeks while *T. catappa* significantly (P=0.05) inhibited progeny at 1.5% followed by 1.5% *S. melongena* and 1.5% *C. esculenta*. Seeds of *P. vulgaris* treated with 1.5% *T. catappa* also had the least significant weight loss of 0.93 ± 0.17 g compared to the control which had the highest significant weight loss of 55.68 ± 0.79 g. Though all the plants studied caused significant increase in adult *A. obtectus* mortality, reduction in progeny emergence and *P. vulgaris* seed weight loss than the control. *Terminalia catappa* however, exhibited the best insecticidal potential. *Terminalia catappa and Solanum melongena* were very effective in inhibiting the reproduction and progeny emergence of *A. obtectus*, but increased adult mortality resulting in weight loss suggesting their potential in controlling *A. obtectus* on stored *P. vulgaris*.

Keywords: Mortality; Acanthoscelides obtectus; Phaseolus vulgaris; insecticidal potential; progeny inhibition.

1. INTRODUCTION

The protection of stored grains and seeds against insect pests is a major problem for agriculturists with attendant effect on food security and sustainability. Plants have been recognized as excellent sources of bioactive compounds or secondary metabolites that can serve as alternative substances for pest control. Plant insecticides are natural compounds with insecticidal properties and their use in crop and or grain protection is as old as agricultural practice. They are easily biodegradable, more reliable, environmental friendly [1], cheap, readily available [2], and target specific [3].

The potential and use of Indigenous plants extracts and powders in the control of insect pests in recent years has been recognized by scientist [4,5]. Various types of plant preparations (solvent extracts, powders, essential oils and whole plants) have been assessed for their insecticidal activity, including their action as fumigants, repellents, anti-feedants, anti-oviposition and insect growth regulators [6].

Crop plants are grown for food production to meet the food security need of the people. The produce from crops need to be stored for later use. Stored products are faced with the problem of damage orchestrated by storage insect pests causing great losses to harvested crops hence, necessitating their control. *Solanum melongena*, *Parkia biglobosa. Ipomoea batatas*, *Colocasia esculenta*, *Tridax procumbens* and *Terminalia catappa* reported to possess medicinal and insecticidal properties are readily available and accessible to farmers in rural communities in Nigeria, hence can be use as grain protectants. The objective of this research is to evaluate the insecticidal potential of these plants leaves powders against *Acanthoscelides obtectus* Say on stored *Phaseolus vulgaris* L.

Solanum melongena L. (Family: Solanaceae) also known as eggplant is a species of night shade grown for its edible fruit. Eggplant is used for medicinal purposes. Various parts of the plant; powder or ash, decoction are used for curing diabetes, dysentery, cholera, bronchitis, toothache, asthenia, haemorrhoids and skin infections. *S. melongena* also possesses narcotic, anti-asthmatic and anti-rheumatic properties. In several countries eggplant has magical uses. It is used as a symbol of protection, good health and female fertility [7]. Ethanolic extract of *S. melongena* showed potent activity against *Sitophylus oryzae*, Carpenter ant Pantry weevil [8]. *Solanum melongena* leaves extract showed the presence of flavonoids, alkaloids, tannins and steroids [9].

Parkia biglobosa (Jacq.) R. Br. Ex G. Gon (Fabaceae) also called African locust bean, monkey cutlass tree, two ball nitta-tree, fern leaf is a multipurpose tree legume found in many African countries. The seeds, the fruit pulp and the leaves are used to prepare numerous foods and drinks, and to feed livestock and poultry [10]. Quantitative phytochemical analysis of *P. biglobosa* revealed that the leaves contained phenols, flavonoids, tannins, saponins, cardiac glycoside, steroid, terpenoid, alkaloid and anthraquinones in variable amounts. The fruit pods of *P. biglobosa* are used to produce an insecticide powder, which is added with water and sprayed on crops. Aqueous pod husk extract of *P. biglobosa* could serve as a biopesticide for sustainable and safety grain storage [11]. Musa and Lawal [12] reported that the leaves and seeds of *P. biglobosa* possess insecticidal activity against *Trogoderma granarium* Everts. Ethanol and petroleum ether seed extracts of African locust bean were found to possess the ability to protect the seeds of *Vigna unguiculata* from infestation damage caused by *Callosobruchus maculatus* [13].

Ipomoea batatas Lam. (Family: Convolvulaceae): *Ipomoea batatas* commonly called sweet potato is a major food crop in the subtropical regions of the world. It is an herbaceous perennial vine that has purplish flowers, large nutritious tuberous roots and heart-shaped lobed leaves. Sweet potato is a widely cultivated food plant native to tropical America. The leaves and shoots are used traditionally as medicine. The roots contain a toxic laxative ipomoein [14]. Essential oil from sweet potato vines inhibited the growth of some pathogenic bacteria and fungi [15]. Health-wise, *I. batatas* help prevent vitamin A deficiency, contains anti-diabetes, anti-cancer, anti-inflammatory and antimicrobial properties. *Ipomoea batatas* guard against ulcer, help in minimizing the risk of cardiovascular diseases, improve hair and skin, aid in digestion, blood pressure regulation, can boast fertility, improve good vision. It is a memory-enhancing food and help in weight management. It also helps in the management of stress [16]. Phytochemicals present in the leaves of *Ipomoea batatas* include tannins, alkaloids, steroids, glycosides, saponins, flavonoids, and soluble carbohydrates [17]; terpenes/steroids, coumarins, anthraquinones, alkaloids, flavonoids, saponins, tannins phenolic acids [18]

Colocasia esculenta (Taro) (L.) Schott (Family: Araceae): Is an annual herbaceous edible medicinal plant from tropical and sub-tropical regions [19], [20]. Its corms are rich in carbohydrates, protein, thiamine, riboflavin, niacin, oxalic acid, calcium oxalate, minerals, lipids, unsaturated fatty acids and anthocyanins [21]. Traditionally *C. esculenta* has been used as a medicinal plant for curative purposes. A wide variety of bioactive compounds can be extracted from all plant parts. These compounds have been reported to possess important pharmacological activities including anticancer [22], antihyperlipidaemic/ antihypercholestero-laemic [23], anxiolytic [24], wound healing [25], antimelanogenic [26], anti-inflammatory [27] probiotic [28], antihypertensive [29], antidiabetic [30,31], antioxidant [32], hepatoprotective [33], anti-inflammatory and antimicrobial [34], anti-helminthic [35], proliferative [36] and hypo-lipidaemic properties. Roy et al. [37] reported the insecticidal efficacy of *Colocasia esculenta* tuber agglutinin (CEA) against two devastating hemipterans: *Bemisia tabaci* and *Lipaphis erysimi*. Phytochemical analysis of *C. esculenta* leaves revealed the presence of alkaloids, glycosides, flavonoids, terpenoids, saponins, tannins, phenols and oxalate [38,39,40].

Tridax procumbens L. (Asteraceae): *Tridax procumbens* is a very promising species that produces secondary metabolites reported to have a variety of medicinal uses including among others, anti-anemic, anti-inflammatory, anti-diabetic and anesthetic properties [41]. Essential oils extracted from *T. procumbens* are reported to have insecticidal activity against *Musca domestica, Culex quinquefasciatus, Dysdercus similis and Supella* spp. [42]. A petroleum ether extract from flowers protects cowpea seeds from damage by the bruchid *Callosobruchus maculatus* [43]. The leaves of *T. procumbens* possess alkaloids, polyphenols, tannins, flavonoids (catechin and flavones), saponins, glycosides, carbohydrates, carotenoids, hydroxycinnamates, phytosterols, moderate benzoic acid derivatives and lignans, [44,45,46].

Terminalia catappa L. (Myrtales: Combretaceae): Compounds extracted from the leaves of *T. catappa* were potent insecticides, feeding deterrents and progeny production inhibitors against *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.) and *Callosobruchus chinensis* (L.) three of the four major pests of stored grains [47]. Leaf extract of *T. catappa* is an effective herbal larvicidal and pupicidal agent against *Aedes aegypti* [48]. *Terminalia catappa* is used by traditional healer for the treatment for worm [49]. Alkaloids, flavonoids, and tannins reported in *T. catappa* are known for their anti-microbial properties [50]. Tannins are also known to reduce herbivory and decrease larval growth. Phytochemical screening of *T. catappa* leaf extract revealed the presence of tannins, saponins, flavonoids, alkaloids, anthraquinones, steroids, saponin glycosides and cardiac glycosides; resins, reducing sugars [51]; alkaloids, reducing sugar, resins and steroids [52].

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was carried out in the Department of Zoology and Environmental Biology, University of Calabar, Cross River State, Nigeria. Cross River State is located at 5º45^{1}N and 8º30^1 and has an area of 2.156 km^2.

2.2 *Phaseolus vulgaris* Seeds

Seeds of *Phaseolus vulgaris* were bought from the Goldie Market in Calabar, Cross River State, Nigeria. The damaged seeds were sorted by hand-picking leaving the undamaged ones (unbroken seeds with no feeding holes). The undamaged seeds were kept in a refrigerator at -18^{o}C for one day for sterilization. These unbroken seeds were used for assessment.

2.3 Collection, Preparation of Plants Powder

The fresh leaves of *S. melongena*, *P. biglobosa. I. batatas*, *C. esculenta*, *T. procumbens* and *T. catappa* were harvested from plants in Calabar Municipality Local Government Area of Cross River State, Nigeria in October 2015 and were authenticated in the Department of Plant and Ecological Studies, University of Calabar, Nigeria. The experiment lasted for three months. The leaves were shade-dried for one week and milled separately with the aid of an electric milling machine (Super Master, Model SMB2977, Japan) and sieve through a cloth-mesh of 0.25 mm to obtain a homogenous powder which were separately stored in air-tight containers and used for evaluation within two days.

2.4 Insecticidal Activity of Powders

To evaluate the insecticidal potential of the five plants powders against adult mortality of *A. obtectus* the beans were treated separately with each powder. The leaf powder of each plant was assessed at different concentrations of 0.5%, 1.0%, 1.5% and 0% w/w as the control and mixed separately 100 g of *P. vulgaris* in 125 ml plastic containers. Twenty unsexed adults *A. obtectus* (one-day old) were introduced into each of these containers and covered with perforated lid to promote aeration and prevent insects escape. The experiment was laid out in a completely randomized design. Adult mortality was assessed at 2, 4, 6, 8, 10, 12 and 14 days after treatment. The insects were considered dead if appendages did not move when prodded with a fine brush. Dead insects from the substrate were removed after sieving through a 5 mm sieve. The insects were allowed to stay for 5 minutes after prodding with a brush to assure if the individuals were dead or just paralyzed. If they moved, they were reintroduced on substrate.

2.5 Assessment of the First Filial Generation Inhibition Efficacy of the Plant Powders

After mortality test assessment, all insects (dead and alive) were removed carefully and the experimental set-up kept undisturbed for six weeks. The number of adult progeny emergence was obtained by counting at fourth, fifth and sixth week. The number counted gave the cumulative progeny emergence at the seventh week revealing the reproduction inhibition potential of the plants studied.

At the end of seventh week, all insect and the frass were removed and the seeds of *P. vulgaris* were reweighed.

2.6 Statistical Analysis

Data obtained were subject one-way analysis of ANOVA to check for significant differences among the various treatments using SPSS version 17.0 software for probability level.

3. RESULTS

3.1 Effect Plants Leaves Powder on the Cumulative Percentage Mortality of *Acanthoscelides obectus* on *Phaseolus vulgaris*

Results in Table 1 revealed that at 14 days after treatment (DAT), significant (P=0.05) differences in the cumulative mean mortality of adult *A. obectus* were observed among different concentrations of test plants leaves powder of *S. melongena*, *P. biglobosa*., *I. batata*s, *C. esculenta*, *T. procumbens* and *T. catappa* and the control on stored *P. vulgaris*. Leaves powder of *T. catappa* at concentrations of 0.5%, 1.0% and 1.5% had the highest significant (P=0.05)

Table 1. Effect of different concentrations of six plants leaves powder on the cumulative percentage mortality of *Acanthoscelides obectus* on *Phaseolus vulgaris*

Plant	Treatment	Days after treatment (DAT)						
		2	4	6	8	10	12	14
Solanum	0.5%	1.03 ± 0.09^{b}	3.33 ± 0.01^{c}	4.45 ± 0.11^{b}	13.27±0.22^{e}	13.92 ± 0.72^{f}	15.52±0.55^{e}	18.27±0.37^{d}
melongena	1.0%	3.03 ± 0.04^{d}	5.67 ± 0.01^{de}	8.44 ± 0.24^{d}	16.29 ± 0.47^{g}	16.97 ± 0.21^{e}	19.56±0.47^{gh}	35.18± 0.68^{h}
	1.5%	6.34 ± 0.06^{f}	9.29 ± 0.80^{h}	11.19 ± 0.18^{g}	17.57 ±0.39^{g}	17.70 ± 0.37^{g}	27.31±0.68^{k}	39.41± 0.52^{i}
Parkia	0.5%	2.93 ± 0.08^{c}	3.97 ± 0.17^{c}	5.92 ± 0.16^{c}	6.73 ± 0.58^{b}	7.08 ± 0.09^{h}	7.94±0.51^{b}	11.49±0.54^{c}
biglobosa	1.0%	4.66 ± 0.01^{e}	5.89 ± 0.29^{de}	8.09 ± 0.08^{d}	9.08 ± 0.65^{c}	11.30± 0.57^{b}	12.00 ±0.58^{d}	20.38 ±0.42^{d}
	1.5%	6.98 ± 0.05^{f}	7.66 ± 0.02^{ef}	8.77 ± 0.06^{d}	9.57 ± 0.16^{c}	11.90 ± 0.70^{e}	18.98 ±0.41^{f}	28.00 ±0.58f
Ipomoea	0.5%	1.34 ± 0.01^{b}	8.38 ± 0.09^{g}	9.59 ± 0.19^{e}	9.63 ± 0.49^{c}	9.09 ± 0.31^{d}	9.19 ±0.24^{c}	10.87±0.48^{b}
batatas	1.0%	3.34 ± 0.01^{d}	10.60 ± 0.33^{i}	11.45 ± 0.49^{g}	11.62 ± 0.16^{d}	12.01± 0.19^{d}	12.51±0.54^{d}	13.44±0.72^{c}
	1.5%	7.90 ± 0.16^{g}	13.26 ± 0.36^{l}	14.92 ± 0.39^{i}	17.28 ± 0.55^{g}	17.68 ± 0.37^{h}	17.48 ± 0.51^{f}	19.77±0.60^{d}
Colocasia	0.5%	0.33 ± 0.01^{a}	4.96 ± 0.39^{d}	6.56 ± 0.18^{d}	7.09 ± 0.23^{b}	7.54 ± 0.30^{b}	7.48 ±0.36^{b}	8.31 ±0.52^{b}
esculenta	1.0%	4.67 ± 0.01^{e}	7.40 ± 0.13^{ef}	8.31 ± 0.11^{d}	9.28 ± 0.22^{c}	10.31 ± 0.48^{cd}	11.77 ±0.34^{d}	13.65 ±0.62^{c}
	1.5%	7.66 ± 0.01^{g}	9.65 ± 0.38^{h}	13.44 ± 0.29^{h}	14.19 ± 0.34^{f}	15.44 ± 0.25^{c}	18.33 ±0.51^{fg}	25.71±0.54^{ef}
Tridax	0.5%	1.00 ± 0.01^{b}	3.59 ± 0.16^{c}	7.05 ± 0.82^{e}	10.52 ± 0.37^{d}	13.99 ± 0.54^{f}	20.77±0.40^{f}	11.41±0.49^{c}
procumbens	1.0%	1.50 ± 0.03^{b}	5.30 ± 0.35^{de}	7.33 ± 0.88^{e}	12.55 ± 0.23^{e}	18.30 ± 0.74^{e}	23.41 ±1.20^{g}	24.60 ±0.64^{e}
	1.5%	2.99 ± 0.02^{c}	6.20 ± 0.18^{e}	7.59 ± 0.83^{e}	16.65 ± 0.69^{g}	21.60 ± 0.46^{i}	25.41 ±0.39^{h}	31.24 ±0.60^{g}
Terminalia	0.5%	0.00 ± 0.00^{a}	2.50 ± 0.06^{b}	5.74 ± 0.08^{e}	20.03 ± 0.96^{h}	21.92 ± 0.45^{i}	25.83±0.75^{l}	31.82±3.45^{g}
catappa	1.0%	0.00 ± 0.00^{a}	5.58 ± 0.20^{de}	8.37 ± 0.28^{d}	21.08 ± 0.65^{hj}	24.29 ± 0.98^{j}	29.20±0.59^{i}	36.24±0.79^{h}
	1.5%	0.00 ± 0.00^{a}	6.64 ± 0.22^{f}	10.54 ± 0.36^{jf}	22.21 ± 1.02^{i}	25.98 ± 0.49^{k}	30.10±0.05^{l}	40.21±0.71^{i}
Control		0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.33 ± 0.01^{a}	0.33 ± 0.01^{a}	1.25 ± 0.04^{a}	1.30 ±0.05^{a}	2.99±0.01^{a}

Values are means of three replicates ± SEM; Means followed by same superscript letters in each column are not significantly different, while means followed by different superscript letters are significantly different at (P=0.05) according to Duncan Multiple Range Test; DAT = Days after treatment

Table 2. Effect of six plants leaves powder on the cumulative progeny emergence and reproduction

Plant	Treatment	Weeks after treatment (WAT)		
		4	5	6
Solanum melongena	0.5%	11.11 ± 0.78^{f}	14.39 ± 0.61^{g}	18.81 ± 0.26^{d}
	1.0%	7.81 ± 0.54^{b}	9.24 ± 0.50^{c}	17.31 ± 0.76^{c}
	1.5%	7.07 ± 0.45^{b}	8.75 ± 0.45^{b}	13.17 ± 0.25^{b}
Parkia biglobosa.	0.5%	13.18 ± 0.59^{h}	18.36 ± 0.51^{k}	19.43 ± 0.43^{d}
	1.0%	10.97 ± 0.31^{e}	13.13 ± 0.33^{f}	21.71± 0.30^{e}
	1.5%	10.98 ± 0.18^{e}	9.93 ± 0.30b^{b}	21.78 ± 1.13^{e}
Ipomoea batatas	0.5%	17.52 ± 0.44^{j}	19.41 ± 0.46^{c}	15.75 ± 0.79^{c}
	1.0%	15.58 ± 0.90^{j}	18.32 ± 0.71^{k}	21.54 ± 0.63^{e}
	1.5%	12.88 ± 0.45^{g}	14.86 ± 0.58^{h}	18.61 ± 0.55^{d}
Colocasia esculenta	0.5%	16.87 ± 0.53^{k}	18.74 ± 0.51^{k}	11.40 ± 0.60^{b}
	1.0%	14.94 ± 0.18^{i}	15.56 ± 0.50^{j}	18.71 ± 0.47^{c}
	1.5%	13.24 ± 0.32^{h}	10.96 ± 0.43^{d}	12.34 ± 0.77^{b}
Tridax procumbens	0.5%	15.86 ± 0.52^{jij}	18.11 ± 0.49^{k}	18.38 ± 0.57^{d}
	1.0%	9.70 ± 0.62^{d}	11.00 ± 0.58^{e}	17.74 ± 0.30^{c}
	1.5%	8.88 ± 0.45^{c}	11.10 ± 0.65^{e}	16.54 ± 0.72^{c}
Terminalia catappa	0.5%	11.71 ± 0.85^{f}	14.95 ± 0.84^{h}	18.02 ± 1.02^{d}
	1.0%	7.71 ± 0.56^{b}	9.51 ± 0.50^{c}	13.42 ± 0.58^{b}
	1.5%	6.50 ± 0.35^{a}	7.17 ± 0.40^{a}	9.06 ± 0.69^{a}
Control		88.00 ± 0.58^{m}	148 00 ± 0.5^{l}	181.33 ± 0.88^{g}

Values are means of three replicates ± SEM; Means followed by same superscript letters in each column are not significantly different, while means followed by different superscript letters are significantly different at (P=0.05) according to Duncan Multiple Range Test; WAT - Weeks after treatment

Table 3. Effect of six plants leaves powder on weight loss

Plant	Treatment	Weeks after treatment (WAT)		
		4	5	6
Solanum melongena	0.5%	6.08 ± 0.51^{g}	9.11 ± 0.34^{f}	9.27 ± 0.50^{g}
	1.0%	5.25 ± 0.67^{ef}	5.14 ± 0.24^{d}	7.69 ± 0.55^{efg}
	1.5%	3.07 ± 0.51^{b}	4.92 ± 0.54^{c}	5.57 ±1.61^{c}
Parkia biglobosa	0.5%	7.78 ± 0.64^{hi}	7.15 ±1.12^{def}	7.42 ± .05^{efg}
	1.0%	5.40 ± 0.59^{ef}	6.60 ± 0.61^{e}	7.27 ±1.28^{efg}
	1.5%	4.39 ±1.31^{be}	4.20 ± 0.29^{ab}	6.66 ± 0.30^{d}
Ipomoea batatas	0.5%	6.40 ± 0.89^{efg}	7.81 ± 1.15^{ef}	8.22 ± 0.56^{f}
	1.0%	6.00 ± 0.58^{g}	6.59 ± 0.42^{e}	8.10 ± 0.59^{df}
	1.5%	5.39 ± 0.36^{ef}	6.43 ± 0.38^{be}	8.28 ± 0.55^{f}
Colocasia esculenta	0.5%	7.44 ± 0.23^{h}	6.86 ± 1.12^{f}	9.14 ± 0.64^{g}
	1.0%	6.56 ± 0.27^{ghi}	7.10 ± 1.02^{def}	8.00 ± 0.15^{fg}
	1.5%	6.27 ± 1.08^{gh}	6.15 ± 0.82^{e}	5.74 ± 0.53^{c}
Tridax procumbens	0.5%	6.26 ± 0.63^{gh}	7.32 ± 1.06^{g}	8.51 ± 0.12^{f}
	1.0%	5.70 ± 0.54^{g}	6.67 ± 0.60^{f}	6.54 ± 0.17^{def}
	1.5%	5.48 ± 1.48^{ef}	4.33 ± 0.40^{ab}	5.89 ± 0.58^{ce}
Terminalia catappa	0.5%	3.51 ± 0.04^{bcd}	6.67 ± 0.88^{f}	7.74 ± 0.63^{cfg}
	1.0%	3.14 ± 0.74^{bc}	4.23 ± 0.39^{ab}	4.44 ± 0.83^{b}
	1.5%	0.93 ± 0.17^{a}	2.81 ± 0.45^{a}	3.35 ± 0.36^{a}
Control		24.78 ± 0.66^{j}	39.44 ± 0.55^{g}	55.68 ± 0.79^{h}

Values are means of three replicates ± SEM; Means followed by same superscript letters in each column are not significantly different, while means followed by different superscript letters are significantly different at (P=0.05) according to Duncan Multiple Range Test; WAT - Weeks after treatment

mean mortality of 31.82±3.45^{g}, 36.24±0.79^{h} and 40.21±0.71^{i} followed by *S. melongena* 18.27±0.37^{d}, 35.18± 0.68^{h} and 39.41± 0.52^{i}, followed by *T. procumbens* 11.41±0.49^{c}, 24.60 ±0.64^{e} and 31.24 ±0.60^{g} respectively. Mean mortality values for *C. esculenta* at 1.0%, *I. batatas* at 1.0%, *P. biglobosa* at 0.5% and *T. procumbens* at 0.5% had comparable effects on mortality. *Terminalia catappa* at 1.0% and 1.5% had similar effects as *S. melongena* at 1.0% and 1.5%. The control however, showed the least significant mortality.

3.2 Effect of Leaves Powder on the Cumulative Progeny Emergence and Reproduction

At six weeks after treatment, the powders of all the plants studied depicted significant (P=0.05) effect individually on progeny emergence relative to the control. The control gave the highest mean cumulative emergence of *A. obtectus* of 181.33 ± 0.88[g] which differed significantly (P=0.05) from the progeny emergence in all the treatments. At concentration 1.5% *T. catappa* had the lowest number of progeny emergence of 9.06 ± 0.69[a] followed by 1.0% (13.42 ± 0.58[b]) and 0.5% (18.02 ± 1.02[d]) when compared to the control. Statistically, *T. catappa* at 1.0%, *S. melongena* at 1.5%, *C. esculenta* at 0.5% and 1.5% had comparable effects. *Colocasia esculenta* at 1.0%, *I. batatas* at 0.5% had similar effects.

3.3 Effect of Leaves Powders on Weight Loss and Seed Damage

At six weeks post-treatment the least significant (P=0.05) weight loss was observed with *P. vulgaris* seed treated with *T. catappa* at 0.5% (7.74 ± 0.63[cfg]), 1.0% (4.44 ± 0.83[b]) and 1.5% (3.35 ± 0.36[a]). This is followed by *S. melongena* at 0.5%, 1.0% and 1.5% with weight reduction values of 9.27 ± 0.50[g], 7.69 ± 0.55[cfg] and 5.57 ±1.61 [c] respectively as against the control which had the highest weight loss of 55.68 ± 0.79[h]. 1.0% and 1.5% *T. catappa* had comparable effect, 0.5% *C. esculenta* and 0. 5% *S. melongena* had similar effects on weight loss of *P. vulgaris* seed.

4. DISCUSSION

Insecticidal potential of six plants leaves powders against *A. obtectus* Say on stored *P. vulgaris* L. was evaluated. Results of this investigation revealed that the leaves powders of the *S. melongena*, *P. biglobosa, I. batatas*, C. *esculenta*, *T. procumbens* and *T. catappa* had different levels of insecticidal activity against *A. obtectus*. It was observed that though all treatment levels of the different plants used in this study were effective in decreasing *A. obtectus* population under laboratory conditions, their effectiveness were directly proportional to concentration and exposure period as seen with highest adult mortality at highest concentration of 1.5% and at six days after treatment. Our finding agrees to earlier reports of insecticidal properties and the use of plants in the control of insect pests. [53] evaluated the bioactivity of powders from 18 plant species on *Acanthoscelides obtectus* (Say) and reported that powder from aerial part of *Chenopodium ambrosioides* d.2 derivation caused the most efficient repellence, total adult mortality and no oviposition, followed by rinds of fruits of *Citrus sinensis* (cv. Pera) and leaves of *Lafoensia glyptocarpa*. Leaves of *Coriandrum sativum* were non repellent but caused total adult mortality and no oviposition. Also powders from aerial part of *C. ambrosioides* d. 1, from leaves of *Eucalyptus citriodora*, *Mentha pulegium*, *Ocimum basilicum*, *O. minimum* and *Ruta graveolens*, from rinds of fruits of *Citrus reticulate* (cv. Murcote) and from fruits of *Melia azedarach* and *L. glyptocarpa* were all repellent to *A. obtectus.* Extracts of *Urtica dioica* L. and *Taraxacum officinale* L. exhibited significant insecticidal activity against *Acanthoscelides obtectus* [54]. Gums extracted from the bark of *Anacardium occidentale* are effective insecticide [55]. Powders from the plant parts (leaf, stem and root) of *Chromolaena odorata* exhibited insecticidal activity against the cowpea beetle, *Callosobruchus maculatus* [56]. Mofunanya and Nta [57] reported on the insecticidal ability of *Telfairia occidentalis*, *Piper guineensis*, *Gmelina arborea*, *Bryophyllum pinnate*, *Amaranthus viridis* and *Musanga ceropolides* with *P. guineensis* and *G. arborea* exhibiting the highest insecticidal activity in the management of *Acanthoscelides obtectus on stored Phaseolus lunatus*.

Results of this study also showed a reduction in the number of progeny that emerged from all the treated seeds of *P. vulgaris* relative to the control. This result indicated that prevention of progeny emergence was exclusively due to treatment since the insects in control samples were higher than in the treated samples meaning that the tested insects were capable of effective oviposition. Thus the powders of the test plants either suppressed oviposition or killed the larvae hatching from eggs laid. One of the basic characteristics of an effective grain protectant is the ability to reduced progeny production in the treated grain. This is in consonance with previous reports by Hojat et al. [58] who studied the insecticidal potential of two medicinal plants *Verbascum* *cheiranthifolium* (Boiss) and *Verbascum speciosum* (Scrophulariaceae) on mortality and progeny production against adult *Sitophilus oryzae* L. and found that extract of *V. cheiranthifolium* was more effective than *V. speciosum* against adult *S. oryzae* thus, could be used for the protection of stored grains from infestation of insect pests. Mofunanya and Nta [59] evaluated the insecticidal potential of n-hexane leaf extract of *Solanum tuberosum*, *Annona muricata*, *Cymbopogon citrates*, *Vernonia amygddalina*, *Caesalpina pulcherima* and *Lantana camara* and reported that all test plants extracts at high concentration of 3 and 5% caused significant increase in repellant and mortality, but a significant ($P \leq 0.05$) reduction in oviposition, fecundity, progeny emergence and seed damage relative to control. These results suggest the presence of different phytochemical compounds in these plants.

The fact that the leaves powders of *S. melongena*, *P. biglobosa. I. batatas*, *C. esculenta*, *T. procumbens* and *T. catappa* in this study exhibited insecticidal activity against *A. obtectus* may be due to the presence of toxic phytochemicals or secondary metabolites such as saponins, tannins, alkaloids, steroids, cardiac glycosides, flavonoids and phenolics [60,61]. These phytochemicals have been reported to possess insecticidal potentials against insect pests. They affect various aspects of insect larval fitness, such as survivorship, growth, and development. Saponins have obvious insecticidal properties. De Geyter [62] reported that saponins causes increase in mortality levels, decrease in reproduction, reduced level of food intake and weight reduction in insects. These effects may be attributed to saponins making the food less attractive for eating, causing digestive problems, causing moulting defects or having toxic effects on cells. Chaieb [63] reported that saponins interacts with cholesterol disturbing the synthesis of ecdysteroid; saponins also inhibits protease enzyme and is toxic to insect cells. The innate protective abilities of phenolic compounds against invading organisms has been reported [64]; as signal and plant defense molecules. Flavonoids, a class of phenolic compounds has been reported [65] to possess anti-feeding and attracting deterrent properties, thus are toxic to insects, fungi, nematodes and weeds. Tannins are another group of phytochemical that are toxic to small mammals [66]. They act as a defense mechanism in plants against pathogens and herbivores [67]. Alkaloids are naturally occurring complex compounds in plants that are toxic to insects [66]. Alkaloids (1,2-dehydropyrrolizidine) are a class of metabolites well-known feeding deterrents against herbivores and are toxic to a wide range of non-adapted animals [68], indicating their potential for pest management.

The highest adult mortality and lowest progeny emergence observed in this study with *T. catappa* and *S. melongena* powders may be attributed to the presence of bioactive compounds in these plants. *T. catappa* has a wide range of metabolites, including alkaloids, reducing sugars, saponins, tannins, resins, steroids, flavonoids and glycosides [69,70]. The high level of toxicities in *T. catappa* explains the reduction in adult population of *A. obtectus* on stored *P. vulgaris* induced by treatment with this plant. The same toxic properties are responsible for anti-microbial activity and anti-herbivory [71]. *Terminalia catappa*'s toxicity is related to its insecticidal properties. The plant mimicked properties of commercial insecticide, with toxic effects on *Drosophila melanogaster* larvae.

5. CONCLUSION

The findings of our study revealed that our native plants investigated have insecticidal properties in decreasing *A. obtectus* population in a decreasing order *T. catappa* > *S. melongena* >*T. procumbens* > *P. biglobosa* > *C. esculenta* > *I. batatas* on stored *P. vulgaris*. This results implicate their use in the control of *A. obtectus* on stored *P. vulgaris*.

COMPETING INTERESTS

Authors have declared that there is no conflicting interest.

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