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Potentials of Aqueous Extract of Pod Husk *Parkia biglobosa* (Jacq.) Benth as a Biopesticide in Okra (*Abelmoschus esculentus* (L.) Moench) Production

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OOF, OOA and OYA designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Authors OOA and DOO performed parts of the Laboratory analyses of the study. Authors OOA, OYA and OOF performed the field study. Authors OOF, OOA and OYA also managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study evaluated potentials of aqueous extract of pod husk of *Parkia biglobosa* as a biopesticide in okra production.
Study Design: The study employed a radomized complete block design with seven treatments (5, 10, 15 and 20% *Parkia biglobosa* aqueous pod husk extract (PPHE), 2.5 ml dimethoate + cypermethrin (D+C) – recommended, 5.0 ml (D+C), control – 500 ml of water) and replicated three times.
Place and Duration of Study: Crop Garden of Department of Crop Protection and Environmental Biology, University of Ibadan (7°34'N and 3° 54'E) between April and July 2016.
Methodology: The leaves, seeds, pod husks and bark of *Parkia biglobosa* were collected, authenticated and analyzed for their phytochemical compositions using standard procedures.

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Aqueous extract of the pod husk of the plant (PPHE) was found to contain the highest phytochemicals qualitatively and quantitatively which formed the basis of using it as a biopesticide. A field study was conducted at the crop garden of Department of Crop Protection and Environmental Biology, University of Ibadan, to assess the potency of the extract as a biopesticide and a synthetic insecticide - Dimethoate 14.5% + Cypermethrin 5.5% (D+C) on the management of flea beetles on NHAe-47-4 okra variety. The seven treatments (5, 10, 15 and 20% *Parkia biglobosa* aqueous pod husk extract (PPHE), 2.5 ml dimethoate + cypermethrin (D+C) – recommended, 5.0 ml (D+C) (synthetic), control – 500 ml of water) were applied weekly on okra plants from two Weeks After Sowing (WAS) till 12 WAS. Data were collected on growth and yield parameters, dry matter accumulation of *A. esculentus* and flea beetle populations. Data were analyzed using descriptive statistics and ANOVA at P = 0.05.

Results: Results revealed that treatment 20% PPHE had relatively higher values of growth parameters which compared favorably (p≤0.05) with 2.5 ml and 5 ml (D+C). Yield parameters; Number of fruits and fruit weights from 20%PPHE also compared favorably with 2.5 ml and 5 ml (D+C) with no significant difference ($P > 0$ .05) and with the same trend in dry root weight. While the dry shoot weight of 2.5 ml (D+C) treatment (p≤0.05) was different from other treatments. The control treatment however, revealed significant differences (p<0.05) in having reduced growth and low yield when compared with the treated plots.

Conclusion: This study showed the efficacy and potency of *Parkia biglobosa* aqueous pod husk extract (PPHE) in suppressing the flea beetles due to its highest quantities of phytochemicals. The 20% concentration also enhanced the growth and yield of okra and performed relatively well with the recommended dose (2.5 ml) of D+C. The aqueous pod husk extract, therefore could serve as a biopesticide for food sustainability and safety.

Keywords: Abelmoschus esculentus; Parkia biglobosa; phytochemicals; flea beetles; biopesticide.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the popular fruit vegetables cultivated and consumed in Nigeria. It is cultivated for its fibrous fruits or pods containing round, white seeds and its leaves. The fruits are harvested when immature and eaten as vegetable which are a good source of carbohydrate, protein, fats, vitamins and minerals [1,2]. Okra is prone to damage by various insect pests, they include flea beetles (*Podagrica uniforma and Podagrica sjostedti*), whiteflies (*Bemisia tabaci*), cotton stainer (*Dysdercus superstitious*) [3] to name a few. Flea beetles defoliate okra leaves at the seedling to harvest stage which reduces the photosynthetic areas of the leaves and consequently results in reduction in okra fruit yields [4].

Conventional methods of protecting crops depend on the use of synthetic chemical pesticides due to their swift action in eradicating pests [5]. The management of pests using chemical pesticides is however, being discouraged because of their negative effects such as adverse health effects, environmental pollution, destruction of wildlife habitats, pest resistance/ resurgence, pesticide residue, high cost of purchase, non-availability, etc. [6,7]. The drawbacks of synthetic pesticides have necessitated the need for sustainable alternatives (biopesticides) that are easily biodegradable, more reliable, environmental friendly [8], cheap, readily available [9] and target specific [10]. The use of biopesticides can greatly decrease the use of conventional pesticides, while achieving almost the same level of crop yield.

Parkia biglobosa (Jacq.) Benth is a perennial deciduous tree of high commercial value; it is used as a source of food, medicinal agents, timber, fuel and fibre [11]. In West Africa, the seeds of *P. biglobosa* provide a rich source of vegetable protein for humans; the husks are not eaten by humans, but they serve as feed for livestocks [12,13]. The fruits are fermented to a condiment called 'dawa-dawa' or 'iru' used as a flavour intensifier for soups and stews [14,15]. The extracts from *P. biglobosa* have been used as natural pesticides against different pests and diseases due to the phytochemicals present in different parts of the plant. Phytochemicals are certain non-nutritive, biologically active plant chemicals which have some disease preventive properties. They provide plants with colour, flavour and natural protection against pests [16].

Fawole and Abikoye [17] discovered that *Fusarium* wilt of cowpea could be managed with *Parkia* husk ethanolic extract. The effectiveness of *P. biglobosa* ethanolic seed extract in controlling *Meloidogyne incognita* infestation in tomato plants was reported [18]. Also [7] discovered the antifeedant effect of petroleum ether and ethanolic seed extracts of *Parkia biglobosa* against cowpea bean storage pest (*Callosobruchus maculatus*).

Bukar et al. [19] determined the phytochemical composition of aqueous extracts of leaves and pods of *P. biglobosa* and found out that aqueous extracts of the pods had the highest phytochemical composition. Sherah et al. [20] compared the phytochemical composition of the plant's stem bark and seed husk methanolic extracts and found that the seed husk had higher phytochemical composition. Udobi and Onaolapo, [21] reported that the leaves, stem bark and roots of the plant contain relatively equal number of phytochemicals. There has been little or no research to determine the specific part of all parts of the plant (leaves, seeds, bark and pod husk) that contains the highest number and concentration of phytochemicals. There is also insufficient information on the potentials of *P. biglobosa* aqueous extracts in managing insect pests of okra and on the performance of okra plants treated with it. Hence, the present study was undertaken to determine the phytochemical composition of different parts of *Parkia biglobosa* and performance of okra plants treated with *P. biglobosa* aqueous pod husk extract.

2. MATERIALS AND METHODS

2.1 Experimental Materials

The leaves, bark, pods and seeds of *P. biglobosa* were collected in February, 2016 from Tede town in Atisbo Local Government Area, Oyo state, which falls within latitude 08°34^{1}N and longitude 003°27^{1}E. The plant samples were identified and authenticated at the herbarium of Forestry Research Institute of Nigeria, Jericho, Ibadan with voucher number 110449.

Okra seeds of an early maturing variety, NHAe-47-4 were purchased from National Horticulture Research Institute (NIHORT), Idi-Ishin, Ibadan. Synthetic chemical insecticide 'Scorpion' (Dimethoate 14.5% + Cypermethrin 5.5%) was purchased from SARO Agrosciences Limited, Oluyole, Ibadan, Oyo state.

2.2 Phytochemical Screening

The plant parts (leaves, bark, pods and seeds) were air dried for 2 weeks to constant weight at room temperature of 28.71± 1.77°C and relative humidity of 77.64 ± 8.07%. They were pulverized using Rico MG '601' Grinder Mixer and weighed. The milled powdered samples were sieved with 2 mm sieve, weighed and packaged in sample bottles for analyses. Qualitative and quantitative phytochemical assays were carried out at the Organic Chemistry Research Laboratory of the Faculty of Pharmacy, University of Ibadan and Femtop Analytical Laboratory, Idi-Ishin, Ibadan.

2.2.1 Phytochemicals sample extraction

Cold water extraction sample screening was used as described earlier [22]. Each of the finely milled plant part (28 g in weight) was dissolved in 140 ml of distilled water in a 250 ml conical flask and covered with aluminium paper for 24 h continuously shaken on a shaker after which it was filtered. The filtrate was concentrated on a water bath at 40°C and labeled. All samples were determined in triplicates. The following phytochemicals were determined: Phenol, Flavonoid, Tannin, Cardiac glycoside, Steroid, Terpenoid, Alkaloid, Antraquinone and Saponin using the standard methods of [23,24] and [25].

2.3 Preparation of Aqueous Extract of *Parkia biglobosa* Pod Husk

The pod husk had the highest quantities and concentrations of phytochemicals, as such; its aqueous extract was used in managing okra insect pests on the field. The aqueous extracts of *P. biglobosa* pod husks were prepared at the Toxicology and Physiology Research Laboratories of the Department of Crop Protection and Environmental Biology. The aqueous extract of the pod husk was obtained according to the method of Oshimagyne [26] with a modification by soaking 420 g of milled pod husk in 2,100 ml of water (ratio 1:5) for 24 h. It was sieved using muslin cloth and the solution recovered from it served as the stock solution. The concentration of the stock solution of the biopesticide was 20%; other concentrations (5%, 10% and 15%) were prepared from the stock solution by serial dilution. The extracts were stored in refrigerator at 20°C for 24 h prior to use to prevent putrefaction and degradation of phytochemicals present in them and were used for the bioassay [9].

2.4 Treatments

The performance of *P. biglobosa* aqueous pod husk extract (PPHE) on NHAe-47-4 okra plants was compared to a synthetic insecticide (Dimethoate 14.5% + Cypermethrin 5.5%) using the following treatments: T1 - Control (500 ml of water or 0% extract); T2 – 2.5 ml of D+C in 500 ml of water (recommended); T3- 5 ml of D+C in 500 ml of water; T4- 20% extract; T5 – 15% extract; T6 – 10% extract and T7 – 5% extract. All the treatments were sprayed on the leaves of okra plants, respectively in the field.

2.5 Field Study

This was conducted at the Crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan during the wet season (April – July) 2016. The total area was 22.3 m x 10.7 m with individual plot sizes of 0.9 m x 0.9 m and an alley of 2m between each plot. Each of the seven treatments was replicated three times and laid out in a randomized complete block design (RCBD). Two seeds of NHAe-47-4 okra variety were sown per stand at a depth of 2cm; spacing of 0.3m x 0.3m was left between each stand to give a total of 16 stands per plot. Missing stands were supplied at one week after sowing (WAS), while seedlings were later thinned to one seedling per stand two WAS. Regular weeding was carried out manually in order to prevent competition, infestation of pests and diseases and also to ensure maximum growth of the crop. The plants were sprayed weekly using a knap sack sprayer (CP3) with the treatments listed above from 2WAS till 12WAS in order to manage the insect pests.

2.6 Data Collection

Four plants in the middle of each plot were tagged as representative samples for data collection at 4 WAS, 8 WAS and 12 WAS. These sampling periods covered the active vegetative development, anthesis and physiological maturity in okra. Data were collected on growth parameters (plant height, stem diameter, number of leaves produced and leaf area), yield parameters (Number of days to flowering, Number of fruits per plant, Number of fruits per plot, Fresh weight of fruits per plot) and dry matter accumulation (dry root per plant, dry root per plot, dry shoot per plant and dry shoot per plot). Insect population was assessed weekly.

2.7 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) software at 5% level of significance. Means were separated using Duncan Multiple Range Test (DMRT). Results are presented as mean ± standard error of the mean (SEM).

3. RESULTS

3.1 Qualitative Phytochemical Analysis

Qualitative phytochemical analysis of powdered samples of the different parts (leaves, bark, pod husk and seeds) of *Parkia biglobosa* is presented in Table 1. The pod husk contained all the phytochemicals assayed (Phenol, Flavonoid, Tannin, Saponin, Cardiac glycoside, Steroid, Terpenoid, Alkaloid and Antraquinone). The bark contained most of them, but had negligible amount of Saponin; the leaves contained significant amount of Phenol, Flavonoid, Cardiac glycoside, Alkaloid, Antraquinone and negligible amount of Tannin, Saponin, Steroid, and Terpenoid. The seeds contained the least number of phytochemicals; Phenol, Flavonoid, Cardiac glycoside and Alkaloid were present, while the others were negligible.

Table 1. Qualitative phytochemical screening of different plant parts of *Parkia biglobosa*

Phytochemicals	Samples			
	Leaves	Bark	Pod husk	Seeds
Phenol	++	+++	+++	+
Flavonoid	+	++	++	++
Tannin	-	++	++	-
Saponin	-	-	+	-
Cardiac glycoside	++	++	++	+
Steroid	-	+	+	-
Terpenoid	-	++	++	-
Alkaloid	+	+	+	+
Antraquinone	+	+	+	-

Key: + → slightly present; ++ → moderately present; +++ → highly present; - → absent or negligible

3.2 Quantitative Phytochemical Analysis

Quantitative phytochemical analysis of the different parts of *P. biglobosa* is presented in Table 2. Significant differences (P<0.05) were shown in the quantities mg/100 g of all the phytochemicals in different parts of *P. biglobosa* plant. Results from the phenol content revealed the pod husk had the significant higher quantity

(1579.06 mg/100 g), while the lowest value (382.74 mg/100 g) was from the seed part. The pod husk showed significant higher (P<0.05) quantity of flavonoid (180.33 mg/100 g) from the results, while the leaves had significant lower (P<0.05) quantity (90.50 mg/100 g). Tannin obtained from the results showed the pod husk having significant (P<0.05) maximum value (136.67 mg/100 g), while the significant minimum value (15.94 mg/100 g) was from the seed. Significant higher (P<0.05) quantity of Saponin (12.09 mg/100 g) was obtained from pod husk part of *P. biglobosa*, while the seed had a significant (P<0.05) lower quantity (1.90 mg/100 g). The cardiac glycoside quantity (95.83 mg/100 g) in pod husk was significantly (P<0.05) higher over other plant parts, while the seed had the significantly (P<0.05) minimum quantity (13.13 mg/100 g). The steroid result revealed higher quantities in pod husk and the stem with no significant difference (P>0.05), however, the seeds recorded significant lower (P<0.05) value (5.61 mg/100 g).

Pod husk had significant higher (P<0.05) value (68.30 mg/100 g) in terpenoid, while the seed part obtained significant minimum value (7.97 mg/100 g) in terpenoid. A significantly higher (P<0.05) value (41.67 mg/100 g) of anthraquinone was obtained from pod husk, while the lowest value (5.71 mg/100 g) was obtained from the seed. The seed part of *P. biglobosa* revealed a significant higher (P<0.05) value (2.86%) of alkaloid, while the leaf part had the significant lower (P<0.05) alkaloid value (1.10%) from the results.

3.3 Plant Height

The effects of *Parkia biglobosa* aqueous pod husk extract (PPHE) and synthetic insecticide (Dimethoate 14.5% + Cypermethrin 5.5%) (D+C) on the plant height of okra plants are presented in Fig. 1. There was no significant difference (P>0.05) in the plant height (cm) among all the treatments at 4WAS. There was no significant difference (P>0.05) between plots treated with synthetic insecticide (2.5 ml and 5 ml), 20% and 15% PPHE at 8WAS. Significantly lower (P<0.05) values were observed at 8 WAS on control plots (73.60 cm) and plots treated with 5% (77.35 cm) and 10% (82.82 cm) PPHE when compared to the other treatments. The result also showed no significant difference (P>0.05) among all the treatments at 12 WAS except the control (97.14 cm) and 2.5 ml synthetic insecticide (132.34 cm) which had lower and higher values, respectively.

3.4 Stem Diameter

The effects of PPHE and synthetic insecticide (D+C) on the stem diameter (cm) of okra plants are presented in Fig. 2. There was no significant difference (P>0.05) in the stem diameter of all the plots (treatments) in all growth stages of okra plant.

3.5 Number of Leaves

The number of leaves with different treatments revealed significant differences (P<0.05) at 4 WAS as presented in Fig. 3. Plots treated with 2.5 ml of synthetic insecticide had higher number of leaves; this was not significantly different (P>0.05) from plots treated with 20%, 15% and 5% PPHE. There was no significant difference (P>0 .05) in the number of leaves of plots treated with 10% PPHE and the control (0%) plots, they both had lower values. The number of leaves on all the plots was not significantly different (P>0.05) at 8 WAS except the control plots which had lower values (9.33). Plots treated with synthetic insecticide (2.5 ml and 5 ml), 20% and

Table 2. Quantitative phytochemical analysis of different parts of *Parkia biglobosa*

Phytochemicals	Samples			
	Leaves	Bark	Pod husk	Seeds
Phenol (mg/100 g)	$690.00^c±6.57$	$1350.07^b±3.50$	$1579.06^a±6.12$	$382.74^d±8.51$
Flavonoid(mg/100 g)	$90.50^d±0.43$	$102.77^c±1.68$	$180.33^a±0.97$	$115.88^b±1.17$
Tannin (mg/100 g)	$18.71^c±1.06$	$114.98^b±1.56$	$136.67^a±2.27$	$15.94^c±1.17$
Saponin(mg/100 g)	$6.08^c±0.44$	$7.42^b±0.11$	$12.09^a±0.12$	$1.90^d±0.09$
Cardiac glycoside (mg/100 g)	$74.58^c±1.24$	$86.23^b±1.84$	$95.83^a±1.73$	$13.13^d±0.71$
Steroid (mg/100 g)	$8.23^b±0.35$	$38.28^a±1.05$	$40.67^a±1.02$	$5.61^c±0.28$
Terpenoid (mg/100 g)	$9.36^c±0.53$	$57.48^b±0.77$	$68.30^a±1.11$	$7.97^c±0.58$
Alkaloid (%)	$1.10^c±0.07$	$1.80^b±0.09$	$2.04^b±0.09$	$2.86^a±0.18$
Antraquinone (mg/100 g)	$32.40^c±0.56$	$37.49^b±0.80$	$41.67^a±0.75$	$5.71^d±0.31$

a, b, c, d, Means along the same row with different superscripts are significantly (P<0.05) different

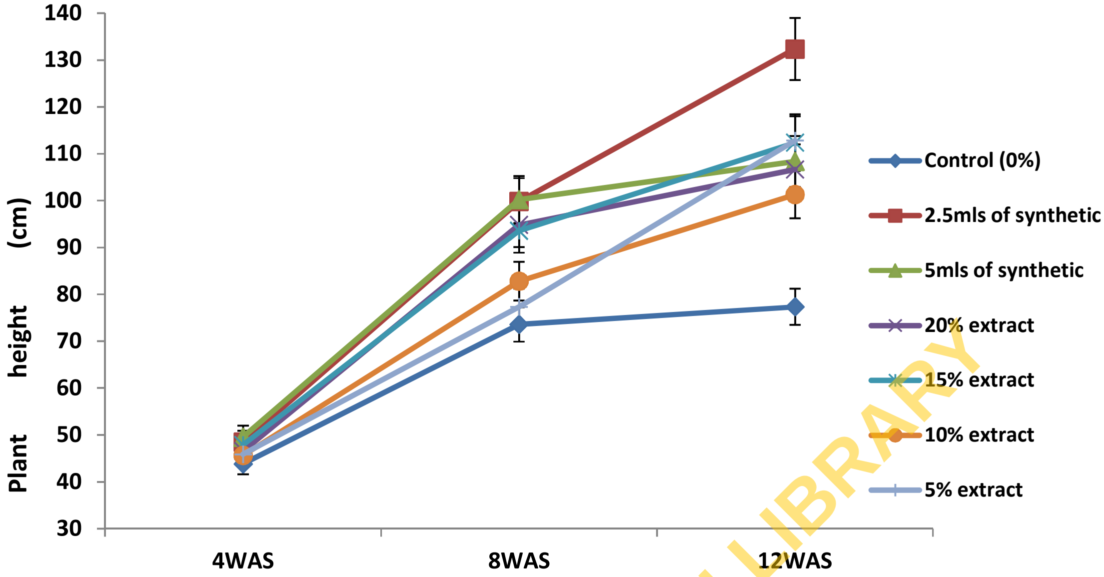

Fig. 1. Effects of *P. biglobosa* aqueous pod husk extract and synthetic insecticide (Dimethoate + Cypermethrin) on the plant height (cm) of okra plants

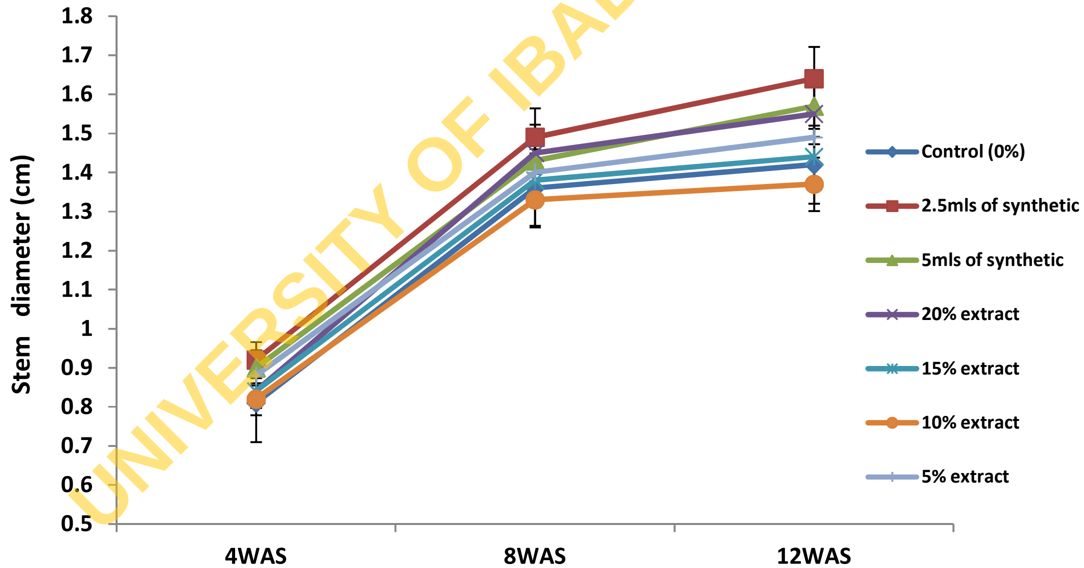

Fig. 2. Effects of *P. biglobosa* aqueous pod husk extract and synthetic insecticide (Dimethoate + Cypermethrin) on the stem diameter (cm) of okra plants

5% PPHE had no significant differences (P>0.05) at 12 WAS. Lower values were obtained from the control (13.42), 15% (14.08) and 10% (13.92) PPHE plots, respectively.

3.6 Leaf Area

The effects of PPHE and synthetic insecticide (D+C) on the leaf area (cm^2) of okra plants are presented in Fig. 4. The leaf area of plots treated with synthetic insecticide (2.5 ml and 5 ml), 20%, 15%, 10% and 5% PPHE had no significant differences (P >0.05) at 4 WAS. Only the control plots had reduced leaf area. The control plots also had the lowest leaf area (65.76 cm^2) at 8 WAS, no significant difference (P>0 .05) was observed in the leaf area among plots treated with synthetic insecticide (2.5 ml, 5 ml) and 20% PPHE. There was no significant difference (P>0.05) in the leaf area of plots treated with 15%, 10% and 5% PPHE. A similar trend was also observed at 12 WAS, control plots had the lowest leaf area (68.36 cm^2), while there was no significant difference (P>0.05) among plots treated with the synthetic insecticide (2.5 ml, 5 ml) and 20% PPHE. All other treatments had similar values.

3.7 Yield Parameters

The effects of PPHE and synthetic insecticide (D+C) on the yield parameters of okra are presented in Table 3. There was no significant difference (P >0.05) in the number of days to flowering among all the treatments. Significant differences (P<0.05) were shown in the number of fruits per plot, number of fruits per plant and fresh weight of fruits per plot. Synthetic treated plots at 2.5 ml had the highest values (254.66; 15.92) for both fruits per plot and per plant, respectively, although with no significant difference (P>0.05) from the plots treated with 5mls (D+C), 20% and 5% PPHE. However, plots treated with 15% and 10% PPHE were significantly different (P<0.05) from other treated plots. The control plots had significant lower (P<0.05) values (108.00; 6.75) from fruits per plot and per plant, respectively.

Results from fresh fruit weight (g) revealed that, the 2 ml (D+C) treated plots had the highest fruit weight (2107.25 g), followed by 5 ml (1635.63 g) and 5% PPHE (1618.24 g) with no significant difference (P>0.05). However, the control had the significant reduced (P<0.05) value (847.31 g) fresh fruit weight.

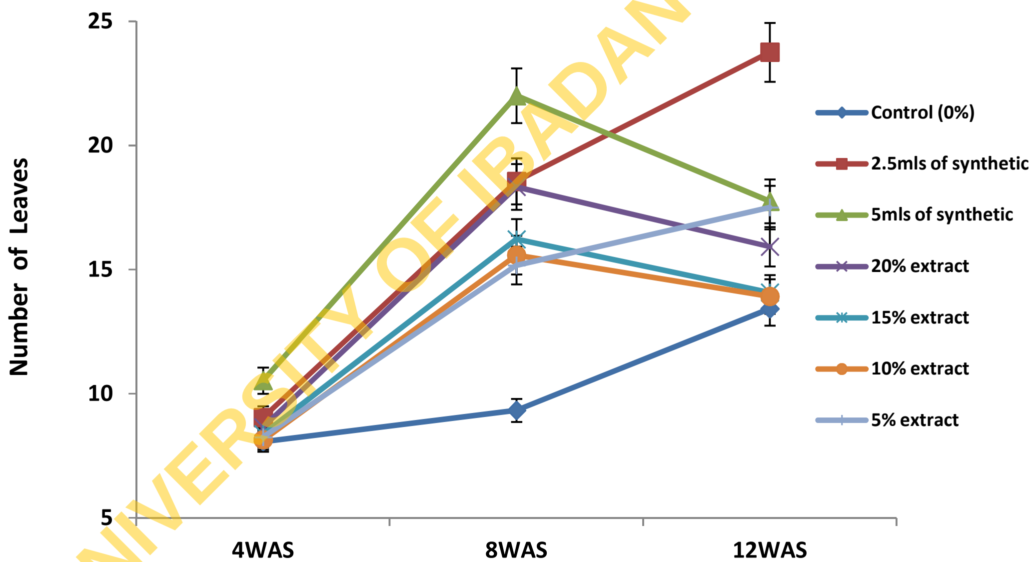

Fig. 3. Effects of *P. biglobosa* aqueous pod husk extract and synthetic insecticide (Dimethoate + Cypermethrin) on the number of leaves of okra plants

Table 3. Effects of *P. biglobosa* aqueous pod husk extract and synthetic insecticide (Dimethoate + Cypermethrin) on the yield parameters of okra

Treatments	Number of days to flowering	Number of fruits per plot	Number of fruits per plant	Fresh weight of fruits per plot (g)
Control (0%)	49.00^{a}±2.00	108.00^{d}±16.00	6.75^{d}±1.00	847.31^{d}±12.85
2.5 mls of synthetic	46.00^{a}±1.00	254.66^{a}±8.74	15.92^{a}±0.54	2107.25^{a}±46.23
5 mls of synthetic	53.00^{a}±3.00	202.671^{abc}±7.02	12.67^{abc}±1.06	1635.63^{ab}±156.98
20% extract	44.33^{a}±1.45	192.00^{abcd}±40.85	12.00^{abcd}±2.55	1533.28^{bcd}±326.59
15% extract	50.00^{a}±5.69	117.33^{cd}±45.63	7.33^{cd}±2.85	978.29^{cd}±383.48
10% extract	45.33^{a}±1.67	157.33^{bcd}±14.67	9.83^{bcd}±0.92	1234.51^{cd}±153.05
5% extract	46.66^{a}±1.45	209.33^{ab}±25.54	13.08^{ab}±1.59	1618.24^{ab}±168.24

a, b, c, d, Means along the same row with different superscripts are significantly (P<0.05) different

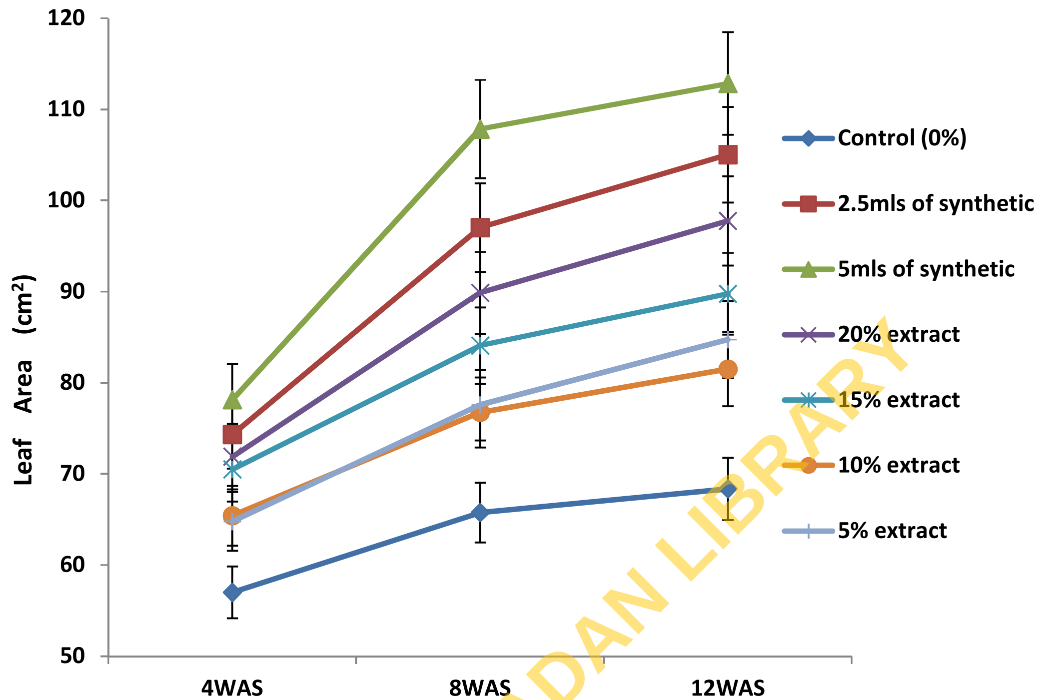

Fig. 4. Effects of *P. biglobosa* aqueous pod husk extract and synthetic insecticide (Dimethoate + Cypermethrin) on the leaf area (cm^2) of okra plants

3.8 Dry Matter Accumulation

The effects of the different treatments on dry matter accumulation are presented in Table 4. There was no significant difference (P>0.05) in the dry matter accumulation by the root per plant and plots with synthetic insecticide (2.5 ml, 5 ml), 20% and 5% PPHE, although 2.5 ml had the highest dry matter values (10.41 g; 166. 56 g), respectively. Plots treated with 10%, 15% PPHE and control plots showed no significant differences (P> 0 .05), however, 15% PPHE had the lowest dry matter values (5.57 g; 86.24 g) for root per plant and plot, respectively. The control plots and all plots treated with different concentrations of the extract (20%, 15%, 10% and 5%) showed no significant differences (P> 0.05) in dry matter accumulation by the shoots in both per plant and plot. Also there was no significant difference (P> 0.05) between the plots treated with the synthetic insecticide (2.5 ml, 5 ml), although 2.5 ml had the highest values (55.08 g; 881.31 g) in shoot per plant and plot, respectively. However, the control had the lowest values (17.79 g; 284.58 g), respectively in the dry matter accumulation by the shoots.

Table 4. Effects of *P. biglobosa* aqueous pod husk extract and synthetic insecticide (Dimethoate + Cypermethrin) on dry matter accumulation

Treatments	Dry root per plant (g)	Dry root per plot (g)	Dry shoot per plant (g)	Dry shoot per plot (g)
Control (0%)	5.82^{b} ±0.87	93.08^{bc}±13.85	17.79^{b}±3.39	284.58^{b}±54.28
2.5 mls of synthetic	10.41^{a}±1.19	166.56^{a}±19.00	55.08^{a}±11.64	881.31^{a}±86.30
5 mls of synthetic	9.80^{ab}±1.40	156.75^{ab}±22.42	41.51^{ab}±9.33	664.16^{ab}±149.30
20% extract	6.97^{ab}±1.91	111.52^{abc}±30.56	17.79^{b}±3.39	368.71^{b}±105.76
15% extract	5.57^{b}±1.56	86.24^{c}±24.82	26.08^{b}±5.59	417.33^{b}±89.13
10% extract	5.82^{b}±0.84	93.17^{bc}±13.39	23.19^{b}±6.61	370.99^{b}±107.09
5% extract	7.79^{ab}±0.75	124.59^{abc}±11.93	26.32^{b}±5.57	421.18^{b}±9.57

a, b, c, Means along the same row with different superscripts are significantly (P<0.05) different

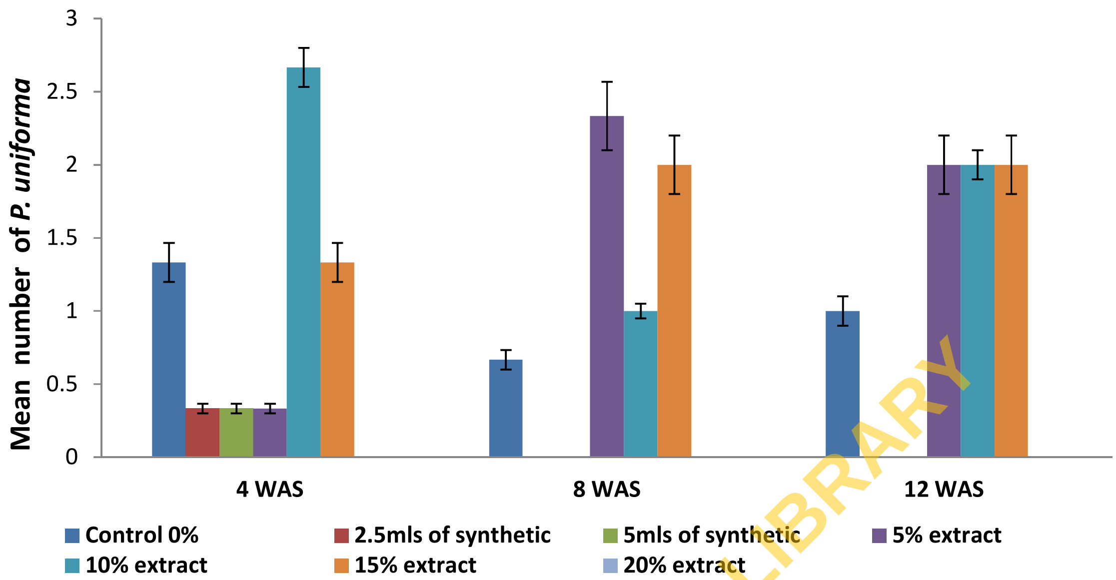

Fig. 5. Mean number of *P. uniforma* on okra plots sprayed with different treatments

3.9 Effects of *Parkia biglobosa* Aqueous Pod Husk Extract (PPHE) and Synthetic Insecticide (Dimethoate + Cypermethrin) (D+C) on the Flea Beetles

Results presented in Figs. 5 and 6 showed the insect count on plots sprayed with the different treatments. *Podagrica uniforma* were absent on plots sprayed with 20% PPHE at 4 WAS, 8 WAS and 12 WAS. Occurrence of *Podagrica sjostedti* was highest on plots sprayed with 10% PPHE at 4 WAS and 8 WAS. None was observed on all the plots at 12 WAS.

4. DISCUSSION

This study showed that aqueous extract of *P. biglobosa* pod husk contained the highest number of phytochemicals of all the plant parts studied. The phytochemicals include phenols, flavonoids, tannin, saponin, cardiac glycoside, steroid, terpenoid, alkaloid and anthraquinone. This is in agreement with the report of Abagale et al. [27], who discovered the presence of saponin, glycoside, flavonoids, tannin and polyphenols in *P. biglobosa* pod husk. Olorunmaiye et al. [28] also reported the use of the pod husk in producing an insecticide powder or dust which is used in protecting crops from insect pests.

The result of the quantitative phytochemical analysis of powdered samples of the different parts of *P. biglobosa* showed that the pod husk (which is an epidermal cell) contained the highest quantity of phytochemicals. Wayne et al. [29] reported that high active compounds are usually found in epidermal cells due to their protective and supportive functions.

During the study, plots treated with 5 ml of synthetic insecticide (Dimethoate+ Cypermethrin) (D+C) had relatively higher growth parameters. This could be due to the higher concentration of the synthetic active ingredients present in it. The performance (growth and yield) of okra plants treated with 20% and 5% aqueous extracts of *P. biglobosa* pod husk (PPHE) was comparative to those treated with 2.5 ml of synthetic insecticide (D+C) (recommended dose), although the later had higher values. Rehman et al. [30] reported similar result. The superiority of husk extracts to husk powder or dust in pest management and in stimulating the growth and yield of crops may be related to water and nutrient uptake in the soil [17].

There were no significant differences in the population of flea beetles among most of the treatments used; this could be due to the low concentration of Saponin in the aqueous pod husk extract. De Geyter et al. [31] reported that Saponin possesses insecticidal activity that causes mortality.

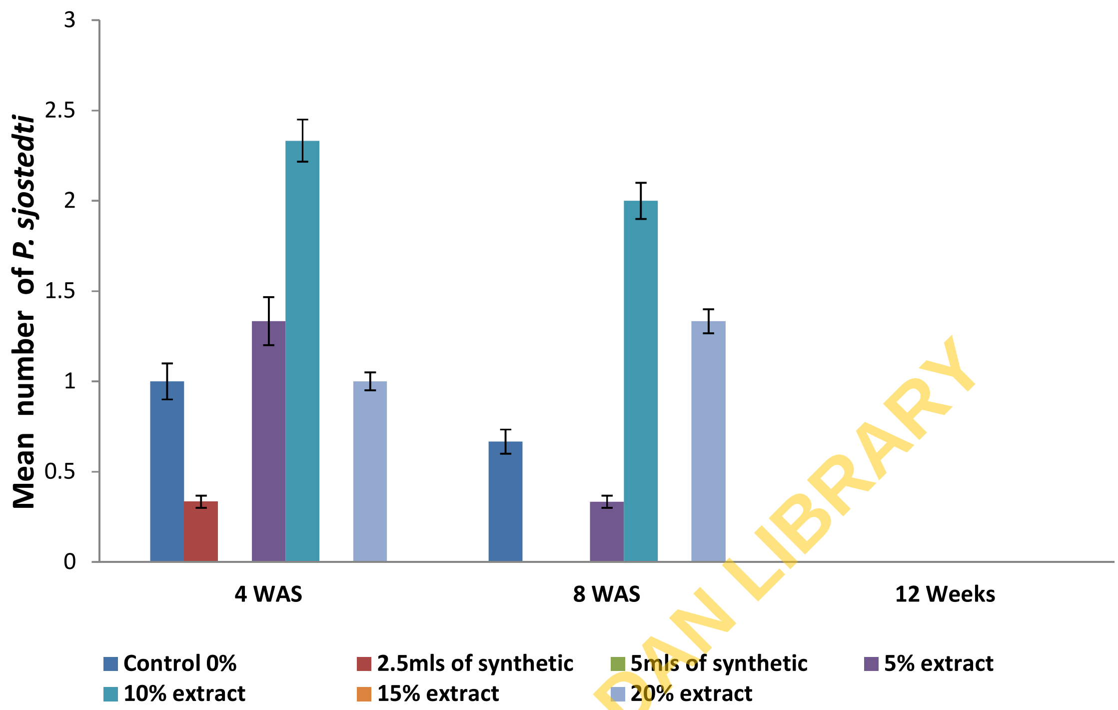

Fig. 6. Mean number of *P. sjostedti* on okra plots sprayed with different treatments

5. CONCLUSION

This present study showed that, the aqueous extract at 20% concentration of *P. biglobosa* Pod husk (PPHE) improved the growth and yield of okra plants, as its performance was comparative to plants treated with 2.5 ml of synthetic insecticide (Dimethoate+ Cypermethrin) (D+C). It is also revealed in this study that, the efficacy of *P. biglobosa* can be equal to the conventional pesticide, especially for crops like fruit vegetable (okra). It might be concluded that the aqueous extracts (PPHE) served as insect repellants because the insect population was inversely proportional to the number of application. Hence, its use as a biopesticide is encouraged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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