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Use of plant-derived insecticides for the control of *Podagrica* spp. of *Abelmoschus esculentus* (L.) in Southeastern Nigeria

Emeasor K. C.[1], Uwalaka O. A.[2] and Nnaji M. C.[1]

[1]Department of Plant Health Management, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2]National Horticultural Research Institute, Mbato Outstation, Okigwe, Imo State, Nigeria.

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ABSTRACT

A field experiment was conducted in 2015 cropping season to evaluate the efficacy of some plant-derived insecticides against Okra flea beetles, *Podagrica uniforma* and *Podagrica sjostedti*. The plant materials evaluated included leaves and stems of castor oil plant (*Ricinus cummunis*), Barbados nut plant (*Jatropha curcas*) and Goat weed (*Ageratum conyzoides*). The okra [*Abelmoschus esculentus* (L.) Moench] variety used was NH47 - 4. The leaves and stems of the plants used in the experiment were collected from Ntalakwu in Bende L.G.A., Abia State Nigeria, washed, air-dried and then ground to a fine powder. The experimental design was randomized complete block design (RCBD) with seven treatments and four replicates. The efficacy of the treatments was evaluated based on reduction in population of the flea beetles. The results obtained show that all the plant materials tested significantly at P<0.05 reduced *P. uniforma* and *P. sjostedti* infestation with low damage and high fruit yield when compared with the untreated plots. Among all the treatments evaluated, *Ricimus cummunis* stem*, A. conyzoides* stem, and *J. curcas* leaf aqueous extracts significantly (P<0.05) reduced the population of the two flea beetles with percentage reduction of 63.38, 57.08 and 55.24%, respectively. The plots treated with *J. curcas* stems had the highest fruit yield of 11.67 kg/ha and significantly (P<0.05) had the least fruit damage 0.25 kg/ha when compared with other plant extracts. The potential of plant derived insecticides in controlling these insect pests of okra have been proven and hence could be a good alternative for synthetic insecticide because of their attendant benefits.

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench.] is one of the most important vegetable crops and a source of nutrition (4550 kcal/kg) for human consumption. It ranks first before other vegetable crops (Babatunde et al., 2007). *A. esculentus belongs* to the family Malvaceae. Okra originated in tropical and sub-tropical areas, in North-east Africa centre and Asia. It is widely distributed in many tropical areas of the world especially in Sudan, Egypt and Nigeria. Okra is usually grown on a wide range of soils, but well drained fertile soils with adequate organic matter results in high yield.

The total area under okra production is reported to be 1148.0 ha. It is mainly grown in India, Nigeria, Sudan, Pakistan, Ghana, Egypt, Benin, Saudi Arabia, Mexico and Cameroon. Largest area and production is in India (9,623,718 tons) followed by Nigeria (2,039,500 tons)

*Corresponding author. E-mail: kingsleychidiemeasor@yahoo.com.

(FAOSTAT, 2014).

Okra plays an important role in the human diet (Kahlon et al., 2007; Saifullah and Rabbani, 2009), by supplying fats, proteins, carbohydrates, phosphorous, calcium, iron, sulphur, fibre, minerals and vitamins (Lamont, 1999; Owolarafe and Shotonde, 2004; Gopalan et al., 2007; Arapitsas, 2008; Dilruba et al., 2009; Kumar et al., 2004). Okra fruit is usually boiled in water resulting in slimy soups and sauces, which are relished. The fruits also serve as soup thickener. Okra seed can be dried, and the seeds are a nutritious material that curds, or roasted and ground to be used as coffee additive or substitute (Moekchantuk and Kumar, 2004). Okra's fibre content is made up of both soluble and insoluble fibre. Soluble fibre of okra helps to prevent diabetes and high blood cholesterol while insoluble fibre regulates digestive system function (Kumar et al., 2004).

Insect pests' infestation is one of the major factors militating against cultivation of okra in Nigeria. Different growth stages of okra have been known to be attacked by these insects. Okra was observed to have shared the same broad spectrum of insect pests with cotton and hibiscus. Among these insect pests, *Podagrica* spp. have been reported to have caused economic damage (Odebiyi, 1980). According to Banjo and Fasunwom (2010), *Podagrica* spp. attack the lamina of the foliage and matured leaves of the okra plant which result to reduction of the photosynthetic ability of the crop leaves. The insect is also responsible for transmission of mosaic virus. This infection could result to 20-50% yield reduction. These insects cause significant yield losses.

In view of the aforementioned destructive activities of *Podagrica* spp., effective control measures become imperative in order to have a high yield. Generally, synthetic insecticides are the most effective means of controlling insect pests due to their quick action and long lasting effect. However, most of these synthetic insecticides have been banned in developed countries. This is in connection with development of insect resistance, environmental pollution, and carcinogenic effect, insects' elimination of beneficial fauna and different human health problems (Trumper and Holt, 1998). In addition, most of the synthetic chemicals in Nigeria are not available and the available few are not affordable to the farmers due to the harsh economic situation. These problems emanating from synthetic chemicals necessitated the idea of developing effective, cheap and easily biodegradable alternative products. The use of plant-derived insecticides is in recent time being investigated by researchers as possible replacement for synthetic insecticides because they are highly degradable in the environment, causes little or no toxicity to human, safer, more readily available, easy to formulate and affordable (Dudu and Williams, 1991). This study was carried out to evaluate the efficacy of some plant materials (*R. cummunis, J. curcas* and *A. conyzoides*) for the control of *P. uniforma* and *P. sjostedti* in the field; to assess the effect of these plant materials on the reduction of damage caused by the okra flea beetles and to determine the influence of these treatments on the yield of okra.

MATERIALS AND METHODS

The field experiment was conducted at the Teaching and Research Farm of the College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Umudike is located at latitude 5° 28' North, longitude 7° 35' East and an altitude of 122 m above sea level. A variety of okra (NH47-4) for this study was obtained from National Seed Service, Umudike. The experimental design used was Randomized Complete Block Design (RCBD) with seven treatments replicated four times. The treatments were: *J. curcas* stem, *J. curcas* leaves, *R. cummunis* stem, *R. cummunis* leaves, *A. conyzoides* stem, *A. conyzoides* leaves and the control.

The experimental units comprised 28 beds, each measuring 2 m × 2 m (4 m^2) with a space of 0.5 m between beds and 2 m between replicates. Land preparation involving slashing, ploughing and harrowing were done and making of beds were also done with hoe. The total area of the land used for the trial was 17.5 m × 10 m (175 m^2). All standard agronomic practices were carried when necessary. The NH47-4 okra seeds were sown to the field at the spacing of 60 cm between rows and 30 cm between plants and 2 seeds were sown per hole maintaining the depth of 2 cm, planting population per bed was 36 seeds with 18 stands per bed while 1,008 seeds with 504 stands was the overall plant population. Before sowing, okra seeds were tested for viability by soaking them in water for 24 h where the non-viable seeds floated and was separated from the viable ones and then discarded and the viable seeds were planted. Those stands that failed to germinate after one week of planting were supplied to get the accurate number of stands on each bed.

Preparation and application of plant materials

The plant materials (botanicals) namely Barbados nut, (*J. curcas*), Castor oil (*R. cummunis*), and goat weed (*A. conyzoides*) stem and leaf used for the experiment were obtained from Ntalakwu in Bende L.G. A., Abia State, Nigeria. The plant materials were washed, air-dried at the prevailing temperature of the immediate surrounding (28 - 32°C) and then ground to a fine powder with motorized grinder. Thereafter, 100 g each of the six ground plant materials were poured into 2 L capacity plastic buckets and mixed with 2 L of water and allowed to stay for 24 h. The solutions in each respective container were sieved with muslin cloth to get the various extracts used for the trial.

Table 1. Effect of plant-derived insecticides on the population of *P. uniforma* of okra [*A. esculentus* (L.) Moench] in the field.

Treatment	Number of *P. uniforma* per plant/plot					
	2WBA	**4WBA**	**6WBA**	**2WAA**	**4WAA**	**6WAA**
J. curcas leaf aqueous extract	17.00	14.00	18.50	7.25	8.00	10.75
J. curcas stem aqueous extract	19.80	21.25	18.25	8.75	10.00	10.00
R. cummunis leaf aqueous extract	18.20	17.00	19.50	8.50	9.00	10.25
R. cummunis stem aqueous extract	23.20	20.00	18.25	6.00	9.00	7.50
A. conyzoides leaf aqueous extract	17.50	17.00	20.50	7.25	8.50	8.75
A. conyzoides stem aqueous extract	16.00	21.00	15.50	8.75	9.50	6.50
Control	20.20	21.75	22.00	25.75	28.75	26.50
$LSD_{0.05}$	Ns	Ns	Ns	4.11	3.91	3.99
Significance	Ns	Ns	Ns	***	***	***

ns, Non-significant; *****,** significant at P<0.01; **WBA,** weeks before application; **WAA,** week after application.

Table 2. Effect of plant-derived insecticides on the population of *P. sojostedti* of okra [*A. escunlentus* (L.) Moench] in the field.

Treatment	Number of *P. sjostedti* per plant/plot					
	2WBA	**4WBA**	**6WBA**	**2WAA**	**4WAA**	**6WAA**
J. curcas leaf aqueous extract	14.75	14.75	15.75	7.00	8.00	5.25
J. curcas stem aqueous extract	15.50	13.75	12.75	8.50	7.00	6.00
R. cummunis leaf aqueous extract	14.50	14.25	14.00	8.25	6.00	7.50
R. cummunis stem aqueous extract	14.50	15.00	13.50	5.75	5.75	6.00
A. conyzoides leaf aqueous extract	16.00	14.25	16.50	7.00	7.25	7.50
A. conyzoides stem aqueous extract	15.50	13.50	15.25	7.25	5.25	6.50
Control	19.00	21.00	23.00	21.75	22.50	25.25
$LSD_{0.05}$	Ns	4.75	4.10	4.12	2.33	3.01
Significance	Ns	***	***	***	***	***

ns, Non-significant; *****,** significant at P<0.01; **WBA**, weeks before application; **WAA,** week after application.

The treatments (extracts from each of the six plant materials were applied on the plots with a 2 L capacity manually operated hand sprayer. This commenced two weeks after crop establishment and was done at two weeks interval and for six times.

Data collection and analysis

Insect collection and identification started ten days after crop emergence. This was done before and after spray using direct count method by carefully walking along the rows of each plot and counting the number of insects seen and at four days interval in the early hours of the day (6.00 am - 7.30 am). Assessment of infestation was based on the population of the insects pests and crop damage was assessed based on the number of holes/punctures on the leaves, number of defoliated leaves per plot, number of damaged fruits per plot, number of fresh fruit per plot, weight of fresh fruit per plot and weight of damaged fruit per plot were determined.

Data collected from the trial were subjected to statistical analysis. Analysis of variance (ANOVA) tests were conducted and means were separated using the least significant difference (LSD) at 5% level of probability.

RESULTS

Results of the effect of the application of some plant-derived insecticides on the population of *P. uniforma* and *P. sjostedti* on okra, *A. esculentus* during the 2015 cropping season at Umudike, Southeastern Nigeria are presented in Tables 1 and 2, respectively. Results obtained showed that application of plant-derived insecticides had significant effect (P<0.05) on the population of the flea beetles (*Podagrica* spp.) (Tables 1 and 2). Mean number of *P. uniforma* at 2, 4 and 6 weeks before application (WBA) showed no significant differences (P>0.05). Mean number of *P. uniforma* per plant per plot ranged from 14.00 – 23.20 with 2 – 6 WBA (Table 1). At 2, 4

Table 3. Percentage leaf defoliation of *A. escunlentus* (L.) Moench as affected by application of plant-derived insecticides.

Treatment	Percentage leaf defoliation per plant/plot					
	2WBA	4WBA	6WBA	2WAA	4WAA	6WAA
J. curcas leaf aqueous extract	2.00	2.25	2.75	2.00	2.25	2.75
J. curcas stem aqueous extract	2.00	2.25	2.50	2.25	2.25	2.50
R. cummunis leaf aqueous extract	2.00	2.25	2.50	2.00	2.25	2.50
R. cummunis stem aqueous extract	2.00	2.50	2.75	2.00	2.50	2.75
A. conyzoides leaf aqueous extract	2.25	2.50	2.50	2.25	2.50	2.50
A. conyzoides stem aqueous extract	2.00	2.75	2.75	2.25	2.75	2.75
Control	2.75	3.75	4.25	3.00	4.00	4.75
$LSD_{0.05}$	0.39	0.79	0.82	0.48	0.75	0.76
Significance	***	***	***	***	***	***

*****,** significant at P<0.01; **WBA**, weeks before application; **WAA,** week after application.

and 6 weeks after application (WAA), the population of *P. uniforma* ranged from 7.25 – 28.75 per plant per plot in which the untreated plots recorded the highest number of *P. uniforma* per plant per plot of 25.75, 28.75 and 26.50 at 2, 4 and 6 WAA, respectively (Table 1).

R. cummunis stem aqueous extract was most efficacious in the reduction of *P. uniforma* population on okra with 63.38%, this result was closely followed by the application of *A. conyzoides* stem and leaf aqueous extracts which had 55.65 and 52.86% reduction in *P. uniforma* population on okra, respectively. However, the untreated plots had the least percentage reduction in *P. uniforma* population of 26.64% (Table 1).

Results in Table 2 revealed that the plant-derived insecticides significantly (P<0.05) reduced *P. sjostedti* infestation in the field. From general point of observation, all the tested plant-derived insecticides were effective against *P. sjostedti* population on okra compared to the control plots (that is, untreated experimental units). At 2, 4 and 6 WAA, the infestation level of *P. sjostedti* was very high ranging from 12.75–23.00 per plant (Table 2). Reduction in the population of *P. sjostedti* was observed at 2, 4 and 6 WAA; the population ranged from 5.25 – 25.25. Aqueous stem extract of *R. cummunis* was most effective against *P. sjostedti* with 59.32% reduction in the number of the flea beetles (Table 2). *A. conyzoides* stem, *J. curcas* leaf and *A. conyzoides* leaf aqueous extracts applied as plant-derived insecticides were also effective in the control of *P. sjostedti* infestation, reducing their numbers by 57.08, 55.24 and 53.47% respectively (Table 2). However, the results also indicated that the control plots had the highest infestation level by *P. sjostedti* and percentage reduction of the flea beetle was lowest (10.33%) in the untreated plots (Table 2).

Analysis of variance conducted on the percentage of okra per plant per plot showed that significant differences (P<0.05) existed between the plant-derived insecticides evaluated for their efficacies at 2, 4 and 6 weeks before and after treatment application (Table 3). Control experimental units had the highest mean leaf defoliation of 3.58 and 3.92 before and after treatment application respectively. Leaf defoliation was lowest (2.33) in plots sprayed with *J. curcas* leaf and stem aqueous extracts each respectively and this may also be attributed to the higher fruit yield recorded in plots treated with these plant materials (Tables 3 and 4).

Fresh fruit yield of okra was highest (10.02 tha^{-1}) in plots treated with *J. curcas* stem aqueous extract, followed by *A. conyzoides* stem aqueous extract (9.91 tha^{-1}), *R. cummunis* leaf aqueous extract (9.89 tha^{-1}), *A. conyzoides* leaf aqueous extract (9.84 tha^{-1}), *J. curcas* stem extract (9.69 tha^{-1}) and 9.49 tha^{-1} was obtained from plots sprayed *R. cummunis* stem aqueous extract (Table 4). The lowest fresh weight (5.37 tha^{-1}) was obtained from the control experiments and this may be attributed to the high infestation by *Podagrica* spp. and high defoliation rate recorded from these plots.

Pod density per plot was highest (11.67) in *R. cummunis* stem extract treated plots, followed by *J. curcas* leaf extract treated plots (10.88) and the control plots recorded the least pod density of okra per plot of 5.71 (Table 4).

R. cummunis stem aqueous extract treated plots had the least (0.25) damaged pods and this result was closely followed by *A. conyzoides* leaf aqueous extract treated plots (2.00). These two results are significantly different (P<0.05) when compared with the other treatments applied. Similar trend was also observed on damaged fruit yield in which the least damage yields of 0.003 and 0.032 tha^{-1} were obtained from plots treated with *R. cummunis* stem and *A. conyzoides* leaf aqueous extracts respectively (Table 4).

Discussion

Insect pest infestation is one of the factors militating against effective and meaningful cultivation of okra in Nigeria. Among the insect pests, *Podagrica* spp. ranked first and have been reported to have caused economic damage of over 80% yield loss (Odebiyi, 1980). Also, Banjo and

Table 4. Effect of plant-derived insecticides on the yield of okra *A. escunlentus* (L.) Moench.

Treatment	Fresh fruit weight (tha^{-1})	Pod density per plot	Damaged pod density per plot	Damaged fruit weight (t/ha^{-1})
J. curcas leaf aqueous extract	10.02	10.88	5.25	0.03
J. curcas stem aqueous extract	9.69	9.38	3.50	0.25
R. cummunis leaf aqueous extract	9.89	10.58	2.75	0.02
R. cummunis stem aqueous extract	9.49	11.67	0.25	0.003
A. conyzoides leaf aqueous extract	9.84	10.04	2.00	0.023
A. conyzoides stem aqueous extract	9.91	9.96	5.00	0.04
Control	5.37	5.71	5.50	0.04
$LSD_{0.05}$	1.37	3.28	3.39	0.025
Significance	***	***	***	***

*****,** significant at P<0.01.

Fasunwon (2010), reported that *Podagrica* spp. attack the lamina of the foliage which result to reduction of the photosynthetic ability of crop leaves. Their reports corroborate the findings of this present study that okra if left unprotected in the field will record high defoliation rate as a result of infestation by *Podagrica* spp. Parh et al. (1997), reported that *P. uniforma* and *P. sjostedti* are major okra defoliators and fruit feeders. The results of this trial have shown that the application of plant-derived insecticides significantly reduced the population of the flea beetles on okra plants, thereby minimizing leaf surface area damage and consequently causing increased yield compared to the untreated okra plants. These research findings support the earlier reports of Gerard and Ruf (1991), Russel and Lane (1993) and Emimal (2010), that plant extracts consist of complex mixtures of bioactive constituents and plant metabolites which produce toxic effects if ingested by the insect pests and leading to rejection of host plants. Also, these bioactive constituents and metabolites act as antifeedants, which inhibit oviposition, disturb insect growth and development.

Findings from this present study revealed that all the plant-derived insecticides significantly reduced the population of flea beetles, thereby reducing their infestation and enhanced plant growth and yield. These findings agree with the reports of Krishnareddy et al. (1995), Ogunjobi and Ofuya (2007), Adesina and Idoko (2013) and Adesina and Afolabi (2014), who reported in their various works that okra plants treated with plant extracts recorded higher yields as compared to the untreated okra plants.

The efficacies of plant-derived insecticides against okra flea beetles have been earlier reported by several researchers (Dike and Mbah, 1992; Attieri, 1993; Oparaeke, 1997). The study also revealed the insecticidal potentials of all the plant materials evaluated against *Podagrica* spp. especially *R. cummunis* stem, *A. conyzoides* stem and leaf of *J. curcas* in that order of performance respectively.

The current study has revealed that aqueous extracts of leaf and stem of *J. curcas*, *A. conyzoides* and *R. cummunis* used as plant-derived insecticides for the control of *P. uniforma* and *P. sjostedti* in okra field were effective and significantly reduced the population of the insect pests compared with the untreated okra plants. *R. cummunis* stem, *A. conyzoides* stem and *J. curcas* stem gave more impressive results than other plant materials used.

It is a clear fact that some plant materials have insecticidal properties as proven by many studies conducted by research scientists and as demonstrated by the findings of this present study. Therefore, I recommend that concerted efforts be made towards the commercialization of the production of plant-derived insecticides, development of preservation techniques and education of farmers on the benefits of protecting their crops with plant-derived insecticides and dangers of chemical insecticides to man and his environment. For the control of okra flea beetles, I recommend that *J. curcas*, *A. conyzoides* and *R. cummunis* stem aqueous extracts be adopted as they are easily sourced, cheap and suitable alternatives to synthetic insecticides.

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