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Control of field insect pests of mung bean (*Vigna radiata* L. Wilczek) using some plant extracts in Umudike, Nigeria

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Field trials were conducted at Umudike, Nigeria, during the 2015 and 2016 cropping seasons to determine the efficacy of plant extracts from seven plant species against field insect pests of mung bean, *Vigna radiata* L. Wilczek. The extracts tested were obtained from scent leaf (*Ocimum gratissimum*), neem leaf (*Azadirachta indica*), bitter leaf (*Vernonia amygdalina*), garlic (*Allium sativum*), turmeric (*Curcuma longa*), plantain (*Musa paradisiaca*) peel and Negro pepper (*Xylopia aethiopica*). Karate (Lambda-cyhalothrin EC) at 50 mL was introduced as a check in the trials. The experimental design was a randomised complete block design (RCBD) with three replicates. Data were collected weekly on the insect population densities, yield and yield components. The results indicated that all the treatments were effective against mung bean insect pests (*Aphis craccivora* [aphid], *Bemisia tabaci* [whitefly], *Amrasca biguttula biguttula* [jassid] and *Zonocerus variegatus* [grasshopper]). There was a significant ($p \leq 0.05$) reduction in the population of insects on the plots treated with plant extracts and karate in 2015 and 2016 cropping seasons. The population densities of grasshoppers in 2015 and whitefly in 2016 were significantly lower in the treated plots compared with the control plots. *Azadirachta indica* and *C. longa* extracts recorded the highest seed yield of 50.00 kg/ha and 42.33 kg/ha in 2015 and 2016, respectively. No significant differences were observed between the plant extracts and karate, which recorded significantly higher yields when compared with the control (23.30 kg/ha). All the plant extracts used exhibited insecticidal activity against the insect pests of mung bean. It is, therefore, recommended that these plant extracts can be used for the control of mung bean insect pests to achieve sustainable production, food security and quality.

Introduction

Mung bean (*Vigna radiata* L. Wilczek*)* belongs to the family Fabaceae (Lambridges & Godwin 2006). It is a good source of proteins, carbohydrates and vitamins for the human race all over the world. It is an important grain legume and is extensively grown in tropical and subtropical countries of the world (Asante, Tamo & Jackai 2002). It is a low-input short-duration crop, and is priced for its seeds which have high protein level, are easily digestible and consumed as food. Because of its non-flatulent behaviour (digestibility) and high protein level, it has an edge over other pulses (Ghafoor, Ahmad & Quyyum 2003). It has the ability to fix nitrogen to the soil because of its root nodules (Hoorman, Islam & Sundermeier 2009).

Mung beans are attacked by a host of insect species. The sap-sucking insects such as *Aphis craccivora, Empoasca* spp., *Cicadella viridis, Bemisia tabaci* (whitefly) are the major pests of mung bean (Isman 2008). These insects not only reduce the vigour of the plant by sucking the sap, but also transmit diseases which reduce the rate of photosynthesis and ultimately cause a reduction in yield (Asawalam & Anumelechi 2014).

Insecticides are used as effective means to control insect population in the field and store. The toxic residues of these chemicals have adverse effects on humans and the environment. They can persist in the soil; hence, their use has been discouraged (Isman & Machial 2006; Rajendran & Sriranjini 2008). Plant-derived materials are more readily biodegradable and less toxic to mammals and may retard the development of resistance (Asawalam & Anaeto 2014). Neem seed kernel extract has been reported to be effective in reducing insect damage on mung bean. Neem oil and tamarind extracts are also effective against major sucking insect pests of mung bean (Kabir et al. 2014). Similarly, Ibekwe and Emosairue (2011) reported that neem seed kernel extract was effective in reducing insect damage on mung bean.

The objectives of the study were to:

1. evaluate the effectiveness of selected plant extracts on insect population densities and mung bean pod damage.
2. determine the effect of these plant extracts on the yield and yield-related components of mung bean.

Materials and methods

Experimental site

The experiment was conducted at Umudike, Nigeria, in 2015 and 2016 cropping seasons. Umudike is located at a latitude of 5°28′ north, longitude of 7°55′ east and altitude of 122 m above sea level. It has a total rainfall of about 2177 mm per annum and an average temperature of about 26°C.

Experimental design and treatments

The experiment was laid out in a randomised complete block design (RCBD), with three replicates. The treatments (Table 1) were seven plant materials and karate (Lambda-cyhalothrin). An amount of 50 mL of karate was mixed with 1 L of water in a pump and spray hand sprayer (Ceiba-Geigy, Basel Switzerland) and then shaken thoroughly before use, and 100 mL of the plant extracts was equally used. A control was set up in which there was no treatment.

Source of experimental materials

The plant parts were sourced from Michael Okpara University of Agriculture, Umudike (MOUAU) environment. *Allium sativum* and *Xylopia aethiopica* were from Ndoro Market, while *Curcuma longa* was sourced from the National Root Crops Research Institute (NRCRI), Umudike. The karate (Lambda-cyhalothrin) was bought from an agro-chemical shop in Umuahia, Nigeria. The mung bean variety, NM 92, collected from the Agronomy Department of MOUAU was used in the study.

Field preparation and agronomic practices

The experimental site was cleared of its vegetation and beds of 4 m × 4 m were prepared. Three seeds of the cultivar NM 92 were planted on the beds using a spacing of 50 cm × 25 cm and a depth of 5.0 cm. The seedlings were thinned down to one per stand at 10 days after plant emergence. Stands with seeds that failed to germinate were re-planted five days after planting. Weeding was carried out manually with a hand-hoe at two weeks after emergence and thereafter at three week intervals until crop maturity. Fertiliser (NPK 15:15:15) at the rate of 156 kg/ha was applied in each stand of the mung bean after three weeks of planting using the ring method.

TABLE 1: Plants evaluated for insecticidal properties.

Scientific name	Common name	Family	Parts used
Ocimum gratissimum	Scent leaf	Lamiaceae	Leaf
Azadirachta indica	Neem	Meliaceae	Leaf
Vernonia amygdalina	Bitter leaf	Asteraceae	Leaf
Allium sativum	Garlic	Liliaceae	Bulb
Curcuma longa	Turmeric	Zingiberaceae	Rhizome
Musa paradisiaca	Plantain	Musaceae	Peel (ash)
Xylopia aethiopica	Negro Pepper	Annonaceae	Seed

Preparation of plant extracts and application of treatments

An amount of 100 g of each fresh sample of the plant materials was milled using a Thomas milling machine (Model ED 5) and mixed with 1.0 L of distilled water and left overnight before filtering with a muslin cloth after stirring. Dried peels of wood ash from plantain (*Musa paradisiaca*) were grounded and 100 g was mixed with 1 L of water and left overnight prior to extraction.

Treatments were applied at 21 days after sowing and at weekly intervals till the maturity stage. The insecticide (karate) was sprayed (50 mL per 15 L of water) with the aid of a knapsack sprayer. During the spray operations, a polythene sheet (1 m high) was held between the plot boundaries to stop the drift of insecticide from plot to plot.

Data collection

Plant height: The height of the sampled plants (12 plants per plot) was measured using a meter rule from the soil level to the tip of the plant.

Yield and yield parameters

No. of pods per plant: The number of pods per plant was assessed from the two middle rows of each plot by visual counting.

Pod length: The length (cm) of each pod from the sampled plants was measured using a meter rule and recorded.

No. of seeds per pod: The seeds contained per pod in the 12 tagged plants were counted and recorded.

Mean weight of seeds (g): The number of seeds produced by each of the tagged plants was weighed after shelling, and the mean weight per plant was determined.

Percentage pod damage: This was calculated using the following formula:

$$\frac{\text{Total number of damaged pods}}{\text{Total number of pods assessed}} \times \frac{100}{1}$$

Yield: Harvesting of deep brown coloured pods commenced when they were matured and continued till the stands started drying. Pods from the two middle rows of each plot were harvested at crop maturity and kept separately in labelled polythene bags for determination of yields with MP Citizen Electronic Weighing Balance (0.001 g sensitivity). The total grain yield was then translated to kg/ha.

Insect population count

Assessment of the insect pest populations was done by visually counting 10 randomly-selected plants per plot in the middle row. Sampling commenced at 14 days after planting and at weekly intervals between 7.30 and 9.30 when the insects were relatively less active.

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and means were separated using Fisher's protected least significant difference at 5% level of probability.

Data on insect population (counts) were transformed using square root transformation, while those in percentage were arcsine transformed prior to data analysis.

Results and discussion

Mean population densities of insects on mung bean treated with plant extracts and karate

The mean population of insects (number per plant) on mung bean treated with plant extracts and karate in 2015 and 2016 cropping seasons is presented in Tables 2 and 3, respectively.

The result showed that the major insects identified in mung bean were aphids, jassids, whiteflies and grasshoppers. Significantly ($p \leq 0.05$) lower populations of insects were recorded in the plots treated with the plant extracts and karate when compared with the control. Karate recorded the least population of aphids (*Aphis craccivora*), jassids (*Amrasca biguttula biguttula*), whiteflies (*Bemisia tabaci*) and grasshoppers (*Zonocerus variegatus*) at five weeks after planting (WAP), in both 2015 and 2016 cropping seasons.

The population of aphids was reduced from 20.67 to 14.67 at five WAP and to 11.33 at six and seven WAP, in 2015, respectively. However, in 2016, the population of aphids in the plot treated with karate was reduced from 18.33 to 9.70 and 7.67 at six and seven WAP, respectively. Plots treated with *X. aethiopica* recorded lower population of aphids, which did not differ significantly ($p \leq 0.05$) from plots treated with *C. longa*, *A. sativum*, *A. indica* and *M. paradisiaca*.

The result indicated that significantly lower numbers of jassids, whiteflies and grasshoppers were observed in the treatment with the plant extracts compared with the control, in both 2015 and 2016. However, the control recorded significantly higher ($p \geq 0.05$) number of jassids, whiteflies and grasshoppers. The populations of jassids in plots treated with karate did not differ significantly from that treated with various plant extracts, at six and seven WAP in 2015. However, in 2016, plots treated with karate recorded significantly lower number of jassids when compared with the plots treated with various plant extracts at six and seven WAP. Significantly lower populations of whiteflies were recorded in plots treated with karate than in plots treated with various plant extracts at six WAP in 2015. Similar trends were observed at six and seven WAP in 2016. At seven WAP, in 2015, only plots treated with *A. sativum* recorded significantly higher number of whiteflies when compared with plots treated with karate. Significantly lower populations of grasshopper were recorded in plots treated with karate than in plots treated with various plant extracts at six and seven WAP in both 2015 and 2016 cropping seasons. These results support the findings of Kabir et al. (2014), who

TABLE 2: Mean population densities of insects on mung bean treated with plant extracts and karate in 2015 cropping season.

Plant	Aphids			Jassids			Whiteflies			Grasshoppers		
Extracts	5 WAP	6 WAP	7 WAP	5 WAP	6 WAP	7 WAP	5 WAP	6 WAP	7 WAP	5 WAP	6 WAP	7 WAP
Allium sativum	40.67	25.00	18.00	32.00	19.00	14.00	30.00	17.33	13.33	27.33	17.00	12.00
Azadirachta indica	42.33	29.00	19.00	31.67	21.67	15.00	27.00	15.33	10.67	21.00	15.00	11.67
Curcuma longa	38.00	25.67	19.67	33.00	19.00	14.00	30.00	18.33	12.00	31.33	19.67	14.33
Musa paradisiaca	40.67	24.67	15.33	30.67	19.00	14.00	28.00	15.33	11.00	25.00	14.67	11.00
Ocimum gratissimum	44.67	30.67	23.33	29.67	19.33	16.33	28.33	17.00	11.33	21.00	12.67	9.33
Vernonia amygdalina	44.67	32.00	22.00	37.67	19.00	13.00	25.67	15.33	11.33	20.00	15.33	10.33
Xylopia aethiopica	36.00	20.67	15.67	28.33	16.33	12.67	26.00	17.67	11.33	26.00	16.67	12.00
Karate	20.67	14.67	11.33	10.33	20.00	16.00	15.33	12.33	9.33	15.00	11.00	6.00
Control	61.67	52.00	48.00	32.00	30.67	23.00	27.67	22.33	18.33	36.67	32.33	37.33
LSD (0.05)	6.71	4.51	3.55	5.67	3.11	3.39	7.34	3.56	3.06	5.94	2.68	3.09

LSD, least significant difference; WAP, weeks after planting.

TABLE 3: Mean population densities of insects on mung bean treated with plant extracts and karate in 2016 cropping season.

Plant	Aphids			Jassids			Whitefly			Grasshopper		
Extracts	5 WAP	6 WAP	7 WAP	5 WAP	6 WAP	7 WAP	5 WAP	6 WAP	7 WAP	5 WAP	6 WAP	7 WAP
Allium sativum	59.33	52.70	39.67	44.33	37.67	34.00	16.67	10.67	10.00	32.67	22.00	16.33
Azadirachta indica	47.67	38.30	31.00	50.33	38.67	32.67	22.33	16.33	12.67	34.00	22.00	14.00
Curcuma longa	60.00	43.70	38.00	40.00	32.00	29.33	29.33	17.67	15.67	37.67	28.33	20.67
Musa paradisiaca	57.00	48.70	43.33	38.67	30.67	25.67	22.67	16.33	10.67	36.33	24.00	17.00
Ocimum gratissimum	54.00	44.30	32.00	43.67	33.00	28.00	23.33	14.00	11.00	34.33	19.67	11.67
Vernonia amygdalina	63.33	55.30	48.00	44.33	32.00	29.67	20.00	14.33	11.33	30.33	20.00	16.33
Xylopia aethiopica	48.00	47.00	40.33	37.33	30.33	26.00	23.67	17.67	13.33	39.33	24.00	19.33
Karate	18.33	9.70	7.67	13.67	9.33	6.67	9.00	5.67	3.33	12.67	8.00	4.67
Control	72.67	64.70	62.33	44.33	42.33	36.67	38.00	34.67	32.00	39.67	37.33	31.00
LSD (0.05)	8.38	9.68	6.92	8.11	7.72	7.16	3.56	3.56	2.98	8.64	7.60	4.31

LSD, least significant difference; WAP, weeks after planting.

TABLE 4: Effect of selected plant extracts and karate on yield and yield components of mung bean in 2015 cropping season.

Plant extract	Plant height (cm)	Number of pods	Pod length (cm)	Weight of pods (g)	Number of seeds	Weight of seeds (g)	Yield (kg/ha)
Allium sativum	76.72	42.97	7.24	22.50	11.90	0.49	49.30
Azadirachta indica	75.71	45.50	7.37	22.52	12.80	0.55	55.00
Curcuma longa	76.30	43.63	7.79	24.10	11.17	0.53	53.00
Musa paradisiaca	74.30	43.93	7.96	23.38	12.13	0.51	50.70
Ocimum gratissimum	73.62	39.73	7.54	22.06	12.07	0.53	53.30
Vernonia amygdalina	75.11	39.50	7.52	21.02	12.43	0.51	51.30
Xylopia aethiopica	71.25	41.00	7.31	21.62	12.13	0.49	48.70
Karate	75.24	43.43	7.61	23.74	11.87	0.60	59.70
Control	70.07	7.50	6.77	7.13	5.90	0.23	23.30
LSD (0.05)	7.02	4.27	0.79	1.96	1.58	0.10	10.24

LSD, least significant difference.

TABLE 5: Effect of selected plant extracts and karate on yield and yield components of mung bean in 2016 cropping season.

Plant extracts	Plant height (cm)	Number of pods	Pod length (cm)	Weight of pods (g)	Number of seeds	Weight of seeds (g)	Yield(kg/ha)
Allium sativum	72.51	26.97	6.97	13.46	11.93	0.41	41.00
Azadirachta indica	71.93	28.50	7.47	14.75	11.20	0.35	35.33
Curcuma longa	75.07	27.93	6.67	13.83	11.67	0.42	42.33
Musa paradisiaca	73.87	29.93	7.23	13.05	12.13	0.35	34.67
Ocimum gratissimum	69.30	27.53	7.11	16.70	11.70	0.43	37.67
Vernonia amygdalina	73.33	24.87	7.07	15.88	12.10	0.36	36.33
Xylopia aethiopica	72.83	29.27	7.53	12.48	12.27	0.41	41.00
Karate	71.33	25.83	7.63	24.93	12.87	0.47	46.67
Control	65.93	8.93	6.83	5.67	8.07	0.21	21.33
LSD (0.05)	7.54	3.56	0.66	3.47	1.33	0.10	7.49

LSD, least significant difference.

reported that aphids, whiteflies and jassids were the major sucking insects of mung bean.

Kabir et al. (2014) reported that neem seed oil and ripe tamarind fruit extract reduced the populations of jassids and whiteflies on mung bean and also increased yield. The results of the present study also agree with the findings of Hossain et al. (2010), who reported that the application of neem leaf, garlic clove and allamanda leaf reduced the population of sucking insects of mung bean. This study corroborates the findings of Asawalam (2006) and Isman (2008) who reported the insecticidal activities of plant extracts in suppressing the populations of *Mylabris pustulata* and *Megalurothrips sjostedti* on mung bean and sucking insect pests of mung bean, respectively. The results agree with the reports of Ahmed, Akhauri and Yadav (2002), who reported that scheduled spraying of insecticides and neem products reduced the population of whiteflies and jassids.

Effect of selected plant extracts and karate on yield and yield components of mung bean

Tables 4 and 5 show the effects of selected plant extracts and karate on yield and yield components of mung bean in 2015 and 2016 cropping seasons, respectively. The results revealed that the control plots recorded the lowest plant height in 2015 (70.07 cm) and 2016 (65.93 cm). The plant height of the mung bean treated with various plant extracts was not significantly different from that treated with karate in both years and was also not significantly different from the control in 2015. In 2016, only mung bean plants treated with extracts of *C. longa*, *M. paradisiaca* and *V. amygdalina* were significantly different in plant height from the control. Similar observations were recorded for the number of pods. However, all the extracts and karate resulted in significantly higher number of pods per plant compared to the control in both 2015 and 2016. Similar trends were observed for pod length. The weight of mung bean pods was significantly ($p \leq 0.05$) lower for the control in 2015 (7.13) and 2016 (5.67) compared to the plant extracts and karate. The pod weight of mung bean treated with various plant extracts and karate was not significantly ($p \geq 0.05$) different.

The number of seeds, weight of seeds and yield (kg/ha) of mung bean were significantly higher for the plant extracts and karate than for the control (23.30 kg/ha in 2015 and 21.23 kg/ha in 2016). This result corroborates the findings of Kabir et al. (2014), who reported that neem seed oil and ripe tamarind fruit extract had significantly higher mung bean yield than that of control. Asawalam and Anumelechi (2014) reported significantly higher yield in mung bean treated with some plant extracts in Umudike, Nigeria.

Pod damage on mung bean treated with plant extracts and karate

The effect of plant extracts and karate on pod damage of mung bean is presented in Table 6. Significantly higher number of damaged pods (39.00) and percentage pod damage (40.93%) were recorded for the control plots in 2015. Similarly, higher number of damaged pods (47.83) and percentage pod damage (54.92%) were observed in 2016. The number of damaged pods in plots treated with the plant extracts, except *X. aethiopica* and *O. gratissimum*, did not differ significantly from that treated with karate in 2015. However, in 2016, karate recorded the least number of damaged pods (18.81), which differed significantly from *O. gratissimum* (23.87), *M. paradisiaca* (23.20), *C. longa* (22.50), *X. aethiopica* (22.42), and *V. amygdalina* (22.15).

TABLE 6: Pod damage on mung bean treated with plant extracts and karate during 2015 and 2016 planting seasons.

Plant extracts	2015		2016	
	No. of damaged pods	Percentage pod damage	No. of damaged pods	Percentage pod damage
Allium sativum	16.67	7.88	20.98	12.87
Azadirachta indica	15.32	7.00	20.80	12.63
Curcuma longa	16.32	7.97	22.50	14.80
Musa paradisiaca	16.35	7.97	23.20	15.57
Ocimum gratissimum	19.08	10.70	23.87	16.50
Vernonia amygdalina	16.40	8.05	22.15	14.27
Xylopia aethiopica	18.09	9.73	22.42	14.60
Karate	15.11	6.80	18.81	10.42
Control	39.00	40.93	47.83	54.92
LSD (0.05)	2.79	3.11	3.31	4.15

LSD, least significant difference.

These results are in agreement with that of Asawalam and Osondu (2013) and Ibekwe and Emosairue (2011), who reported reduced pod damage on cowpea treated with plant extracts. The reduced pod damage with the plant extracts could be because of the ability of the plant extracts to penetrate tissues of the insects, thereby disrupting the cell cycle (Isman 2008). Rouf and Sardar (2011) reported a significant reduction in pod damage with significantly higher yield of country bean treated with crude seed extract of neem, black pepper mahogari and garlic bulb. Nwachukwu and Asawalam (2014) proved the potential of *A. sativum* containing allicin for biorational control of maize grains against *Sitophilus zeamais* infestation and damage.

Conclusion and recommendation

This study confirmed that the major insect pests identified on mung bean were *A. craccivora*, *A. biguttula biguttula*, *B. tabaci* and *Zonocerus variegatus*. Significantly lower population of the insects was recorded in the plots treated with plant extracts, which compared favourably with karate. The study showed that yield and yield parameters were significantly higher in treated plots than in the control plots.

Furthermore, plant extracts from different parts of *A. sativum, A. indica, C. longa, M. paradisiaca, O. gratissimum, V. amygdalina* and *X. aethiopica* have insecticidal activity against insect pests of mung bean. Because of the hazardous effect and high cost of the synthetic chemicals, these relatively safe and cheaper plant extracts can be used to control insect pests in mung bean. The study has also added new knowledge regarding the use of botanical insecticides to control *B. tabaci*, a vector of mung bean yellow mosaic virus.

Based on the results of this study, it is recommended that extracts of these plant parts should be used for the control of insect pests of mung bean. There is a need for identification of the active constituents of the plant extracts and possibly their formulation. The Food and Agriculture Organization (FAO) of the United Nations declared 2016 as the International Year of Pulses (IYP). Pulses include all beans, peas and lentils such as mung bean, etc. There is a need to encourage farmers to grow crops such as mung bean for sustainable food production, healthy diets, food security and quality nutrition using botanical insecticides as a control strategy against insects, and where feasible they should be incorporated into an integrated pest management programme.

Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors' contributions

E.F.A. designed the experiment and supervised the field studies, statistical analysis, data interpretation and drafting the manuscript. E.C. conducted the field work, collection of data and reporting of research findings.

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