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Field survey of diseases, pest and efficacy of three plant powders against flea beetles of Okra (*Abelmoschus esculentus* (L.) Moench

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Abstract

Field survey to identify diseases, insect pests of okra (*Abelmoschus esculentus* (L.) MOENCH) and to evaluate the efficacy of three plants powder on flea beetles in Abraka, Oria, Eku and Ovu inland was conducted. Diseased okra parts were collected for isolation and identification in the laboratory using standard mycological manual while two methods of insect capture were employed; handpicking for wingless insects and use of hand net for flying insects. Insect were identified using standard taxonomic keys with the aid of hand lens and light microscope. Laboratory efficacy was done using contact method at 0.5, 1.0, 1.5 and 3.0% in three replicates. The concentrations of Permethrin (at 0.5, 1.0, 1.5 and 3.0%) served as control. Six (6) fungi were isolated from different diseased plants with frequency of occurrence as leaf spot (70%), fruit rot and stem rot (15%) respectively. Isolated fungi with their percentage frequency include *Aspergillus fumigantus* (16.67%), *Cercospora species* (31.91%), *Fusarium oxysporum* (9.05%), *Fusarium solani* (13.33%), *Mucor* species (19.05%), and *Trichoderma hazianum* (10.0%). The insect pest were *Podagrica sp.* (38.23%), *Plagiodera versicolor* (19.80%), *Platycorynchus peregrinus* (7.17%), *Solenopsis sp.* (6.14%) amongst others. *Podagrica sp* was used for the study due to its abundance. The various concentrations of powders from *Aframomum melegueta, Denettia tripetala* and *Zingiber officinale* used against the test insects showed significant differences ($p<0.05$) in the insect mortality. The highest mortality (%) was recorded in *D. tripetala* (LC_{50}= 0.56 and LC_{95}= 3.02) compared to Permethrin (LC_{50}= 0.24 and LC_{95}= 1.49). The highest mortality time was recorded in Permethrin (LT_{50}= 9 hours) compared to *D. tripetala* (LT_{50}= 13hour/30minutes) and other powders. Therefore, the use of these plant powders especially that of *D. tripetala* can be a good alternative to the commercial pesticide in insect post control thereby improving environmental safety and avoiding food poisoning.

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Introduction

Okra, *Abelmoschus esculentus* (L.) Moench family Malvaceae, is an important vegetable plant grown widely in the tropical and subtropical regions of the world (Saifullah and Rabbani, 2009). The leaves and immature fruits of okra are encapsulated with varieties of soluble and insoluble nutrients, fiber which aids in the reduction of pain, serum cholesterol, risk of heart diseases, colorectal cancer, moisturizing the skin, inducing sweat and labour during childbirth, preventing scurvy, diabetes, and kidney diseases, and maintenance of the healthiness of intestinal tract (Akbar and Khan, 2015). Fresh okra fruit shows the following nutritional qualities: 2.1g protein, 0.2g fat, 8g carbohydrate, 3g calories, 1.7g fiber, 175.2mg minerals, 232.7mg vitamin and 88ml of water per 100g of edible portion, its edible leaf per 100g contains about 81ml water, 56 calories, 11g carbohydrates and 4.4g protein. Mature seeds of 100g okra contain 20% edible oil and 20.23 crude proteins due to high lysine content and it is a good source of vitamin C (Siemonssma and Kouame, 2004).

The production of okra is faced with problems relating to insect pest and disease attacks, reducing the growth and crop yield. Flea beetles are known to be among the most damaging, and difficult to control insect pest attacking varieties of okra in Nigeria (Fasunwon and Banjo, 2010). The okra flea beetles, *Podagrica species* pose heavy threat to okra each year. They have been observed to be the major agent of punched holes, mutilations and defoliations on leaves, fruits and flowers alike. The beetle appear in twos during favourable reproductive seasons and a number of them may be observed feeding on the young emerging leaves or tender stems of okra plant (Amuji *et al.*, 2012). A detailed study on the population densities of insect pests as well as their distribution in farm locations is important for the efficient control. The commonest fungi attacks known includes the blossom and fruit blight (*Choamephora cucurbitarum*) and cotton root rot (*Phymatotrichum mnivorum*) which leads to leaf wilt and yellowing as well as plant death. Another fungi diseases is the southern blight (*Fusarium oxygsporum*). Unlike humans are herbivores of fresh parts of okra, insect pests as well seriously and constantly attacked the plant reducing the growth and crop yield. In the same vein, the commonest insect pests of okra include leafhoppers, aphids, corn earworm, Japanese beetle, wireworms and sting bug. That new trend of insect pests and disease species may be recurring with time graduating into field deterioration triggered the objective of this study. To identify the diseases and insect species of *A. esculentus* in different farm locations in Delta State and to compare the efficacy of three plant powders to commercial pesticide on the mortality of flea beetles.

Materials and methods

Study area

The field study was carried out in Abraka and its environs. It includes Site I, Delta State University, Oria, Abraka, Eku and Ovu Inland all, in Ethiope East Local Government Area, Delta State, Nigeria. Abraka can be traced on the map between Latitude $5^{o}45^{I}$ and $5^{o}50^{I}$ North of the equator and Longitude 6^{o} and $6^{o}15^{I}$ East of the greenish meridian. The study was carried out within August to October, 2013 under rain-fed condition. The location is within the equatorial climate belts of Nigeria with mean temperature of 30^{o}C. The area is characterized with a total annual rainfall ranging from 288mm in December to 628.9mm in September (Efe and Aruegodore, 2003). The sizes of the farms under study ranged between 0.5 to 1.5 hectares.

Sample Collection and Identification of Insect pests

Sample collection of insect pest was carried out biweekly within the hours of the day. It was carried out using handpicking for wingless insects, aspirators for tiny Insects, and hand nets for active insects. The insects collected in a jar containing 70% alcohol were taken to the Department of Animal and Environmental Biology (AEB) Laboratory for identification. The preserved insects were identified utilizing standard taxonomic keys prescribed by Zim and Cottam, (2000). The plants were sampled irrespective of stages.

Sample collection and Identification of fungi

Plant diseases found to be present on leaves (leaf spot disease), stem (stem rot disease), fruit (fruit rot), was collected from the various farms and taken to Botany Laboratory for further studies. The diseased tissue sections were surface sterilized with 70% ethanol for 3 minutes and rinsed with sterile distilled water to eliminate surface contaminants. The diseased tissues were cut into pieces and plated onto already set potato dextrose agar (PDA). Two to three pieces were placed per plate. The plates were then incubated at room temperature for three days. Mycelial growth observed were repeatedly transferred to a fresh potato dextrose agar (PDA) plates until pure cultures of fungal isolates were obtained. Identification was done by microscopic examination with a standard mycological manual by Barnet and Hunter (1999). The percentage occurrence of the various isolated was calculated using the formula:

Relative occurrence (%) =

$$\frac{\text{No collected /isolated}}{\text{Total number of collected/ isolated}} X\ 100$$

Plant collection and preparation

Powders from three plants which includes alligator pepper (*Aframomum melegueta*), pepper fruit (*Dennettia tripetala*) and ginger rhizome (*Zingiber officinale*) were used for the insect mortality studies. These were purchased from Abraka market, air dried in the laboratory at room temperature (30±2ºC) and blended into powder. The powder obtained were stored in tight containers until when needed (Ojianwuna and Umoru, 2010).

Exposure of flea beetles to various treatments

The okra flea beetles were exposed to 0.5, 1.0, 1.5 and 3.0g of alligator pepper, pepper fruit, and ginger fruit (plant powders). Permethrinin the concentrations of 0.5, 1.0, 1.5 and 3.0g served as the control. Ten flea beetles were introduced into transparent plastic containers containing treatments in 3 replicates. Okra leaves were introduced into the containers as substrates for treatment applications. The containers were netted to prevent the insects from escaping. The experimental test was exposed for 72 hours. Insect mortality was recorded from < 12 hours of exposure till the end of exposure hours through physical observation of the transparent container and a slight shake to check if beetle showed sign of movements.

Data Analysis

Data on adult mortality of *Podagrica spp.* with respect to concentrations of treatments was presented in percentage. Data was subjected to probit analysis (XL STAT, 2019) for determination of 50% lethal concentrations (LC_{50}) and 95% (LC_{95}) and associated statistics. Probit kill from treatment concentrations was compared using Turkeys test at 5% probability level.

Result and discussion

Fungi isolation and disease symptoms

The fungi species isolated from the infected *Abelmoschus esculentus* (okra) were *Trichoderma hazionum, Mucor species, Aspergillus fumigantus, Fusarium solani, Fusarium oxysporum* and *Cercospora species. Cercospora species* (31.91%) occurred more frequently followed by *Mucorspecies* (19.05%) (Table 1). The percentage occurrence of diseases isolated from *A. esculentus*are shown in Fig. 2 below. Leafspot was the most occurred while fruit and stem rots of *A. esculentus* were subsequently followed with lowest percentage of occurrence. The symptoms of leafspot disease are caused by *Cercopora species,* fruit by *Mucor species* and *Trichoderma hazianum,* and stem rot by *Aspergillus fumigantus* and *Fusarium solani.* The leafspot disease was characterized by brown spot on leaves. Among the diseases of cultivated *A. esculentus* in the farm locations surveyed, leafspot diseases were more in occurrence compared to stem and fruit rots. Leafspot were most observed on the older leaves. Dinler and Gunay (2018) reported that fungi are one of the causes of economic losses in vegetable including okra. Youssef and Palmateer, (2008) have implicated *Aspergillus niger, Aspergillus fumigantus,* and *Fusarium species* as mycological agents of fruits and leaves of okra. The leafspot diseases has been reported to be widespread and caused by *Cercospora*amongst others (Shahzady *et al.,* 2017, Behrooz *et al.,* 2017).

Table 1. Fungi isolated from diseases of *A. esculentus.*

S/N	Fungi isolated	No. of isolation	Relative occurrence (%)	Disease type
1	*Aspergillus fumigantus*	35	16.67	Stem rot
2	*Cercospora species*	67	31.91	Leafspot
3	*Fusarium oxysporium*	19	9.05	Stem rot, leafspot
4	*Fusarium solani*	28	13.33	Stem rot, leafspot
5	*Mucor species*	40	19.05	Fruit rot
6	*Trichorderma hazianum*	21	10.00	Fruit rot

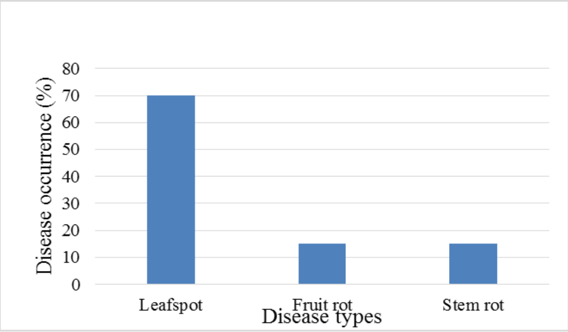


Fig. 2. Percentage occurrence of diseases of *A. esculentus.*

Insect pest assessment

The insect pests associated with the parts of *A. esculentus* is shown in Table 2. Five (5) Order including Coleoptera, Orthoptera, Hemiptera, Hymenoptera and Diptera were encountered of which Coleoptera predominated. *Podagrica sp.* under the Family Chrysomelidae was recorded as the major feeders of okra leaves, fruits and stem. A total of 293 insect pests was collected. Other insect pests are *Plagiodera versicolora* (58), *Platycorynus peregrinus* (21), *Solenopsis species* (18), *Lule species* (7) and *Dysdercus cingulatus*(4) were also collected from the different parts of the plant including leaves, stems, flowers and fruits, and leaf stalks. The number of insect pest species and their relative abundance is shown in Fig. 3 below. Orthopterans were reportedly low. The highest percentage abundance was recorded for *Podagrica species*. The presence of *Podagrica sp.* as the major insect pests of *A. esculentus* led to the design of intervention. Leaf beetles (Coleoptera) were the major pests found on cultivated vegetables along Jakara river, in Kano State. The total number of other insect pests collected was considerably high. Echezona *et al.* (2010) reported that the application of nitrogen fertilizers in different concentrations resulted in high presence in the population count of *Podagrica species* in the field. This could be the reason for the higher species of flea beetles recorded in this study. The beetles were found feeding and punching holes on leaf surfaces of okra resulting in leaf defoliation, reduced photosynthesis, and thereby reducing the fruit yield (Nderitu *et al.,* 2008).

Table 2. Insect pests associated with *A. esculentus* parts.

S/N	Insect pests	Order	No. of species	Family	Relative abundance (%)	Part present
1	*Harmonia axyridis*	Coleoptera	4	Coccinellidae	1.37	Leaves
2	*Platycorynus peregrinus*	Coleoptera	21	Chrysomelidae	7.17	Leaves, stems
3	*Melanoplus differentialis*	Orthoptera	3	Acrididae	1.02	Leaves, stems Leaf stalks
4	*Plagiodera versicolora*	Coleoptera	58	Chrysomelidae	19.80	Leaves, stems, leaf stalks, fruits
5	*Tenerus species*	Coleoptera	1	Cleridae	0.34	Leaves
6	*Podagrica species*	Coleoptera	170	Chrysomelidae	58.02	Leaves, fruits, stems
7	*Schizonycha species*	Coleoptera	1	Scarabaeidae	0.34	Leaves, fruits, flower
8	*Lule species*	Diptera	7	Platystomatidae	2.39	Leaves, fruits
9	*Solenopsis species*	Hymeloptera	18	Formicidae	6.14	Leaves, flowers, fruits, stems, leaf stalks
10	*Halyomorpha halys*	Hemiptera	2	Pentatomodae	0.68	Leaves
11	*Popillia japonica* larvae	Coleoptera	2	Scarabaeidae	0.68	Leaves
12	*Corythucha species*	Hymenoptera	1	Tingidae	0.34	Leaves
13	*Dysdercus cingulatus*	Hemiptera	4	Pyrrhocoridae	1.37	Leaves
14	*Lucilia sericata*	Diptera	1	Calliphoridae	0.34	Leaves

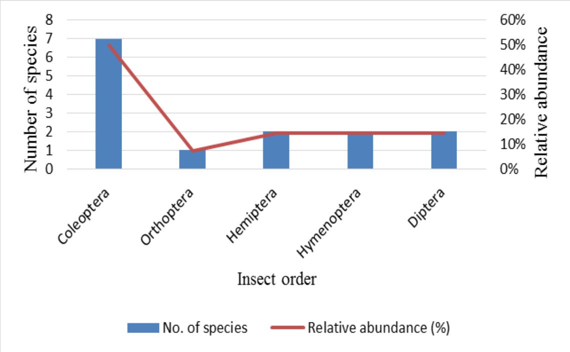


Fig. 3. Number of insect pest species and their relative abundance.

Toxicity bioassay

Effect of concentrations

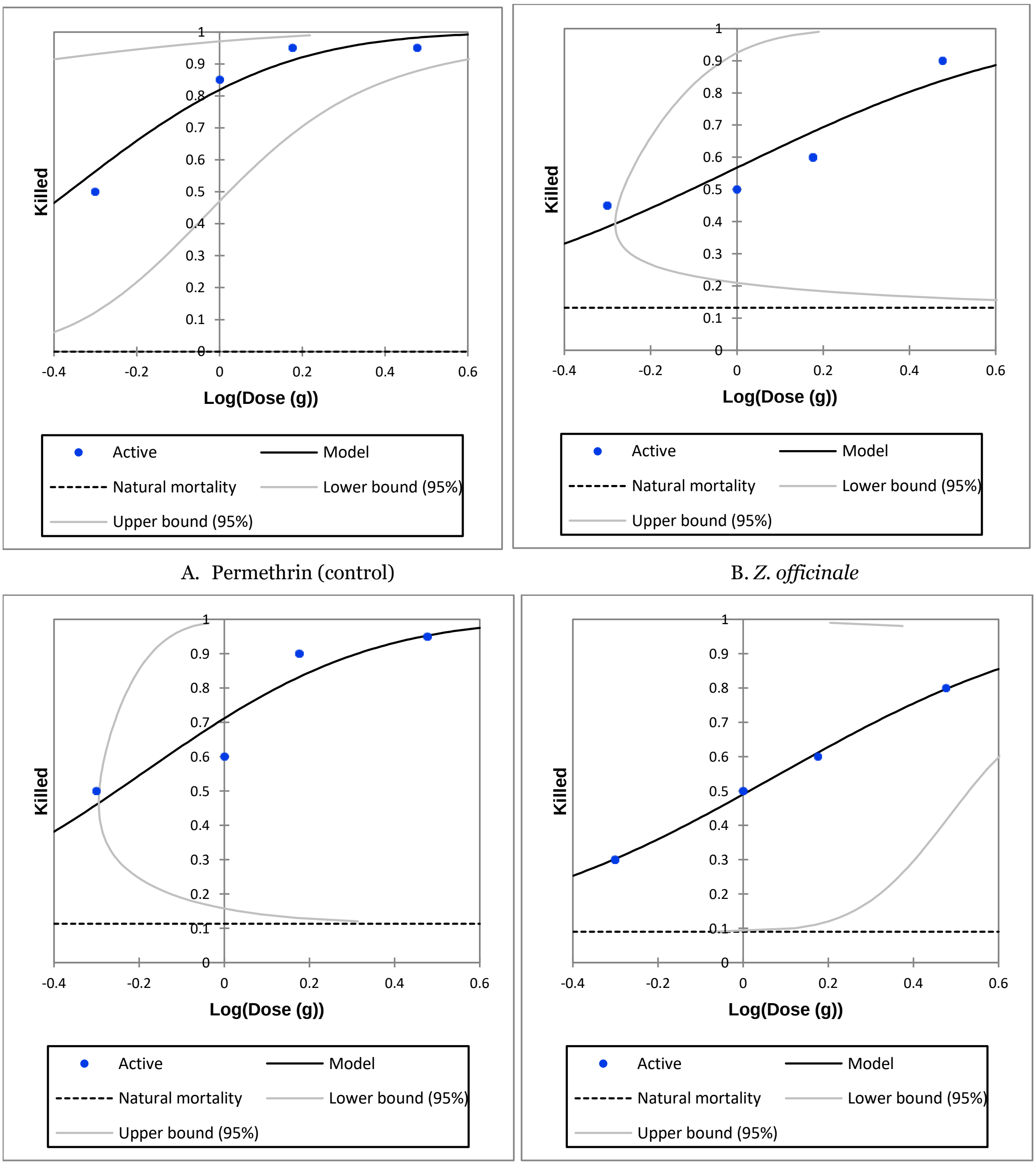
The mortality of the adult flea beetles *Podagrica spp.* due to individual concentrations of plant powders is shown in Table 3. Best concentration (3.0%) of *D. tripetala* caused the greatest mortality compared to the other plant powders and the control, Permethrin. Permethrin recorded LC_{50} and LC_{95} of 0.24 and 1.49 is respectively low compared to other treatments revealing that it was more effective. *D. tripetala*on the other hand recorded LC_{50} and LC_{95} of 0.56 and 3.02. 1.0% concentration of *Z. officinale, D. tripetala*and Permethrin caused 50% mortality in the test insects excluding *A. melegueta*. Optimum concentrations of Commercial pesticide and plant protectants caused high mortality in *Podagrica spp* (Fig. 4). This study adopted *Podagrica* species for the efficacy study because of its abundance and that their activities negatively impact the plant. Exposure of the flea beetles to plant powders from various concentrations of *A. melegueta, Z. officinale and D. tripetala*, and the control showed great mortality. The use of various plant materials are already being adopted for various grain crops in storage in Nigeria. The mortality of *Podagrica* species as a result of all concentrations started less than 12 hours after treatment and was lethal at 48 hours of exposure. The toxic mortality of these plant powders have been reported on other insects (Ukeh *et al.,* 2009, 2010, Okpako *et al.,* 2013, Adesina *et al.,* 2015).

Table 3. Percentage probit estimation of different concentration of the three plant powders and commercial pesticides on mortality of *Podagrica species.*

Treatment	Conc. (g)	Probit mean kill	% Probit mortality	Lower CI= 95%	Upper CI= 95%	LC_{50}	LC_{95}
Z. officinale	0.50	7.52^{m}	37.60	0.24	18.95		
	1.00	11.41^{i}	57.05	2.20	18.86		
	1.50	13.59^{g}	67.95	5.52	18.73		
	3.00	16.62^{c}	83.10	16.24	16.98	0.78	7.90
A. melegueta	0.50	6.03^{n}	30.15	1.79	19.99		
	1.00	9.79^{k}	48.95	1.82	19.93		
	1.50	12.23^{h}	61.15	2.24	19.83		
	3.00	15.94^{e}	79.7	8.29	19.47	1.02	9.00
D. tripetala	0.50	9.12^{l}	45.60	0.01	19.97		
	1.00	14.30^{f}	71.50	1.16	19.93		
	1.50	16.66^{c}	83.30	5.55	19.88		
	3.00	19.00^{a}	95.00	18.46	19.38	0.56	3.02
Permethrin	0.50	11.03^{j}	55.15	0.37	19.81		
(Control)	1.00	16.50^{d}	82.50	5.36	19.97		
	1.50	18.40^{b}	92.00	11.12	19.93		
	3.00	18.40^{b}	92.00	11.11	19.93	0.24	1.49

The toxic effect of the three plant powders compared to the commercial pesticide was concentration dependent. Higher concentrations favoured higher mortality of the insects. There was significant differences in the percentage mean mortality of *Podagrica* species at all concentrations of the plant powders and Permethrin. The toxic effect of *D. tripetala* was higher than that of *A. melegueta* and *Z. officinale* and compared favorably with that of Permethrin. The effect is in the descending order of *D. tripetala* to *Z. officinale* to *A. melegueta*. The lethal concentrations (LC_{50} and LC_{95}) of the botanical powders followed the same pattern which is in the descending order of *D. tripetala* to *Z. officinale* to *A. melegueta*. Similar results on the effect of neem kernel extracts on flea beetles has been reported

(Kwaifa *et al.*, 2015). Reduction in insect infestation of okra fruits with various botanical insecticides such as neem, ginger, garlic, turmeric amongst others have been reported (Javed *et al.,* 2018).



A. Permethrin (control) B. *Z. officinale*

C. *D. tripetala* D. *A. melegueta*

Fig. 4. Effect of the control and three plant powders on mortality of *Podagrica species.*

Effect of exposure time

The influence of exposure time on mortality of the adult flea beetles *Podagrica spp.* due to various concentrations of plant powders and Permethrin is shown in Fig. 5 to 8 below. Within *A. melegueta,* the highest mortality was recorded at 18 hours (15% mortality), 24 hours (30%), 18 hours (40%) and 18 hours (40%) for 0.5 to 3.0g concentrations respectively. The highest mortality for various concentrations of *D. tripetala* was 18 hours (30% mortality) for 0.5g, 12 hours (40%), 12 hours (50%), and 12 hours (55%) for 1.0 to 3.0g respectively. The highest mortality occurred 18 hours after exposure for *Z. officinale* in 30% respectively for 0.5 and 1.0g, and

40% and 50% for 1.5 and 3g respectively. Within Permethrin, the commercial pesticide, the highest mortality was recorded at 12 hours (30% mortality) and 12 hours (55%) for 0.5 and 1.0g respectively, while 6 hours (95%) was respectively recorded for 1.5 and 3g. Irrespective of concentration, mortality ended from 24 – 36 hours, 18 – 24hours, 24 hours, and 12 – 18hours after exposure for *A. melegueta*, *D. tripetala*, *Z. officinale*, and Permethrin respectively. The LT_{50} for the respective treatments were 19 hours/30minutes, 15 hours/30 minutes, 18 hours and 9 hours for *A. melegueta*, *D. tripetala*, *Z. officinale*, and Permethrin.

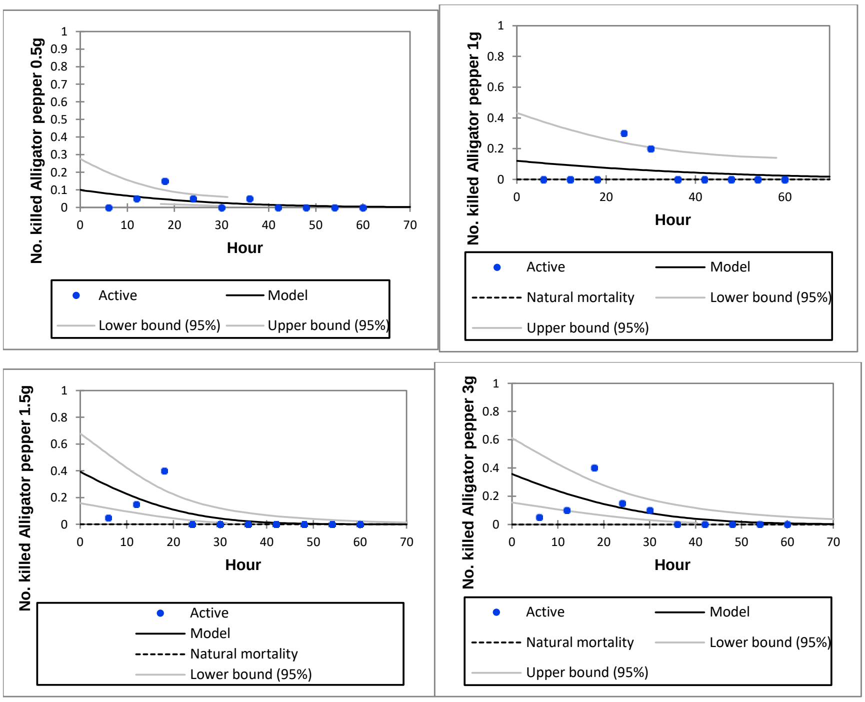


Fig. 5. Effect of various concentration of *A. melegueta* on mortality time (LT_{50}= 19 hours/30mintes).

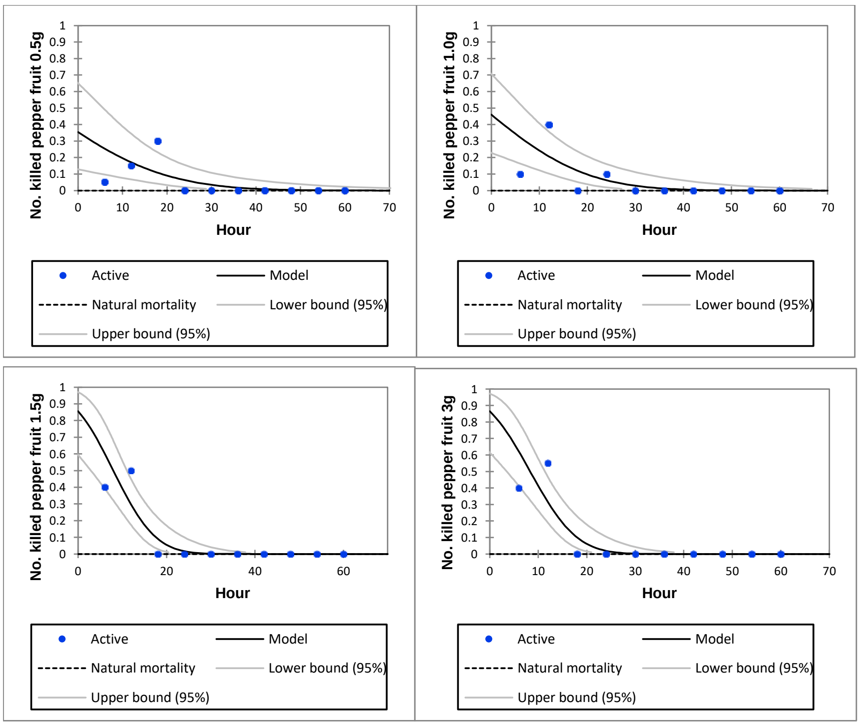


Fig. 6. Effect of various concentration of *D. tripetala*on mortality time. (LT_{50}= 13 hours/30mintes).

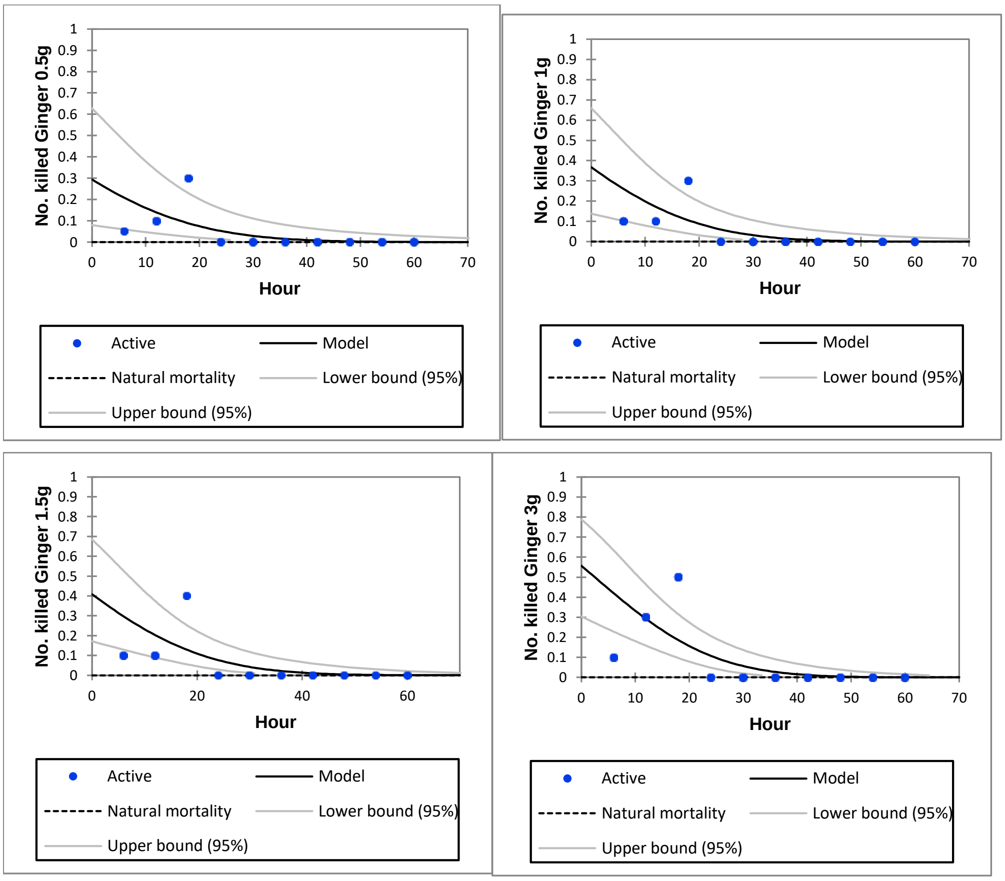


Fig. 7. Effect of various concentration of *Z. officinale* on mortality time. (LT_{50}= 18 hours).

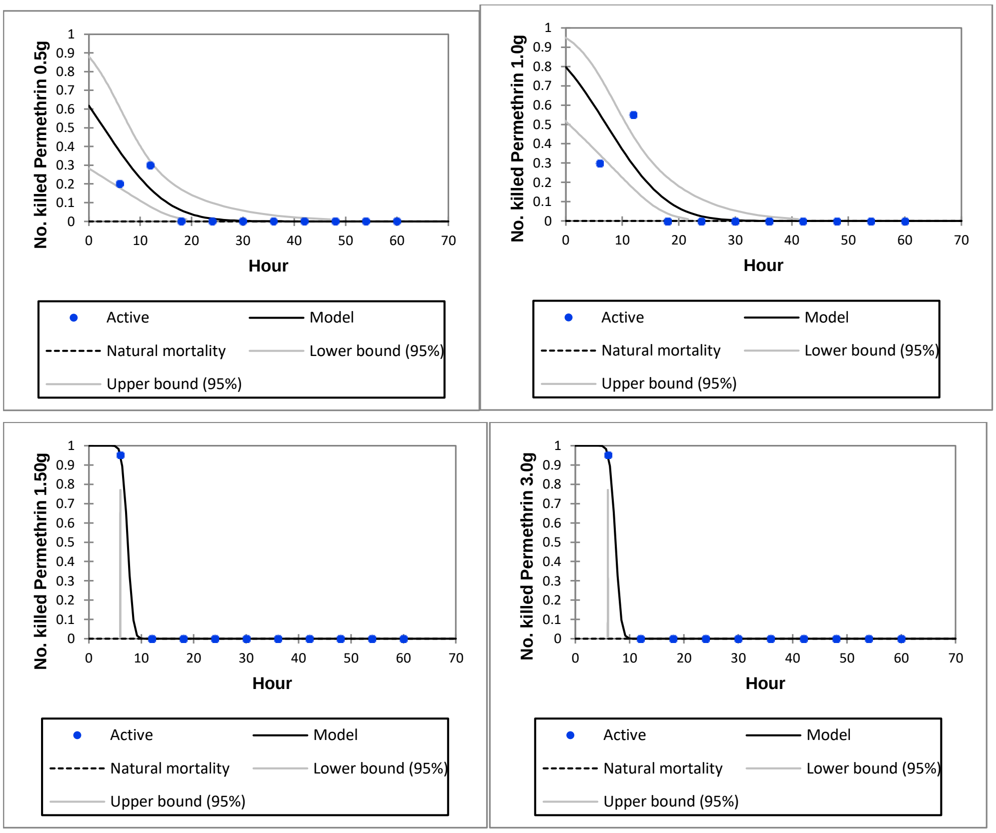


Fig. 8. Effect of various concentration of Permethrin (control) on mortality time. (LT_{50}= 9 hours).

The best concentrations of the plant powders and the control in this study were effective. In less than 24 hours, Pepper fruit and Permethrin caused notable mortalities. Although, ginger followed causing mortality at exactly 24 hours after exposure. Ginger extracts have been reported to significantly reduce the population of *Podagrica uniforma* amongst others in the field (Amuji *et al.,* 2012). It is remarkable to note that Permethrin in contact exposure of best concentrations caused highest mortalities at LT_{50} concentrations of 9 hours compared to the best concentrations of pepper fruit that caused mortalities at 13 hours/30 minutes. This is suggestive that powders of *D. tripetala* can be a good alternative to *Z. officinale, A. melegueta* and the control. Powdered botanicals have been reported to be responsible for the great mortalities in insect pests (Dubey *et al*., 2010, Sarmamy *et al*., 2011 and Gulzar *et al*., 2017). Reasons are yet to be known but could probably be related to the physiological effects on insect pests.

Conclusion

The findings of this study have revealed that leafspot is the major disease of cultivated okra (*Abelmoschus esculentus* (L.) Moench) in various locations. *Podagrica* species was more abundant. Although, all concentrations of commercial pesticide and plant powders caused average mortality, but, the use of best concentrations of plant powders especially that of *D. tripetala* can be a good alternative to the commercial pesticide in improving environmental safety and avoiding food poisoning.

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