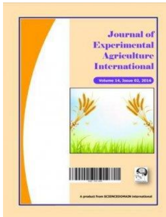

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Control of Maize Stem Borer (*Busseola fusca* F.) Infestation Using Extracts of *Carica papaya* and *Cymbopogon citratus* and Furadan

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Authors' contributions

This work was a collective efforts of the authors. Author KCE designed the study, wrote the protocol and wrote the manuscript. Author UJD carried out the field experimentation and collected the data. Analyses of the data were jointly performed by the two authors as well as the review and approval of the final manuscript.

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ABSTRACT

A field trial was conducted at the Teaching and Research Farm of the Michael Okpara University of Agriculture, Umudike to evaluate the insecticidal potentials and rates of application of seed extract of *Carica papaya* and leaf extracts of *Cymbopogon citratus* and Furadan for the control of maize stem borer, *Busseola fusca*. *C. papaya* leaf ash was applied at the rate of 3 g per plot, while the *C. papaya* seed powder was applied at the rate of 4.5 g per plot. *C. citratus* leaf ash was applied at the rate of 3 g per plot, while Furadan was applied at 1.5 g per plot and the control had no treatment (0 g). Each treatment was replicated three times. The experiment was laid out in a Randomized Complete Block Design (RCBD). Data collected were insect population, growth and yield of maize for 2,4,6,8 weeks after planting (WAP). The results showed that all the treatments differed significantly from the control ($P \leq 0.05$) on the number of holes on the leaves per plot, on the number of holes on maize stem per plot and number of larvae per maize stem. Growth and yield of maize were significantly increased ($P \leq 0.05$) due to the protection given by the plant materials. *C. citratus*

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leaf ash and *C. papaya* leaf ash and seed powder demonstrated strong insecticidal activity against maize stem borer, *B. fusca*, and therefore can be used as replacement for Furadan. *C. papaya* leaf ash at 3 cg per plot and seed powder at 4.5 g per plot as well as *C. citratus* leaf ash at the rate of 3 g per plot are recommended.

Keywords: Plant-derived insecticides; Busseola fusca; pest control.

1. INTRODUCTION

Maize (*Zea mays* L.) belongs to the grass family Poaceae and originated from Mexico and it is the world's third cereal crops after wheat and rice. Its consumption is projected to increase by 50% globally, 93% in Sub-Sahara Africa from 1995-2020 [1]. It is a staple food in many regions of the world and an important source of carbohydrate, protein, iron, minerals, vitamin B and vitamin C [2]. Africans consume maize in various forms such as porridges, pastes, and beer. Green fresh maize is eaten baked, roasted or boiled. Every part of the maize namely the grain, leaves, stalk, tassel, and the cob has economic value and can be used to produce a large varieties of food and non-food products [3].

The crop is widely cultivated throughout the world and its production each year is more than any other grain. The world maize production is 1,076.2 million metric tonnes in which the United States was the largest producer with maize production volume amounting to about 370.96 million metric tonnes [4]. Nigeria is the largest maize producer in Africa, with South Africa holding the second place. Annually, Nigeria produces about 8 million metric tonnes of this food crop [5].

In Nigeria, maize is a staple food with socio-economic importance. It is grown for its grain which contains 65% carbohydrate, 10-12% protein and 4-5% fat [6].The crop also contains the trace elements such as carotene, Thiamine, Ascorbic acid and Tobophenole [7]. Maize is a major source of cornstarch (maize floor) a major ingredient in cooking and many industrialized food products. The crop is mainly used for human food and livestock feed. The stem and the cob are used in the manufacturing of pulp, abrasives and even as fuel for cooking [8].

Production of maize is however threatened by insect pest such as maize stalk borer *Busseola fusca* F (Lepidoptera: Noctuidae) [9,10]. The insect is a common pest in many African countries including Nigeria. Damage is caused by the caterpillars, which first feed on the young leaves and later enter into the stems, killing the growing points of the plant and causing dead-heart that disrupts the flow of nutrients to the grain [11]. Infested young plants show small holes and 'window- panes in the leaf whorls where tissue have been eaten. Symptoms in maize plants include dead-heart, plant death, internal feeding and presence of frass in the stems [10]. Older caterpillars tunnel into the stems, and eat out long frass-filled galleries, which weaken the stems and cause breakage [11]. Yield reductions occur every year due to insect pest feeding, or stalk lodging. The potential yield of maize within an environment could be realized when pests are managed by scouting field regularly and applying treatments when necessary.

Grain damaged by the stem borers become susceptible to secondary infection by moulds such as *Aspergillus flavus* which produce aflatoxin, a toxic by- product that is extremely poisonous to humans which can lead to cancer [10]. Maize stem borer are difficult to control with insecticides [12] because the current spray-based methods have been found to be ineffective against the internal feeders in addition to being costly and hazardous [13]. Also, pest is increasingly developing resistance to conventional synthetic insecticides due to climate change [14]. For instance, all the minor global climate models forecast high temperatures that will promote high pest populations [15]. This, therefore, necessitates further research work on alternative to controlling maize stem borer *B. fusca* more effectively. Plant-derived pesticides are one of the alternatives to synthetic chemicals and are considered environmentally friendly. The efficacy of plant-derived pesticides has been demonstrated not only in post -harvest grain infestation by insects [16] but also in the control of various field insect pest species. The most widely used is the Neem extracts (*Azadirachta indica A. Juss*. (Meliaceae) [17]. Several studies on the insecticidal potentials of plant-derived pesticides to control *Busseola fusca* have been reported [18,19,20,16]. Plant materials with insecticidal properties will be of immense help to resource poor farmers who produce over 95% of food consumed since they are locally available and biodegradable and cost effective [20].

The objective of this research work was to evaluate the insecticidal potentials of *Carica papaya* seed powder, *Carica papaya* leaf ash and *Cymbopogon citratus* leaf ash for the control of *Busseola fusca*, to determine the application rates of the plant materials for the control of maize stem borer *B. fusca* and evaluation of the effect of the treatment on the growth and yield of maize.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted from June through September 2016 cropping season at the Michael Okpara University of Agriculture Western Farm Umudike. Umudike, which is located on the latitude 5°29[1]N and longitude 7°33[1]E with average annual rainfall of 2177mm and temperature of 29°C-31°C with relative humidity of 50-90% in the rain-forest ecological zone of Southeastern Nigeria [21].

2.2 Source of Materials

The planting materials used for this study were three varieties of maize seeds, Oba Super 1 and Oba Super II and Bende White obtained from College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike. These maize varieties are commonly cultivated in the Umudike agro-ecosystem. Oba Super 1 and Oba Super II are improved varieties while Bende White is a local variety. *Carica papaya* seeds and leaves; *Cymbopogon citratus* leaves were sourced locally from the University community. Furadan insecticide, which has an active ingredient of Carbofuran was obtained from an Agro-chemical shop in Aba. Planting was done on a well ploughed, harrowed and pulverized soil.

2.3 Experimental Layout

The experimental design was a Randomized Complete Block Design (RCBD) with three replications. There were a total of five treatments including the control, applied in a total of 45 plots. The entire experimental area was 23 m x18 m (414 m^2) with each plot measuring 3 m x 2.5 m (7.5 m^2), 0.5 inter plot and 1 m intra plot spaces. Each plot had 40 stands of maize and 1 seed per hole with the planting spacing of 75 cm x 25 cm. A plant population of 53333.33/ hectare was maintained for the trial.

Table 1. Soil Physico-chemical properties of the experimental site in 2016 cropping season

Physical properties	2016
Sand g/kg	759.00
Silt g/kg	80.00
Clay g/kg	161.00
Textural class	Sandy loam
Chemical properties	
pH(H_2O)	4.50
Phosphorous (Mg/kg)	13.50
Total Nitrogen (g/kg)	0.90
Organic Carbon (g/kg)	2.20
Organic matter (g/kg)	3.78
Calcium (cmol/kg)	2.80
Magnesium (cmol/kg)	1.40
Potassium (cmol/kg)	0.07
Sodium (cmol/kg)	0.22
Exchange acidity (cmol/kg)	1.98
ECEC (cmol/kg)	76.35

2.4 Preparation and Application of Plant Extracts

The plant materials were air-dried for two weeks in a well-ventilated area. The dry *C. papaya* seed and leaves were ground into powder using Thomas milling machine (Model ED-5) at National Root Crop Research Institute, Umudike. The *C. citratus* was burnt to ashes. Furadan was applied to the soil in a ring method while the plant extracts in powder form were applied on the leaves. Both treatments were separately applied at different rates. Furadan was applied at 1.5 g while the plant materials were applied at 3 g and 4.5 g to each plot. Control experiment had no plant extract or synthetic pesticide. Each treatment was replicated three times in Randomized Complete Block Design (RCBD).

2.5 Experimental Evaluations of *B. fusca* Damage on Parts of Maize Plant

Assessment on number of holes made by *B. fusca* on maize plant was obtained from ten stands of maize which were selected from the two middle rows set aside for data collection for number of holes made by *B fusca*. Each leaf of maize was assessed by counting the number of holes on the leaves, the means were obtained by adding up the number of holes gotten from the leaves of selected ten maize plants and divided by ten, starting from 2 weeks after planting (WAP).

The number of holes made by *B. fusca* on maize stem were assessed in the field starting from 2 WAP by counting the number of holes on the stems set aside for data collection for number of holes on the stem. The number gotten from the ten stems were added together and divided by ten in other to get the mean number of holes on the stem.

The number of *B. fusca* larvae on maize plant on a plot were carefully assessed randomly from the selected maize plants by adding the number of larvae on the leaves of maize and the number of larvae on the stems of maize plant starting from 2 WAP to 8 WAP.

The assessment on the number of holes made by maize stem borer (*B. fusca*) was done by counting the number of holes on the leaves and the number of holes on the stem and by adding them together to get the number of holes per plot.

2.6 Yield Assessment

At 75 to 80 days after planting (DAP), the cobs were harvested according to the treatments and placed in medium sized polythene bags. The cobs were measured and weighed when fresh, after sun-drying for two weeks and the grains weighed when dried using sensitive balance and the weight recorded.

2.7 Statistical Analysis

The data collected were subjected to statistical analysis using Analysis of variance (ANOVA) and the mean separation was carried out using least significant difference (LSD) at 5% significance [22].

3. RESULTS

3.1 Effects of Plant Extracts and Furadan on the Number of Holes on Maize Leaf Caused by *Busseola fusca*

Results presented in Table 2 show the effect of extracts of the plant materials and Furadan on number of holes caused by *B. fusca* per maize leaf. Analysis of variance indicated significant difference ($P \leq 0.05$) between the treatment means on number of holes per leaf of maize across the weeks under observation during the 2016 cropping season. The synthetic pesticide (Furadan) recorded the least mean number of holes per leaf of the maize plant; 0.00, 0.00 and 0.60 at 2,4,6 and 8 weeks after planting (WAP) respectively and these results significantly ($P \leq 0.05$) differed when compared with other treatments (Table 2). This was followed by Maize plants that were treated with *C.citratus* leaf ash which recorded 1.43, 1.43, 1.46 and 2.43 as mean number of holes per maize leaf at 2, 4, 6 and 8 WAP respectively and followed by those treated with *C. papaya* seed powder which recorded 1.70, 2.23, 2.43 and 2.67 at 2, 4, 6 and 8 WAP respectively. Those treated with *C. papaya* leaf ash recorded 2.20, 3.17, 3.06 number of holes at 2, 4, 6 and 8WAP whereas the highest number of holes was obtained from the control experiment (15.13). All the treatments had significant effect in controlling the number of holes per leaf of maize when compared with the control which recorded the highest mean values of holes per leaf across the weeks under observation (Table 2).

3.2 Effects of Plant Extracts and Furadan on Number of Holes on Maize Stem Caused by *B. fusca*

The results presented in Table 3 show that maize plants treated with the synthetic insecticide, (Furadan) recorded no hole (0) on the maize stem in 2, 4, 6 and 8 WAP, followed by maize plants treated with *C. citratus* leaf ash which gave mean values of 0, 0, 0, 0 and 0.26, at 2,4,6 and 8 WAP respectively whereas those maize plants that were treated with *C. papaya* seed powder and *C. papaya* leaf ash ranked the third and fourth respectively in controlling the number of holes per stem 8 WAP. This implies that Furadan is the most effective in controlling the number of holes per stem in maize, followed by *C. citratus*. The highest mean values were obtained from the control with the mean values of 0, 0.50, 2.37, 4.06 at 2, 4, 6 and 8 WAP. The mean values of number of holes per stem of maize treated with *C. citraus* leaf ash, *C. papaya* seed powder and *C. papaya* leaf ash were significantly different ($P \leq 0.05$) from those obtained in the control experiment during 2016 cropping season in Umudike.

3.3 Efficacy of Plant Extracts and Furadan in the Control of the Number of Holes Caused by *B. fusca* on Maize Leaf and Stem on a Plot

Table 4 shows the efficacy of extracts of the plant materials and Furadan in controlling the number of holes made by *B. fusca* per plot. Maize plants that were treated with Furadan had the best result in reducing the number of holes per plot with the mean values of 0, 0, 0 and 0.60 at 2, 4, 6 and 8 WAP respectively, followed by maize plants treated with *C. papaya* seed powder which gave mean values of 0.97, 1.43, 1.77 and 1.53 at 2, 4, 6 and 8 WAP respectively and followed by *C. citratus* leaf ash and *C. papaya* leaf ash at 2, 4, 6 and 8 WAP. There were no significant differences among the treatments. This implies that Furadan, *C. papaya* seed powder and *C. citratus* leaf ash were effective in reducing the number of holes per plot. The highest number of holes was obtained from the control experiment with the mean values of 5.80, 8.33, 12.23 and 19.20 at 2, 4, 6 and 8 WAP. The effect of Furadan, *C. papaya* seed powder, *C. citratus* leaf ash and *C. papaya* leaf ash were significantly different (P≤ 0.05) from control experiment in controlling the number of holes made by *B. fusca* per plot 8 WAP.

Table 2. Effect of plant extracts and Furadan on the number of holes on maize leaf caused by *Busseola fusca*

Treatments	Mean number of holes on maize leaf and WAP (week)			
	2WAP	4WAP	6WAP	8WAP
Cymbopogon citratus leaf ash (3 g)	1.43	1.43	1.46	2.43
Carica papaya leaf ash (3 g)	2.20	3.17	3.06	3.60
Carica papaya seed powder (4.5 g)	1.70	2.23	2.43	2.67
Furadan (1.5 g)	0	0	0	0.60
Control	5.80	8.33	9.50	15.13
LSD (0.05)	1.08	0.97	0.52	1.28

WAP = Weeks after Planting
LSD = Least Significant Difference

Table 3. Effect of plant extracts and Furadan on the mean number of holes on maize stem caused by *B. fusca*

Treatments	Mean number of holes on maize stem 8 WAP			
	2WAP	4WAP	6WAP	8WAP
Cymbopogon citratus leaf ash (3 g)	0	0	0	0.26
Carica papaya leaf ash (3 g)	0	0	0.30	1.10
Carica papaya seed powder (4.5 g)	0	0	0	0.47
Furadan (1.5 g)	0	0	0	0
Control	0	0.50	2.73	4.06
LSD (0.05)	NS	NS	0.54	0.63

WAP = Weeks after Planting
LSD = Least Significant Difference
NS = Non - significant

Table 4. Efficacy of plant extracts and Furadan in controlling the number of holes on maize leaf and stem made by *Busseola fusca* in a plot

Treatments	Mean number of holes on maize leaf and stem and WAP (week)			
	2WAP	4WAP	6WAP	8WAP
Cymbopogon citratus leaf ash (3 g)	1.70	2.27	2.43	4.87
Carica papaya leaf ash (3 g)	2.20	3.17	3.47	4.70
Carica papaya seed powder (4.5 g)	0.97	1.43	1.77	1.53
Furadan (1.5 g)	0	0	0	0.60
Control	5.80	8.33	12.23	19.2
LSD (0.05)	1.27	0.97	1.67	1.46

WAP = Weeks after Planting
LSD = Least Significant Difference

3.4 Effect of Plants Extracts and Furadan on Number of Larvae per Stem of Maize Plant

The results presented in Table 5 show the efficacy of plant extracts and Furadan in controlling the number of larvae per stem at different time intervals. The analysis of variance indicated significant difference ($P \leq 0.05$) in number of larvae per stem between the treatments across the different periods of application.

The synthetic chemical, (Furadan) was most effective in reducing the number of larvae per stem; 0, 0, 0 and 0.33 at 2, 4, 6 and 8 WAP. This was followed by maize plants treated with *C. papaya* seed powder with mean values of 1.40, 1.63, 2.00 and 1.83 at 2, 4, 6, and 8 WAP respectively and then by *C. citratus* leaf ash and *C. papaya* leaf ash (Table 4). The treatments had significant effect in reducing the number of larvae per stem when compared with the control experiment which recorded the highest mean values of number of larvae per stem at different time of application.

3.5 Effects of Extracts of Plant Material and Furadan on Yield of Infested Maize during 2016 Cropping Season in Umudike

Table 6 shows the effect of extracts of plant material and Furadan on the yield of maize during 2016 cropping season in Umudike. Maize plants treated with Furadan recorded the best yield at 8 WAP in all the yield attributes except in number of cobs per plant which was non-significant ($P \geq 0.05$). Maize plants treated with leaf ash of *C. citratus* gave the second best of all the yield attributes except in ear height where *C. papaya* leaf ash was ranked second and had a mean value of 25.27 cm. *C. papaya* seed powder ranked the second best treatment after Furadan in fresh weight of the husk cobs with the mean value of 213.5 g. In number of cobs per plant, Furadan and *C. citratus* ash recorded the mean values of 1.33 while others treated with *C.papaya* seed powder and *C.papaya* leaf ash had the same mean value of 1.00 which was not significantly different ($P \leq 0.05$) from the control experiment. In number of grains per cob, *C. papaya* seed powder gave the second best result (314.3) after Furadan (323.3) followed by *C. citratus* as the third (275.3). *C. papaya* seed powder ranked the second best in the dry grain weight with the mean of 57.53g and *C. citratus* ranked the third with the mean value of 54.90g. For number of cobs per plot, *C. papaya* seed powder was the second best after Furadan with the mean value of 35.68 followed by *C. citratus* that have the mean of 34.60. The yield attributes in all the treatments were significantly ($P \leq 0.05$) higher than those from the control which gave the lowest mean values with the exception in number of cobs per plant where there was no significant difference during 2016 cropping season. The assessment of 100 seed weight/ cob, Furadan treated crops had the highest mean value of 38.05g. This was followed by *C. papaya* seed powder treated plants with 35.77 g then *C. citratus* with 35.57g, *C. papaya* leaf ash 33.53 g. The control had the least weight of 100 seeds (25.67 g).

4. DISCUSSION

The use of plant extracts for the protection of crops from insect pests have been reported as one of the oldest crop protection methods [23]. The findings of this study revealed that treatment and time of application had significant effects on the relative abundance of *B. fusca* affecting maize. The results indicated that application of

Table 5. Effect of different treatments on the number of larvae per stem of maize plant at different time interval

Treatments	Number of larvae and period of application			
	2WAP	**4WAP**	**6WAP**	**8WAP**
Cymbopogon citratus leaf ash (3 g)	2.00	2.13	2.47	2.70
Carica papaya leaf ash (3 g)	2.37	3.10	2.60	2.87
Carica papaya seed powder (4.5 g)	1.40	1.63	2.00	1.83
Furadan (1.5 g)	0	0	0	0.33
Control	4.37	7.33	9.43	6.57
LSD (0.05)	0.54	0.47	0.91	0.88

WAP = Weeks After Planting
LSD = Least Significant Difference

Table 6. Effects of plant extracts and Furadan on yield of infested maize during 2016 cropping season in Umudike

Treatments	Ear height (cm)	No of cobs /plant	No of cobs /plot	Fresh weight of husk cob (g)	No of grains /cob	Dry grain weight per plant (g)	100 seeds weight/cob (g)
Cymbopogon citratus leaf ash (3 g)	25.17	1.33	34.60	208.4	275.3	54.90	35.57
Carica papaya leaf ash (3 g)	25.27	1.00	31.64	203.2	226.0	48.60	33.53
Carica papaya seed powder (4.5 g)	22.23	1.00	35.68	213.5	314.3	57.53	35.77
Furadan (1.5 g)	26.67	1.33	38.00	217.7	323.3	61.43	38.05
Control	18.33	1.00	17.00	118.5	187.4	39.47	25.67
LSD (0.05)	1.64	NS	2.79	9.89	14.17	3.49	3.55

WAP = Weeks after Planting
LSD = Least Significant Difference
NS = Non - significant

extracts of the test plant materials and Furadan significantly reduced the population and damage caused by the maize stem borer (*B. fusca)* on maize. It can be deduced from this study that damage by stem borer on maize plant increased with time. As can be observed, the severity of damage in terms of the number of holes on the leaves and stems, the number of larvae per stem of maize plant increased over the time interval between 2WAP and 8WAP. The damage done by the stem borer, *B. fusca* was reflected on the yield attributes. The ear heights for the treated plots were higher than the control. Apart from the synthetic insecticide treated plots which had the highest ear height, plot treated with *Carica papya* leaf ash, *Cymbopogon citratus* leaf ash had very high ear heights comparable to Furadan. The plants extracts as well as Furadan offered significant protection to the maize plant and that was reflected on all the yield parameters, the only exception being the number of cobs per plant, which was non-significant. This implies that maize production could be more profitable by applying the treatments at appropriate time. This result is in line with the findings by Fuglie [24] who showed that timely application of plant extracts prevented an initial build-up of infestation pressure and consequently increased the yield of crop. The significant reduction of infestation of *B. fusca* by the application of extracts of these plant materials, and Furadan could be due to the effective deterrent and suppressive activities of their active ingredients (Papain [*C. papaya]* and Citral α- pinene [*C. citratus]*) on the insect pest [25]. The results also showed that application of plant extracts on maize plant significantly ($P \leq 0.05$) reduced the population of *B. fusca* when compared with the control which agrees with the findings of Brooke and Hines [26] who reported that plant extracts of *A. indica*, and *J. gossyiifolia* at 10, 15 and 20% killed *B. fusca* very quickly and reduced their population by about 70% compared with untreated control. Furthermore, the results obtained from the study showed that the plots treated with *C. papaya* and *C. citratus* extracts gave significant ($P \leq 0.05$) control of *B. fusca* than control implying that these plant extracts possess insecticidal properties that could be lethal to a wide range of insects including *B. fusca*. Thus reduction of *B. fusca* population in this study must have led to the increase in cob and maize grain yield on plots treated with these plant extracts. This result corroborates the findings of [16] who reported that application of different plant materials as biopesticides in the control of different species of stem borers led to increase in crop yield. Also [27], in a field trial found that *Tephrosia vogelii* Hook extract effectively reduced maize stem borer number and damage symptoms and improved grain yield. Studies in China showed that the leaves and twigs of *Tephrosia vogelii* possess strong antifeedant stomach poison and growth inhibiting effects against many insects including stem borers [28]. The results of this study also agree with [29], who found out that extracts of Neem leaves mixed with leaves of *Cymbopogon citratus* could be toxic to *B. fusca* and consequently resulted in considerable reduction in their numbers. Some researchers who worked on the effect of Furadan on *B. fusca* population and other maize stem borers found it to be more effective than botanicals when both were applied under the field condition [30]. The higher destructive effect of Furadan when compared with *C. papaya* and *C. citratus* in this study could be due to its standardized active ingredient that had “knock down" effects on the insect pest immediately it comes in contact with Furadan whereas the low efficacy of the plant extracts could be among other reasons, due to lack of "knock down" effect and rapid breakdown (non-persistence) of the biochemical compounds. The effectiveness of the synthetic insecticide is a confirmation of the report by Brooke and Hines [[26] that chemical insecticide have been the primary control agent for agricultural pests. However, the mean number of *B*. *fusca* population was significantly reduced in plots treated with extracts of the plant materials when compared with the control experiment indicating that maize could be adequately protected against *B. fusca* infestation by extracts of these plant materials as pesticide alternatives (bio pesticides) to increase maize and food production in Nigeria.

5. CONCLUSION

It is therefore concluded from this study that seed extracts of *C. papaya* and leaf extracts of *C. citratus* reduced the population and damage caused by the maize stem borer, *B. fusca*. Maize yield also improved by the application of these plant materials. Application of *C. papaya* seed powder extract was done at the rate of 4.5 g per plot and *C. papaya* leaf ash was done at the rate of 3 g per plot while *C. citratus* leaf ash was applied at the rate of 3 g per plot. These plant extracts are suitable alternatives to Furadan for the control of maize stem borer.

This study also revealed that the synthetic insecticide, Carbofuran (Furadan) has superior protectant activity to the plant-derived insecticides.

Cymbopogon citratus leaf ash and *Carica papaya* leaf ash and seed powder have demonstrated strong insecticidal activity against Maize Stem Borer, *Busseola fusca*, and therefore can be used as replacement for Furadan, which is being phased out on the grounds of environmental and health implications. *Carica papaya* seed powder at 4.5 g per plot, *C. papaya* leaf ash at 3 g per plot as well as *C. citratus* leaf ash at 3 g per plot were effective in the control of *B. fusca*. Therefore, for the control of *B. fusca*, *C. papaya* leaf ash at 3 g per plot and seed powder at 4.5 g per plot as well as *C. citratus* leaf ash at the rate of 3 g per plot are recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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