CONTROL OF MAIZE STEM BORER (*Busseola fusca* F.) INFESTATION USING EXTRACTS OF *Carica papaya* and *Cymbopogon citratus* AND FURADAN IN UMUDIKE.

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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 properties 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*. The study was carried out using three varieties of maize, Oba super I, Oba super II and Bende white. The plant-derived insecticides were applied at the rates of 3g, 4.5g and Furadan at 1.5g to each maize stand in the field and the control had no treatment (0g). 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 ($P \leq 0.05$). Furadan reduced the number of holes on the leaves and stem as well as recorded the highest plant growth and yield. This was followed by *C. citratus* leaf ash and *C. papaya* seed powder. *C. citratus* leaf ash and *C. papaya* seed powder are therefore recommended as alternatives to systemic insecticide (Furadan) for the control of maize stem borer in the field.

Keywords: *Control of Maize stem borer, Busseola fusca, plant-derived insecticide*

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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 [12]. 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 [3]. 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 [13].

The crop is widely cultivated throughout the world and its production each year is more than any other grain. ~~The United State produces 40% of the world's harvest.~~ The world production was 817 million tonnes in 2009, more than rice (678 million tonnes) or wheat (682 million tonnes) [7]. In 2009 over 159 million hectares (390 million acres) of maize were planted with the yield of 5 tonnes/hectare. Africa produces 7% of the 598 million tonnes produced worldwide from 138 million hectares in 2000 and the highest producer in Africa is Nigeria with nearly 8 million tonnes [13].

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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 [14].The crop also contains the trace elements such as carotene, Thiamine, Ascorbic acid and Tobophenole [9]. 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 (Mbah and Ogbodo, 2013).

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Production of maize is however threatened by insect pest such as maize stalk borer *Busseola fusca* F (Lepidoptera:Noctuidae) [3,24]. 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 [20]. 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 [24]. Older caterpillars tunnel into the stems, and eat out long frass-filled galleries, which weaken the stems and cause breakage [20]. 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 [24]. Maize stem borer are difficult to control with insecticides [28] because the current spray-based methods have been found to be ineffective against the internal feeders in addition to being costly and hazardous [6]. Also, pest are increasingly developing resistance to conventional synthetic insecticides due to climate change [11]. For instance, all the minor global climate models forecast high temperatures that will promote high pest populations [10]. 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 [27] but also in the control of various field insect pest species. The most widely used is the Neem extracts (*Azadirachta indica* A. Juss. (Meliaceae) [23]. Several studies on the insecticidal potentials of plant-derived pesticides to control *Busseola fusca* have been reported [27,1,22,25]. 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 [25]

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 during 2016 cropping season at the Michael Okpara University of Agriculture Western Farm Umudike. Umudike, which is located on the latitude 5^0 29^1N and longitude 7^0 33^1E with average annual rainfall of 2177mm and temperature of 29^0C-31^0C with relative humidity of 50-90% in the rain-forest ecological zone of Southeastern Nigeria [16].

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. *Carica papaya* seeds and leaves; *Cymbopogon citratus* leaves were sourced locally from the University community. Furadan insecticide was obtained from an Agro-chemical shop in Aba. Planting was done on a well ploughed, harrowed and pulverized soil.

2.3 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

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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 1.5g while the plant materials were applied at 3g and 4.5g to each plot. Control experiment had no plant extract or synthetic pesticide. Each treatment was replicated three times in Randomized Complete Block Design (RCBD).

2.4 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 23m x18m (414m^2) with each plot measuring 3m x 2.5m (7.5m^2), 0.5 inter plot and 1m intra plot spaces. Each plot had 40 stands of maize and 1 seed per hole with the planting spacing of 75cm x 25cm. A plant population of 53333.33/ hectare was maintained for the trial.

2.5 Assessment on number of holes made by *B. fusca* on maize leaf: Ten stands of maizew 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).

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2.6 Assessment on number of holes made by *B. fusca* on maize stem: 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.

2.7 *Busseola fusca* larvae assessment on a plot: The number of *B. fusca* larvae on maize plant on a plot were carefully assessed random from the selected maize plant by adding the number of larvae on the leaves of maize and the number of larvae on the stem of maize plant starting from 2 WAP to 8 WAP.

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

2.9 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.

2.10 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 [17].

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 1 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 1). 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 1).

Table 1: Effect of plant extracts and Furadan on the number of holes on maize leaf caused by *Busseola fusca.*

	Mean number of holes on maize leaf and WAP (week)			
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**
Cymbopogon citratus leaf ash (3g)	1.43	1.43	1.46	2.43
Carica papaya leaf ash (3g)	2.20	3.17	3.06	3.60
Carica papaya seed powder (4.5g)	1.70	2.23	2.43	2.67
Furadan (1.5g)	0.00	0.00	0.00	0.60
Control	5.80	8.33	9.50	15.13
LSD (0.05)	1.08	0.97	0.52	1.28

3.2 Effects of plant extracts and Furadan on number of holes on maize stem caused by *B. fusca*

The results presented in Table 2 show that maize plants treated with the synthetic insecticide, (Furadan) recorded no hole (0.00) 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 0.00, 0.00, 0.00, 0.00 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 was obtained from the control with the mean values of 0.00, 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.

Table 2: Effect of plant extracts and Furadan on the mean number of holes on maize stem caused by *B. fusca*.

	Mean number of holes on maize stem 8 WAP			
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**
Cymbopogon citratus leaf ash (3g)	0.00	0.00	0.00	0.26
Carica papaya leaf ash (3g)	0.00	0.00	0.30	1.10
Carica papaya seed powder (4.5g)	0.00	0.00	0.00	0.47
Furadan (1.5g)	0.00	0.00	0.00	0.00
Control	0.00	0.50	2.73	4.06
LSD (0.05)	NS	NS	0.541	0.63

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 3 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 0.00, 0.00, 0.00 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 ($P \leq 0.05$) from control experiment in controlling the number of holes made by *B. fusca* per plot 8 WAP.

	Mean number of holes on maize leaf and stem and WAP (week)			
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**

Cymbopogon citratus leaf ash (3g)	1.70	2.27	2.43	4.87
Carica papaya leaf ash (3g)	2.20	3.17	3.47	4.70
Carica papaya seed powder (4.5g)	0.97	1.43	1.77	1.53
Furadan (1.5g)	0.00	0.00	0.00	0.60
Control	5.80	8.33	12.23	19.2
LSD (0.05)	1.27	0.97	1.67	1.46

Table 3: Efficacy of plant extracts and Furadan in controlling the number of holes on maize leaf and stem made by *Busseola fusca* in a plot.

3.4 Effect of plants extracts and Furadan on number of larvae per stem of maize plant.

The results presented in Table 4 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; 0.00, 0.00, 0.00 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.

	Number of larvae and period of application			
Treatments	**2WAP**	**4WAP**	**6WAP**	**8WAP**

Cymbopogon citratus leaf ash (3g)	2.00	2.13	2.47	2.70
Carica papaya leaf ash (3g)	2.37	3.10	2.60	2.87
Carica papaya seed powder (4.5g)	1.40	1.63	2.00	1.83
Furadan (1.5g)	0.00	0.00	0.00	0.33
Control	4.37	7.33	9.43	6.57
LSD (0.05)	0.54	0.47	0.91	0.88

Table 4: Effect of different treatments on the number of larvae per stem of maize plant at different time interval.

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

Table 5 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 25.27cm. *C. papaya* seed powder ranked the second best treatment after Furadan in fresh weight of the husk cobs with the mean value of 213.5g. 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 35.77g then *C. citratus* with 35.57g, *C. papaya* leaf ash 33.53g. The control had the least weight of 100 seeds (25.67g).

Table 5: 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 (3g)**	25.17	1.33	34.60	208.4	275.3	54.90	35.57
***Carica papaya* leaf ash (3g)**	25.27	1.00	31.64	203.2	226.0	48.60	33.53
***Carica papaya* seed powder (4.5g)**	22.23	1.00	35.68	213.5	314.3	57.53	35.77
Furadan (1.5g)	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

4. DISCUSSION

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The use of plant extracts for the protection of crops from insect pests have been reported as one of the oldest crop protection methods [26]. 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 extracts of the test plant materials and Furadan significantly reduced the population and damage caused by the maize stem borer (*B. fusca)* on maize. 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 [8] 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 material, and Furadan could be due to the effective deterrent and suppressive activities of their active ingredients on the insect pest [15]. The results also showed that application of plant extracts on maize plant significantly (P≤0.05) reduced the population of *B. fusca* when compared with the control which agrees with the findings of [27] 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≤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 [27] 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 [18], 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 [5]. The results of this study also agree with [19], 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

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other maize stem borers found it to be more effective than botanicals when both were applied under the field condition [21]. 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 [2] 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 three plant materials. These plant extracts are suitable alternatives to Furadan for the control of maize stem borer.

Comment [RO14]: to associate the text of conclusion with the information of the experimental data obtained to justify the conclusion.

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REFERENCES

1. Assefa G.A, and Ferdu A. (1999) Insecticidal activity of Chinaberry, endod and pepper tree against the maize stalk borer *Busseola fusca* (Lepidoptera: Noctuidae) in southern Ethiopia. *International Journal of Pest Management.* 45:9-13.
2. Brooke, E., and Hines, E. (1999). Viral biopesticides for Heliothine control-fact of fiction? *Today's life Science* 11: 38-45.
3. CGIAR, (1996). Consultative Group on int. *Agricultural.Research. News*. 3(1):2-3)
4. Chabi-Olaye, A, Nolte, C., Schulthess, F. and Borgemeister, C. (2005). Efects of grain legumes and cover crop on maize yield and plant damage by *Busseola fusca* (Lepidoptera: Noctuidae) in the humid forest of southern Cameroon. *Agriculture, Ecosystems & Environment*. 108, 17-23.
5. Chiu, S.Z (2003). Laboratory of insect Toxicology, South China Agriculture University, Guangzhoi 510642, *China Entomologia Sinica* (No 4): 365-374.
6. Clive, J. (2003). Global review of commercialized transgenic crops: 2002 feature: Bt maize (ISAAA Brief No. 29). Ithaca, NY*: International Service for the Acquisition of Agric-Biotechnology Applications.*
7. FAO (2009), Food and Agriculture Organization of the United Nations, Statistics Division. "Maize, Rice and Wheat: area harvested, production quantity, yield''.http://faostat. Fao.org/site/56/Default.aspx? Page ID=567.
8. Fuglie, L.J. (1998). Producing food without Pesticide: local solution to crop pest control in West Africa. *Church-world service, Dakar Senegal*, pp: 158.
9. Groote, H.M. (2002). Identifying Farmers preference for new maize varieties in Eastern Africa. 1st edition , CIMMYT Publishers, Nairobi, PP.102.
10. Hulme, P. (2005). Adapting to climate change: Is there scope for ecological management in the face of global threat: *Journal of Applied Ecology.* 30: 55-58pp.

11. I.N.E.R.A. (1999). Resultats preliminaries des activities de Researche: Rapport Campagne 1998-1999. (Preliminary result of the research activities: Report covering 1998-1999 Quagadougou, Burkina Faso: 35-41.

12. IFPRI (2010). International food policy research Institute India.

13. IITA (2009). (www.maize-project –details.aspx IITA) Accessed in July 2009.

14. Iken, J.E and Amusa, N.A., (2004). Maize research and production in Nigeria. *African journal of Biotechnology vol.3* (6) pp.302-307.

15. Mihale, M.J., Deng, A.L., Selemani, H.O, Mugisha-Kamatenesi, M. Kidukuli A.W.,and Ogendo J.O.(2009) Use of indigenous knowledge and synthetic pesticides in the management of field and storage pest around Lake Victoria basin in Tanzania. *African Journal of Environmental Science. Technology*. 3: 251-259. 3(9):

16. National Root Crops Research Institute Meteorological data 2016.

17. Obi, I.U (2002). Statistical Methods of Detecting Differences between Treatments Mean and Research Methodology in Nigeria.116pp.

18. Okech, S.H.O., Kaposhi, C.K.M., Chisembu, K., and Mundia, M.P (1997). Potential of *Tephrosia vogelii* water extract for the control of maize stalk borer, *Chilo partellus*. *African Journal of plant protection* 7: 17-25.

19. Oparaeke, A.M, M.C. Dike and C.I. Amatobi, (2006). Botanical pesticide mixtures for insect pest management of cowpea, *Vigna uniguiculata* (L). Walp plants- the legume flower bud thrips, *Megalurothrips sojotedi* Trybom. *Journal of sustainable Agriculture*. 29:5- 13.

20. Pascal, M. (1998). Crop losses caused by maize stem borer (Lepidoptera: Noctuidae, Pyralidae). In Cote d'Ivoire, Africa: Statistical model based on damage assessment during the productive cycle. *Journal of Econometric. Entomology*. 91:512-516.

21. Pesticides Action Network (PAN, 2003). Les pesticide au Cameroun. Monitoring and Briefing. No. 7, June 2003 *African: pesticide Action Network*. p 44.

22. Ratnadass A. and Wink. M.(2012). The phorbolester fraction from *Jatropha curcass* seed oil: potential and limits for crop protection against insect pests. *International Journal of Molecular Science*. 13: 16157- 16171.

23. Schmutterer, H. (1990). Properties and Potentials of natural pesticides from the Neem
tree, *Azadirachta indica*. *Annual Review Entomology*.35:271-298.

24. Setamou, M., Schulthess, F., Poehling, H.M.and Borgemeister, C. (2000). Monitoring
and modeling of field infestation and damage by the maize ear borer *Mussidia nigrivennella* (Lepidoptera: Pyralidae) in Benin, West Africa. *Journal of Econometric Entomology*. 93:650-657.

25. Shiberu .T. (2013) *In vitro* evaluation of aqua extracts of some botanicals against maize borer, *Busseola fusca* F. (Lepidoptera: Noctuidae). *Journal of Plant Pathology. Microbiology*.4:179.

26. Thacker, J.M.R. (2002). An introduction to Arthropod pest control, Cambride, UK, Cambride University press. Pp 343.

27. Valencia, A., Frerot B., Guenego H., Munera D.F., Gossi De Sa M.F., and Calatayud, P.A.(2006). Effect of *Jatropha gossyiifolia* leaf extracts on three Lepidoptera species. *Review. colomb. Entomology*.32:45-48.

28. Vitale, J. Boyer, T. Vaiene, R. and Sanders J. H. (2007). The economic impact of introducing Bt technology in small holder cotton production systems of West Africa: A case study From Mali. AgBioForum, 10 (2), 71-81.Available on the World Wide Web: http://www.agbioforum.org.