fjrs.futa.edu.ng

FUTA Journal of Research in Sciences

ISSN: 2315-8239

FUTA Journal of Research in Sciences, 2013 (1): 54-62

INSECTICIDAL ACTIVITY OF POWDER AND EXTRACTS OF *DELONIX REGIA* SEED AGAINST MAIZE WEEVIL, *SITOPHILUS ZEAMAIS* (COLEOPTERA: CURCULIONIDAE)

O.E. Ajayi

Department of Biology, Federal University of Technology, P.M.B.704, Akure Ondo State, Nigeria.

ajfumeu@yahoo.co.uk

ABSTRACT

Toxicity of powder, ethanol and essential oil extracts of *Delonix regia* (Bojer ex Hook.) Raf. seed against *Sitophilus zeamais* (Motschulsky) was assessed in the laboratory. Four treatment levels (0.5%, 1.0%, 1.5% and 2.0% (w/w powder, w/v ethanol extract and v/v oil) were evaluated. Untreated experiment was set-up as controls for all treatments; solvent treated experiment was included for ethanol extract treatment. All treatments were replicated four times in completely randomized design. Adult mortality was monitored for 120 h at 24 h interval. Toxicity of the extracts was concentration and exposure period dependent. All the treatments applied had significant $p< 0.05$ effect on mortality of *S. zeamais*. Seed oil was the most effective while powder was the least. Mortality in oil treated experiment ranged between 7.50% and 82.50% at 24 h; 27.50% and 82.50% at 48h, and 62.50% and 100% at 72 h. At 96 h post treatment 0.5% v/v treatment caused 77.50% mortality while 100% was recorded at 1.0 – 2% v/v treatment levels. All oil treatment concentrations caused 100% mortality at 120 h post-treatment. Ethanol extract caused 2.50% mortality at 24 h, 48 h, and 72 h in 0.5%, 1.0% and 2.0% treatment concentrations while 7.50% was recorded in 1.5% treatment concentration. The highest mortality in ethanol treatment was 12.5% at 120 h post treatment in 1.5 and 2.0% w/v treatment levels. In seed powder treated experiment, mortality ranged between 0.00% and 10.00%. At 96 h post treatment, mortality was between 2.50% and 17.50% for all treatments. Seed oil had greater potential for the control of *S. zeamais*. Therefore it could be incorporated in integrated pest management in grain storage system.

Keywords: *Delonix regia,* Extract, Mortality, Seed powder, *Sitophilus zeamais,* Toxicity

INTRODUCTION

Maize (*Zea mays* L.) is presently recognized as one of the most important food crops cultivated in tropical countries (Asawalam and Hassanali, 2006). It forms a cheap source of dietary carbohydrate (Rouanet, 1992), for human and livestock in Nigeria. Golob et al. (1999) reported that about 60-80 percent of maize produced in Nigeria is stored at the farm level for the purpose of ensuring food supplies and seeds as well as a form of saving to cover future cash need through sale or gift-exchange. However, maize storage is greatly constrained by insect damage; and this has greatly hampered the projected achievement of food security in the developing countries (Arannilewa *et al*., 2006; Rouanet, 1992). The report of International Institute of Tropical Agriculture (IITA), (1995) estimated that the post-harvest loss in stored maize due to a complex of insect pests on an annual average was 30% of grain dry weight. Consequently, preserving maize grains safely on the farm and the identification of the most cost-effective type of storage system and methods of pest control to use, have posed significant problems to the farmers. According to Nukenine *et al*. (2002) and Ngamo *et al.* (2004), the maize weevil, *Sitophilus zeamais* (Motsch.) is the most important post-harvest insect pest causing severe damage to stored maize grain in the tropics.

Sitophilus zeamais (Curculionidae: Coleoptera) is a primary, field-to-store pest of maize. The adults attack whole grains and larva feeds and develop entirely within grain (Storey, 1987). Ileleji *et al*. (2004) inferred that the development of this pest in a stored grain mass could result in total damage of the grain kernels. To prevent such losses however, most small holders rely on the use of synthetic insecticides; but the high cost, toxicity to non-target organisms, inherent environmental hazards and the development of resistance by insect pests have limited their effective use for maize storage (Al- Moajel, 2006) thus there is a need for an effective, easy to use, biodegradable alternative that will be safe effective, easy to use, biodegradable and safe to human health and the environment (Arannilewa *et al*., 2006).

The use of plant powder and extracts in the control of stored products insects has been ancient practice (Qi and Burkholder, 1981; Secoy and Smith, 1983; Ho *et al.*, 1994; Talukder and Howse, 1995; Huang *et al*., 2002; Lale and Yusuf, 2001; Al-Moajel, 2003). Essential oils and individual compounds from medicinal and aromatic plants have been known to exhibit anti-feedant properties against a number of insects (Huang *et al*., 2000; Koschier *et al*., 2002). Lajide *et al.* (1998) reported the effectiveness of some of these plant powders by causing mortality of *S. zeamais*. Asawalam *et al*. (2007) also suggested that the weevils would prefer to avoid maize grains treated with any plant powder. Therefore, this study evaluated the effectiveness of dry seed extracts (crude and essential oil) of *Delonix regia* as protectant of stored maize grains against damage by the maize weevil, *S. zeamais.*

MATERIALS AND METHODS

This study was carried out in the laboratory under tropical condition of 28 ± 2 ^{o}C and relative humidity of 75 ± 5%. The maize grains used as substrate in this study was obtained from Open market in Akure Ondo State, and stored temporarily in a deep freezer at -20 ^{o}C for 72 h to eliminate insipient infestation of insects (Adedire and Ajayi, 2003).

Insect Culture

Adult *S. zeamais* used for the study was obtained from naturally infested maize grains in open market in Akure, Ondo State, Nigeria. From this stock, pure culture was raised on maize grains to obtain new generations in the laboratory at ambient temperature 28 ± 2 ^{o}C and relative humidity 75 ± 5% following the method described by Asawalam (2006). Freshly emerged adults of *S. zeamais* were then used for the experiment.

Plant Collection and Extract preparation

Dry seeds of *D. regia* dry seeds were collected from the premises of the Federal University of Technology Akure (FUTA), Ondo State, Nigeria. The plant identity was authenticated at the Department of Forestry and Wood Technology of the same University. The seeds were crushed and the yellow cotyledon was removed, and thereafter milled into fine powder using Fooder Hammer Milling Machine (MODEL SLC 500, (KW) 7.5, (KG) 1500) at the Department of Animal Production and Health (APH) in the Federal University of Technology Akure (FUTA).

Crude extract of *D. regia* was prepared by soaking the seed powder in 98% ethanol in a plastic container with tight-fitted lid as described by Harbone, (1984). After 72 h, the solution was filtered with muslin cloth. The filtrate was concentrated in rotary evaporator while the solvent was collected in separate round bottomed flask. The slurry (extract) obtained was exposed to natural air to get rid of the remaining solvent in it. Extract obtained was kept in dark bottle and stored in refrigerator at -4 ^{o}C for subsequent use.

Extraction of the essential oil was carried out in a 1000 ml Soxhlet apparatus at 65 ^{o}C on a heating mantle using hexane. The solvent was separated from the oil using rotary evaporator and thereafter exposed to get rid of traces of hexane in it. The oil thus obtained was kept in dark bottle and stored in a dark cupboard at room temperature.

Bioassay for Toxicity

Toxicity bioassay of seed powder and extracts of *D. regia* on adult *S. zeamais* was done following the method of Asawalam *et al*. (2007) and Akinkurolere *et al*. (2006) respectively. Twenty grammes of maize grain were used as substrate in 5cm diameter plastic container. The powder, 0, 0.5, 1.0, 1.5 and 2.0 mg/g of the grain were thoroughly mixed with the maize to ensure uniform coating. Ten newly emerged unsexed adults *S. zeamais* were introduced into the containers and covered with the lid (Zapata and Guy, 2010).

Concentrations of ethanol extract, 0%, 0.5 %, 1.0%, 1.5%, and 2.0% w/v was prepared by adding 0.05, 0.1, 0.15 and 0.2g of the extract to 10 ml of ethanol respectively. One ml of each concentration was applied to each replicate and thoroughly mixed with the grain by shaking. The containers were left opened for 1 h to allow traces of ethanol to dry off and then 10 newly emerged unsexed adult *S. zeamais* were introduced into the containers and covered with the lids.

Oil extract, 0.05, 0.1, 0.15 and 0.2 ml was added to 10 ml of hexane to give 0.5 %, 1.0%, 1.5%, and 2.0% v/v respectively. The oil concentrations at 1 ml per replicate were thoroughly agitated to ensure uniform coating. The containers were left opened for 1 h so as to allow traces of hexane to dry off and then 10 newly emerged adult *S. zeamais* were introduced into the containers and covered with lids. Solvent treated and untreated experiments were set up as the control experiments. All treatments were replicated four times. Mortality of the insect was observed and recorded at 24 h interval for 120 h.

Statistical Analysis

Data obtained were arcsine transformed and subjected to one way Analysis of Variance (ANOVA). Means were compared with Duncan's New Multiple Range Test (DNMRT) at 5% level of confidence. Mean and standard error of Back-transformed data were used in the figures. All statistical analyses were carried out using SPSS version 16 for windows (SPSS, 2003).

RESULTS

Effect of *Delonix regia* seed powder on the mortality of adult *S. zeamais*

Figure 1 presents the results of the test of *D. regia* seed powder on the mortality of adult *S. zeamais*. Mortality of the insect was not concentration-dependent. The highest adult mortality at 24 h post-treatment was 5.0% in 1.0mg/g seed powder treated maize followed by 2.50% mortality in 0.5mg/g treatment. Zero percent mortality was recorded in 1.5 and 2.0mg/g treatment. At 120 h after treatment, 30% was the highest mortality recorded and this was obtained at 0.5 and 1.0 mg/g treatments. There was no significant differences ($p>0.05$) between mortality recorded in all the treatment concentrations and controls in all the hours of observation (Table 1).

Effect of ethanol extracts of *D. regia* seed on the mortality of adult *S. zeamais*

Mortality of adult *S. zeamais* exposed to ethanol extracts of *D. regia* seed is shown in Figure 2. Mortality at various extract concentrations increased with increase in exposure periods. The treatment with 1.5% v/w of ethanol extracts caused the highest adult mortality (7.5%) recorded at 24 h post treatment. There was no significant differences ($p>0.05$) between mortality recorded in all the treatment concentrations and controls in all the durations of observation (Table 1). Mortality increased with increase in exposure hour from 2.5% at 24 h exposure to 12.5% at 120 h exposure in 2.0mg/g treatment.

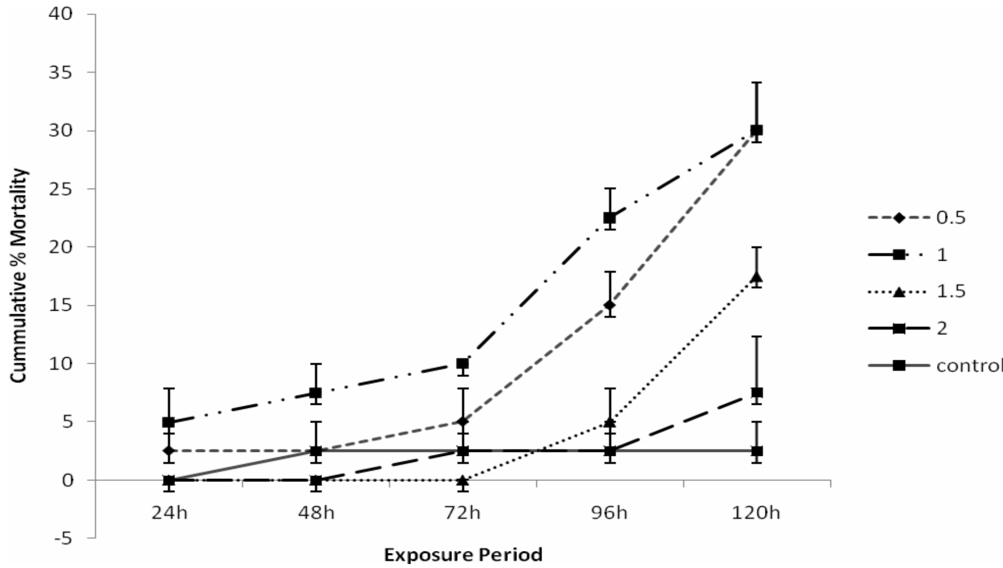

Figure 1: Mortality of *S. zeamais* exposed to seed powder of *D. regia.* (Mean cumulative % mortality ± SE).

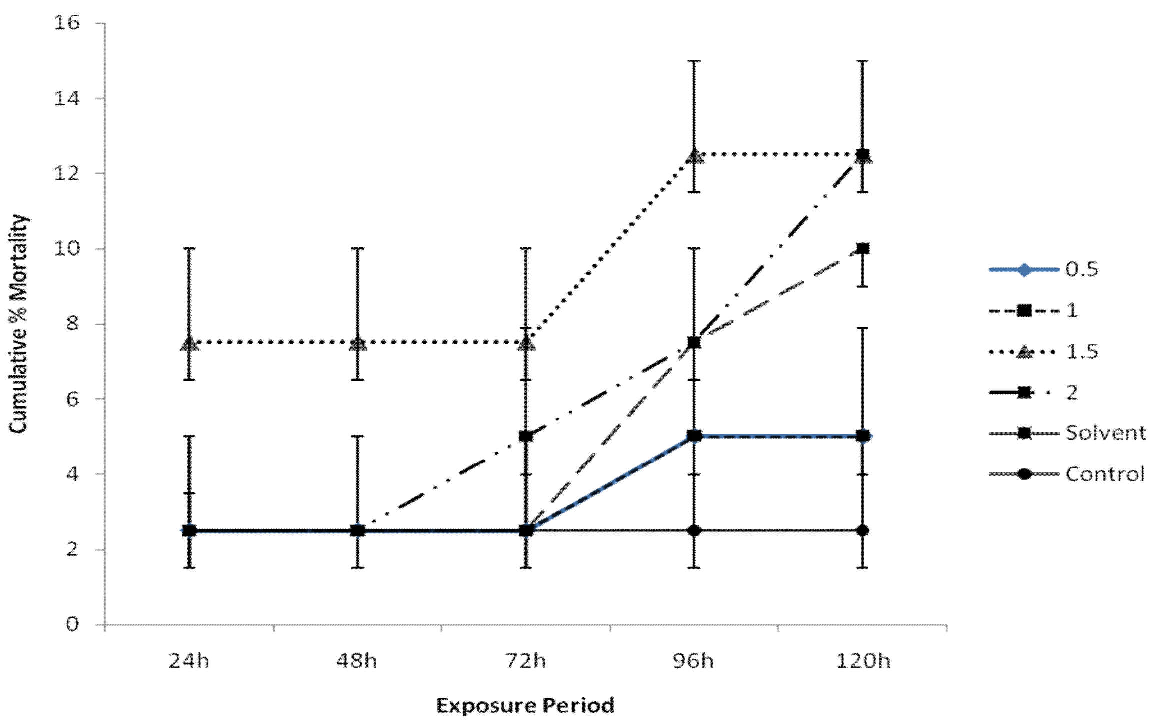

Figure 2: Mortality of *S. zeamais* exposed to ethanol extract of *D. regia* seed (Mean cumulative % ± SE).

Effect of essential oil extract of *D. regia* seed on mortality of adult *S. zeamais*

Figure 3 shows the cumulative percent mortality of *S. zeamais* exposed to oil of *D. regia* seed. Insect mortality increased with exposure period at the various concentrations of treatments. The effect of the oil extracts differed significantly ($p<0.05$) across the various concentrations used in all the durations of observation (Table 1). Mortality recorded was 7.50%, 32.50% 42.50% and 82.50% at 0.5, 1.0, 1.5 and 2.0% v/v respectively at 24hrs post-treatment. At 96 h post-treatment, 100% adult mortality was recorded at 1.0%, 1.5% and 2.0% treatment concentrations of the oil. Zero mortality was recorded in the control experiments.

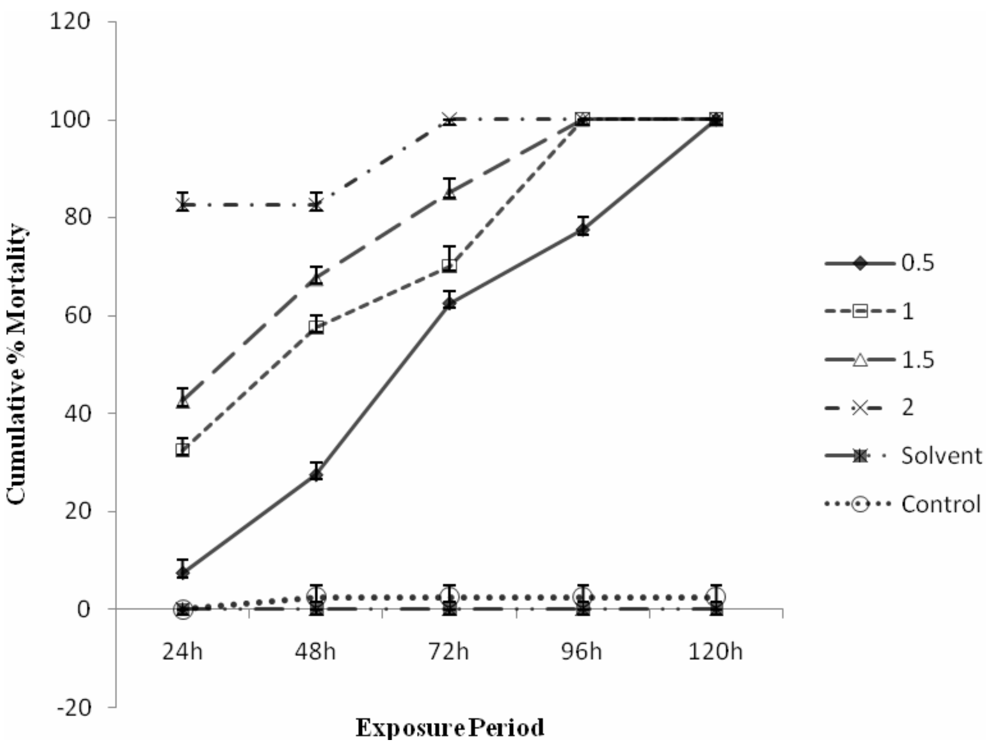

Figure 3: Mortality of *S. zeamais* exposed to seed oil of *D. regia* (Mean Cumulative % Mortality ± SE)

Table 1: Result of analysis of variance on mortality of *S. zeamais* recorded for 120 h at 24 h interval on maize treated with powder and extracts of *D. regia* seed.

Treatment	*OP (h)	DF	MS	F	*P* value	Alpha (α)
	24	4	0.200	1.714	0.199	<0.050
	48	4	0.375	1.324	0.306	<0.050
Seed powder	72	4	0.575	2.029	0.142	<0.050
	96	4	2.075	1.915	0.160	<0.050
	120	4	6.375	1.700	0.202	<0.050
	24	5	0.242	0.757	0.592	<0.050
	48	5	0.167	0.462	0.800	<0.050

Ethanol extract	72	5	0.175	0.360	0.869	<0.050
	96	5	0.467	0.646	0.668	<0.050
	120	5	0.742	1.302	0.307	<0.050
	24	5	41.500	13.105	0.000	<0.050
	48	5	48.242	19.848	0.000	<0.050
Seed oil	72	5	71.767	69.827	0.000	<0.050
	96	5	96.567	491.486	0.000	<0.050
	120	5	104.042	2497.000	0.000	<0.050

* OP = Observation period

Note: The degree of freedom is 4 because solvent experiment was not included in seed-powder treatment.

DISCUSSION

Delonix regia seed powder and its ethanol extract were not toxic to *S. zeamais* but the oil was very effective at killing the insect. Antimicrobial activities of *D. regia* are well documented (Ravil *et al*., 2012; Jahan *et al*., 2010). Also, larvicidal activities (Aina *et al*., 2009) of different parts of this plant against insects of medical importance have been reported but the aspect of insecticidal activity against stored products pests has not been well explored (Nadra, 2004). There is no report on the use of any part of the plant against *Sitophilus* species. Similar results of non-effectiveness of some plant powders had been reported; Ogunleye and Adefemi (2007) reported that powder of *Garcinia kolae* had no lethal effect on *S. zeamais* in all treatments and the control even at 3 d post treatment. Fekadu *et al*. (2012) evaluated some botanical powders and oils for the control of *S. zeamais* and reported that the most potent botanicals are the oils. Emeazor and Okorie (2008) also reported that pulverized orange rind at six different doses from 0.5-3.0g had no significant mortality effect on adult *S. zeamais* for 42 days of observation. The results above, suggest that the seed is not effective in powder form. The relatively higher mortality observed at lower concentrations of the powder treatment might be as a result of the insect rubbing their body with the oily powder in the course of active movement which is inhibited by higher concentration of the powder. The mortality obtained in treatment with ethanol extract of the seed compared to its oil shows that the seed is not toxic.

Plant oils are commonly used in insect control because they are relatively efficacious against virtually all life stages of insects (Don-Pedro, 1989, 1990; Adedire, 2003). This is in agreement with the result obtained in this study. Oil of *D. regia* seed resulted in higher mortality of *S. zeamais* compared to the powder and ethanol extract of the seed. This finding is in conformity with the report of Yalamanchilli and Punukollu (2000) who observed that the oil from the leaves of *Curcuma domestica* could effectively protect the seeds, against *Callosobruchus chinensis*, at 2.0% concentration. Bekele *et al*. (1997) also reported that *Ocimum kenyense* at 0.3% caused 35% of *Z. zemais*. The result is also concomitant with the findings of Al-Moajel (2006) that affirmed the insecticidal effect of *Sesbania sesban* seed oil on *Sitophilus granarius.* Ahmed *et al.* (1999) reported that after three days of treatment, 100% mortality of adult C. *chinensis* was recorded on neem oil-treated beans. Within 2 days, Fekadu *et al*. (2012) recorded 95% and 100% adult mortality of *S. zeamais* in *Brassica carinata* oil and *Gossypium hirsutum* oil treatment respectively. The potency of the oil might not be unconnected with the reason stated by Don-Pedro (1990) that oils of plant origin are highly lipophilic; and therefore have the ability to penetrate the cuticle of insects. Also the oil by contact could block the spiracles of the insect, leading to death by asphyxiation (Adedire and Ajayi, 2003). Though all the concentrations of oil extract evaluated proved active in the control of *S. zeamais*, the effectiveness is concentration and exposure period dependent. The low insect mortality recorded in the solvent-treated experiments shows that the insect mortality that occurred in extract-treated experiments was not influenced by the solvents.

CONCLUSION

This investigation has revealed the potential of *D. regia* seed as plant derived insecticide against the maize weevil, *S. zeamais* in Nigeria. It is clear that the population of *S. zeamais* cannot be controlled by *D. regia* seed powder. The seed oil may have blocked the insect spiracles resulting in higher insect mortality. Availability of this plant makes it a promising material in improving the traditional grain storage practices.

REFERENCES

Adedire, C.O. (2003). Use of nutmeg *Myristica fragans* (Houtt.) powder and oil for the control of cowpea storage bruchid, *Callosobruchus maculatus* (Fabricius). Journal of Plant Diseases and Protection 109 (2): 193–199.

Adedire, C.O. and Ajayi, O.E. (2003). Potential of sandbox, *Hura crepitans* (L.) seed oil for protection of cowpea seeds from *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) infestation. Journal of Plant Diseases and Protection 110 (6): 602-610.

Ahmed, K. S, Itino, T. and Ichikawa T. (1999). Effects of plant oils on oviposition preference and larval survivorship of *Callosobruchus chinensis* (Coleoptera: Bruchidae) on azuki bean. Applied Entomology and Zoology 34 (4): 547–550.

Aina, S. A, Banjo, A. D, Lawal, O. A, Okoh, H. I, Aina, O.O. and Dedeke, G.A. (2009). The toxicity of extracts of *Tetrapleura tetraptera* (Aridan), *Delonix regia* (Flame of the Forest) and *Raphia vinifera* (Raffia Palm) on the Larvae of Anopheles gambiae. Academic Journal of Entomology 2(2): 67-70.

Akinkurolere, R. O. Adedire, C. O and Odeyemi O. O (2006). Laboratory evaluation of the toxic properties of forest anchomanes, *Anchomanes difformis* against pulse beetle *Callosobruchus maculatus* (Coleoptera: Bruchidae), Journal of Insect Science 13: 25-29.

Al-Moajel, N. H. (2006). Use of *Sesbania sesban* (L.) Merr seed extract for the protection of wheat grain against the granary weevil, *Sitophilus granarius* (L.) (Coleoptera: Curculionidae). Scientific Journal of King Faisal University (Basic and Applied Sciences 7(2): 121-136.

Arannilewa, S.T., Ekrakene, T. and Akinneye, J.O. (2006). Laboratory evaluation of four medicinal plants as protectants against the maize weevil, *Sitophilus zeamais* (Mots). African Journal of Biotechnology 5(21): 2032-2036.

Asawalam, E.F. (2006). Insecticidal and repellent properties of *Piper guineense* seed oil extract for the control of maize weevil, *Sitophilus zeamais*. Electronic Journal of Entomology and Agricultural Food Chemistry 5(3): 1389-1394.

Asawalam, E. F. and Hassanali, A. (2006). Constituents of the essential oil of Vernonia amygdalina as maize weevil protectants. Tropical and Subtropical Agroecosystems 6: 95- 1002.

Asawalam, E. F., Emosairue, S. O., Ekeleme, F. and Wokocha, R. C. (2007). Insecticidal effects of powdered parts of eight Nigerian plant species against maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae), Electronic Journal of Entomology and Agricultural Food Chemistry 6(11): 2526-2533

Bekele, A.J., Obeng-Ofori, D. and Hassanali, A. (1997). Evaluation of *Ocimum kenyense* (Ayobangira) as source of repellents,toxicants and protectants in storage against three major stored product insect pests. Journal of Applied Entomology 121: 169- 173

Don-Pedro, K. N. (1989). Mode of action of fixed oils against eggs of *Callosobruchus maculatus* (F.) Pesticide Science 26: 107-115.

Don-Pedro, K. N. (1990). Insecticidal activity of fatty acid constituents of fixed vegetable oils against *Callosobruchus maculatus* (F) on cowpea. Pesticide Science 30: 295– 302.

Emeazor, K. C and Okorie, C.C. (2008). Comparative efficacy of sweet orange, *Citrus sinensis* (L.) rind powder and oil for the control of maize weevil, *Sitophilus zeamais* (Motschulsky). Journal of Tropical Agriculture, Food, Environment and Extension 7(1) 9-14

Fekadu, G., Watoke, S. and Santiago D.R. (2012) Evaluation of Plant Powders and Cooking Oils against Maize Weevil, *Sitophilus zeamais* M. (Coleopteran: Curculionidae) under Laboratory Conditions, Molecular Entomology 3(2): 4- 14 (doi: 10.5376/me.2012.03.0002)

Golob P, Moss C, Dales M, Fidgen A, Evans J and Gudrups I. (1999). The use of spices and medicinals as bioactive protectants for grains. FAO Agricultural Services Bulleti*n* No 137. Food and Agriculture Organization of the United Nations, Rome.

Harbone, J. B. (1984). Phytochemistry Methods: A Guide to Modern Techniques of Plant Analysis 2nd Edition Chapman and Hall, London, Pg. 24, pp.101-130.

Ho, S. H, Cheng, L. P. L, Sim, K. Y and Tan, H. T. W. (1994). Potential of cloves, *Syzygium aromaticum* (L.) Merr. and Perry as a grain protectant against *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. Postharvest Biological Technologies 4: 179-183

Huang, Y., Lam, S. L and Ho, S. H. (2000). Bioactivities of essential oil from *Elletaria cardamomum* (L.) Maton. to *Sitophilus zeamais* Motschulsky and *Tribolium castaneum* (Herbst). Journal of Stored Products Research 36: 107–117.

Huang, Y., Tan, J. M. W. L, Kini, R. M and Ho, S. H. (2002). Toxic and antifeedant action of nutmeg oil against *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. Jounal of Stored Products Research 33: 289–298.

IITA (1995). Plant Health Management Division. Annual Report. Pg 43.

Ileleji, K. E, Maier, D. E and Woloshuk, C.P. (2004). Maize weevil, *Sitophilus zeamais* (Motschulsky) Adult survival, reproduction and control in stored corn under three temperature management strategies (Summer 2003 Pilot-Bin Trials). International Quality Grains Conference Proceedings, 1-11.

Jahan, I., Rahman, M., Rahman, M., Kaisar, M., Islam, M., Wahab, A. and Rashib, M. (2010). Chemical and biological investigations of *Delonix regia* (Bojer ex Hook.) Raf. Acta Pharmaceutica 60 (2):207-215 (Online) 1846-9558, ISSN (Print) 1330-0075, DOI: 10.2478/v10007-010-0018-7

Koschier, E. H, Sedy, K. A and Novak, J. (2002). Influence of plant volatiles on feeding damage caused by the onion thrips *Thrips tabaci*. Crop Protection 21: 419–425.

Lajide, L., Adedire, C. O, Muse, W. A and Agele, S. O (1998). Insecticidal activity of powders of some Nigerian plants against the maize weevil *Sitophilus zeamais* (Motsch) Entomological Society Nigeria Occasional Publications 31: 227 – 235.

Lale, N. E. S and Yusuf, B. A. (2001). Potential of varietal resistance and *Piper guineense* seed oil to control infestation of stored millet seeds and processed products by *Tribolium castaneum* (Herbst). Journal of Stored Products Research 37: 63-75.

Nadra, H. A. (2004). Testing some various botanical powders for protection of wheat grain against *Trogoderma granarium* Everts. Journal of Biological Sciences 4(5): 592-597.

Nelson, Z. and Guy, S. (2010). Repellency and toxicity of essential oils from the leaves and bark of *Laurelia sempervirens* and *Drimys winteri* against *Tribolium castaneum*. Industrial Crops and Products, **32**: 405 – 410.

Ngamo, T. L. S, Goudoum, A, Ngassoum, M. B, Mapongmetsem, P. M, Kouninki, H. and Hance T. (2004). Persistance of the insecticidal activity of five essential oils on the maize weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae). Journal of Agriculture and Applied Biological Sciences 69(3): 145-147.

Nukenine, E. N., Monglo, B., Awason, I., Ngamo, L. S. T, Thuenguem, F. F. N and Ngassoum M. B. (2002). Farmer's perception on some aspects of maize production and infestation levels of stored maize by *Sitophilus zeamais* in the Ngaoundéré region of Cameroon. Journal of Biological and Biochemical Science 12(1): 18-30.

Ogunleye, R. F. and Adefemi, S. O. (2007). Evaluation of the dust and methanol extracts of *Garcinia kolae* for the control of *Callosobruchus maculatus* (F.) and *Sitophilus zeamais* (Mots). Journal of Zhejiang University Science B. 8(12): 912–916. doi: 10.1631/jzus.2007.B0912

Qi, I.T and Burkholder, W. E. (1981). Protection of stored wheat from the granary weevil by vegetable oils. Economic Entomology 74: 502-505

Ravil, C., Jothi, L.S, Johnson, M. A. A and Mahalakshmi, R. (2012). Biological activity and phytochemical analysis of the flower extracts of *Delonix regia* (Boj. Ex Hook.) Raf. Asian Pacific Journal of Tropical Biomedicine, 1-6.

Rouanet, G. (1992). The Tropical Agriculturist, CTA, Macmillan, London pp. 1002.

Secoy, D. and Smith, A. (1983). Use of plants in control of agricultural and domestic pests. Economic Botany 37:28-57.

Storey, C.L. (1987). Effect and control of insects affecting corn quality. In S.A. Watson and P.E. Ramstad (Eds.). Corn Chemistry and Technology, 185-199. American.

SPSS (2003). Statistical Package for Social Sciences, 10.0 for windows. SPSS Inc. Illinios, USA.

Talukder, F.A and Howse, P.E (1995). Evaluation of *Aphanamixis polystachya* as a source of repellents, antifeedants, toxicants and protectants in storage against *Tribolium castaneum* (Herbst). Journal of Stored Products Research 31(1): 55-61.

Yalamanchilli, R.P and Punukollu, B. (2000). Bio-efficacy studies on leaf oil of *Curcuma domestica* Valeton: Grain protectant activity. Journal of Medicinal and Aromatic Plant Sciences 22 (1):715–716.