FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 3 No. 3, September, 2019, pp 230 –234

INSECTICIDAL ACTIVITY OF THREE PLANTS EXTRACTS AGAINST *SITOPHILUS ZEAMAIS* ATTACK ON MAIZE SEEDS UNDER HERMETIC STORAGE CONDITION

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ABSTRACT

A research was conducted to evaluate the insecticidal effects of three plants extracts obtained from *Uvaria chamae, Plumbago zeylanica* and *Jatropha curcas* on *Sitophilus zeamais* which causes significant damage and economic loss to stored maize grains in Nigeria. Seeds of maize grains introduced with the test organism were treated with the three plants extracts at five different concentrations: 0.5, 1.00, 2.00, 4.00 and 8.00 mg/l with three replications per treatment and control. The control is treated with distil water. The seeds were stored under hermatic condition for a period of six months. The results obtained were analyzed using Analysis of Variance with Least significant difference used to separate the means. The result obtained revealed that, the ethanolic extracts offered comparable protection to the maize grains against the test insect for the six months duration. There was no grain damage on treated maize grains due to insect infestation for two months for *U. chamae* and *P. zeylanica*, while *J. curcas* gave three months protection. There was significant difference ($P \leq 0.05$) between the control and treated maize grains respectively. The mortality of the insects was used to compute mean lethal concentration (LC_{50}) values by probit analysis and it was found that, extract from *U. chamae* with 48h LC_{50} value of 1.778 mg/l was the most toxic against *S. zeamais* adult followed by *J. curcas* and *P. zeylanica* with LC_{50} values of 1.869 and 2.353 mg/l respectively. All the concentrations tested showed appreciable toxicity against each test insect species. The computed mortality values of the test organism due to the effects of the extracts gave significantly ($P \leq 0.05$) higher toxicity against *S. zeamais* by 8.00 mg/l. The effect of the extracts are concentration dependents and increase with increase in concentration. The result implies that, the *U. chamae* ethanolic extracts have higher insecticidal potentials for use during storage of maize grains to ensure food security, profit maximization and availability of seeds for the next planting season without being damaged by these test insect species.

Keywords: Hermetic storage, Insect pest, Plants Extracts, *Sitophilus zeamais.*

INTRODUCTION

In Africa, farmers and vendors store grains for short periods ranging from three to six months (Ogendo *et al.,* 2004). The storage periods are mostly determined by the size of production of the crops, the market demands and the needs of the farmers. During storage, varying degrees of losses in quality and quantity of the stored produce occur due to the combined effects of insects, moulds and seed respiration (Oke and Muniru, 2001). The major constraints in the storage of grains in Nigeria are insects and vertebrate pests. The high moisture content in dried seeds promotes the growth of insects and so affects the viability of the seeds in storage (Murdock *et al*., 2012; Bradford *et al*., 2016). Stored grains are known to be infested by over 200 insect pests (Odeyemi and Daramola, 2000) from harvest to storage and can result in important financial losses (Lazzari and Lazzari, 2002). The important insect pest of maize in Nigeria is the maize weevil *Sitophilus zeamais* (Mostch).

Smiderle (2007) reported that losses may reach 10% of the total product each year and this translates to 10,000,000 tons of grain lost per year. FAO (2013) reported annual food losses amounting to 1.3billion metric tons or enough food to feed 2 billion people. According to World Bank report, sub Saharan Africa losses food grains worth about 4billion dollars every year and these losses play a critical role in influencing the life of millions of small holder farmers (Gustavsson *et al*., 2011).

In Nigeria, grains are protected from insects by the use of synthetic chemicals that infer other side-effects and are not eco-friendly. Hermetic (Air tight) storage which is commonly used in Africa prevents many insects from entering and also causes death due to suffocation. It also stops water from getting into the stored grain from outside. However the airtight nature of the hermetic storage leads to moisture migration and condensation, which leads to caking of the grains. This study therefore aimed at investigating the effect of some plant extracts in the protection of maize grains against maize weevil (*Sitophilus zeamais*) infestations.

MATERIALS AND METHODS

Test Plants

Fresh seeds of *Jatropha curcas*, bark of *Uvaria chamae* and stem of *Plumbago zeylanica* were procured from vendors at

Oyingbo market in Lagos and identified in the Herbarium of the Department of Botany, University of Lagos, Nigeria. The voucher numbers for the three test plants were given as follows: For *J. curcas* is LUH 3288, *U. chamae* is LUH3292 and for *P. zeylanica* is LUH 3290.

Source of Insects: The larvae and adults of *S. zeamais* were derived from a laboratory mass rearing facility. Insects were supplied with fresh maize seeds and were reared in wood cages according to the technique describe by Dabire *et al*. (2005). Toxicity tests were carried out on 1st, 3rd and 5th instars larvae and adults of *S. zeamais*.

Preparation of Plants Ethanolic Extracts: Fresh bark of *Uvaria chamae*, stem of *Plumbago zeylanica* and seeds of *Jatropha curcas* plants were air dried at room temperature, pounded to fine powder by pestle and mortar according to the protocols described by Dabire *et al*. (2008). The ethanolic extracts were prepared by soaking 100g of each powder in 150ml of 95% ethanol and shaken in orbital shaker at 120 rpm. The preparations were left to stand for another 24 hours and then filtered through a gauze and then Whatman No 1 filter paper. The filtrates were concentrated to dryness at 40°C under reduced pressure on a rotary evaporator and were stored in a refrigerator at −4°C until the need arise. Different concentrations of 0.5, 1.00, 2.00, 4.00 and 8.00 mg/l were prepared from each of the plant materials.

Disinfestation of Test Maize Seeds

Maize grains (*Zea mays* var. TZESR-20) were obtained from Bariga market, Lagos. They were identified at the International Institute of Tropical Agriculture (IITA), Ibadan. All damaged seeds and debris were sorted out from the grains after which disinfestations was carried out in an oven at 50°C for six hours to kill all life stages of insects within the grains. The grains were then left respectively for 24 hours to stabilize at ambient conditions as described by Ito and Ighere (2017)**.**

Culture of Test Insects

Sitophilus zeamais (Motsch) were maintained on disinfested maize grains. Fifty unsexed 7-14 day old adults of *S. zeamais* were introduced into 500g of disinfested maize grains (var-TZESR-20) in 1L kilner jars respectively in five replicates in the laboratory. All adult insects were left for seven days to allow for oviposition, after which they were removed. They were then left undisturbed until adults were observed to emerge. At each peak of emergence, the adults were removed and used to set up new cultures. Series of fresh cultures were made from these to ensure regular supply of adult insects of known ages for use in subsequent experiments (Dabire *et al*., 2008).

Hermetic Storage of Ethanolic Extract of Test Plants on Maize for a Period of Six Months

Five kilograms of disinfested maize grains were measured into plastic containers. Concentrations of 0.5, 1.00, 2.00, 4.00 and 8.00 mg/kg of the ethanolic extracts of *J. curcas*, *P. zeylanica* and *U. chamae* were applied on the grains and manually agitated and left to air dry. The maize grains were afterwards placed into jute bags and replicated three times. The seeds in the control were treated with distil water. Thirty unsexed insects were released into each bag as well as that of the control. The bags were kept inside drums in the laboratory. Monthly readings were taken for six months in which 100g of the treated and untreated cowpea/maize were taken from each bag and assessed for insect damage according to Odeyemi and Daramola (2000).

Insect Damage in Grains

Monthly insect damage in each treatment and control was determined from 100g batches of grains in each jute bag as described by Odeyemi and Daramola (2000):

$$\text{Percentage weight loss} = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u (N_d + N_u)} \times 100$$

Where:

W_u =weight of undamaged grains

N_u = Number of undamaged grains

W_d = weight of damaged grains

N_d =Number of damaged grains

Data Analysis

The data obtained was analyzed using Analysis of variance (ANOVA) using SPSS (11.0 versions) with Least Significant Difference used to compare the means.

RESULTS

The result for the effect of ethanolic plant extracts in preventing maize seeds damage by *S. zeamais* infestation is presented in Figure 1. The result shows that, the ethanolic extracts offered comparable protection to the maize seeds against the test insects for the period of six months. The effect is concentration dependent and increases with increase in concentration of the extracts. The result also showed that, extracts from *J. curcas* impart high insecticidal activity against *S, zeamais* infestation as such there was no grain damage on treated maize grains due to insect infestation for two months for *U. chamae* and *P. zeylanica*, while *J. curcas* gave three months protection. There was significant difference ($P \leq 0.05$) between the control and treated maize grains respectively with the treated plants providing better protection.

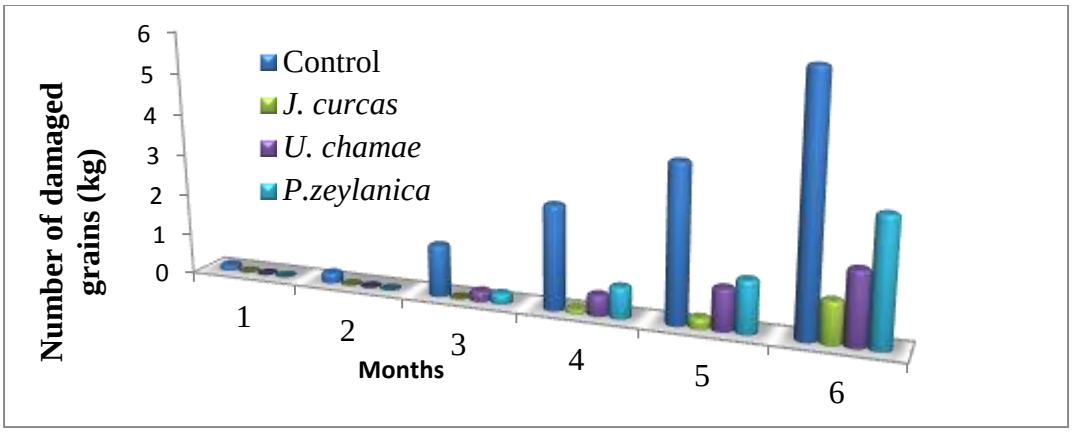

Fig. 1: Damage of maize grains protected with test plant extracts

The result for the toxicity of the extracts to *S. zeamais* is presented in Table 1. The result indicated that, the toxicity of *U. chamae* with 48h LC_{50} value of 1.778 mg/l was the most toxic against *S. zeamais* adult followed by *J. curcas* and *P. zeylanica* with LC_{50} values of 1.869 and 2.353 mg/l respectively.

Table 1: Toxicity of various test plant ethanol extracts on *S. zeamais* adults during preliminary screening.

Ethanolic extracts	24hr LC_{50} (mg/l)	95% CL	TF	48hr LC_{50}	95% CL	TF
Jatropha curcas	3.934	2.369-99.587	1.07	1.869	-0.157-5.250	1.05
Uvaria chamae	3.687	2.057-18.111	1.00	1.778	-0.161-5.582	1.00
Plumbago zeylanica	5.316	-0.506-0.071	1.44	2.353	0.425-17.344	1.32

CL = Confidence Limit

Test of significance = LC_{50} values with no overlap in 95% confidence limits are significantly different

Toxicity Factor (TF) = $\frac{\text{48hr } LC_{50} \text{ value of the least toxic compound}}{\text{48hr } LC_{50} \text{ value of the more toxic compound}}$

However, the result for the mortality of *S. zeamais* due to treatment with the ethanolic extracts is presented in Table 2. The result shows that, all the three formulations of ethanolic extracts were effective on *S. zeamais* with the highest mortality values ranging from 41.5-46.5% at 0.5mg/l and 83.2-98.1% at 8.0mg/l respectively (Table 2). The result revealed that, the highest mortality is recorded among *U. chamae* treated extracts while the least is found from *J. curcas* extracts.

Table 2: Mortality of *S. zeamais* adults during exposure to grains treated with ethanol extracts of test plants

Ethanolic extract	0.00mg/l	0.5mg/l	1.00mg/l	2.00mg/l	4.00mg/l	8.00mg/l
Jatropha curcas	0.00 ^{a}	46.5^{a}	70.0 ^{b}	77.6^{c}	82.4^{c}	83.2^{c}
Uvaria chamae	0.00 ^{a}	41.5^{c}	76.0^{a}	81.2^{a}	94.3^{a}	98.1^{a}
Plumbago zeylanica	0.00 ^{a}	43^{b}	66.5^{c}	78.0^{b}	87.1^{b}	93.7^{b}

- **Each datum is a mean of three replicates**
- **Mean values bearing the same letters are not significantly different by LSD at P = 0.05)**

DISCUSSION

The persistence of the extracts of *J. curcas, U. chamae* and *P. zeylanica* tested against the storage pests in this study suggested that all the three plants exhibited insecticidal activity against *S. zeamais*. The treated seeds were protected from damage by the weevil for two months probably by repelling the insects or inducing toxicity on to the insects. This finding is in line with the findings of Dales (1996) that most of the reports assumed insecticidal/repellent activities with stored products insects. This is also in conformity with the work of Belmain *et al*. (2001), Ketoh *et al*. (2005) and Dabire *et al*. (2008) who individually reported insecticidal activities of some plant

extracts against insect pests by repellency. The non-volatility of the insecticidal constituents may be responsible for the ability of the test plants to serve as protectants of stored maize grains in hermetic storage for up to 60 days for maize seeds as demonstrated in this study. This finding indicated that, the extracts are effective against the weevil for during storage for a period of two months without any damage. This observation is in agreement with that of Jadher and Jadher (1984) who reported that *J. curcas* extract totally prevented egg hatch even after 33 days of treatment. Also Adebowale and Adedire (2006) found that the *J. curcas* extract was effective as a grain protectants as no bruchids developed in grain legumes stored for 12 weeks. Boateng and Kusi (2008) reported that the persistency of *J. curcas* extract declined from the 15th day to 60th the day in storage. However, Ivbijaro (1983) reported that maize grains mixed with dry neem seeds were protected for 6 months in storage from damage by *S. oryzae*. However, Makanjuola (1989) reported that neem extract protected cowpea seeds against *C. maculatus* for 5 months, but offered moderate protection against *S. zeamais*. Also Dales (1996) in his study has shown that the activity of plant extracts can last up to six months. As typical of bioinsecticides, the biological activity of the extract declined with time and this may reduce their potential as stored grain protectant. Thus, the renewal of the application of the extracts for storage seeds protection against *S. zeamais* infestation should be renewed after two months of storage. The high loss of toxic potency of the Jatropha seed extracts applied to grains when kept for a 60-day period could be ascribed to rapid degradation of the biological active compounds as reported by Boateng and Kusi (2008).

The toxicity of the three plant extracts on the test organism signifies the relative importance of the extracts in preventing the damage induce by *S. zeamais* on stored maize grains. This may probably increase the longevity of the seeds and their market qualities without disrupting the nutritional qualities. This finding is in conformity with the work of Ahuchaogu *et al*. who reported the insecticidal potential of *J. curcas* extracts on insect pest of cowpea, Similarly, Abu *et al*. (2018) reported the insecticidal potentency of *U. chamae* extracts against insects pests of stored seeds. More so, Mukesh *et al*. (2017) reported the bio-insecticidal activity of *P. zeylanica* on human and agricultural pathogens. The insecticidal potency of plant extracts was also reported by Adeniyi *et al*. (2010) who reported that plant extracts from *Vernonia amygdalina* (leaf) at 4.0% concentration resulted in higher toxicity (measured as percentage mortality) to *Acanthoscelides obtectus*. This finding therefore adds to the existing data on the efficacy of plant extracts as biopesticides of stored food as highlighted by Adeniyi *et al*. (2010) that extracts from leaves of *Oscimum gratissimum*, *Sida acuta*, *Telfaria occidentalis* and *V. amygdalina* possess good insecticidal potential because of their phytochemical constituents and the order of toxicity at different concentrations was 4.00 > 3.00 > 2.00 > 1.00%. This is similar to the finding of the present study. The toxicity of the ethanolic extracts of the test plants used in this study is in agreement with that reported by Ijeh and Ejike (2011) and Alabi *et al.* (2005) who individually reported that, aqueous extract of the leaves of *Vernonia sp*. has high phytotoxic properties.

CONCLUSION

The ethanolic extracts of *Uvaria chamae, Jatropha curcas* and *Plumbago zeylanica* showed high toxicity to *S. zeamais* as such exert protection against its infestation and damage to stored grains.

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