Biocidal Activities of Seed Oils of *Jatropha curcas* and *Moringa oleifera* on Development of African Maize Stalk borer, *Busseola fusca* Fuller (Lepidoptera: Pyralidae)

Sule, H.^{1*}, Peter, E.² and Ibrahim, K.¹

¹Department of Crop Protection, Bayero University Kano, Nigeria.

²Department of Agronomy, Federal University Gashua, Yobe State, Nigeria

Abstract

Laboratory experiment was conducted at the Department of Crop Protection Laboratory, Faculty of Agriculture, Bayero University, Kano, in order to assess the effect of oils obtained from the seeds of *Jatropha curcas* and *Moringa oleifera* on African Maize Stalk Borer (*Busseola fusca* Fuller). The effects of the plant seed oils on larvae mortality, pupae and adult emergence were tested on freshly cut leaves/stem of maize 3-4 cm long) and treated with the prepared plant oils at various concentrations (10, 20, and 30%) and control (0%). The experiment was laid out in a completely randomized design and replicated four times. The results showed that both plant seeds oils were lethal to the developmental stages of *B. fusca*, causing mortality (21%) to the larvae, and subsequently preventing and/or suppressing pupae (2.08) and adult emergence (1.95). Treatment at 30% concentration was found to be more lethal to all the developmental stages of the test insect. Based on the findings of this study, it is recommended that any of the plant seed oils at 30 % concentration could be used to manage *B. fusca*.

Keywords: *Jatropha curcas*, *Moringa oleifera*, seed oil, larvae, African maize stalk borer, *Busseola fusca*.

INTRODUCTION

Busseola fusca (Fuller), also known as the African Maize Stalk Borer (AMSB), is a moth, indigenous to tropical Africa (Harris and Nwanze, 1992). It is considered the most important pest of maize in Sub-Saharan Africa (SSA). This pest has been reported to

cause great damage and yield losses across Africa (Robert *et al.*, 2014). These result from mechanical damage to maize plants (Amudavi *et al.*, 2009). The damage is heightened by the destruction of the growing points in the whorl, causing dead heart situation, loss of photosynthetic leaf area due to foliar feeding, lodging due to burrowing into the stem and extensive damage to young kernels by second and third instar larvae

*Correspondence email:
hsule.cpp@buk.edu.ng

(Ofor *et al.*, 2009). Damage resulting from the stem borers' infestation on maize plant can cause between 20-40% losses during cultivation, and between 10-100% during postharvest and storage (Bosque-perez, 1990; Robert *et al.*, 2014; Kendall *et al.*, 2014). As such the damage caused by *B. fusca* on maize crop plant had contributed to food shortage and affected self-sufficiency.

In Nigeria, controlling *B. fusca* is primarily through the usage of chemical control. This approach, despite being effective and popular among farmers, has its attendant problems such as environmental pollution, pesticide residue in food chain, development of insecticide resistance, and toxicity to non-target organisms and is not affordable to most poor resource farmers (Clieve, 2003). In recent times, much attention has been given to biopesticides, as a favoured alternative source of protectant against insect pests both in the field and in the store. The use of botanicals for the control of agricultural pests are considered to be environmentally friendly and cost effective (Rausell *et al.*, 2000). Besides they are readily available and affordable which makes them more acceptable to farmers in developing countries, especially, Nigeria; where they readily incorporated as a major component of integrated pest management programme (Mukhtar *et al.*, 2018). In line with this trend of research, this study investigated the lethal effects of oils of *J. curcas* and *M. oleifera* seeds on the immature stages and general development of *B. fusca*.

MATERIALS AND METHODS

Experimental Site

The study was carried out in the Entomology Laboratory of the Department of Crop Protection, Faculty of Agriculture, Bayero University, Kano, Nigeria. This location lies

within Longitude 9°30'N and Latitude 8°42'E at about 481m above sea level (Mustapha *et al.*, 2017).

Plant Material Collection, Preparation and Extraction of Seed Oils

The plants materials (*J. curcas* and *M. oleifera*) evaluated for insecticidal activity against *B. fusca* were collected from Orchard of Faculty of Agriculture, Bayero University, Kano (B.U.K). The seeds of the plant materials were dried under shade and decorticated to obtain the kernels. Thereafter, the dried seeds were milled using electric grinder to obtain a fine powder. Oil extraction from the seeds was carried out in the Department of Animal Science Laboratory, B.U.K using Soxhlet Extraction Apparatus. The pulverized plant samples (100 g each) were dissolved in petroleum ether (250 mL), the system was heated for about 5 cm above a hot electric hot plate while cold water was allowed to flow in and out of the condenser compartment to cool the system. After many refluxes for about 3 hours, the petroleum ether evaporated leaving behind oil-content inside the container.

Larval Collection

The larvae used for the study were collected by handpicking and beat sampling techniques from Pesticide free Maize plants at the Farm/Orchard of Faculty of Agriculture, Bayero University, Kano. The larvae were placed in a transparent plastic container measuring 25 x 20 cm and 8 cm deep lined with tissue paper and covered with muslin cloth and transported to the Laboratory.

Larval Rearing

The collected larvae of *B. fusca* were reared in groups of 10 individuals in transparent plastic cup measuring of 8.5cm in diameter

at the top, 6cm in diameter at the bottom and 5cm in depth lined with tissue paper and covered with muslin cloth. The larvae were fed with fresh young stalks and succulent leaves of maize. These food materials were changed and replaced with fresh ones every 2 days. The larvae were allowed to pupate in same containers. After emergence, 50 adults were transferred to a cage measuring 45 x 45cm for mass breeding to obtain homogenous and sufficient population for the experiment. Cotton wool soaked with 10% honey solution were provided as food. Tissue papers were spread and hanged and also a small fresh branch of maize plant carrying young leaves and stalk were dipped in a bottle containing water to keep it turgid as an oviposition site to the adult insect inside the cage. These branches were renewed daily to attract the moths for egg laying.

Hatched neonates of *B. fusca* (1st instar larvae) were collected with camel hair brush and introduced onto young leaves of maize in a transparent plastic cup of 8.5cm in diameter at the top, 6cm in diameter at the bottom and 5cm in depth lined with moist filter papers. Feeding and changing of food materials were continued up to the stage needed for the termination of experiment (3rd instar larvae).

Plant Seed Oil Concentration Preparation

The plant oil extracts were diluted with petroleum ether as a carrier solvent in a bottle to obtain the different serial concentration levels as follows:

- i. 500 µl of *Jatropha* oil into 5000 µl of petroleum ether (10% concentration)
- ii. 1000 µl of *Jatropha* oil into 5000 µl of petroleum ether (20% concentration)
- iii. 1500 µl of *Jatropha* oil into 5000 µl of petroleum ether (30% concentration)
- iv. 500 µl of *Moringa* oil into 5000 µl of petroleum ether (10% concentration)
- v. 1000 µl of *Moringa* oil into 5000 µl of petroleum ether (20% concentration)
- vi. 1500 µl of *Moringa* oil into 5000 µl of petroleum ether (30% concentration).

Laboratory Bioassay and Assessment of Mortality

The experiment was conducted for 72 hrs under laboratory condition at room temperature of $24\pm 2^{\circ}\text{C}$. Freshly collected young leaves/stem of maize were cut into pieces of 3-4 cm long. Twenty pieces of the cut plants parts were uniformly sprayed with different concentration (10%, 20% and 30%) of *J. curcas* and *M. oleifera* seed oils with control (petroleum ether), and allow to dry for 30 minutes to allow the petroleum ether evaporate and/or dry off under laboratory condition, and then placed in a plastic container measuring 8.5 cm at the top, 6cm in diameter at the bottom and 5cm deep lined with tissue paper. Thereafter 10 3rd instar larvae of *B. fusca* from the reared specimens were collected using camel brush from maize leaves and dissected stalks and introduced into the container covered with muslin cloth and allowed to feed. The experiment was laid out in a complete randomized design with 4 replications.

Dead larvae in each of the treatment replicate were counted and recorded at 24, 48 and 72 hours after introduction. The larvae were considered dead when they were unable to move when prodded with a fine hairbrush; after which they were removed from the test container.

Assessment of Pupal and Adult Emergence

Number of pupa that emerged were counted and recorded in each of the treatment replicates 3 to 5 weeks after introduction of the test larvae or after initial infestation. Conversely, number of adult insect that emerged were also counted and recorded after a pupal period of 7 to 14 days in each of the treatment replicates.

Data Analysis

The original mortality data were corrected by Abbott's formula for natural mortality in untreated controls (Nwanko *et al.*, 2015). The corrected mortality data obtained in percentages were arc-sine transformed and data obtained from pupa and adult emergence that was recorded as zero, along with other numerical data; were transformed with $\sqrt{n+1}$. The transformed data were subjected to two way analysis of variance (ANOVA) using Genstat 17th Edition Software. Differences between means were separated using Turkey's HSD test at 95% level of probability.

RESULTS

Table 1 presents the effects of seed oils and concentration of *Jatropha curcas* and *Moringa oleifera* on the larvae of *B. fusca*. The results show no significant difference ($P>0.05$) in the mortality caused by both plant oils to larvae of *B. fusca* at 24, 48 and 72 hours exposure. Moreover, the effect of time of exposure at 24 hr did not cause significant mortality ($P>0.05$) at 30, 20 and

10% concentrations; but 30% concentration caused higher mortality and was significantly different ($P<0.05$) from the control (0%). At 48 and 72 hours, the same trend was observed among the concentrations. The result indicates that mortality caused by the plant seed oils increases with time and concentration levels as more mortality was recorded after 72 hr and 30% concentration when compared with the remaining treatments.

The results obtained on the effect of plant seed oils and concentrations on the pupa emergence of *B. fusca* are shown in Table 2. The results showed no significant difference ($P>0.05$) in the number of pupae that emerged between the two plant seed oils. When concentration was considered, 30% concentration recorded less number of pupae emergence but was not statistically different ($P>0.05$) from 20 and 10% concentrations. However, all the concentration levels were statistically different ($P<0.05$) with the control which recorded more pupae emergence.

Table 3 shows the emergence of adult *B. fusca* exposed to oils of *J. curcas* and *M. oleifera* seeds. The results showed no significant difference ($P>0.05$) in the number of adults that emerged between the two plant oils. Also, the number of adult emergence was not significantly different ($P=0.05$) from each other at all concentration levels except from the control. However 30% concentration recorded less number of adult emergence when compared with the remaining treatments.

Table 1: Percentage Larva Mortality of *B. fusca* at 24, 48 and 72 hours after Treatment

Treatments	Mean larvae Mortality (%)		
	24 Hrs	48 Hrs	72 Hrs
Plant seed oils			
<i>Jatropha curcas</i>	3.3 (10.5 ^a)*	15.4 (23.1 ^a)	21.3 (27.5 ^a)
<i>Moringa oleifera</i>	7.5 (15.9 ^a)	14.6 (22.5 ^a)	18 (25.1 ^a)
SED	4.302	5.03	5.29
Concentration (%)			
10	4.4 (12.08 ^{ab})	9.2 (17.71 ^{ab})	19.9 (26.49 ^a)
20	8 (16.45 ^{ab})	27.9 (31.90 ^a)	30.8 (33.75 ^a)
30	17 (24.35 ^a)	36.3 (37.04 ^a)	42 (40.39 ^a)
Control (0)	0.00 (0.00 ^b)	0.64 (4.61 ^b)	0.64 (4.61 ^b)
SED	6.08	7.11	7.48

*Figures in parenthesis are arc sine values to which SED are applicable. Means followed by same superscripts within same column are not significantly different (P<0.05) Turkey's HSD test.

Table 2: Number of pupae of *B. fusca* at 3-5 weeks after treatment

Treatment	Mean No. Pupae
Plant seed oils	
<i>Jatropha curcas</i>	1.93 ^a
<i>Moringa oleifera</i>	2.08 ^a
SED	0.1605
Concentration (%)	
10	1.86 ^b
20	1.77 ^b
30	1.47 ^b
Control (0)	2.93 ^a
SED	0.2270

Means followed by same superscripts within same column are not significantly different (P>0.05) Turkey's HSD test.

Table 3: Mean Adult Emergence of *B. fusca* on maize plant after a pupal period of 7 to 14 days

Treatment	Mean Adult Emergence
Plant seed oils	
<i>Jatropha curcas</i>	1.72 ^a
<i>Moringa oleifera</i>	1.95 ^a
SED	0.1607
Concentration (%)	
10	1.47 ^b
20	1.61 ^b
30	1.36 ^b
Control (0)	2.891 ^a
SED	0.2273

Means followed by same superscript within same column are not significantly different (P>0.05) Turkey's HSD test.

DISCUSSION

The results of this study showed that oils obtained from *J. curcas* and *M. oleifera* seeds had negative effects on the development of *B. fusca*, causing larvae mortality and subsequently preventing and/or suppressing pupal and adult emergence. These results are in agreement with previous reports by Dubey *et al.* (2010), Gupta *et al.* (2010) and Arnubio *et al.* (2006), who reported that various extracts of neem, physic nut, tobacco and pyrethrum flower can be used to control Lepidopteran stem borer species. Also, Harinder and Klaus (2009) reported that leaf and seed extracts of various botanicals can be highly toxic to larvae of *B. fusca*.

The lethal activity of the two bio-pesticides on the development of *B. fucas* may be caused by insecticidal properties of the two plant seed oils. Previous studies conducted with plant oils have demonstrated their larvicidal and antifeedant activity, capacity to delay development, adult emergence and fertility, as well as deterrent effects on oviposition (Naumann and Isman, 1995; Oyedele *et al.*, 2000; Lengai *et al.*, 2020), and arrestant and repellent action (Landolt *et al.*, 1999).

The reports of Van der vossen and Mkamilo (2007), showed that *Jatropha* seed oil contains toxic compounds such as esters diterpenoid 12-deoxy-16-hydroxy-phorbol and curcin; which have pesticidal properties against insects such as the cotton bollworm (*Helicoverpa armigera*) and the cowpea bruchid (*Callosobruchus maculatus*). It has also been shown that *Moringa* seed oil contain a cocktail of fatty acids; Linoleic, Linolenic, Oleic (Leone *et al.*, 2016) which are known to be toxic to insects and cause mortality.

The findings of the current study are consistent with those of Asmare *et al.* (2011)

who investigated the efficacy of some botanicals on stem borers *B. fusca* (Fuller) and *Chilo partellus* (Swinhoe). Tadele (2013), investigated the effects of different botanical insecticide strategy against *B. fusca* under laboratory conditions and shown that methanol extracts of *Jatropha* oil containing phorbol esters have strong insecticidal effects against larvae of field insect pests (Asmare *et al.*, 2011). Plant oils are volatile natural complex secondary metabolites characterized by a strong odor having pesticidal potential (Chang and Cheng, 2002). The findings of this study clearly shows that insecticidal activity of plant seed oils depend on the concentration of the plant oil in the solution as seen in the effect of various concentrations of the plant oils on the development of *B. fusca*. Bamaiyi *et al.* (2007) showed that higher concentrations and longer exposure periods were needed to achieve appreciable levels of control, which concurred with the results obtained in this study. Oparaeke and Dike (2005), Asawalam and Emosairue (2006) in separate studies reported that the efficacy of various plant products tested against storage insect pests' increase with increasing dose of plant products.

CONCLUSIONS AND RECOMMENDATIONS

The results showed that both plant seed oils were found to be lethal to *B. fusca*. 30% concentration is found to be more lethal to all the developmental stage of the test insects. Based on the findings of this study, it is recommended that any of the plant seed oils at 30% concentration could be used to manage *B. fusca*.

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