DOI: https://dx.doi.org/10.4314/gjass.v23i1.11

GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 23, 2024: 113-122
COPYRIGHT© BACHUDO SCIENCE CO. LTD PRINTED IN NIGERIA ISSN 1596-2903 e-ISSN: 2992 – 4499
www.globaljournalseries.com.ng, Email: globaljournalseries@gmail.com

PERSISTENCE AND REPELLENCY POTENTIALS OF *Balanites aegyptiaca* AND *Azadirachta indica* SEED OILS AGAINST TROPICAL WAREHOUSE MOTH (*Ephestia cautella* WALKER) IN STORED MAIZE

SHEHU, A., MALGWI, A. M AND MEDUGU, M. A.
Email: meduguduhu@mau.edu.ng
Orchid ID: http://orcid.org/0000-0002-7233-6879

(Received 9 September 2024; Revision Accepted 18 October 2024)

ABSTRACT

A study was conducted to assess the persistence and repellency potentials of seed oils of desert date (*Balanites aegyptiaca*) and neem (*Azadirachta indica*) against the tropical warehouse moth (*Ephestia cautella* walker), Dichlorvos (DDVP) was used as a positive control. Different concentrations of neem and desert date oils (10, 15, 20, and 25 ml/l) and DDVP (10 ml/l) were used to treat 100 g of maize grains, while repellency of the insect to the oils on treated filter paper was also assessed at the same dose rates, arranged in a completely randomized design with three replications. The data were analyzed using analysis of variance (ANOVA), and means were separated using the New Duncan Multiple Range Test (NDMRT) at 0.05 %. Results showed that Dichlorvos, desert date and neem seed oils caused 100 % mortality, and repellency of 33.33, 86.67 and 66.67 %, respectively after 72 hours. The oils remain effective for 12 weeks with percent mean damage (80.71 % and 92.36 %) and weight loss (29.76 % and 59.79 %) when treated with a high dose (25ml/l) and longer duration of 12 weeks, respectively while, the control has 81.18 and 34.36 % of grain damage and weight loss, respectively. The positive control (DDVP) has 63.89 % and 21.49 % of grain damage and weight loss. It is, therefore, concluded that desert date and neem seed oils significantly caused *E. cautella* mortality. This has proven that desert date and neem seed oils provide good protection to maize grains and could be considered as a substitute to Dichlorvos.

KEYWORDS: *Azadirachta indica; Balanites aegyptiaca; Ephestia cautella*; Repellency; Persistence.

INTRODUCTION

Maize (*Zea mays*) is a cereal plant that has several species that exist and consist of different colors, sizes, grain shapes, and textures, white, yellow and red maize are the most commonly cultivated types (Medugu *et al.,* 2020). Maize serves as a vital source of proteins and calories to billions of people in developing countries particularly in Africa, Mesoamerica and Asia and is used as animal feed (Mondal and Chakraborty, 2016). Maize is also used as a staple food, feeds for livestock and poultry, and as a raw material for many industrial products (Badu-Apraku *et al.,* 2006).

Maize therefore has a considerable potential to enhance food security and the productivity and sustainability of the crop-livestock system (Medugu *et al.,* 2020) and also significantly contributes towards the national food self-sufficiency strategy (Rukuni *et al.,* 2006; Demissie *et al.,* 2008; FAO, 2009). In 2018, Nigeria produced about 10.2 million tons of maize from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2009).

Insect pests are the principal cause of maize grain losses [Dubale *et al.,* 2012; Simbarashe *et al.,* 2013] which results in major economic losses, and in Africa where subsistence grain production supports the

Shehu, A., Department of Crop Protection, Faculty of Agriculture, Modibbo Adama University, P.M.B 2076 Yola, Adamawa State, Nigeria
Malgwi, A. M., Department of Crop Protection, Faculty of Agriculture, Modibbo Adama University, P.M.B 2076 Yola, Adamawa State, Nigeria
Medugu, M. A., Department of Crop Protection, Faculty of Agriculture, Modibbo Adama University, P.M.B 2076 Yola, Adamawa State, Nigeria

livelihood of the majority of the population, and grain losses caused by storage pest which threatens food security (FAO, 2009). This problem is more serious in the tropics and sub-Saharan Africa, where farmers battle with poverty, limited knowledge, poor agricultural infrastructure, low crop protection knowledge, unfavorable climatic conditions, and poor storage structures (Lenne, 2000). In these regions stored grains losses can reach 25-40% (Eziah *et al.,* 2011).

The tropical warehouse moth, *Ephestia cautella* Walker is an important storage pest of maize. The larva can cause substantial damage to maize grain as a secondary pest, but can also attack the whole grain at the site of the embryo, in which the germ is removed completely, and may thus be of special importance as pests in seed grain (Shehu *et al.,* 2010). The larvae feed externally on maize grains and the grain will never germinate when used as a seed. Contamination of the infested commodity also occurred from the large quantity of webbing that was spun over its surface. Their frass, faeces and bad odour also result into serious contamination of the grains (Shehu *et al.,* 2010). Chemical pesticides is been widely used for the control of insect pests of stored grains (Medugu *et al.,* 2020). The wide spread use of synthetic insecticides for the control insect pests is of global concern due to its associated hazards and exorbitant prices (Cherry *et al.,* 2009; Nwosu, and Nwosu, 2012). The most common alternative control of storage insect pests is the use of reduced-risk insecticides such as plant extracts as a replacement to conventional insecticides, mostly organophosphates (Medugu and Tame, 2021). Nevertheless, poor farmers in developing countries mix different plant products to protect stored grains against insect pest infestation (Obeng-Ofori, 2007). Additionally, it has been an ancient practice to mix neem extracts in stored grains against insect pests (Ramesh, 2007). Neem has reasonable insecticidal properties which is more environmentally friendly and safe and less expensive in comparison with synthetic pesticides (Emmanuel, 2019). In addition, desert date has been reported to cause insect mortality, repellent effects and reduced grain damage of stored sorghum (Elamin and Satti, 2013).

While, on the other hand, the use of resistant varieties is effective and acceptable by society. However, some researchers have reported that the resistance of maize to insect attack is related to some physical, chemical, and biochemical characteristics of a maize variety (Medugu *et al.,* 2020). Consequently, since environmental safety is a global concern, a better understanding of bio-pesticide mode of action and regulatory issues may help further to raise their profile among the farmers, manufacturers, government agencies, policymakers, and the common people to realize their contributions to sustainability (Kumar and Singh, 2015). Therefore, this study is aimed at assessing the persistence and repellant potentials of desert date and neem seed oils to *E. cautella* in stored maize grains.

MATERIALS AND METHODS

Study Site

Laboratory experiments were conducted in the Laboratory of the Department of Crop Protection, Faculty of Agriculture, Modibbo Adama University, Yola. Nigeria. The work was conducted between June to August, 2022 at a Laboratory temperature range of 27 - 35°C and relative humidity of 55 - 75 % located on coordinate of latitude $9^0$20"49'N and longitude $12^0$29"41'E in the year 2022 (Google Compass, 2022).

Sources of Experimental Materials

Dichlorvos (2, 2-dichlorovinyl phosphate/DDVP) was acquired from an agrochemical shop in Yola, Adamawa State while seeds of neem and desert date were picked in the University surroundings of Modibbo Adama University, Yola and College of Education premises in Yobe State, Nigeria, respectively. Freshly harvested maize grains were purchased from maize farmers in Yola town.

Rearing *Ephestia cautella*

Parent stocks of *E. cautella* were obtained from infested maize grains in Yola grain market, and reared on poultry mash in a glass jar according to (FAO, 2022). However, semovita was added to increase the rate of larval growth (Shehu *et al.,* 2010). The poultry mash and glass jars were sterilized thermally at 60°C for 3 hours so as to kill any insect or pathogens that may harbor in the grains, and allowed to cool down at room temperature (Allotey and Azeleclor, 2000). Twenty unsexed *E. cautella* adults from the parent stock were picked to infest the mash in the glass jar. The glass jar was then covered with a perforated rubber lid to aid ventilation and prevent of escape of insects from the jar. The jar was then kept on tray smeared with oil so as to prevent insects or mites from crawling into the cultures, and kept in the Laboratory bench. *E. cautella* parent used in infesting the mash was then removed from the culture after three days of oviposition period. The emerging F_1 progeny (2 - 3 days old) was used for the experiment (Shehu *et al.,* 2010).

Extraction of Desert Date and Neem Seed Oils

The desert date and neem seed oils were extracted by method described by Akinjide, 2019) with some modifications (Figure 1).

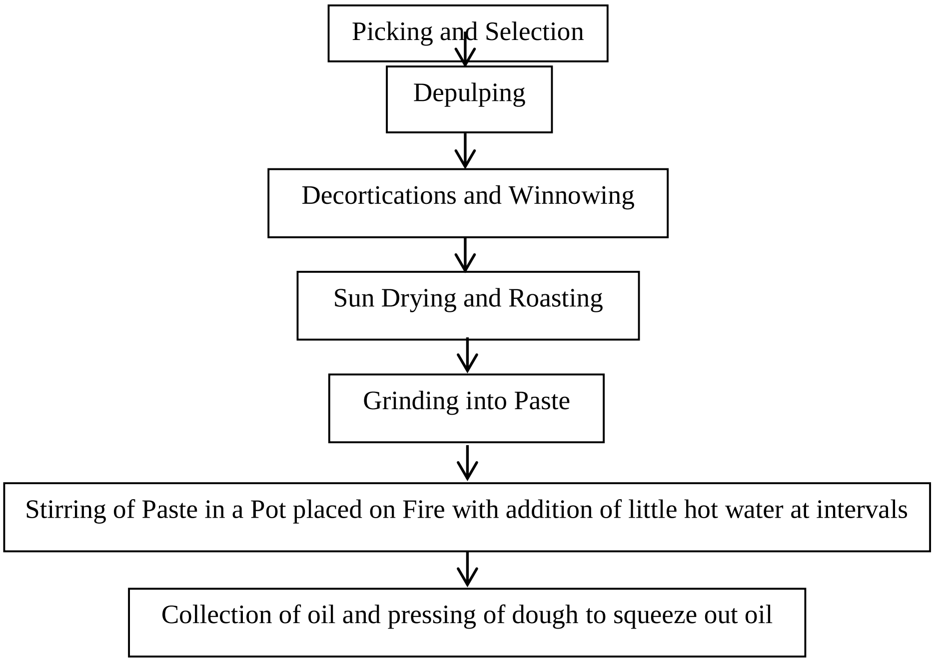

Figure 1: Extraction of Desert date and Neem Seed Oils Flow Chart

Preparation and Disinfection of Samples before Bioassay

The experimental jars and pristine maize grains used for the experiment were cleaned and sterilized thermally as above, and allowed to equilibrate for 24 hours in the laboratory (Lenne, 2000). The desert date and neem seed oils were dissolved in water with liquid soap as emulsifier (Adarkwah *et al.,* 2011; Shehu *et al.,* 2010). Four different concentrations of desert date and neem seed oils of 10, 15, 20, and 25 ml/l were made each, DDVP at 10 ml/l served as positive control and untreated grains as negative control. The experiment was laid in completely randomized design (CRD) with three replicates. The sample preparations were carried out prior to the bioassay.

Bioassay and Data Collection

Effects of desert date and neem seed oils to E. cautella

To assess the toxicity effects of these oils by topical application, ten larvae were placed in 10 petri dishes each, where 1µl of each of the concentrations (10, 15, 20 and 25 ml/l) of desert date and neem seed oils and DDVP (10 ml/l) were applied to the dorsal surface of the larvae using micropipette while water was applied to the control larvae. Treated larvae were transferred to Petri dishes containing maize grits as food. The treatments were arranged in a completely randomized design (CRD) with three replications. Mortality was assessed after 24, 48, 72 and 96 hours. A larva is considered dead when probe three times and there was no response (Boateng, and Kusi, 2008).

Abbott's (1925) formula was used to correct percentage mortality where control mortality is up to 5 as adopted by [42].

$Cm = Pt - Pc/100 - Pc.$

Where; Cm = Corrected mortality;

Pt = Percentage mortality on treatment;

Pc = Percentage mortality on control.

Percent mortality was computed as follows:

$$\text{Mortality (\%)} = Nd/N \times 100.$$

Where; Nd = Number of dead insect;

N = number of introduced insects.

Persistency of desert date and neem seed oils on treated maize grains

To assess the persistence of these oils, ten glass jars containing 100 g of maize grains each were treated with four different concentrations (10, 15, 20 and 25 ml/l) of desert date and neem seed oils each and 10ml/l of DDVP with control treatment, arranged in a completely randomized design replicated three times. Four different sets of such treatments were made. Twenty unsexed adult insects were used to infest the first set at 3 weeks, the second set at 6 weeks, the third set at 9 weeks and the fourth set at 12 weeks after treatment (WAT) (Medugu *et al.,* 2021). In each case, data for grain damage and weight loss were recorded.

Repellency potential of desert date and neem seed oils to E. cautella larvae

The repellant action of the desert date and neem seed oils to *E. cautella* larvae was assessed in a choice bioassay method as described by (Shehu *et al.,* 2010).

In this experiment, solutions containing desert date and neem seed oils at four different concentrations (10, 15, 20, and 25 ml/l) each and DDVP at 10 ml/l were applied to half part of filter paper while the other halves were treated with water to serve as the control. The treated filter papers were air dried under shade for 3 hours to evaporate the moisture. Full discs were then remade by attaching treated halves to untreated halves of same dimensions with sellotape. Each full filter paper was placed in a Petri dish and 10 larvae of *E. cautella* were released at the centre of each filter paper. The petri dishes were then arranged in a completely randomized design replicated three times. The number of insect present on control (Nc) and treated sides (Nt) were counted and recorded after 1, 24, 28, and 72 hours. Per cent repellency (PR) values were computed as;

$PR = [(Nc - Nt)/(Nc+Nt)] \times 100.$

Where: PR = Percent repellency;
Nc = Number of insects present on control;
Nt = Number of insects present on treated side.

Data Analysis

Data obtained on mortality, persistency and repellency were subjected to analysis of variance (ANOVA) using SAS software, version 9.4 (SAS institute, Cary, NC, USA) and means difference were separated using New Duncan Multiple Range Test (NDMRT) at 0.05 % probability level.

RESULTS AND DISCUSSIONS

Toxicity of Desert Date and Neem Seed Oils via Topical Application

The results on the toxicity effects of desert date and neem seed oils are summarized in Table 1. There was no significant difference ($p<0.05$) among the percentage mean mortality caused by the different concentrations of desert date and neem seed oils to *E. cautella* larvae and between the percentages mean mortality caused by DDVP. Contact toxicity of the oils to *E. cautella* larvae applied topically to the dorsal surface was toxic to the larva which is in agreement to the findings of (Agboka, *et al.,* 2009) who also reported that contact toxicity of neem oil at 0.5 % resulted in 60 % mortality to gypsy moth after 48 hrs. The toxicity effects of neem seed oil might be due to findings by (Schmutterer, 2022) who reported that topical application of neem oil caused antifeedant secondary effects such as gut disorders and mortality due to the presence of Azadirachtin. Azadirachtin prevents both ecdysis and apolysis, and can cause death before or during molting (Shiferaw *et al.,* 2011). The result showed that toxicity increases with increasing dose rate and time (Shehu *et al.,* 2010). Treatment with DDVP at 10 ml/l, desert date seed oil at 15, 20 and 25 ml/l, and neem seed oil at 20 ml/l caused 100 % mortality within 24 hours.

This was also reported by (Elamin and Satti, 2013) and (Medugu *et al.,* 2021) who worked on effects of Calneem™ oil (a registered neem oil product) on *E. cautella,* they recorded high mortality of 90 - 100 % on neem and 96.67 - 100 % on desert date oil within the first 24 hours of treatment. However, the result showed that all the treatments caused significantly higher mortality to *E. cautella* larvae than the untreated (0.00 %) grains. In contrast to the findings of (Shehu *et al.,* 2010) who reported that neem oil at 7 ml/l concentration, caused low mortality after 24 hours and induced 65 % mortality to larvae of *E. cautella* within 5 days. This could be attributed to the low concentration (2 - 7 ml/l) used by them as compared to this work in which 10 - 25 ml/l were used. After 48 hours, 100 % mortality was recorded on grains treated with all the different concentrations of the desert date seed oil. The findings by (Medugu *et al.,* 2020) also reported that extracts from desert date seeds was found to have high insecticidal effects. The effectiveness of the desert date seed oil indicates a possible contact action of the major active constituent of the oil (Saponins). In addition, (Chothani and Vaghasiya, 2011) reported that steroidal saponins is believed to be the main active ingredient that possessed the insecticidal activities of desert date seeds against variety of pests. In the case of neem seed oil, 93.33 to 100 % were recorded on grains treated with all the different concentrations of the neem seed oil with no mortality in the control treatment. Toxicity effects of neem seed oil might be due to findings by (Schmutterer, 2022) who reported that topical application of neem oil caused antifeedant secondary effects such as gut disorders and mortality due to the presence of Azadirachtin. Azadirachtin prevents both ecdysis and apolysis, and can cause death before or during molting (Shiferaw *et al.,* 2011). Furthermore, at 72 hours of treatment, 100 % mortality was achieved in all the treatments with no mortality in the control. This is in contrast to the findings of (Medugu *et al.,* 2021) who reported that all concentrations (2, 3, 4, 5 and 6 ml/l) of neem oil caused significant mortality of *E. cautella* which ranged from 32.5 to 55 % after 96 hours exposure period. However, the best level of performance was recorded on grains treated with DDVP at 10 ml/l, desert date seed oil at 15, 20 and 25 ml/l and neem seed oil at 20 and 25 ml/l with 100 % mortality each. However, there was no significant difference between all the treatments and the control at 24 hours after treatment. It has also been reported by Raguraman and Singh (2008) that, topical application using Arnold's hand micro applicator at the rate of 0.5 µl per insect at 3, 2, and 1 % concentrations of neem oils showed negligible mortality after 24 and 48 hours of treatment. This is a clear indication that mortality increases with increasing dose rates and time as reported by Shehu *et al.* (2010) and Medugu *et al..,* (2021).

Morakchi and Bendjazia, (2016) reported that topical application of Azadirachtin to third instar larvae interfered with the endocrine events and disrupted the moulting and normal development of *Drosophila melanogaster.* The effectiveness of the neem oil indicates a possible contact action of the major active constituent of the oil (Azadiractin). Furthermore, Chothani and Vaghasiya, (2011) reported that extracts from different parts of desert date seeds showed insecticidal activities against a variety of insect pests, of which *E. cautella* is not an exception to belong to the same order. However, the high saponin content in desert date seed kernel was found to have high insecticidal effects (Chapagain *et al.,* 2008). Based on the above findings, mortality caused by these seed oils increased their protectant potential against insect damage to grains in store.

Table 1 Toxicity Effects of Desert Date and Neem Seed Oils to *E. cautella* Larvae

Treatments (ml/l)	Percent mean mortality with time (hrs.)		
	24	48	72
Control	0.00[a]	0.00[c]	0.00[b]
Neem oil			
10	90.00[a]	93.33[b]	100.00[a]
15	90.00[a]	96.67[ab]	100.00[a]
20	100.00[a]	100.00[a]	100.00[a]
25	96.67[a]	100.00[a]	100.00[a]
Desert date oil			
10	96.67[a]	100.00[a]	100.00[a]
15	100.00[a]	100.00[a]	100.00[a]
20	100.00[a]	100.00[a]	100.00[a]
25	100.00[a]	100.00[a]	100.00[a]
DDVP	100.00[a]	100.00[a]	100.00[a]
CV (%)	5.91	2.90	0.00
P≤F	< 0.0001	< 0.0001	< 0.000

Means in same column with the same alphabets are not significantly different (P≤0.05) using NDMRT; CV = Coefficient of Variation.

Repellency Effects Desert Date and Neem Seed Oils to *Ephestia cautella* Larvae

Table 2 showed the repellency effects of desert date and neem seed oils to *Ephestia cautella*. The result showed that desert date and neem seed oils caused high repellency of *E. cautella* with a repellency range of 93.33 - 100 % by neem seed oil and 46.67 - 80.00 % by desert date seed oil after 1 hour compared to DDVP which had 53.33 %. This is in agreement to the study conducted by Shehu *et al,* (2010) who reported that neem oil (Calneem oil) was highly repellent to *E. cautella* with repellency range of 50-75 %. Also, Bhatnagar *et al.,* (2001) demonstrated high repellent effects of neem seed oil against *C. maculatus.* Adarkwah *et al.* (2011) also reported that neem oil (Calneem oil) induced repellency range of 80-100 % to *Tribolium castaneum.* However, neem seed oil also exerted significant repellent effects of 72.7 % on larvae of khapra beetle (Elamin and Satti, (2013). The result showed no significant difference (P≤0.05) between the repellency caused by different concentrations of the neem seed oil (86.67 - 100 %) and desert date seed oils (66.67 - 86.67 %) after 24 hours. The repellent effects of the oils were maintained up to 72 hours with no significant difference (p<0.05) among the different concentrations of neem seed oil and among the different concentrations of desert date seed oil. Another study reveals that the essential oil from desert date have strong repellency activity against the red flour beetle with a percentage repellency of 89.95 % at 8 % concentration, and 81.00 % at 4 % concentration (Mokhtar *et al.,* 2020). The repellent effect may be due to high or good quantity or quality of bioactive compounds in the desert date oil such as fatty acids (Mokhtar *et al.,* 2020). These fatty acids have strong repellency action against many insect pests (Zhu *et al.,* 2018). This repellent action of this oil increases its protective potential for grain protection against insect pests attacks.

However, repellency seems to decrease on the third day in most of the treatments. The insects also survived on the untreated side in the petri dishes for four days. The outcome of the repellency reveals that the two oils have no cumulative effects as the insect survived for four days on the untreated side of the filter paper in the covered Petri dish. The overall best repellent effect was recorded on neem at 10 ml/l, followed by desert date oil at 20 ml/l though DDVP at 10 ml/l has the least repellency compared to all the different levels of the oils.

Table 2 Mean Percentage Repellency Effects of Desert Date and Neem Seed Oils to *E. cautella* Larvae

Treatments (ml/l)	Percent repellency with time (hours) 1	24	48	72
Neem oil				
10	100.00[a]	86.67[a]	80.00[ab]	86.67[a]
15	93.33[ab]	86.67[a]	73.33[ab]	80.00[a]
20	100.00[a]	100.00[a]	80.00[ab]	86.67[a]
25	93.33[ab]	86.67[a]	80.00[ab]	73.33[a]
Desert date oil				
10	66.67[abc]	66.67[ab]	73.33[ab]	66.67
15	46.67[c]	66.67[ab]	66.67[ab]	66.67[a]
20	80.00[abc]	86.67[a]	93.33[a]	86.67[a]
25	73.33[abc]	66.67[ab]	80.00[ab]	80.00[a]
DDVP	53.33[bc]	40.00[b]	40.00[b]	33.33[b]
CV (%)	19.41	20.69	20.30	24.62
P≤F	< 0.0445	< 0.0496	< 0.0313	< 0.0404

Means in same column with the same alphabets are not significantly different (P≤0.05) using NDMRT;
CV ＝ Coefficient of Variation

Persistency of Desert Date and Neem Seed Oils on Treated Maize Grains

The result on the maize grains damage caused by *E. cautella* stored for twelve months is presented in table 3. Desert date and neem seed oils gave high protection to treated grains against damage by *E. cautella* compared to untreated grains (Table 3). There was a significant difference (P≤0.05) between the grain protection made by the oil treatments and the control which has percent mean damage of 25.81 % and weight loss of 6.64 %. The oils also gave high protection to treated grains against damage by *E. cautella* compared to untreated grains when infested at three weeks after treatment. The effectiveness of neem seed oil is in agreement to study conducted by Saxena, (2006) who found out that cowpea seeds treated with neem oil (5 ml/kg) resulted in protection against *Callosobruchus* spp for several months.

Mean percentage damage of 2.58 % and 9.79 % weight loss of 1.08 % and 3.87 % of neem and desert date seed oil, respectively were observed on grain treated with the lowest concentration (10 ml/l) (Table 3). A significant difference (P≤0.05) was observed between the grain protection made by all treatments (0.00 - 9.79 %) and the control (66.86 %) but no significant difference (P≤0.05) between the oils (0.00 - 9.79 %) and DDVP (0.00 %). Besides, DDVP at 10 ml/l, neem seed oil at 15 ml/l, and desert date seed oil at 20 ml/l performed equally without damage (0.00 %) on the grains at six weeks after infestation (Table 3). Stoll, (2005) reported that treatment of 1 kg of beans with 2 - 3 ml of neem oil protected beans for six months.

The result at nine weeks after infestation also showed that neem and desert date seed oils gave good protection to treated grains against damage by *E. cautella* compared to untreated grains (Table 3). The highest mean percent damage was recorded on the control (68.1 %) and the lowest damage was recorded on grains treated with DDVP (4.28). There was no significant difference among the protectant ability of the different concentrations of the oils (5.13 - 9.54 %) and also between the oils and DDVP (4.28 %) except at the lowest concentration (l0 ml/l) of neem seed oil (14.13 %). The highest percentage weight loss (17.61 %) was recorded in the control and the lowest weight loss (2.40 %) was recorded on grains treated with highest concentration (25 ml/l) of desert date seed oil. There was a significant difference (P≤0.05) between the grain weight loss recorded on the treatments (2.40 - 7.85 %) and the control (17.61), but no significant difference between the weight loss recorded on the oils (2.40 - 7.85 %) and DDVP (6.69 %). The overall best performance was recorded on DDVP (10 ml/l) followed by desert date oil (25 ml/l) and then neem (25 ml/l), but the difference between them was not significant (Table 3). Saxena, (2006) reported that the application of 1 to 3 parts of neem oil per 100 parts of Bengal gram rendered complete protection against *C. chinensis* for at least l35 days. Similarly, Shehu *et al.* (2010) reported that neem oil gave good protection of maize against damage by *E. cautella* for period of ten (10) weeks.

The oils gave poor protection to the treated grains against damage by *E. cautella* when treated maize grains were infested at twelve weeks after infestation (Table 3). The lowest damage (63.89 %) was recorded on grains treated with DDVP while more than 70 % damage was recorded on grains treated with different concentrations of the oils. This it is in agreement with the findings of Danjumma *et al.,* (2019) who reported that balanites powders significantly minimized grain damage and infestation at 96 days post-treatment. Also balanites oil significantly reduced sorghum damage by 30 % (Elamin and Satti, 2013). There was no significant difference (P≤0.05) between the damage recorded on the treatments (63.89 - 90.15 %) and the control (81.18 %).

However, there was also no significant difference (P≤0.05) between the weight loss recorded on the treatments and the control (Table 3). The protectant ability of treatments was generally poor and irregular at twelve weeks after infestation (Table 3). The result of this finding showed that neem and desert date seed oil gave 100 % protection to the treated grain with 0 % damage at all the concentrations at three WAI. In addition, a study conducted on cowpea and Bambara groundnut, neem oil at 8 ml/kg seed not only reduced oviposition, but also killed larvae. The activity persisted for more than 90 days on cowpea and for 180 days on Bambara groundnuts (Saxena, 2006).

Table 3 Mean Percentage (%) Damage and Weight Loss of Maize caused by *E. cautella* after 3, 6, 9 and 12 weeks after treatment with Desert Date and Neem Seed Oils

	Mean % damage and weight loss							
Treatment	**3 weeks**		**6 weeks**		**9 weeks**		**12 weeks**	
(ml/l)	**GD**	**WL**	**GD**	**WL**	**GD**	**WL**	**GD**	**WL**
Control 0.00	25.81a	6.64^{a}	66.86^{a}	20.54^{a}	68.10^{a}	17.61^{a}	81.18^{abc}	34.36^{bc}
Neem oil								
10	0.00^{b}	0.00^{b}	2.58^{c}	1.08^{cd}	14.13^{b}	7.85^{b}	90.15^{ab}	55.83^{ab}
15	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{d}	9.54^{bc}	7.65^{b}	86.35^{ab}	48.84^{b}
20	0.00^{b}	0.00^{b}	0.00	0.00^{d}	8.67^{bc}	2.82^{c}	83.45^{ab}	24.64^{c}
25	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{d}	9.79^{bc}	3.87^{bc}	80.71^{abc}	29.76^{bc}
Desert date								
10	0.00^{b}	0.00^{b}	9.79^{b}	3.87^{b}	8.64^{bc}	4.27^{bc}	73.43^{bc}	29.76^{bc}
15	0.00^{b}	0.00^{b}	3.45^{c}	2.26^{bc}	6.91^{bc}	2.93^{c}	89.75^{ab}	35.98^{bc}
20	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{d}	7.58^{bc}	3.99^{bc}	78.69^{abc}	29.07^{bc}
25	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{d}	5.13^{c}	2.40^{c}	92.36^{a}	59.79^{a}
DDVP	0.00^{b}	0.00^{b}	0.00	0.00^{d}	4.28^{c}	6.69^{c}	63.89^{c}	21.49^{c}
CV (%)	24.72	17.43	20.34	10.11	22.33	15.02	11.75	13.68
P≤F	<0001	<0001	<0001	<0001	<0001	<0001	0.0490	0.0904

Means in same column with the same alphabets are not significantly different (P≤0.05) using NDMRT; CV = Coefficient of Variation; GD = Grain damage; WL = Weight loss

CONCLUSION

This study assessed the effects of desert date and neem seed oils against *E. cautella* and DDVP was used as standard reference product. The effects of desert date neem seed oils were assessed using contact toxicity by topical application, repellency potential and persistence of the oils for 12 weeks storage period. The assays were conducted by treating 100 g of maize grains 10, 15, 20 and 25 ml/l doses of desert date and neem seed oils each with DDVP at 10 ml/l. The results revealed that *Ephestia cautella* is turning out to be a primary insect pest capable of attacking intact grains as against its status as a secondary pest. The results obtained suggested that desert date and neem seed oils have good potential for their use in stored product pest management systems.

The study also showed that desert date and neem seed oils contain insecticidal and repellent properties. Toxicity of the oils at 10 - 25 ml/l caused 100 % larval mortality at 72 hours after treatment. Besides, contact toxicity of desert date and neem seed oils by topical application caused high mortality of 96.67 - 100 % and 90 - 1 00 %, respectively within the first 24 hours after treatment. Consequently, these treatments also significantly caused repellency of 93.33 - 100 % and 46.67- 80 % by desert date and neem seed oils, respectively which was maintained for up to 72 hours.

Strong repellent effects make it possible for desert dates and neem seed oils to minimize damage by controlling the pests through physiological disturbance, phagodeterrance and repellence more than toxicity. The desert date and neem seed oils can protect maize grains against *E. cautella* for at least 12 weeks regardless of whether the grains were infested before treatment or not as the toxicity of the oils lasted for up to 12 weeks with a percent mean damage of 8.67 % on grains treated with neem oil at 20 ml/l and 5.13 % on grains treated with desert date oil against the control with 68.1 % damage. This could become an important alternative or supplement to synthetic insecticides. Resource-poor farmers can effectively use the oils to protect their grains in store. *Ephestia cautella* is turning out to be a primary insect pest capable of attacking intact grains as against its status as a secondary pest. Desert date and neem seed oils (20 ml/l and 25 ml/l) were found to be effective as DDVP.

However, further studies should be carried out on the persistence, palatability and hazards that might be associated with the oils.

ACKNOWLEDGMENT

Authors, sincerely appreciate all the laboratory staff that assisted during during the set-up of the experiment and data collection. The authors also acknowledge Modibbo Adama University, Yola, for providing a conducive environment to carry out this research.

REFERENCES

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology; 18: 265-267.

Adarkwah, C., Obeng-Ofori, D., Adler, C., Buttner, C., Reichmuth, C. and Scholler, M., 2011. Integration of calneem oil and parasitoids to control Cadra cautella and Cocyra cephalonica in stored grain cereals. Phytoparasitica. 39: 223-233.

Agboka, K., l'vlawufe, A. K., Tamo, M. and Vidal, S., 2009. Effects of plant extract; and oil emulsions 011 the maize cob borer Mussidia nigrivcnella (Lepidoptera: Pyralic.ac) in laboratory and field experiments. International Journal of Tropical Insect Science 29(04): 185 – 194.

Akinjide, O. B., 2019. Analysis of Balanite aegyptiaca (aduwa) Oil used as a Brake Fluid in Mechanical Brake System. International Journal of Engineering and Technology Research, 17: (5) 206 - 218.

Allotey, 1. and Azeleclor, W., 2000. Some aspects of the biology and control using botanicals f the rice moth, Corcyra cephalonica (Stanton) on some pulses. Journal of Stored Product Research, 36(3): 235-243.

Arege, A., Manyong, V. M., Gockowski, J., Coulibaly, O. and Abele, S., 2006. A Framework for Conceptualising Impact Assessment and Promoting Impact Culture in Agricultural Research. International Institute of Tropical Agriculture. Pp. 1-30.

Badu-Apraku, B. and Fakorede, M. A. B., 2006. Zea mays L. In: Brink, M. and Belay, G. (Edts). Cereals and pulses. Plant resources of tropical Africa 1. PROT A, Wageningen, Netherlands.297 pp.

Bhatnagar, A., Bhadauria, N. S. and Jakhmola, S. S., 2001. Efficacy of vegetable oils against pulse beetle, Callosobruchus maculatus in cowpea. Indian journal of Entomology. 63 (3): 237-239.

Boateng, B. A. and Kusi, F., 2008. Toxicity of Jatropha Seed Oil to Callosobruchus maculatus (Coleoptera: Bruchidae) and its Parasitoid, Dinarmus basalis (Hymenoptera: Pteromalidae). Journal of Applied Sciences Research. 4(8): 945- 951.

Chapagain, B. P., Saharan, V.and Wiesman, Z., 2008. Larvicidal activity of saponins from Balanites aegyptiaca callus against Aedes aegyptimosquito, Bio resources Technology. 99: 1165-1168.

Cherry, A. J., Bantino, A., Djegui, D., Lomers, C., 2005. Suppression of the stem borer Sesamia calamistis Lepidoptera: Noctuidae in maize following seed dressing, topical application and stem injection with African isolates of Beauveria bassiana. International Journal of Pest Management, 50: 67 - 73.

Chothani, D. L. and Vaghasiya, H. U., 2011. A review on Balanite aegyptiaca Del (desert date): phytochemical constituents, traditional uses, and pharmacological activity. Pharmacognosy Reviews. 5(9): 55-62.

Danjumma, B. J., Majeed, Q. and Ibrahim ND., 2019. Organoleptic properties of maize treated with the botanicals. Journal of Entomology and Zoology Studies, 7(4): 1320-1325.

Demissie, G., Tefera, T., and Tadesse, A., 2008. Efficacy of Silicosec, filter cake and wood ash against the maize weevil Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae) on three maize genotypes. Journal of Stored Product Research, 44: 227-231.

Dubale, B; Waktole, S; Solomon, A; Geremew, B. and Sethu, M. R., 2012. Influence of Agro-ecologies, Traditional Storage Containers and Major Insect Pests on Stored Maize (Zea mays L.) in Selected Woredas of Jimma Zone. Asian Journal of Plant Sciences, 11: 226-234.

Elamin, M. M. and Satti, A. A., 2013. Insecticidal potentialities of Balanites aegyptiaca extracts against the khapra beetle (Trogoderma granarium). Global Advanced Research Journal of Environmental Science and Toxicology. 2(1): 05-10.

Emmanuel, T. O., 2019 Insecticidal Effect of Neem (Azadirachta Indica) Extracts Obtained from Leaves and Seeds on Pests of Cowpea (Vigna Unguiculata). Journal of Agriculture and Veterinary, 2(4): 20-28.

Eziah, V. Y., Sackey, I., Boateng, B. A. and Obeng-Ofori, D., 2011. Bio efficacy of neem oil (Calneem™), a botanical insecticide against the tropical warehouse moth, Ephestia cautella. International Research Journal of Agricultural Science and Soil Science. 1(7): 242-248.

Food and Agriculture Organization, 2009. Food and Agriculture Organization of the United Nations, Statistics Division 2009. “maize, rice and wheat: Area harvested, production quantity, yield”.

Food and Agriculture Organization, 2022. Agris record on publication of National Resource Institute NRI, 1996. A guide to insect pests of Nigerian crops: Identification, Biology and Control. Federal Ministry of Agriculture and Natural Resources, Nigeria and the Overseas Development Administration, U.K, 253 pp.

Google Compass, 2022.

Kumar S. and Singh A., 2015. “Biopesticides”: present status and the future prospects,” Journal of Fertilizers and Pesticides, vol. 6, no. 2, 2015.

Lenne, J., 2000. Pests and poverty: The continuing need for crop protection research. Outlook on Agriculture. 4: 235-250

Medugu, M. A., Okrikata, E., Dunuwel, D. M., 2020. Management of Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae) using Nigerian raw diatomite. Journal of Applied Science and Environmental Management, 24(9): 1663-1669.

Medugu, M. A. and Tame, V. T., 2021. Influence of Morphological and Morphometric Characteristics of some Maize Varieties against Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae) Infestation in Northeastern Nigeria. Journal of Agriculture and Veterinary Science, 14, Issue 5 Ser. (I) 36 - 43.

Medugu, M. A., Malgwi, A. M. and Nahunnaro, H., 2021. Evaluation of the Efficacy of Some Plant Powders Against Callosobruchus maculatus, FAB. in Stored Vigna unguiculata under Laboratory Conditions in Yola, Nigeria.

Nigerian Journal of Tropical Agriculture, Vol. 23, 234-242. website:www.njtamau.com

Mokhtar, M. M., Jianfeng, L., Du, Z. and Cheng, F., 2020. Chemical composition and repellency activity of essential oil from desert date seeds against the red flour beetle. International Journal of Advanced Engineering Research and Science.7(8): 275 - 279.

Mondal, E. and Chakraborty, K., 2016. Azadirachta indica - A Tree with multifaceted applications: An Overview. Journal of Pharmaceutical Science and Research. 8(5): 299-306.

Morakchi, S. K. and Bendjazia, R., 2016. Growth and molting disruption effects of azadirachtin against Drosophila melanogaster (Diptera: Drosophilidae). Journal of Entomology and Zoology Studies. 4(1): 363-368.

Nwosu, L. C. and Nwosu, U. I., 2012. Assessment of maize cob powder for the control of weevils in stored maize grain in Nigeria. Journal of Entomological Research, 36 (3): 21-24.

Obeng-Ofori, D., 2007. The use of botanicals by resource poor farmers in Africa and Asia for the protection of stored agricultural products. Steward Postharvest Review, 6 (5): pp 1-8.

Raguraman, S. and Singh, D., 1997. Biopotentials of Azadirachta indica and Cedrus deodara oils on Callosobruchus chinensis. Pharmaceutical Biology35 (5): 344–348.

Rahman, A. and Talukder, F. A., 2006. Bioefficacy of some plant derivatives that protect grain against the pulse beetle, Callosobruchus maculatus. Journal of Insect Science, 6: 3 10pp. insectscience.org/6.03

Ramesh, C.S., 2017. practical application of neem against pest of stored products G-152, palam Vihar, Gurgaon 122 017, India. E-mail: susaxena@satyam.net.in.

Rukuni, M., Tawonezvi, P. and Eitcher, C., 2006. Zimbabwe’s Revolution Revisited. Sable Press Private Limited, Zimbabwe.

Saxena, R. C., 2006. Practical applications of neem against pests of stored products.\Proceedings of Methyl Bromide Alternatives and Emissions Reduction, pp. I10-114.

Shiferaw, B., Boddupalli, M. P. and Muariane, B., 2011. Crops that feed the world. Past success and future challenges to the role played by maize in global food security. Food Security.3, 307 – 327.

Schmutterer, H., 2022. An Online Publication of Schmutterer, H., 1990. Properties and potentials of natural pesticides from neem tree. Annual Review of Entomology. 35: 271-298.

Shehu, A., Obeng-Ofori, D and Vincent, Y. E., 2010. Biological efficacy of Calnecm 1M oil against the tropical warehouse moth Ephestia cautella (Lepidoptera: Pyrallidae) in stored maize. International Journal of Tropical Insect Science. 30 (4): 207-213.

Simbarashe, M., James, C. and Sipiwe, G., 2013. Screening of Stored Maize (Zea mays L.) Varieties Grains for Tolerance Against Maize Weevils, Sitophilus zeamais (Motsch.). International Journal of Plant Research. 3(3): 17-22

Stoll, G., 2005. Natural crop protection in the Tropics. Margraf Publishers Scientific Books. Second enlarged and revised edition. 377pp.

Zhu,1. 1., Cermak, S. C., Kenar, J. A., Brewer, G., Haynes, K. F. and Boxler, D., 2018. Better than DEET repellent compounds derived from coconut oil. Scientific Reports, 8, 14053 https://doi.on;;/] (). J038/s41598-0J8-32373-7 Retrieved on 21 February 2021.