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Use of *Azadirachtaindica, Metarhizium anisoplae*, Carbaryl 85% EC and Malathion 57% EC to Control Aestivated *Aspongopus viduatus* (Hemiptera: Dinidoridae)

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Abstract

Melonbug Aspongopus viduatus could cause losses of 100% in water melon Citrulus lanatus (Thuab.). Control has relied on pesticides that are no longer safe, and relatively costive, these making its control difficult for the small farmers. This study initiated to investigate new control methods to reduce health and environmental hazards (toxicitytohuman, animal, non-target organisium, environmental contaminations, etc.), namely the use of friendly biocontrol (Azadirachtaindica, entomopathogenic fungi Metarhizium anisoplae, Melsch), as well as less persestant pesticides (malathion 57% EC and carbaryl 85% EC), against the adult of melon bug Aspongopus viduatus during aestivation period (to avoid toxicity to man, animal, environment contaminations, non targed insects, reducing cost of control etc.) in thefield. The control was carried out using spray and dust methods during aestivation. Spray and dust materials were tested at different concentrations ranging between 25-50 g / h, 2.5% -1.25%, 425-850 g ai / L, and 256-570 ml ai / L for Metarhizium anisoplae, Azadirachta indica seed water extract, carbaryl, and malathion respectively. The results revealed that carbaryl, malathion, and malathion + sesame oil caused asignificant mortality in the test insect. The effect was dose-depending and the cumulative mortality caused by carbaryl was the best, followed by malathion and malathion + sesame oil for the high and low concentrations respectively; however, Azadirachtin and Metarhizium mortality never reached 10%, 21 days after application, even at higher concentrations, but the very important issue was that the mortality was dose dependant.

Keywords

Dinidoridae Bugs, Summer Dormancy, Biological, Botanical, Chemical, Agents

1. Introduction

1.1. Water Melon (*Citrulus lanatus*, Thuab.)

Watermelon (*C. lanatus*) is one of the important crops. It contains saturated fats, very low sodium and cholesterol, a good source of vitamin A, and vitamin C. It also contains high concentrations of lycopene, which reduces the risk of cancer and other diseases while the seeds contain amino acids and minerals [15]. Water melon compares favorably with the known protein-rich foods such as soyabean, cowpea, pigeon peas and pumpkin [15].

In Sudan *C. lanatus*, Thuab is one of the important trainfed crop grown in Kordofan and Darfur regions as cash, food, feed and water source (insummer) for both human and animals [29, 18, 1]. It is an important source of foreign currency in the country [3, 4, 5, 1, 18]

C. lanatus, (Thuab.) is subjected to multiple insect attacks during the growing season. The most important pest is *Aspongpus viduatus* (Fabr.) (Melon bug) [1].

1.2. *A. viduatus* (melon bug)

A. viduatus is widely distributed in Assia and in the almost all African continent, with a higher incidence in Egypt, Israel, Iran and Turkey [22-43]. In Sudan the pest occurs mainly in Kordofan, Darfur, Kassala, Khartoum, Blue Nile and Upper Nile (Southern Sudan) Provinces [51]. However the insect is an important pest of several crops, it is the main pest of water melon (*C. lanatus*), as well as other important crops such as snake melon [*Cucumismelo,* Tasali (Jurum)], cucumber (*Cucumis sativus*)*,* gourd (*Lagenaria siceraria,* Molina), squirting cucumber (*Ecballium elaterium*), musk melon (*Cucumis melo*)*,* cotton (*Gossypium spp*), a number of wild cucurbits (*Marahspp*) and bitter apple (*Citrullus colocyn*) [51, 28, 10]. However, *A. viduatus* is the most destructive pest threatening *C. lanatus*, Thuab crop [1]. Both adults and nymphs feed on leaves, stems and developing fruits causing wilting and shedding of these parts [51, 29, 2, 1, 28], as well as facilitating secondary disease infections [51-1]. Severe infestation may destroy the plant completely [51, 13, 62, 1], and may lead to total crop failure [12]. Maximum infestation in Sudan occurs during late August and early September which is synchronized with the crop growth stages [1]. More over, its fecundity and reproduction during active period is very high [24]. The total number of eggs laid by a single female averaged 448 ± 0.90 – 741 eggs [7-24]. The main oviposition period, incubation period and hatchability% were 64 ± 17.7, 8.5 ± 0.75 days and 94.4 ± 3.01%, respectively, however the mean developmental periods of the nympha linstars, were 7.9 ± 0.75, 10.9 ± 1.3, 7.14 ± 1.6, 9.8 ± 1.1 and 13.3 ± 1.9 for the 1st, 2nd, 3rd, 4th and 5th nymphal instars respectively [24].

1.3. Insect Control

1.3.1. Synthetic Pesticides

Less persistant pesticides such as carbaryl, malathion etc., needed to be considered in pest control new strateges, as well as in integrated pest management (IPM), for their low toxicity, effectiveness, etc. that, are some of their major positive characteristics.

(i). Carbaryl

Carbaryl belongs to carbamate pesticides [56]. It is a broad spectrum insecticide, it controls a wide range of arthropods pests including, beetles, moths, fleas, flies, lice, mites, krickts, grasshoppers, bugs, thrips, tics, cockroaches, aphids, etc. [38]. Carbry lis moderately toxic when fed to rats, and very low toxicity was observed when inhaled to rat [57]. The acute dermal (skin) toxicity of carbryl expousure is low (low risk level) [55]. It is low in toxicity when tested on the skin of rats and rabbits [56-57]. However, carbaryl as carbamate pesticide doesn't accumulate in mammals, and it is rapidly broken down by the liver and eliminated [42-56]. When carbaryl was fed to rats, it was completely excreted through the urine and feces within 48 hours [9].

(ii). Malathion

Malathion is a low toxicity pesticide, however, the acute dermal (skin) toxicity of malathion expousure is low too (low risk level) [55]. Its absorption or ingestion into the human body is readily metabolized to malaoxon. However, rats exposed for along time to oral ingestion, malaoxon was 61 times more toxic than malathion [11]*, although it was quickly expelled* from the body in three to five days [26]. According to the United States Environmental Protection Agency [58], there is no reliable information on adverse health effects of chronic exposure to malathion.

Both carbaryl and malathion are less persistant pesticides and have so far been used extensively against *A. viduatus* and its nymphs during the growing season [64, 45, 29, 2].

The success of modern synthetic pesticides in controlling insects has led to their wide spread acceptance for agricultural pest control and public health. This because of their rapid action and broad-spectrum activity against most field and storagepests. However, after extensive use of pesticides many serious problems appeared; these include: hazard to man and animals, environmental pollution, destruction of beneficial insects, resistance to insecticides etc. these drawbacks the attention to the need for new safe approaches in pest control strategies [46, 21, 16, 36, 20].

1.3.2. Biocontrol (Botanical and Entamopathogenic) Agents

Based on the above issues the reisanurgent need for active and safe approaches in pest control strategies, safe alternatives such as botanical pesticides (*Azadirachta indica*, *Solana stimaargel*, *Calotrop isprocera*, *Ocimun basilicum*, *Alium sativium* (L.) and friendly entomopathogenic agents (*Metarhiziuman isopliae, Beauveria bassiana, Bacillus thiorngen this*etc.), These active search for safe alternatives (biological pesticides) has been intensified in recent years. Their high biodegradability, affect only target pest, environmently friendly. Other merits of these products include their cheapness, and good availability in African environment, reduce the farmer's dependence on chemical pesticides for pest control [63]. *A. indica* derivatives and *M. anisopliae* entomopathogenic agents are among the promising safe alternatives.

There are many plant extracts as well as entomopathogenic fungi that are known to affect insect pest. These products are renewable, and many showed low mammalian toxicity and are environmentally friendly [54-37].

(i). *Azadirachta indica*, A. Juss

Neem tree *A. indica* (A. Juss) is among safe and friendly active alternatives, it has long been recognized for its properties against insects. Neem derivatives known to affect insect pests. In particular its seed, which contains many related compounds such as triterpenoids, azadirachtin, nimbin, salannin and others. These compounds have biological activity against insects and azadirachtin is the main active ingredient of neem seeds [49-50].

Extracts from seeds of the neem tree *A. indica* active ingredient is azadirachtin. The effect of azadirachtin on insects was investigated by many workers. Their results revealed that, azadirachtin reducing eggs and live progeny, blocking cell division, loss muscles tone, blocking digestion enzyme production in gut and inhibiting protein synthesis in tissues. Azadirachtin also disrupts the endocrine system that control growth and moulting. More over, azadirachtin increase mortality in insects by affecting mouthparts and other chemoreceptors [40, 32, 31, 23].

Azadirachtin has shown to be effective in the field, when used against *Schistocerca gregaria* nymphs infesting barley seedlings at low doses (2 ppm), protected the plants [34]. Other insects such as *Spodoptera frugiperda* (armyworm), *S. littoralis*, Fall (African cotton leaf worm), *Heliothis virescens*, F. (tobacco bud worm) and *Helicoverpa armigera* (old world bollworm) also responded behaviorally to low concentrations of azadirachtin, however azadirachtin at low concentrations (0.1-10 ppm) prevented the insects from feeding and the effect was species dependent. Nevertheless, azadirachtin stimulates specific' deterrent' cells in chemoreceptors and blocks the firing of' sugar' receptor cells, which normally stimulate feeding [8, 53, 33, 30]. Moreover, the antifeedant effects of azadirachtin are highly correlated with the sensory response of chemoreceptors on the insect mouthparts [33].

The treatment of neem plant extracts (*A. indica*) mixed with 5% biosurfactant of diethanolamideolein palm to the cocoa moth *Conopomorpha cramerella* pest showed great influence in controlling the pest [35].

In Sudan, repellency, antifeedant and insecticidal activities of *A. indica* (neem) seed extracts was investigated against *A. viduatus* under laboratory and field conditions. Results showed strong repellency and antifeedant activities [29-2], and when cucurbits treated with *A. indica* a significant increase of yield was achieved compared to the untreated ones [45-2].

(ii). Metarhizium Anisopliae

Fungal pathogens also among friendly active and safe alternatives, use against insect pests. It has been emphasized in many researches, however, *Metarhizium anisopliae* and *Beauveria bassiana*a reprobably the most promising entomopathogens for insect pest control, because they can penetrate directly through the host cuticle, and could be used underharsh climatic conditions [39]. *M. anosipliae* was used against *Agonoscelis pubscens* (Thoub) under field and laboratory conditions. Results revealed that the test insect responded to the effect of the fungus and mortality increased as the concentration increased [17]. Biological test of two pathogenic fugi *Paecilomyces lilacinus* and *Beauveria bassiana* against a sister bug litchi stink bug *Tessaratoma papillosa* (Drury) (Hemiptera, Tessaratomidae), The result revealed that the tow entomopathogenic fugi induced high mortality to *T. papillosa*, with values for cadaverrate LC50 and LT50 of 88.9%, 1.92* 10^7 conidia / mland 4.34 days respectively [27]

Based on the reported activities against insect pests, and their low mammalian toxicity. This study was initiated to evaluate the use of friendly entomopathogenic fungi *Metarhizium anisoplae* (Melsch), *Azadirachta indica*, as well as less persestant pesticides (malathion 57% EC and carbary l85% EC) against the aestivating adult of melon bug, *Aspongopus viduatus* during aestivation period to reduce environmental contamination, human and animal toxicity, as well as reducing the cost of control and etc., that was before the insect reproduction and multiplication in the field. Since the pest reproduction during active period is very high [24].

2. Materials and Methods

2.1. Area of Study

The current study was conducted at Elkhiwai, Kordofan, Sudan. Located about 700 km west of Khartoum atlatitudes 12^{c}8′-13^{c}6′ N and longitude: 9^{c}0′-29^{c}5′E.

2.1.1. Climate

The area lies within the semi-arid desert climate with limited seasonal rain. The rainy season extends from July to October with maximum rainfall in August; average annual rainfallis 382.3 – 400 mm and temperature is 24-32^c C [60].

2.1.2. Soil and Vegetation

The soil is generally sandy (Goz). Vegetation is a mixture of grasses, herbs, shrubs and trees. The trees include *Caleotropis procera* (Oshar), *Acacia senegal* (Hashab), *Guiera senegalensis* (khobeish) *Boscia senegelensis* (kursan), *Albizzia amara* (Arad), *Adanosonia digitata* (Tabaldi), *Ceratonia siliqua* (kharoob) as well as some grasses and herbs such as *Eragrostis megastachya* (Banu), *Geirgeria alatum* (Gadgad), *Aristida adscensionis* (Gau), *Cenchru ssp.* (Haskaneed), *Zornia glochidiata* (Shilini) and *Andropygon gayanus* (Abo-Rakhies) [60, 61, 25].

2.2. Control Materials

Neem seed water extract, metarhizium as well as malathion and carbaryl were tested against *A. viduatus* during the aestivation period under field condition to investigate the efficacy of the botanical gents (*Azadirachta indica*), entomopathogenic fungi (*Metarhizium anisopliae,* Melsch), and less persistant pesticides (carbaryl and malathion) on aestivating *A. viduatus.*

2.2.1. *Azadirachta indica* (neem) Preparation

Neem seed kernels were collected from El Fula, western Sudan 11^c 72′ N 28^c 34′ E. Seeds were cleaned, dried under shed. The dried seeds were grounded manually using a mortar and pestle. The obtained powder was sieved and stored in a sealed glass jar.

Twenty- five grams of neem seed powder was mixed with one liter of water (2.5%) (W/ v) as recommended by Siddig [52- 2]. The mixture was stirred thoroughly using a wooden stick and left to stand overnight, then stirred again after addition of liquid soap at the ratio 4:1 (v/v) (neem to soap) as emulsifier, and 1% molasses (liquid) (v/v) as protectant against uv light and 1% gum arabic (powder) (w/v) as sticker and anti-oxidant [2]. The mixture was filtered with a piece of cloth ready for application.

2.2.2. *Metarhizium* Preparation

Metarhizium anisopliae var-acridium IM I3301.89 was supplied by the Plant Protection Directorate (PPD), Khartoum North, Sudan. The product was transported to the study area in a cool container and kept in a refrigerator for bioassay. Fifty grams of *M. anisopliae* (powder) were taken in a closed tightly black plastic bag (protected from light). About 37.5 ml of diesel oil were injected in the bags (1:0.75 powder to oil ratio) [14] mixed thoroughly to form homogenous paste (dough), poured in a bucket (8 liter), and then topped up to one liter with diesel oil. The solution (5%w/v) was stirred, and then filtered by cloth ready for application.

2.3. Dosage Rates of Applied Materials

Malathion, carbaryl (Sevin) and sesame oil were obtained from local market (Omdurman Central Market, Sudan) used as indicated in Table 1.

Table 1. *Dosage rates of applied materials.*

Materials		Recommended dose	Half dose
1.	Carbaryl 85% wettable powder	850 g ai/L	425gai/L
2.	Malathion 57% EC	570 ml ai/L	256 ml ai/L
3.	Malathion 57% EC + sesame oil	570 ml ai/L malathion + 2.38L seseme oil/h	256 ml ai/L Malathion+1.19L seseme oil/h
4.	Metarhizium	50g Metarhizium + lL diesel oil/h	25g Metarhizium+1L diesel oil/h
5.	Dieseloil (control 1)	2.38l/h	1.19l/h
6.	Neem seed kernel water extract	1kg/40L water (2.5%)	0.5kg/40 L water (1.25%)
7.	Water (control 2)	Water	Water

ai=active ingredient
h=hectar
L=liter
g=gram

2.4. Sampling Methods and Applications

Trees of *Boscia senegalensis* sheltering *A. viduatus* in the study area were selected and divided into four blocks (Topography of the land). Blocks were then divided into seven sub-plots; two trees were randomly chosen from each plot, labeled with colored pieces of cloth and then treated with the selected spraying meterial, using the selected dose (Table 1). The distance between trees was kept at least fifteen meters to avoid drift effect. ULV sprayer was used for *Metarhizium* and diesel application while a knapsack sprayer was used formalathion, Malathion + oil and neem applications. Carbary l85% was dusted manually using a bag of mosquito net. Table 1 shows materials used, rate of application an dused in the treatments.

Control sets in treatments consisted of application of the carrier which was either water or oil (diesel). Number of dead and live insects of the experiments was determined by counting, and the dead ones were removed away.

Dead insect bodies caused by *Metarhizium* fungi were put on Petri – dishes lined with moist filter papers.

2.5. Statistical Analysis

The experiments were arranged in complete randamized block design (CRBD) with four replicates. Mortality was recorded 24 and 48 hrs for malathion and carbaryl and, 1, 2- and 3-weeks post application for neem and *Metarhizium,* nomortality was noticed in the treatment of neem and *Metarhizium* 24-48 hrs after treatment, therefore they prolonged up to three weeks. Data were subjected to analysis of variance and means were separated by fisher's least significant difference (LSD) test using the SAS system.

3. Results

3.1. Effect of Neem Seed Water Extract and *Metarhizium anisopliae* on the Test Insect

Cumulative mortality of aestivating *A. viduatus* caused by 25-50 g / h *M. anisopliae* and 1.25 - 2.5% *A. indica* under field conditions was displayied in Table 2. Results revealed that both control agents (*M. anisopliae* and *A. indica*) caused very low mortality under field condition. However, the respective final mortality of aestivating *A. viduatus* adult caused by half and recommended dose of *A. indica* and *M. anisopliae* were 0.43 - 0.96% and 0.58 -6.75%. Results indicated that mortality of A. *viduatus* 21 days after application in the field using the two mentioned agents never reached 10% even at the higher doses of *M. anisopliae* recommended by FAO [14], and that of *A. indica* recommended by [52-2]. Mortality was dose related. Fungal growth on the dead insect bodies was observed after putting treated insects on Petri-dishes lined with moist filter papers. Numbers inparentheses are the mortality percentage. Means followed by the same letters within a column are not significantly different at $P \leq 0.05$, according to the LSD

(Table 2).

Table 2. *Cumulative mortality caused by Neem (A. indica) seed water extract and Metarhizium anisopliae on aestivating melon bug under field conditions.*

Treatment	Dose	Mortality a week after application	Mortality 2weeks after application	Mortality 3 weeks after application	Total mortality after application
Neem	2.5%	0.78a (0.11%)	0.93b (0.36%)	0.99b (0.48%)	0.95%
	1.25%	0.71a (0%)	0.80b (0.14%)	0.89bc (0.29%)	0.43%
Metarhizium	50g/h	0.80a (0.14%)	1.65a (2.22%)	2.21a (4.38%)	6.74%
	25g/h	0.71a (0%)	1.04b (0.58%)	0.71c (0%)	0.58%
Diesel (control 1)	1L/h	0.80a (0.14%)	1.02b (0.54%)	0.71c (0%)	0.68%
	0.5L/h	0.80a (0.14%)	0.71b (0)	0.71b (0)	0.14%
Control (2)	Water	0.71a (0%)	0.71b (0%)	0.71b (0%)	0.0%
LSD		0.11	0.36	0.23	
±SE		0.07±	0.21±	±0.13	

Means followed the same letters in the same column are not significantly different at $P < 0.05$
Percentage data transferred to arc sign $\sqrt{\% + 0.05}$
Numbers inparenthesis are mortality percentages

3.2. Effect of Carbaryl and Malathion on the Test Insect

Table 3 conveyed the results regarding the use of low persistant pesticides (carbaryl and malathion) tested against *A. viduatus* under field condition during its aestivation period. Results evidenced that, carbaryl, malathion and malathion + sesame oil over 24- 48 hrs after application caused significant mortality on aestivating form of *A. viduatus* (melonbugs) compared to the control. The effect was dose related with mortality ranging from 24.5 - 54.2 to 27.62 - 28.82%; 3.3 -10 to 2.18 - 6.25%; 4.3 - 6.8 to 8.21 -9.95% forcarbaryl, malathion and malathion + sesame oil in the half and recommended dose for the first and second day after application respectively. Results indicate the following overall order of efficacy carbaryl > malathion > malathion + oil.

The respective final mortality of aestivating adult of the test insect caused by half and recommended dose of carbaryl, malathion and malathion + sesame oil two days after application were 62.12 - 83.02%, 5.38 - 16.25%, and 8.21 -9.95%. Numbers inparentheses are the mortality percentage. Means followed by the same letters within a column are not significantly differentat $P \leq 0.05$, according to the LSD (Table 3).

Table 3. *Effect of chemical pesticides on aestivating A. viduatus on the first and scound day after application under field conditions.*

Insecticide	Dose	Dead insects 24 hrs after application	Dead insects 48 hrs after application	Cumulitive Dead insects%
Carbaryl	850 gai/L	6.43^{a} (54.2)	5.99^{a} (28.82)	83.02
	425 gai/L	4.7^{b} (24.5)	5.1^{a} (27.62)	62.12
Malathion	570 mlai/L	3.23^{c} (10)	2.60^{b} (6.25)	16.25
	256 mlai/L	1.91^{d} (3.3)	1.62^{bc} (2.18)	5.38
Malathion+Sesame Oil	570 mlai/L malathion+2.38 seseme oil/h	2.65^{cd} (6.8)	1.81^{bc} (3.87)	9.95
	256 mlai/L malathion+1.19 L seseme oil/h	2.23^{cd} (4.3)	2.14^{b} (3.91)	8.21
Control	Water	0.63^{e} (0.35)	0.77^{c} (0.35)	0.70
LSD		1.16	1.23	
±SE		±0.67	±0.71	

Means followed the same letters in the same column are not significantly different at $P < 0.05$
Percentage data were transferred to arc sign$\sqrt{\% + 0.05}$
Numbers inparenthesis are mortality percentages

4. Discussion

4.1. *Metarhizium anisopliae* and Neem Seed Water Extract

(i). *Metarhizium anisopliae*

Metarhizium anisopliae as environmentaly friendly material caused very low mortality to *A. viduatus* (lessthan 10%, 21 days after application). The relatively very low mortality caused by *M. anisopliae* might be due to the fact that the aestivating insects moved very little during aestivation; hence there was no sufficient contact with the applied materials. However, the test insect in the astivation period hide in dark places, covered itsself with tree leaves, weeds and debrises, which, eventually keeping the target away from being subjected to the control materials, and reduce the reach of the drop-lets of the applied materials. Hidig process is well known behavior among bugs. However, sister stink bug *Hylyomorph halys* (Stal), Hetroptera, Pentatomidae, have fundamental preference for dark places wether or not they are in diapouses, which plays a main role in hiding behavior [62]

The doses used might also be sub-lethal. *M. anisopliae* when used against *Agonoscelis pubescens* (Doraandat) during the resting period caused relatively low mortality (48% after 18 days) [17]. The relatively high mortality of *Agonoscelis pubescens* (Heteroptera) caused by *M. anisopliae* compared to that caused by the same agent to *A. viduatus* (Heteroptera) might be due to the tolerance of the latters pecies against the fungus because some strains of *M. anisopliae* are species specific and are therefore less effective against *A. viduatus*. When *Paecilomyces lilacinus* and *Beauveria bassiana* were used against a sister litchi stink bug *Tessaratoma papillosa* (Drury) (Hemiptera, Tessaratomidae), the result revealed that the tow entomopathogenic fugi induced high mortality to *T. papillosa* [27].

However, *A. viduatus* was found to aestivate under so many types of trees, grasses and herbs during the dry season. In such places it tends to settle on the ground, around the main stem close to the soil surface, or among dead leaves under shelter plants. It astivates covered with the leaves, weeds and debrises [25], which may reduce the drop-lets of the pesticides pray from reaching-the target insect compared to *A. pubescens* that aestivates un-covered on trees' trunks.

(ii). *Azadirachta indica*

Azadirachta indica (neem tree) caused very low mortality to *A. viduatus* (less than 5%, 21 days after, application). The poor performance of neem seed extract against the *A. viduatus* has also been reported by someworkers, they used neem seed water extract against field population of *A. viduatus* (duringtheactiveperiod) and found them less effective [2, 52, 45]. Nevertheless azadirachtin (active ingredient of neem) has shown to be effective in the field, and showed good results against *Schistocerca gregaria* nymphs infesting barley seedlings even at low doses (2 ppm) [23-34]. *Spodoptera frugiperda* (fall armyworm), *S. littoralis* (African cotton leaf worm), *Heliothis virescens* (F.) (tobacco bud worm) and *Helicover paarmigera* (old world boll worm) responded behaviorally to low concentrations of azadirachtin. It also showed antifeedant, repellent and physiological disorder activities, however the effect was species dependent [8, 53, 48, 19, 33]. Also, it was found that neem extracts influenced the fecundity of Homopteran strongly [48]. They inhibited male and female reproduction [41]. The treatment of neem plant extracts (*A. indica*) mixed with 5% biosurfactant of diethanolamide olein palm against the cocoa moth *Conopomorpha cramerella* showed great influence in controlling the pest [35].

For the same reasons mentioned earier, aestivatation of the test insect among dead leaves and debrises covered with these meterials, may reduce the reach of azadirachtin drop-lets and/or any other pesticide spray from reaching-the target and affecting it, therefore it would be eventually less effective. Also some materials are species specific.

The ability of *A. indica* derivatives and *M. anisopliae* (Melsch) to cause significant mortality to the test insect needs further evaluation considering other factors such as climate parameters (temperature, relative humidity, photoperiod, etc.), increasing doses, dosing characteristic, formulation and presentation, application methods, etc.).

4.2. Full Toxic Effect

Theend-points mortality was defined as observation period where treated individuals either died or recovered (i.e. the poison has exerted its full toxic effect) [6]. The post-treatment observation period can have profound effects on dosage response measurement particularly when the speed of the position is dependant on the dosage [59].

Physiological disorder, and increase in death of test insects are expected to occur within or after three weeks post application (especially when use *A. indica*a nd *M. anisopliae*), however it was not possible to evaluate them in this experiment, because physiological studies and post observation (after three weeks) were not done and therefore any evaluation of physiological disorder or increase in mortality of test insects could give false results.

4.3. Carbaryl and Malathion

The less persistant pesticides (carbaryl and malathion) used in the current study concluded that aestivating *A. viduatus* was sensitive to carbaryl and malathion (concentrations 850 gai / L and 570 ml ai / L respectively), however the respective 83% and 62% mortality could occur tow days after application. Most of the tested concentrations were significantly effective with dose-dependant effects. Increasing concentration caused a significant increase in mortality. The results confermed the sensivity of aestivating *A. viduatus* adult to carbaryl and malathion. The obtained results improved by optimize dossages, testing and improving new methods of application.

Carbaryl was the most effective followed indecending order by malathion and malathion + sesame oil (plantoil). The plant oil (sesame) had no synergistic activity and didn't affect the test insect positively, when applied to malathion but, it reduced the action of malathion slightly. Carbaryl was shown by many workers that it was a broad spectrum insecticide, it could control a wide range of arthropods pests including, beetles, moths, fleas, flies, lice, mites, krickts, grasshoppers, bugs, thrips, tics, cockroaches, aphids and etc. [38]

Both carbaryl and malathion had so far been used extensively against *A. viduatus* [45-29], during the growing season, the tow agents were found very effective and showed high mortality especially against nymphs [64, 45, 29, 2].

Since carbaryl is moderately toxic, doesn't accumulate inmammals, rapidly broken down and completely excreted out within few hours [9, 42, 56, 57, 55] as well as malathion that, had low toxicity to mammals, cleaned out mammalian body within few days [26- 55]. Hence, the tow agents are less persistant pesticides, needed to be considered in new approaches of pest control strategies, as well as in integrated pest management (IPM).

The fact that *A. viduatus* is one of the major pest of cucurbits partiulary on water melon. Both adults and nymphs are very distructive, and may even cause total failure of the crop. As the crop fruit is usually consumed by human and animal, and it is a source of cash, water hard currency. There is an additional merit for applicability of using environmentally friendly products (*M. anisopliae,* Melschand

A. indica extracts), Their high biodegradability, affect only target pest, environmently friendly, cheapness, and good availability, as well as the less persistant pesticides (carbaryl and malathion) in *A. viduatus* control. Hence there should be some objections on the use of chemicals in controlling the target pest, since synthetic pesticides in control has caused serious environmental problems which include contamination of the environment, toxicity to man, animals, beneficial insects and other non-target organisms [36, 20, 44]. Validation of these results (the control of aestivated *A. viduatus*) was during aestivation period in limited areas (aestivation areas), could be managed by few workers or technicians to insure safety, effectiveness and proper handling of the pesticides, more over pesticides were less persistant and used before reproduction and multiplication of the test insect, since reproductiveability of the test insect in the growing seasonis very high [24]. Further investigations will be addressed to optimize dossages, and using new techniques, clean-up, separation and identification of the components of active materials of *A. indica* (neem) and use other *M. anisopliae* strains as well as improve methods of application in future work.

5. Conclusions

Carbaryl, malathion and malathion + sesame oil caused significant mortality to the aestivating *A. viduatus.* Effect was dose related and Carbaryl was the best followed by malathion and malathion + sesameoil.

Neem and *Metarhizium* caused very little death to the *A. viduatus* and mortality never reached 10%, 21 days after application.

Control of *A. viduatus* during aestivation is highly needed since the control could be carried out in limited areas, done by few workers or technicians and crried before the target insect reproduction. However, summer is the most suitable period for the control of *A. viduatus*, as the insects at this time area aestivating in large numbers and are subjected to the stress of the dry season (high temperature) which depletes their food reserve.

6. Recommendation

The use of chemicals for the control of *A. viduatus* should be recommended during aestivation period only and must be done by the technicians to ensure safety, effectiveness and proper handling.

The use of neem and Metarhizium for the control of *A. viduatus* in the field needs more investigations with higher concentrations, new application techniques, clean-up, separation and identification of the components of active materials as well as using other *M. anisopliae* strains.

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