International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Evaluation of Water Extracts from Seven Sudanese Plants as Natural Insecticides

Elnile A. A. Yousif[1], Abdalla A. Satti[2]

[1]Sudan University of Science & Technology, College of Agricultural Studies, Khartoum North, Sudan

[2]Environment, Natural Resources and Desertification Research Institute, National Centre for Research, P.O. Box 6096, Khartoum, Sudan

Abstract: ***Laboratory studies were carried out to evaluate the insecticidal potentialities of water extracts prepared from seven indigenous plant species in Sudan. These plants included; Azadirachta indica, Dodonaea viscosa, Lantana camara, Artemisia herba-alba, Ocimum basilicum, Nicotiana rustica and Solenostemma argel. Only leaves extracts were used from these plants, except for A. herba-alba the whole herb was extracted. Three concentrations (2.5%, 5% and 10% w/v) from each plant extract were bio-assayed against the 3rd instar larvae of Trogoderma granarium, as a test insect. All botanical treatments showed positive dose related effects on the pest during various investigation periods. Comparison of the highest concentrations (10%) among all plants showed no significant variations up to three days post exposure. Thenceforth, the ranking in a descending order showed A. indica on the top as the most effective plant, followed by O. basilicum, L. camara, N. rustica, D. viscosa, A. herba-alba and S. argel. No significant differences were found between 5% and 10% concentrations regarding S. argel, A. indica and O. basilicum. Moreover, the latter two plants induced 100% mortalities within 18 days of treatments, preceding other plants, hence considered as the most effective of all tested species. These two plant species, plus L. camara, are recommended for further studies as potent sources of natural insecticides.***

Keywords: Insecticidal effect, water extract, botanical insecticide, delayed effect, *Azadirachta indica*, *Ocimum basilicum*, Sudan.

1. Introduction

Application of conventional chemical insecticides is the main tactic used for controlling different insect pests in agriculture and public health fields all over the world [1]-[2]. Post harvest products in the storage are also subjected to heavy treatments with various insecticides through spays or fumigation. The irrational extensive usage of chemical pesticides during the last century has led to several well known drawbacks in Sudan and elsewhere in the world. They contaminated the environment, affected beneficial fauna, created insecticidal resistant strains of different insect pests, and consequently led to pests' resurgence and outbreaks of secondary species [1]-[3]-[4]-[5]. However, preliminary works in the region proved the occurrence of insecticidal resistant insect species particularly among field and store pests in agriculture [6]-[7]-[8] as well as pests of public health like mosquitoes [9]-[10].

Accordingly, there is a renewal of interest in the use of plant materials and their extracts as protectants for both field crops and stored commodities. Plant materials represent untapped reservoir of chemical constituents required to combat pests attack through repellency, antifeedant action or by showing insecticidal or hormonal activities against various pests. Moreover, such natural products were found to be cheaper, safer, biodegradable, and relatively less toxic to non-target species and domestic animals, as compared to synthetic pesticides. Therefore, several plant extracts have been investigated worldwide and more than 2000 plant species were reported to contain pest control properties, some of them proved promising effects [11]-[12]-[13]-[14]. So far, very little botanical pesticides were formulated for practical use, and hence more research efforts are needed to be fully exploited.

The Sudan, encompassing virtually every geographical and climatic feature from the arid north to the tropical rain forests in the south, is considered as one of the richest African countries in natural flora. Yet, the meager research conducted proved the occurrence of several indigenous plants with encouraging active ingredients against different pests [14]-[15]-[16]. Therefore, a project was put forward to screen potent indigenous flora for insecticidal properties. As an activity in such project, this study was proposed to evaluate the insecticidal effects of seven plant species using aqueous extracts against the larval stage of the Khapra beetle (*Trogoderma granarium*), a pest which commonly utilized in bioassays.

2. Materials and Methods

Laboratory experiments were conducted at the College of Agricultural Studies, Sudan University of Science and Technology- Shambat/ Khartoum North, for the purpose of screening water extracts prepared from seven indigenous plant species as insecticides against the 3rd instar larvae of the khapra beetle (*Trogoderma granarium*). The average room temperature during the experimental period was 29ºC.

2.1. Plants materials and insect culture

The seven studied plants included *Azadirachta indica*, *Dodonaea viscosa*, *Lantana camara*, *Artemisia herba-alba*, *Ocimum basilicum*, *Nicotiana rustica*, and *Solenostemma argel*. Only leaves were used from all plant species, except for *A. herba-alba* the whole plant was used. These plant samples were collected during summer season (April-June), dried under shade condition and stored in paper sacks.

A sample of *Trogoderma granarium* was brought from the Department of Plant Protection, Faculty of Agriculture,

University of Khartoum; and reared for several months to breed under laboratory conditions. Stock of 3rd instar larvae were then secured for the bioassay tests.

2.2. Preparation of water extracts

The dry samples of all plant species were ground finely using an electric blender. A weight of 10g powder from each plant was taken per 250 ml conical flasks where 50 ml of tap water was added, and left to stand overnight (12h). In the second day, such samples were mixed vigorously for about six hours on a magnetic stirrer before filtrations using filter papers (0.9mm). The volumes were completed with water to 100ml to obtain 10% (w/v) concentrations of all plants extracts. Another two concentrations (5% and 2.5%) were also prepared from these extracts through serial dilutions.

2.3. Bioassay treatments

Eighty four clean plastic Petri dishes were prepared to accommodate each experiment. Each 10g sound and clean sorghum (*Sorghum bicolor*) seeds were treated with respective plant aqueous extract concentration, and left to dry for 10 minutes under room conditions. Such treated seeds were introduced in the Petri dishes, including an untreated control, where ten 3rd instar larvae of *Trogoderma granarium* were simultaneously added. Three replications were applied and arranged in a Completely Randomized design. The extract concentrations of the different plants were evaluated in separate experiments, but the highest concentration (10%) of the seven plant extracts were compared in the last experiment.

Investigations of the Petri dishes were done on the 2nd and 3rd days, and thenceforth every 3 days until the end of the experiment (27 days). The number of dead insects and other observations (e.g., feeding activity) were recorded per each count. Data of mortality percents were statistically analyzed; and then compared according to Duncan's Multiple Range Test.

3. Results and Discussion

The larval mortality results obtained from the seven plant extracts at different intervals from treatments were presented in table 1. Generally, all treatments exerted variable mortality effects on the pest, and in most cases some larvae were observed crawling away from the treated seeds, suggesting the presence of repellent effects. The detailed mortality results for each plant were explained below.

Neem leaves water extract at 10% concentration gave the best significant results compared with all other treatments, during the different periods. Such concentration showed its superior effect in 48h and attained 100% mortality on the 18th day, preceding the other treatments. However, from the 10th day and onwards, the medium dosage rate (5%) of neem extract manifested significantly comparable effect with that of its highest dose, which proved the potentiality of neem.

The result of *Dodonaea viscosa* leaves extract at 48h and 72h, manifested significant mortality effect on the insect compared with the untreated control, but without significant differences between the three dosage rates. At the end of first week, the effect of the highest concentration (10%) surpassed the other rates significantly inducing 100% mortality by the end of the third week. However, from this point onwards, the two lower doses showed relatively poor effects.

The highest concentration (10%) of *Lantana camara* gave significantly the highest mortality rates almost during all times of investigations, as compared with the other two concentrations and the control. It scored 100% mortality on the 3rd week. However, the lower doses (5% and 2.5%) started to show significant effects from the 3rd day onwards, compared with those of the control check.

The effect of *Artemisia herba-alba* extract at the three concentrations, during the first week, showed more or less similar significant results compared with the control. From the 10th day onwards, the highest rate (10%) was significantly better, and therefore attained its full mortality percent after 27 days preceding the other treatments.

Regarding "Rehan" *Ocimum basilicum*, the 10% concentration also showed the best significant effect on the second day of treatment. But, in subsequent counts both 10% and 5% levels gave similar significant results when compared with those of the lowest concentration (2.5%) and the untreated check. Termination (100%) of insect mortality for the highest dose was achieved on the 18th day, almost similar to what have been mentioned for neem treatment.

Tobacco (*Nicotiana rustica*) treatments at all concentrations induced significantly similar effect during the first three days. Slightly before the second week and onwards, the 10% extract was significantly superior to other treatments, causing full mortality at the end of 21st day. On the other hand, the two lowest concentrations seemed to lose their insecticidal actions after such period, as appeared from stable mortality data.

Lastly, all concentrations of "Argel" *Solenostemma argel* exerted significantly similar results during the first week, compared with the untreated control. After the first week, the 10% and 5% concentrations were almost significantly better than the lower dose and the control. In other way, no significant difference was appeared between the performances of these two concentrations (10% and 5%).

In general, the results of testing the insecticidal effects of all water extracts of the seven plants, each at three dosage rates (2.5%, 5% and 10%), showed that the rate of insect mortality increases with an increase in concentration and exposure time. Since these plants were observed to show some variable degrees of repellent actions on the pest, hence the chances of getting lethal doses were ultimately increased with an increase in concentration. It is worthy to state that some of these plants such as neem extracts were reported to act in various ways against insects, including repellent effects [13]-[17]. Besides this fact, it seemed that the tested plants exerted their killing effects on insects largely through

stomach action rather than contact action. Therefore, relatively longer time was required to induce their mortality effects.

Moreover, the results of individual plants bioassays proved that the highest concentration (10%) was the best treatment in

Table 1: Insecticidal effects of water extracts* of seven local plant species, when applied at different doses against the 3rd instar larvae of *Trogoderma granarium*.

Doses/ Plant sp.	Mean mortality percents at different days from treatments									
	2	3	7	10	13	16	18	21	24	27
***Azadirachta indica*:**										
10%	13.0a	23.0a	56.0a	73.0a	87.0a	97.0a	100.0a	-	-	-
5%	07.0ab	10.0b	43.0b	67.0a	77.0a	93.0a	97.0a	100.0a	-	-
2.5%	03.0b	03.0bc	33.0b	47.0b	57.0b	67.0b	73.0b	97.0a	100.0a	-
Control	00.0b	00.0c	00.0c	00.0c	00.0c	00.0c	00.0c	07.0b	13.0b	23.0
C.V%	85.7	44.5	15.0	10.7	12.9	7.8	7.3	5.3	3.6	3.5
SE±	0.2	0.3	0.6	6.9	1.0	1.2	1.2	1.1	1.0	1.0
***Dodonaea viscosa*:**										
10%	10.0a	23.0a	43.0a	63.0a	70.0a	80.0a	90.0a	100.0a	-	-
5%	13.0a	17.0a	40.0ab	53.0b	60.0b	67.0b	73.0b	90.0a	90.0a	97.0a
2.5%	10.0a	17.0a	30.0b	43.0c	50.0b	57.0b	63.0b	77.0b	83.0b	87.0b
Control	00.0b	00.0b	00.0c	00.0d	00.0c	00.0c	00.0c	07.0c	13.0c	23.0c
C.V%	86.4	61.1	20.4	12.5	15.7	12.7	12.1	9.02	7.9	6.5
SE±	0.3	0.3	0.5	0.7	0.8	0.9	1.0	1.0	1.0	0.9
***Lantana camara*:**										
10%	23.0a	23.0a	53.0a	70.0a	77.0a	83.0a	97.0a	100.0a	-	-
5%	07.0b	23.0a	37.0b	53.0b	57.0b	63.0b	73.0b	93.0a	100.0a	-
2.5%	07.0b	13.0ab	30.0b	43.0b	50.0b	53.0b	63.0b	77.0b	80.0b	87.0a
Control	00.0b	00.0b	00.0c	00.0c	00.0c	00.0c	00.0c	07.0c	13.0c	23.0b
C.V%	45.6	66.7	21.5	15.5	30.5	10.0	9.6	7.01	7.6	8.2
SE±	0.3	0.4	0.6	0.8	0.9	0.9	1.0	1.0	1.0	0.9
***Artemisia herba-alba*:**										
10%	20.0a	20.0a	37.0a	43.0a	60.0a	67.0a	73.0a	83.0a	97.0a	100.0a
5%	17.0ab	27.0a	27.0ab	37.0b	50.0b	50.0b	57.0b	60.0b	80.0b	87.0b
2.5%	10.0ab	13.0a	17.0ab	30.0b	43.0b	47.0b	53.0b	57.0b	73.0b	80.0b
Control	0.0b	00.0b	00.0b	00.0c	00.0c	00.0c	00.0c	07.0c	13.0c	23.0c
C.V%	51.6	61.2	50.3	27.2	23.5	10.9	9.7	10.7	5.6	8.5
SE±	0.3	0.5	0.6	0.7	0.8	0.8	0.8	1.0	0.9	0.9
***Ocimum basilicum*:**										
10%	17.0a	20.0a	50.0a	60.0a	73.0a	83.0a	100.0a	-	-	-
5%	10.0ab	13.0a	40.0a	50.0a	70.0a	83.0a	90.0a	97.0a	100.0a	-
2.5%	03.0b	13.0a	23.0b	30.0b	43.0b	53.0b	67.0b	80.0b	90.0a	97.0a
Control	00.0b	00.0b	00.0c	00.0c	00.0c	00.0c	00.0c	07.0c	13.0b	23.0b
C.V%	86.1	55.3	20.4	20.2	13.8	15.8	9.8	8.9	7.4	5.0
SE±	0.2	0.3	0.6	0.7	0.9	1.1	1.1	1.1	1.0	1.0
***Nicotiana rustica*:**										
10%	13.0a	23.0a	47.0a	57.0a	73.0a	83.0a	97.0a	100.0a	-	-
5%	17.0a	20.0a	40.0ab	43.0ab	53.0b	60.0b	70.0b	90.0a	97.0a	97.0a
2.5%	03.0a	20.0a	33.0b	37.0b	47.0b	53.0b	60.0b	73.0b	83.0b	83.0b
Control	00.0b	00.0b	00.0c	00.0c	00.0c	00.0c	00.0c	07.0c	13.0c	23.0c
C.V%	92.3	36.5	13.6	25.4	16.3	19.5	14	9.3	5.4	6.3
SE±	0.3	0.3	0.5	0.7	0.8	0.9	1.0	1.0	1.0	0.9
***Solenostemma argel*:**										
10%	10.0a	17.0a	20.0a	43.0a	60.0a	60.0a	70.0a	80.0a	90.0a	93.0a
5%	10.0a	17.0a	17.0a	33.0ab	50.0ab	60.0a	63.0a	73.0a	90.0a	93.0a
2.5%	100a	17.0a	20.0a	27.0b	43.0b	50.0a	57.0a	57.0b	70.0b	70.0b
Control	00.0a	00.0b	00.0b	00.0c	00.0c	00.0b	00.0b	07.0c	13.0c	23.0c
C.V%	42.9	53.9	19.4	19.9	20.4	13.6	13.0	11.6	7.1	9.5
SE±	0.2	0.3	0.5	0.7	0.8	0.9	0.9	1.0	0.9	0.9

*= Only leaves were extracted from all plants, except *A. herba-alba* the whole plant was used.

Means with the same letter (s), in each column of individual plants, are not significantly different at 0.05 level (based on DMR test).

all cases. Therefore, the comparison of mortality results obtained from such plants at 10% concentrations was explained in table 2. On the second day (48h) of treatments, *Lantana camara* leaves gave the highest mortality mean (23.0% dead larvae), followed by *Artemisia herba-alba* (20.0%), *Ocimum basilicum* (17.0%) and *Azadirachta indica* (13.0%). Nevertheless, equally during the second (48h) and third (72h) day's intervals, all botanical extracts exerted more or less comparable low mortality results

without significant differences between them. On the seventh day, the neem treatment surpassed all other treatments significantly in its effect on larvae (56.0% mortality), but without significant differences from *L. camara* (53.0%) and *O. basilicum* (50.0%) treatments. From the second week (16th day) onwards, the results of *O. basilicum* and *Nicotiana rustica* were significantly compared with those of neem and lantana on the top rank. However, following the previous four plants, *Dodonaea viscosa* extract manifested 100% larval mortality by the end of the 3rd week (21 days). Again, all treatments of the studied plants showed progressively increasing effects with an increase in exposure time.

Considering the literature of botanical insecticides, similar results were reported showing the effect of concentrations on the bioactivities of some extracts [13]-[17]-[18]-[19]. On the other hand, the lower concentrations in this study seemed to lose their activities earlier and no progresses in mortalities were observed from most plants during later counts. As mentioned above, the insects might have lower chances in this case to ingest lethal doses with such lower concentrations. The reason could also be attributed partially to the fact that most plant products are characterized by relatively fast degradation rates due to their instability under several climatic conditions such as light and air [20]-[21].

Comparing all plants at 10% concentrations (Table 2) showed no significant differences between insect mortality means during the first three days of treatments, although *Lantana camara* was the best. This ensured what has been mentioned previously about stomach actions of these plants which delayed their killing effects. The delayed effects of some plants preparations including neem were also reported by some authors [13]-[17]-[22].

Therefore, after one week of treatments prominent variations were detected between the different plants extracts. At this stage, *Azadirachta indica*, *Ocimum basilicum* and *Lantana camara* showed the best significant results compared with the other plants. However, after the second week *Nicotiana rustica* achieved significantly similar effect. Considering these plant species, *O. basilicum* extract showed no significant difference between 5% and 10% concentrations during the experimental time as recorded above. This was also applied to *A. indica* and *L. camara* during later counts. Furthermore, the 10% concentrations of *A. indica* and *O. basilicum* induced 100% mortalities within 18 days surpassing other treatments. On the other hand, *N. rustica* and *Dodonaea viscosa* were similar to *L. camara* in that they performed 100% mortalities after three weeks. Although poor insecticidal results were reflected by *S. argel* treatments as compared with the other plants, but this plant species was compensated for that by manifesting significantly equivalent effects at its two concentration levels, 5% and 10%.

Actually several research works were performed in different parts of the world showing the various biological activities of neem on different insect pests, but the literature regarding the other investigated plants were very scanty and scattered. The activities of neem were principally pertained to its constituents of numerous bioactive substances which proved cause insecticidal, repellent, antifeedant and growth regulatory effects on various pests [13]. Sir Elkhatim (2005), showed the insecticidal and repellent actions of neem and *S. argel* aqueous extracts against *Tribolium castaneum* [18]. On the other hand, *O. basilicum* and *L. camara* were also reported as potent insecticidal plants in Sudan [23]-[24]. Deshparadae and Tipins (1977) and Gubara (1983) related the toxic action of *O. basilicum* against the store insects to the presence of several active compounds including for instances; cineale, linalool, methyl cinnamate and methyl chavicol [23]-[25].

In spite of the fact that neem leaves have less amount of active substances compared with seed kernels [13], Siddig (1991) and Siddig and Baleela (2007) working in Sudan showed promising results from using neem leaves water extract against store pests, and recommended their application because of the availability of leaves all the year round [26]-[27]. Although neem leaves, which are less potent than seeds, are used in this study, the findings explained that no one of the chosen plants was better than the neem in controlling the store pest, *T. granarium*. Nevertheless, the current findings proved the biological activities of the seven studied plants, and encouraging more research in this field.

Table 2: Comparison of mortality effects of seven plants water extracts* at 10% concentration on the 3rd instar larvae of *Trogoderma granarium*

Plant sp.	Mean mortality percents at different days from treatments						
	2	3	7	10	16	21	27
A	13.0ab	23.0a	56.0a	73.0a	97.0a	100.0a	-
B	10.0ab	23.0a	43.0bc	63.0b	80.0b	100.0a	-
C	23.0a	23.0a	53.0ab	70.0ab	83.0ab	100.0a	-
D	20.0ab	20.0a	37.0bc	43.0c	67.0bc	083.0ab	100.0a
E	17.0ab	20.0a	50.0ab	60.0b	83.0ab	100.0a	-
F	13.0ab	23.0a	47.0b	57.0bc	83.0ab	100.0a	-
G	10.0ab	17.0a	20.0c	43.0c	60.0c	080.0b	093.0a
Contr.	00.0b	00.0b	00.0d	00.0d	07.0d	013.0c	023.0b
C.V %	55.6	40.4	11.9	14.0	12.1	4.7	2.3
SE±	0.2	0.2	0.4	0.5	0.5	0.6	0.3

*= Only leaves were extracted from all plants, except *A. herba-alba* the whole plant was used.

The seven compared plants were; A= *Azadirachta indica*, B= *Dodonaea viscosa*, C= *Lantana camara*, D= *Artemisia herba-alba*, E= *Ocimum basilicum*, F= *Nicotiana rustica*, G= *Solenostemma argel*. Means followed by the same letter(s), in each column, are not significantly different at 0.05 level (based on DMR test.

4. Conclusion

Comparison of insecticidal effects manifested by leaves water extracts of seven plant species revealed that,

Azadirachta indica, *Ocimum basilicum* and *Lantana camara* were the most effective, in descending order, against the larvae of *Trogoderma granarium*. The potent insecticidal actions obtained by these plants are encouraging for additional advanced research to incorporate such botanical extracts in integrated pest management programmes. However, future studies may include proper evaluation of repellent and antifeedant actions of these extracts, besides their phytochemical analysis through modern techniques. This can be done concurrently with bioassays against different pests, as well as screening of other active plants which might lead to discovery of a plant with better performance than that of the neem extract.

References

[1] El Zorgani, G.A. and Abbadi, K.H. (1986). Pesticides and their residues. In: Bashir S., El Tigani K.B., El Tayeb Y.M., Khalifa H. (eds.), Crop pest management in the Sudan. Proceedings of a Symposium held in Khartoum, February 1978. Published by the Ministry of Agriculture and the University of Khartoum, Sudan. pp. 400-408.

[2] Azami, M.A., Naqvi, S.N.H., Akhtar, K., Ahmed, I. (1996). Determination of cholinesterase in Standard and wild culicine mosquito larvae of Karachi region after treatment with DDT and malathion. Pakistan J. entomol 3(2): 115–124.

[3] Liedholm, B.O., and Amisi, J.L. (1986). Acetyl cholinesterase activity and organochlorine residues in the blood of DLCO-EA and plant protection staff in the Sudan. Crop Pest Management in the Sudan; Proceedings of a Symposium held in Khartoum, Feb. 1978, Ministry of Agriculture and Univ. of Khartoum, Khartoum University Press, Khartoum, pp. 409 – 415.

[4] Abdelrahman, A.A., and Mohamed, A.H. (2002). Integrated pests management in Sudan – methods and future prospects. Seminar of Pests Management in the third Millennium, 24 September 2001, Khartoum, Sudan.

[5] Abdel Bagi, A.O., Ahmed, A.A.M., Elhindi, M., and Ali, A.M. (2006). Impact of pesticides and other chemicals on the environment. Workshop on Post Conflict National Plan for Environmental Management in Sudan, 18 – 20 July 2006 Friendships Hall, Khartoum, Sudan.

[6] Abdel Daffie, E.Y.A., Elhaj, E.A., and Bashir, N.H.H. (1987). Resistance in the cotton whitefly, *Bemisia tabaci* (Genn.), to insecticides recently introduced into Sudan Gezira. Tropical Pest Management, 33 (4): 283 – 286.

[7] Mohamed, A.H. (1987). A study of malathion resistance in *Tribolium castaneum* (Herbst). FAO Workshop on Storage and Preservation of Pests of Stored Agricultural Products. Plant Protection, Khartoum.

[8] Assad, Y.O.H., Bashir, N.H.H., and Eltoum, E.M.A. (2006). Evaluation of various insecticides on the cotton whitefly, *Bemisia tabaci* (Genn.); population control and development of resistance in Sudan Gerira. Resistance Pest Management Newsletter, 15 (2): 7 – 12.

[9] Ranson H, Abdalla H, Badolo A, Guelbeogo WM, Kerah-Hinzoumbe C, Yangalbe-Kalnone E, Sagnon N, Simard F, Coetzee M (2009). Insecticide resistance in *Anopheles gambiae:* data from the first year of a multi-country study highlight the extent of the problem. Malaria Journal 8: 299. doi:10.1186/1475-2875-8-299.

[10] Matambo, T.S., Abdalla, H., Brooke, B.D., Koekemoer, L.L., Mnzava, A., Hunt, R.H., Coetzee, M. (2007). Insecticide resistance in the malaria mosquito *Anopheles arabiensis* and association with the kdr mutation. Medical and Veterinary Entomology 21(1):97–102.

[11] Novozhilov, K.V. (1938). The future of plant protection in agriculture on "Advance in pesticide science (IVPAC). By Gressbuhlor. H. Prergamon press, New York. Part: pp. 15 – 24.

[12] Whitehead, D.L., and Bowers, W.S. (1983). Natural products for innovative pest management (current themes in tropical science), 1st ed. Oxford (Oxford shire), New York, Pergamon Press. 550 pp.

[13] Schmutterer, H. (1995). The neem tree *Azadirachta indica* A. Juss and other meliaceous plants, sources of unique natural products for integrated pest management, medicine, industry and other purposes. VCH, New York. 696pp.

[14] Satti, A.A., Hashim, H.A., Nasr, O.E. (2010). Biologically active chemicals with pesticidal properties in some Sudanese plants. Journal of International Environmental Application & Science 5(5): 767–780.

[15] Dittrich, V., Hassan, S.O. and Ernst G.H. (1985). Sudanese cotton and whitefly: a case study of the emergence of a new primary pest. *Crop Protection*, 4. 161 – 176.

[16] Satti, A.A.; Nasr, O.E., and Bashir, N.H.H. (2004). Technology of natural pesticides: production and uses in Sudan. The Second National Pest Management Conference in the Sudan, 6-9 December 2004, Faculty of Agricultural Sciences, University of Gezira, Sudan.

[17] Satti, A.A. and Elamin, M.M. (2012). Insecticidal activities of two meliaceous plants against *Trogoderma granarium* Everts (Coleoptera: Dermestidae). International Journal of Science and Nature, 3(3): 696 – 701.

[18] Sir Elkhatim M.M. (2005). Efficacy of selected plant products on the control of *Tribolium castaneum* (Herbs.) (Coleoptera: Tenebrionidae). M. Sc. Thesis, University of Khartoum, Sudan.

[19] Satti, A.A. and Nasr, O.E. (2006). Effect of neem *(Azadirachta indica* A. Juss) seed powder and aqueous extracts on the control of some major foliage insect pests of eggplant. *Al Buhuth*, 10(1): 1 – 16.

[20] Casida, J.E. (1983). Development of synthetic insecticides from natural products: case history of pyrethroids from pyrethrins. *Natural Products for Innovative pest Management* (current themes in Tropical Science; V. 2). 1st ed. Pergamon press Ltd, 109 – 126.

[21] Bowers, W.S. (1983). The search for fourth generation pesticides. *Natural products for Innovative Pest*

Management (Current themes in Tropical Science, V. 2) 1st ed. Pergamon press Ltd., 47 – 58.

[22] Satti, A.A.; Bashir, N.H.H.; Elkhidir, E., and Nasr, O.E. (2003). Effect of neem seed kernel and "handal" extracts on muskmelon pests complex. *University of Khartoum Journal of Agricultural Sciences* 11 (1): 40 – 58.

[23] Gubara, A.F.A. (1983). A comparative study on the insecticidal potentialities of Neem (*Azadirachta indica* A. Juss) and Rehan (*Ocimum* spp.). M.Sc. Thesis, University of Khartoum-Sudan.

[24] Elhussein S.A and Bashir N.H.H. (2004). Natural products: the pesticides of the future. The Second National Pest Management Conference in the Sudan, 6 – 9 December, 2004. Faculty of Agricultural Sciences, University of Gezira-Sudan.

[25] Deshparadae, R.S., Tipins, H.P. (1977). Insecticidal activity of *Ocimum basilicum* Linn. Pesticides, 11 (5): 11-21.

[26] Siddig, S.A. (1991). Evaluation of neem seed and leaf water extracts and powders for the control of insect pests in the Sudan. Technical Bulletin No. 6, Shambat Research Station, Agricultural Research Corporation. Sudan.

[27] Siddig, S.A., and Baleela, R.M.H. (2007). The effect of aqueous extracts and powders of neem leaflets at different developmental stages on *Trogoderma granarium* Everts and *Tribolium castaneum* Herbs. *Sudan Journal of Basic Sciences*. Series B, No. 11: 47-60.