Volume 1, Issue 3: 26 –32, 2022

A Study On The Mortality Effects Of Fourteen Botanicals Against (*Callosobruchus maculatus* F.) Infestation On Cowpea (*Vigna unguilata* L. Walp.)

Adamson Daniel*[1], Jirnuya C. Jedison[1]

[1]Department of Crop Protection, Faculty of Agriculture, University of Maiduguri

Received: 11.7.2022 • Accepted: 12.9.2022

Abstract: An investigation to assess the effectiveness of locally available botanical in the control of cowpea weevil (*Callosobruchus maculatus* L.) was conducted in the Department of Crop Protection, Faculty of Agriculture, University of Maiduguri. The experimental materials consist of three local varieties of cowpea namely Chadi bean, Owa bean, and Bokologi bean treated with the fourteen botanicals replicated three times. The adult *C. maculatus* was obtained from old cultures in the laboratory. The treatment including *Moringa oleifera* leaf powder, *M. oleifera* bark powder, *Balanites aegyptiaca* leaf powder, *B. aegyptiaca* bark powder, garlic seed powder, *Capsicum* spp fruit powder, chillic pepper fruit powder, ground nut oil, neem seed oil, sesame seed oil, melon seed oil, bitter leaf powder, tobacco leaf powder, Calotropic procera leaf powder. The concentration use in this research was 5 g, 10 g and 15 g making 30 g. The study showed that the oil extract is capable of killing the adult *C. maculatus* at any concentration. Mortality percentage was taken after 24, 48, 72, 96, 120, 144, 168 and 192 hours on bruchid after treatment has been inoculated in the experimental designs to assess mortality in each beans. There was significant difference in percentage on bokologi bean treated with botanical against *C. maculatus*, at every hour. Likewise, *C. maculatus* in Chadi bean was reduced by *B. aegyptiaca* bark powder, *M. oleifera* leaf powder, *B. aegyptiaca* leaf powder. Garlic seed powder in Owa beans showed excellent result at 192 hours and least mortality at 24 hours.

Keywords: Botanicals, Essential oils, powder, Callosobruchus maculatus, Mortality, Adult emergence.

1. Introduction

Cowpea (*Vigna unguiculata* (L.)) is a major staple food in sub-Saharan Africa; it is among the major sources of protein for human and livestock as reported by [1]. The high protein content of the seed makes it extremely valuable in tropical Africa where meat and fish are expensive for the teeming population thus serving as an alternative to expensive sources of protein [2, 3].

A wide range of insect pests from the order Coleoptera attacks field crops up to storage [4]. Cowpea bruchid, (*C. maculatus*), causes substantial losses in terms of quality (nutritional loss) and quantity such as loss in market values, weight loss, and viability loss [5,6]. Nigeria, the largest

* Corresponding Author's email: adamsondaniel102@gmail.com

producer and consumer, accounts for 48% of production in Africa and 46% worldwide. Africa exports and imports negligible amounts and more than 12.5 million hectares are harvested worldwide, 98% of which is in Africa. Nigeria harvests 3.7 million hectares annually [7]. *Callosobruchus maculatus* had been reported to cause 100% loss to cowpea seed during storage with a loss of 30 million US dollar in Nigeria [8].

Approaches aimed at controlling attack by insect pests have relied heavily on the use of synthetic insecticides [9]. These synthetic chemicals are associated with shortcomings such as the emergence of resistant strains of pests, elimination of natural enemies and non-target species, environmental health hazard, and contamination of foods with chemicals [10]. Plant extracts and essential oils have traditionally been used to kill or repel stored product insects, more so many of them are believed to contain myriads of chemicals that could be insecticidal [11]. Thus, the current study was designed to evaluate the mortality effects of fourteen botanicals against (*Callosobruchus maculatus* F.*)* Infestation on cowpea (*Vigna unguilata* L. Walp.).

2. Materials and Method

2.1. Study Site

The experiment was conducted under ambient temperature of 31-32^0 C and relative humidity of 55-65 % in the Entomology Laboratory, Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, Borno state, Nigeria.

2.2. Source of Cowpea Grain and Botanicals

The three cowpea varieties used in this study include Owo bean, Chadi bean and Bokologi bean were obtained in Monday Market Maiduguri. The botanicals that were used are: *Moringa oleifera* leaf powder, *M. oleifera* bark powder, *Balanites aegyptiaca* leaf powder, *B. aegyptiaca* bark powder, garlic (*Allium sativum)* seed powder, *Capsicum* spp fruit powder, chillic pepper fruit powder, ground nut oil, neem seed oil, sesame seed oil, Melon seed oil, Bitter leaf powder, Tobacco leaf powder, *C. procera* leaf powder, The plant materials used were the dried leaf and bark powder of desert date *B. aegyptiaca*, *B. aegyptiaca* were obtained around the University of Maiduguri (Unimaid) campus. *M. oleifera* bark powder were obtained within University Agriculture Research Farms, while the *Moringa oleifera* leaf was obtained from the Custom market Maiduguri.

2.3. Extraction of Essential Botanicals

All seeds were air dried for two weeks and ground separately into powder. The melon and sesame seeds were obtained from Custom market Maiduguri metropolis. The melon and sesame were fried for about 30 minute and allowed to cool, grounded to powder then small quantity of hot water was added and stirred for about 15 minutes in a bucket or mortar to drain the oil from it. Clean melon seeds were milled into paste using a grinder. The paste was heated to 80^0 C for 15 minutes. Boiled water was later added, and the mixture was left to boil for another 15minutes, to suspend the pulverized melon seeds on stirring. The resulting oil layer was separated by decantation, and the water content eliminated by heating process.

2.4. Rearing of *C. maculatus*

The cowpea storage beetle C. maculatus was cultured on cowpea seeds "Ife Brown" a famous susceptible variety in Nigeria [12]. The seeds were first cleaned of any impurities before disinfested in a deep freezer for 2 weeks. After removal from the freezer, the seeds were left to equilibrate at room temperature for 12–24 h. About 50 pairs of *C. maculatus* adults were introduced into a glass jar containing 200 g of clean Ife Brown cowpea seeds. Thereafter, the setup culture was kept in an insect cage for the emergence of progeny at 30 ± 32^0 C and 55 ± 65 % RH.

2.5. Experimental Procedure

Thirty grams (30g) of each cowpea varieties were weighed into a 200 ml bottle for four different treatments at 0, 5, 10 and 15g levels of the botanicals and each treatment was replicate 3 times. Ten (10) adult of males and females were put into the experimental bottle containing the cowpea. Each was put in to the experimental bottle containing cowpea and the botanicals. The percentage of adult mortality *C. maculatus* was observed after every 24, 48, 72, 96, 120, 144, 166, and 198 hours for ten days. And the results obtained (observed) were recorded against each treatment respectively. This procedure was done for the other cowpea varieties give a total of 30 days for the whole experiment.

2.6. Data Analysis

The data were subjected to analysis of variance (ANOVA) and different means and interaction among treatment concentration per hours of measurement of percentage mortality of *C. maculatus* using LSD at 5 % level of significance.

3. Result and Discussion

3.1. Results

The percentage mortality of C. maculatus on cowpea seeds treated with different concentrations of the essential oils and powder from botanicals at 12, 24, and 48, 72,96, 120 and 192 h is presented in Table 1. Showed that there was a significant mortality on *C. maculatus* treated with extracted plant oil at 192 h compare with 144 h. *Moringa oleifera* bark powder neem oil, shows significant effect at 24 h than other botanicals. At 48 h *Calotropic procera* leaf powder mortality, likewise at 72, 96, 120 and 192 hours. There was no significant different between the treatment at 96 h, likewise at 144 h *B. aegyptiaca* bark powder was significant at 168 and 196 h. Likewise, *C. procera* leaf powder and garlic fruit powder. Most of the botanical prove to be effective again *C. maculatus* at different hours compared with control.

The Table 2 showed, *C. maculatus* in Chadi bean was significantly reduces *Balanites aegyptiaca* leaf powder, *Moringa oleifera* leaf powder, bitter leaf powder and Garlic fruit powder after 96 h. Compared with ground oil, neem oil, sesame seed oil, melon seed oil, garlic fruit powder and *Calotropis procera* leaf powder at 192 h. Mortality percentage was lowest in 96 h, 120 h and 48 h. Table shows that *C. maculatus* was reduces by botanical extract.

Table 3 showed, *C. maculatus* in Bokologi by the effect of botanicals *Balanites aegyptiaca* leaf powder, *Moringa oleifera* leaf powder, give highest mortality than neem oil likewise at 144 h. *Balanites aegyptiaca* leaf powder show more pernicious effect than other. Botanical treatment at 24 h ground oil gave the highest mortality likewise at 192 h, all the same all the botanical prove to be effectives against *C. maculatus* except ground nut oil and neem oil at 72 h.

Table 1: Effect of Botanicals on Percentage Mortality on Owa beans

	Hours							
Treatments	**24**	**48**	**72**	**96**	**120**	**144**	**168**	**192**
Control	18.20^{bc}	0.06^{c}	0.03^{d}	0.10^{c}	0.04^{c}	2.23^{b}	3.43^{ab}	9.27^{a}
GO	33.50^{ab}	-7.11^{c}	7.11^{d}	3.55^{c}	1.78^{c}	1.78^{b}	4.44^{ab}	8.25^{a}
N O	45.72^{a}	0.22^{c}	0.14^{d}	0.29^{c}	0.35^{c}	0.34^{b}	0.09^{b}	6.87^{a}
S O	19.13^{bc}	0.37^{c}	0.06^{d}	0.42^{c}	0.05^{c}	0.70^{b}	0.11^{b}	18.00^{a}
M O	8.28^{c}	14.72^{ab}	16.89^{bc}	17.18^{ab}	15.55^{ab}	16.54^{a}	16.79^{a}	16.69^{a}
BEBP	8.53^{c}	17.22^{ab}	17.47^{b}	18.29^{ab}	17.68^{a}	16.01^{a}	11.58^{ab}	13.87^{a}
MOBP	10.39^{bc}	12.96^{b}	15.59^{c}	15.25^{ab}	16.61^{a}	13.29^{a}	11.89^{ab}	17.67^{a}
BELP	8.13^{c}	15.43^{ab}	16.29^{bc}	16.56^{ab}	15.99^{a}	17.13^{a}	6.77^{b}	13.52^{a}
MOLP	6.92^{c}	15.39^{ab}	16.97^{bc}	16.89^{ab}	17.37^{a}	15.23^{b}	6.43^{b}	5.61^{a}
BLP	9.88^{bc}	14.89^{ab}	17.13^{b}	17.63^{ab}	18.02^{a}	0.34^{b}	11.58^{ab}	18.87^{a}
CLP	16.05^{bc}	14.62^{ab}	17.59^{bc}	17.58^{ab}	19.28^{ab}	4.96^{b}	3.22^{b}	6.34^{a}
GLP	15.47^{bc}	16.43^{ab}	16.96^{bc}	17.89^{ab}	12.99^{a}	0.47^{b}	0.43^{b}	6.85^{a}
CFP	13.62^{bc}	16.06^{a}	16.64^{bc}	13.23^{ab}	17.70^{ab}	12.56^{a}	0.24^{b}	5.61^{a}
CPFP	13.53^{bc}	17.89^{ab}	19.81^{a}	19.96^{a}	7.02^{b}	0.34^{b}	0.09^{b}	11.54^{a}

	19.28[a]	17.33	18.59	18.12		1.03	0.26[a]	2.62
GFP	[bc]	[ab]	[ab]	[ab]	1.05[c]	[b]	[b]	
SE	10.52	2.07	0.81	2.55	3.58	3.36	6.47	7.30

Values are mean of three replications. Mean with the same latter in a column are not significantly different from each other at (*P = 0.05*) according to Duncan multiple test.

Table 2: Effect of Botanicals on Percentage Mortality of Adult *C. maculatus* on Chadi beans

	Hours							
Treatments	**24**	**44**	**72**	**96**	**120**	**144**	**168**	**192**
Control	20.03[a]	0.20[c]	0.11[e]	0.11[c]	0.05[c]	0.47de	0.04[d]	0.15[c]
GO	20.00[a]	1.78[c]	7.11[e]	1.78[c]	1.78[c]	5.33[e]	1.78[d]	1.78[c]
N O	19.78[a]	0.32*c*	0.01[e]	0.28[c]	0.06[c]	1.69[e]	0.04[d]	0.17[c]
S O	20.19[a]	0.10[c]	0.02[e]	0.56[c]	0.13[c]	0.57[de]	0.42[d]	0.21[c]
M O	12.32[bc]	13.34ab	16.92[b]	17.56[a]	18.45[a]	13.31[abc]	6.16[cd]	0.19[c]
BEBP	10.37[c]	16.20[ab]	16.44[bc]	16.88[a]	18.61[a]	19.47[a]	6.37[cd]	6.81[bc]
MOBP	10.54[c]	13.68[ab]	14.53[cd]	17.28[a]	18.34[a]	11.64[abcd]	0.04[d]	0.17[c]
BELP	8.00[c]	15.43[ab]	16.98[b]	17.28[a]	19.20[a]	20.24[a]	7.09[abcd]	0.21[c]
MOLP	9.89[c]	16.50[a]	15.70[bcd]	16.21[a]	17.79[a]	15.25[abce]	17.84[abc]	9.99[ab]
BLP	10.23[c]	13.80[ab]	17.14[b]	17.24[a]	15.52[a]	6.17[ab]	17.62[bcd]	9.96[bc]
CLP	10.78[bc]	15.68[ab]	16.99[b]	17.28[a]	18.73[a]	16.64[abc]	6.71[abc]	6.49[c]
LP	13.53[bc]	13.43[ab]	16.98[bcd]	20.94[a]	17.20[ab]	13.24[bcde]	13.42[cd]	0.21[c]
CFP	12.99bc	13.01[b]	15.92[a]	16.89[b]	12.12[bc]	7.31[de]	6.16[d]	0.19[c]
CPFP	12.37bc	12.54[ab]	19.78[d]	6.55[a]	5.95[bc]	0.47[cde]	0.04[a]	0.15[a]
GFP	13.78bc	12.68[ab]	13.99[bcd]	15.95[a]	6.06[a]	4.31[abcd]	18.70[abc]	18.49[ab]
SE	2.18	1.61	0.93	2.64	3.40	4.96	5.12	4.39

Value are mean of three replications. Mean with the same latter in a column are not significantly different from each other at (P = 0.05) according to Duncan multiple test.

Table 3: Effect of Botanicals on Percentage Mortality on Bokologi beans

	Hours							
Treatments	**24**	**44**	**72**	**96**	**120**	**144**	**168**	**192**
Control	20.23[a]	0.20[c]	0.16[c]	0.53[e]	0.27[c]	1.38[d]	1.01[b]	0.86 [a]
GO	20.00[a]	5.33[c]	3.55[c]	5.33[e]	8.88[c]	1.78[d]	1.78[b]	8.88 [a]
N O	19.93[a]	0.53[c]	0.06[c]	0.12[e]	0.34[c]	0.50[cd]	0.63[b]	0.89

								a
S O	14.95^{abcd}	4.79^{c}	5.15^{b}	4.78^{de}	5.32^{bc}	5.43^{bcd}	5.81^{b}	6.79 a
M O	7.22^{e}	14.60 ab	16.40^{a}	19.29^{a}	13.29^{ab}	6.79^{bcd}	6.23^{b}	6.51 a
BEBP	9.23^{de}	13.46 ab	17.17^{a}	11.14^{bcd}	4.73^{bc}	3.94^{cd}	4.66^{b}	5.81 a
MOBP	9.26^{de}	14.13 ab	15.61^{a}	17.12^{abc}	16.32^{ab}	18.17^{ab} a	20.63 a	0.89
BELP	9.95^{de}	17.13 a	17.48^{a}	17.78^{ab}	18.32^{a} c	13.09^{ab}	0.15^{b} a	0.13
MOLP	6.97^{e}	15.35 ab	16.09^{a}	17.13^{abc}	17.98^{a}	19.21^{a}	3.95^{b} a	4.23
BLP	10.24^{de}	15.39 ab	16.18^{a}	16.89^{ab}	17.07^{ab} c	18.67^{ab}	0.56^{b} a	0.04
CLP	9.59^{bcde}	13.47 a	15.94^{a}	18.12^{abc}	11.32^{ab} d	13.17^{bc}	6.63^{ab} a	7.55
GLP	11.62^{e}	16.13 a	16.14^{a}	16.78^{a}	12.32^{ab}	5.75^{bcd}	6.81^{b} a	0.13
CFP	7.55^{de}	15.94 b	17.40^{a}	18.29^{ab}	11.96^{a}	6.78^{bcd}	6.23^{b} a	6.51
CPFP	8.90^{ab}	10.46 a	17.51^{a}	17.81^{cd}	18.39^{ab}	4.94^{bcd}	5.33^{ab} a	5.47
GFP	16.59^{abc}	18.13 a	18.60^{a}	10.45^{abc}	9.99^{ab} cd	10.83^{ab} b	10.96 2^{a}	11.2
SE	2.98	2.28	1.98	3.01	4.77	5.58	5.84	6.00

Value are mean of three replications. Mean with the same latter in a column are not significantly different from each other at ($P = 0.05$) according to Duncan multiple test.

3.2. Discussion

Plant based insecticides have been used as a substitute to synthetic chemical insecticides that pose environmental health hazard for insect pest control because phytopesticides comes with no threat to the environment and human health [13]. Ileke and Adesina [14] reported that botanical oils contained numerous phytochemicals that could be insecticidal in nature. The present study is to evaluate the efficacy of botanical extracted oil plant in reducing mortality in three local cultivar beans. The result from the study shows that the application of plant extract oil has a significant effect on the Owa bean, Chadi bean and Bokologi bean. *C. maculatus* in Chadi bean was significant reduce by *B. aegyptiaca* bark powder, *M. oleifera* leaf powder, *B. aegyptiaca* leaf powder, garlic seed powder, *C. procera* leaf powder after 96 hours after inoculation but not as effective as the extracted oil from these plants. However, the results according to [15], also showed

that *B. aegyptiaca* bark powder, *B. aegyptiaca* leaf powder, *M. oleifera* leaf powder, *Calotropis procera* and Garlic seed powder has a significant effect. Extract from several parts of *B. aegyptiaca* were showed to exhibit anti-feedants and mollucidal activities against variety of pest and steroidal saponin is believe to be the main cause behind these activities. This study also revealed that botanical (extracted oil) has significant effect on different local cultivars, in conclusion cowpea bean is severely reduces by *C. maculatus.* With variable relation that can be attributed to the seed viability. Based on the results obtained from the percentage mortality of adult *C. maculatus* and the value of analysis of variance, it has proved that the oils extract has a significant effect on all the three varieties than the powder. Raja and John [16], also reported an increase in the mortality of adult C. maculatus with increased rates of different volatile oils as the time of exposure increased. According to Lale [17], the research of using plant essential oils to control stored grain insects has significant effect in the mortality, oviposition and productivity results obtained in the treated sample indicated the possible potential of this oil as an alternative agent for the control of *C. maculatus.* Also, according to Liang *et al.,* [18], his findings revealed that plant oils are generally reported to exert ovicidal action against insect pest of storage products.

4. Conclusions

Based on the findings from these results, the essential oils and powder used in this study could be explored as an alternative bio-pesticide to synthetic insecticide in the protection of stored cowpea against *C. maculatus.* The use of oils at any dosage concentration either at 5 g, 10 g, and 15g is capable of killing the adult *C. maculatus*. The application of oil was more effective than the powdered form in this study. Further work should be done to identify and isolate active compounds contained in these plant powders to determine the efficacy and methods of formulations.

Acknowledgements.

The authors thank The Laboratory Assistants of Research Laboratory, Department of Crop Protection, University of Maiduguri for their assistance during the extraction process.

Funding source.

Funding The authors declare that no fund was received from anybody in carrying out this study. This research study was funded collectively by the authors.

Competing Interests.

The authors declare that they have no competing interests

Ethical Approval.

Not applicable

References

[1] Joy E. I and Kayode D. I. Comparative evaluation of insecticidal properties of essential oils of some selected botanicals as bio-pesticides against Cowpea bruchid, *Callosobruchus maculatus* (Fabricius) [Coleoptera: Chrysomelidae]. *Bulletin of the National Research Centre*, 2020, 44:119.

[2] Olakojo S. A, Ayanwole J. A, Obasemola V.I. Laboratory screening of seeds of cowpea cultivars for tolerance to cowpea beetle in hot-humid environment. *American-European Journal of Agriculture and Environmental Science*, 2007, 2 (5):528–533.

[3] Ileke K. D, Odeyemi O. O, Ashamo M.O. Response of cowpea bruchid, *Callosobruchus maculatus* (Fabr.) [Coleoptera: Chrysomelidae] to Cheese Wood, Alstonia boonei De Wild stem bark oil extracted with different solvents. *Archives Phytopathology Plant Protection*, 2013. 46(11):1357–1370.

[4] Udo I. O. Potentials of *Zanthoxylum xanthoxyloides* (Lam.) for the control of stored product insect pests. *Journal of Stored Product Postharvest Resources*, 2011, 2(3):40–44.

[5] Ofuya T. I. Beans, insects and man. Inaugural lecture series 35. The Federal University of Technology, Akure, Nigeria, 2003, p 45

[6] Ofuya T. I, Kayode O. O, Ogunsola O.J. Fumigation toxicity of crushed bulbs of two *Allium* species to *Callosobruchus maculatus* (Fabr.) (Coleoptera: Bruchidae). *Journal of Agricultural Research,* 2010, 70 (30): 510–514.

[7] Joy E. I and Kayode D. I. Comparative evaluation of insecticidal properties of essential oils of some selected botanicals as bio-pesticides against Cowpea bruchid, *Callosobruchus maculatus* (Fabricius) [Coleoptera: Chrysomelidae]. *Bulletin of the National Research Centre*, 2020, 44:119.

[8] Isman M. B. Botanical insecticide deterrents and repellants in modern agriculture and on increasingly regulated world. Ann Rev Entomology, 2006, 51:45–66.

[9] Ileke K. D, Odeyemi O. O, Ashamo M.O. Response of cowpea bruchid, *Callosobruchus maculatus* (Fabr.) [Coleoptera: Chrysomelidae] to Cheese Wood, Alstonia boonei De Wild stem bark oil extracted with different solvents. *Archives Phytopathology Plant Protection*, 2013. 46(11):1357–1370.

[10] Ileke K. D, Adesina J. M. Biochemical toxicity of two termicides, Xylopia aethiopica and Piper guineense Seeds on Termites, Macrotermes subhyalinus Smeathman (Isoptera: Termitidae) on Albino rat. Utt Prad *Journal of Zoology*, 2018, 38(3):84–94.

[11] Nivea M.S.G, De Oliveira J. V, Navarro D.M. A. F, Dutra K. A, Silva W. A, Wanderley M. J. A. Contact and fumigant toxicity and repellency of Eucalyptus citriodora Hook., Eucalyptus staigeriana F., Cymbopogon winterianus Jowitt and Foeniculum vulgare Mill. essential oils in the management of Callosobruchus maculatus (Fabr.) (Coleoptera: Chrysomelidae, Bruchinae). *Journal of Stored Product Resource*, 2013, 54: 41–47.

[12] Thang T, Dai D, Hoi T, Ogunwande I. Study on the volatile oil contents of Annona glabra L., Annona squamosa L., Annona muricata L. and Annona reticulata L., from Vietnam. *National Product Research*, 2013, 27:1232–1236.

[13] Keita S. M, Vincent C, Schmit J. P, Arnason J.T and Bélanger A. Efficacy of essential oil of *Ocimum basilicum* L. and *O. gratissimum* L. applied as an insecticidal fumigant and powder to control *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). *Journal of Stored Product* Research, 2001, 37: 339-349.

[14] Maia MF, Moore S. J. Plant as repellents: a review of their efficacy, development and testing Malaria. 2011. (Pub Med https://www.ncbi.nlm.nih.gov/pubmed/21411 012).

[15] Ileke K. D, Adesina J. M. Biochemical toxicity of two termicides, Xylopia aethiopica and Piper guineense Seeds on Termites, Macrotermes subhyalinus Smeathman (Isoptera: Termitidae) on Albino rat. Utt Prad *Journal of Zoology*, 2018, 38(3):84–94.

[16] Taroesele, B., Thomas, K. and Seketeme, S. Control of cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae), using natural plant products against Insects, *Journal of Agricultural Sciences*, 2014, 6 (1): 77-84.

[17] Raja N, John W.S. Impact of volatile oils of plants against the cowpea beetle *Callosobruchus maculatus* (FAB.) (Coleoptera: Bruchidae). *International Journal of Integrated Biology*, 2008, 2 (1): 62–6.

[18] Lale N. E. S. The biological effects of three essential oils on *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Journal of African Zoology*, 1991, 105: 357-362.

[19] Tijjani, A., Bashir, K. A., Mohammed, I. Muhammad, A., Gambo, A. and Habu, M. Biopesticides for pests control: a review. *Journal of Biopesticides and Agriculture*, 2016, 3 (1): 6– 13.