Advances in Science and Technology, Vol. 12, No 1&2, September / October 2018, pp 27 - 34

Insecticidal and Anti-ovipositional Activities of the Stem-bark Powder of *Jatropha curcas* (L.) (Euphorbiaceae) Against *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae)

A.D. Adetimehin, S.K. Opuba, B.N. Iloba and O.O. Uyi*

Department of Animal and Environmental Biology, University of Benin, P. M. B. 1154, Benin City, Nigeria

(Submitted: August 15, 2018; Accepted: October 28, 2018)

Abstract

This study investigated the insecticidal and anti-ovipositional activities of the stem-bark powder of *Jatropha curcas* (L.) (Euphorbiaceae) against *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) under laboratory conditions. Five (5) pairs of sexed freshly emerged adults of *C. maculatus* were exposed to cowpea grains (20 g) treated with different concentrations (0.0 g, 1.0 g, 2.0 g, and 3.0 g) of *J. curcas* stem-bark powder for 24, 48, 72, 96 and 120 hours after which percentage mortality was calculated. In the same experimental setup, anti-ovipositional activity of the stem-bark powder of *J. curcas* was determined by counting the number of eggs on each cowpea grain after 120 hours of mating and oviposition by the test insect (=*C. maculatus*). In this study, mortality of *C. maculatus* caused by the stem-bark powder of *J. curcas* was high and observed to be a function of the duration of exposure, but not the concentrations used. At all concentrations (excluding the control – 0.0 g), the stem-bark powder of *J. curcas* demonstrated significant insecticidal activities (92 – 96 %) against *C. maculatus* following a 120 – hour exposure period. At the lowest concentration (1.0 g), the stem-bark powder of *J. curcas* reduced oviposition rate in *C. maculatus* by 65.60 % after 120 hours of mating and oviposition. In conclusion, this study demonstrates the insecticidal and anti-ovipositional activities of the stem-bark powder of *J. curcas* against *C. maculatus* for the first time, and further suggests its usage as a user- and eco-friendly alternative to conventional insecticides in the control of *C. maculatus*.

Keywords: Cowpea, *Jatropha curcas*, *Callosobruchus maculatus*, stem powder, mortality, anti-oviposition

1.0 Introduction

Cowpea, *Vigna unguiculata* L. (Walp) is one of the most important and widely consumed food crops grown in the tropical and sub-tropical regions of the world (Akinkurolere, 2012; Uddin and Abdulazeez, 2013). It is also the most important grain in the farming systems of Nigeria and West Africa at large (Singh *et al*., 2002). Nigeria being the largest producer and consumer, accounts for 61% of its production in Africa and 58% in the world (FAO, 2012). Undoubtedly, cowpea is known to be one of the major sources of protein for teaming populaces in poor tropical countries, accounting for about 60% of protein intake in Nigeria (Ojo *et al*., 2013). Furthermore, its consumption complements the primarily cereal diets of countries that cultivate it as major food crop (Philips *et al*., 2003), and also provides a rich source of calories as well as minerals and vitamins. Despite the nutritional and economic benefits associated with the consumption and production of cowpea, a number of constraints ranging from the lack of adequate storage facilities to the lackadaisical attitude of governments in supplying essential inputs for the support of agricultural activities threaten its continuous production and availability in Nigeria (Uddin and Abdulazeez, 2013). Above all, insect pest infestation constitutes a major constraint in its production and storage (Adebowale and Adedire, 2006).

Callosobruchus maculatus (Fab.) (Coleoptera: Chrysomelidae: Bruchinae) is the most notorious storage pest of cowpea in Nigeria, which starts its attack from the field prior to harvest to storage where the insect population is built up to damaging levels (Ofuya, 2001; Omotoso, 2008). Adult female lays eggs on the seed surface and the hatching larvae burrow into the seed. *Callosobruchus maculatus* larvae feed on the inside of the grains causing weight

*Corresponding Author's E-mail Address: osariyekemwen.uyi@uniben.edu

losses up to 80% after six month of storage (Carvalho *et al*., 2016). Infestation usually affects seed quality, market value and can reduce cowpea seed viability to 2% after 3 months of storage (Adebowale and Adedire, 2006). These losses pose a major threat to food security and future food availability. The control of this pest in storage systems depends primarily on synthetic insecticides such as malathion, pirimiphos-methyl, fenithrithion, methylbromide, deltamethrin and phosphine fumigant (Manzoomi *et al*., 2010; Ojo *et al*., 2013; Carvalho *et al*., 2016). Serious problems of genetic resistance by insect species, pest resurgence, residual toxicity, vertebrate toxicity, widespread environmental hazards and increasing cost of application of the presently used conventional pesticides have resulted in calls for effective, biodegradable pesticides (Rahman and Talukder, 2006; Kedia *et al*., 2015), hence the increasing interests in the use of natural products of plant origin in the control and management of insect pests. For instance, several studies (e.g. Mbaiguinam *et al*., 2006; Ileke *et al*., 2014; Kedia *et al*., 2015; Iloba *et al*., 2016; Uyi and Igbinoba, 2016; Uyi and Obi, 2017) have empirically demonstrated the insecticidal, repellent and anti-ovipositional activities of various plant parts or constituents of botanicals against several stored product pests including *C. maculatus* and pronounced their potential for future commercialization as a bio-rational alternative to control the bruchids in stored leguminous grains.

Jatropha curcas L. (Euphorbiaceae) is a multipurpose perennial shrub native to Mexico and subtropical America, but found growing naturally in most tropical areas of the world (Islam *et al*., 2011). It is an underutilized plant of multiple values, used globally for health care management of plants, humans and domesticated animals (Kumar and Tewari, 2015). Studies on the insecticidal, repellent, anti-feedant and anti-ovipositional activities of various parts of *J. curcas* against pests of agricultural, medical and veterinary importance have been sufficiently investigated (see Rahuman *et al*., 2008; Silva *et al*., 2012; Sabbour and Abd-El-Raheem, 2013; Abdoul *et al*., 2014; Bassem *et al*., 2014; Suleiman *et al*., 2014a; Musa and Olaniran, 2015). Furthermore, studies on the molluscicidal, nematicidal, fungicidal, antimicrobial and antihelminthic activities of the leaf, seed, and/or stem extracts of *J. curcas* are not uncommon (see Liu *et al*., 1997; Sharma and Trivedi, 2002; Igbinosa *et al*., 2009; Juliet *et al*., 2012; Ratnadass and Wink, 2012; Bassem *et al*., 2014). However, there is paucity of information on the anti-ovipositional and insecticidal activities of the pulverised stems of *J. curcas* against *C. maculatus.* Therefore, this study investigated the insecticidal and anti-ovipositional activities of the stem-bark powder of *J. curcas* against *C. maculatus.*

2.0 Materials and Methods

2.1 Collection and Preparation of Plant Powders

Fresh stem-barks of *J. curcas* were collected locally from a compound in the Uwasota area of Benin City (6°22'50"N, 5°35'52"E), Nigeria. Following collection, the stem-barks were washed, chopped and air dried in the room. The dried stem-barks were blended into fine powder using an electric blender and then preserved in an air-tight and water-proof container pending use.

2.2 Insect Culture

The cowpea seed beetle, *C. maculatus* used to establish the insect culture was obtained from infested cowpea seeds purchased locally from Uselu market in Benin City, Nigeria, and the culture of *C. maculatus* was raised in the laboratory of the Department of Animal and Environmental Biology, University of Benin, Benin City (6°22'59"N, 5°36'5"E). Adult *C. maculatus* (males and females) were separated from the cowpea, placed in three 4 – litre aerated plastic containers (with a perforated screw top lid). Containers (with adult beetles) were kept for six (6) days in the laboratory for mating and oviposition. Following mating and oviposition, adult beetles were sieved from the containers and the eggs laid on the seeds were allowed to develop. The plastic containers were left undisturbed until the emergence of the adult beetles. Freshly emerged subsequent generations were used for the experiments.

2.3 Insect Mortality and Oviposition Rate Bioassay

Clean and un-infested cowpea seeds were purchased from Uselu market, Benin City. The cowpea seeds were then examined by physical observation for any existing eggs or larvae before the start of the experiments. Different concentrations of the stem-bark powder viz. 0.0 g, 1.0g, 2.0 g and 3.0 g were weighed and each added to 20 g of clean undamaged and un-infested cowpea seeds in transparent 300 ml plastic containers. The cowpea seeds in the controls contained no plant powder. The containers with their contents were gently shaken to ensure thorough admixture after which 5 pairs of 1 – 3 day old sexed adults of *C. maculatus* were introduced into each container. All treatments including the controls were replicated five (5) times. Adult mortality for all treatments (including the control) was observed and recorded for 24, 48, 72, 96 and 120 hours. The insects were considered dead when they failed to respond to touch when the exposed abdomen was probed gently with a pin. Dead adults were removed at each assessment, counted and recorded.

Anti-ovipositional activity was assessed by taking the counts of the number of eggs laid on each grain in the treated and control containers (using a hand lens) after 7 days of mating and oviposition. Percentage of oviposition deterrence was calculated according to Singh (2011) using the formula.

$$POD = \frac{NCS - NTS}{NCS} \times 100$$

where NCS is the number of eggs laid on control seed and NTS is the number of eggs laid on treated seeds

2.4 Statistical analysis

The effects of three concentrations of *J. curcas* leaf powder on the mortality and oviposition rate of C. maculatus were analyzed using analysis of variance (ANOVA). The differences among significant treatment means were separated using Turkey's Honest Significant Difference (HSD). The relationships between biopesticide exposure time and insect mortality for all concentrations were established using regression analysis. With the exception of the regression analysis that were performed using Genstat 12.0 (VSN International Limited, United Kingdom) all other analysis were performed using SPSS statistical software, version 20.0 (SPSS, Chicago, USA).

3.0 Results

3.1 Mortality

The stem-bark powder of *J. curcas* caused some levels of toxicological effect against *C. maculatus* compared to the control (Figures 1 – 5). When cowpea beetles were exposed to different treatment levels (0.0, 1.0, 2.0 and 3.0 g) of *J. curcas* stem-bark powder for a 24 – hour period, mortality differed significantly ($F_{-3, -19}$= 7.32; P= 0.003) with only the control exhibiting the least mortality (Figure 1). However, mortality did not differ between the three stem powder treatments (1.0, 2.0 and 3.0 g) Figure 1). Following a 48 – hour exposure of the insects to *J. curcas* stem-bark powder, mortality significantly differed ($F_{-3, 19}$ = 13.76; P <0.001) with only the control exhibiting the least mortality (Figure 2). However, mortality did not differ between the three stem powder treatments (1.0, 2.0 and 3.0 g) (Figure 2). In the 72 – hour exposure trial, the concentration of the stem-bark powder significant influenced the number of dead beetles ($F_{--3, 19-}$ = 21.88; P<0.001). Apart from the control that demonstrated the least mortality, all concentrations (1.0g, 2.0g and 3.0g) demonstrated significant but equal insecticidal activity (72 – 76 %) against the bruchid beetle used in the experiment (Figure 3). Similarly, after exposing the bruchid beetles to different concentrations of *J. curcas* stem-bark powder for 96 hours, percentage mortality differed significantly according to concentration ($F_{--3, 19-}$ = 48.23; P<0.001) (Figure 4) with the 3.0g treatment evoking the highest mortality (98%) followed by 2.0g and 1.0g treatments causing 86% and 80% mortalities respectively in *C. maculatus*. Following a 120 – hour exposure period of *C. maculatus* to different concentrations of *J. curcas* stem-bark powder, percentage mortality differed significantly according to concentration ($F_{--3, 19-}$ = 81.43; P<0.001) with only the control exhibiting the least mortality (Figure 5). However, mortality did not differ between the three stem powder treatments (1.0, 2.0 and 3.0 g) (Figure 5). The 3.0 g treatment exhibiting the highest mortality (96%) followed by 1.0 g and 2.0 g treatments causing 94% and 92% mortalities respectively in *C. maculatus.* Overall, regression analysis revealed that percentage mortality in *C. maculatus* increased with an increase in the exposure duration of the insect pest to the stem-bark powder of *J. curcas* (Figure 6).

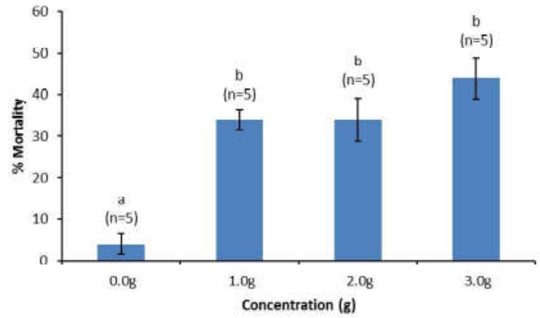

Figure 1: Effects of different concentrations of the stem-bark powder of *Jatropha curcas* on the percentage mortality (mean ± se) of *Callosobruchus maculatus* following a 24 – hour exposure period. Means capped with different letters are significantly different (after Tukey's Honest Significant Difference (HSD) test: P<0.05). Sample sizes are given in parenthesis.

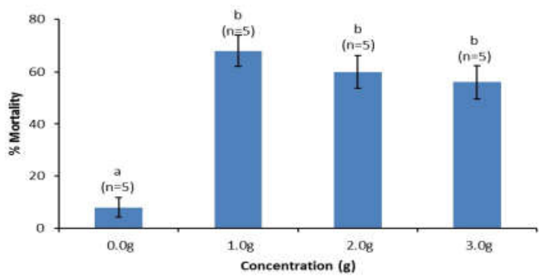

Figure 2: Effects of different concentrations of the stem-bark powder of *Jatropha curcas* on the percentage mortality (mean ± se) of *Callosobruchus maculatus* following a 48 – hour exposure period. Means capped with different letters are significantly different (after Tukey's Honest Significant Difference (HSD) test: P<0.05). Sample sizes are given in parenthesis.

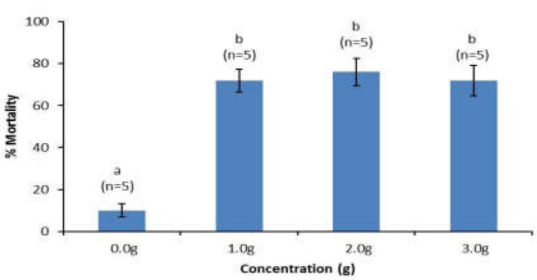

Figure 3: Effects of different concentrations of the stem-bark powder of *Jatropha curcas* on the percentage mortality (mean ± se) of *Callosobruchus maculatus* following a 72 – hour exposure period. Means capped with different letters are significantly different (after Tukey's Honest Significant Difference (HSD) test: P<0.05). Sample sizes are given in parenthesis.

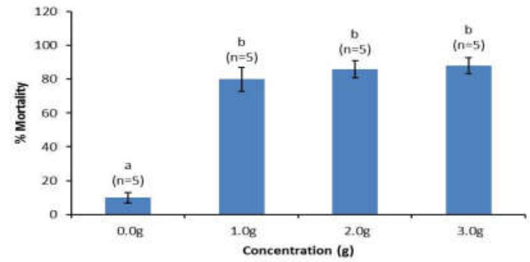

Figure 4: Effects of different concentrations of the stem-bark powder of *Jatropha curcas* on the percentage mortality (mean ± se) of *Callosobruchus maculatus* following a 96 – hour exposure period. Means capped with different letters are significantly different (after Tukey's Honest Significant Difference (HSD) test: P<0.05). Sample sizes are given in parenthesis.

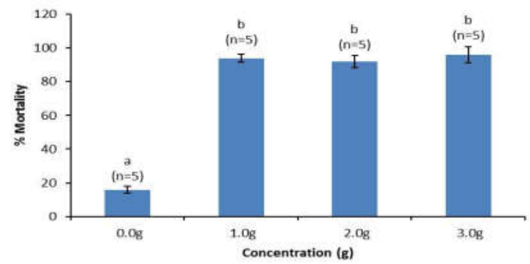

Figure 5: Effects of different concentrations of the stem bark powder of *Jatropha curcas* on the percentage mortality (mean ± se) of *Callosobruchus maculatus* following a 120 – hour exposure period. Means capped with different letters are significantly different (after Tukey's Honest Significant Difference (HSD) test: P<0.05). Sample sizes are given in parenthesis.

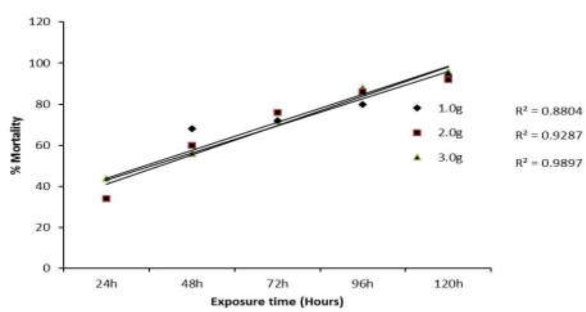

Figure 6: The relationships between the percentage mortality of *Callosobruchus maculatus* and exposure duration at different concentrations of the stem-bark powder of *Jatropha curcas*.

3.2 Oviposition rate

The mean oviposition rate of *C. maculatus* on seeds treated with different concentrations (1.0, 2.0, and 3.0 g) of *J. curcas* stem-bark powder did not differ ($F_{3,19}$ = 1.92; P = 0.167) as all concentrations excluding the control (0.0g) demonstrated significant anti-ovipositional activities against the test insect (Figure 7). The percentage of oviposition deterrence of the stem-bark powder of *J. curcas* at 1.0, 2.0 and 3.0 g concentrations is given as 65.60, 44.46 and 56.20 % respectively (Figure 7).

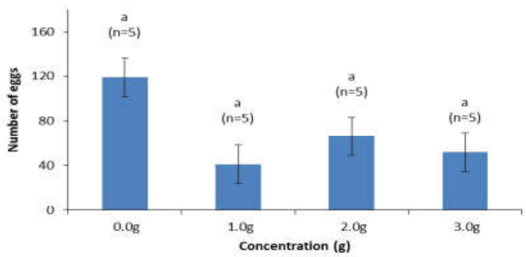

Figure 7: Oviposition rate (mean± se) of *Callosobruchus maculatus* at different treatment levels of *Jatropha curcas* stem-bark powder following 5 days after infestation (DAI). Means capped with the same letters are not significantly different (Tukey's Honestly Significant Difference [HSD] test: P>0.05).

4.0 Discussion and Conclusion

This study examined the toxicological (=insecticidal) activities and oviposition deterrent properties of the stem-bark powder of a multipurpose plant *J. curcas* against an ill-famed pest of cowpea, *C. maculatus*. Results from this current study revealed that the stem-bark powder of *J. curcas* exhibited considerable oviposition deterrent and toxicological activities against the bruchid beetle.

In this study, the percentage mortality of *C. maculatus* was observed to be independent of the concentrations of *J. curcas* stem-bark powder used, as all concentrations demonstrated significant toxicological activities (92 – 96%) against the bruchid beetle following a 120 – hour exposure period. This result corroborates with the findings of other authors (Suleiman *et al*., 2014b; Olufumilayo, 2015; Ofuya *et al*., 2015; Iloba *et al*., 2016; Opuba *et al*., 2018) who reported significant mortalities in *C. maculatus* when cowpea grains were treated with different concentrations of either plant powders or extracts. As observed in other studies (Kouninki, 2010; Iloba *et al*., 2016; Uyi and Igbinoba, 2016; Uyi and Obi, 2017; Opuba *et al*., 2018), percentage mortality of *C. maculatus* in this current study, increased with an increase in the exposure period of the pest to the stem-bark powder of *J. curcas*. The lack of a significant difference in the mortality of *C. maculatus* when exposed to cowpea grains treated with different concentrations (1.0g, 2.0g, and 3.0g) of *J. curcas* stem-bark powder reveals the excellent pesticidal properties of the plant part (stem-bark).

Although, empirical evidences on the oviposition deterrent properties of several plant powders, extracts and/or seed oils including that of *J. curcas* exist against *C. maculatus* (see Adebowale and Adedire, 2006; Singh, 2011; Ojo *et al*., 2013; Adesina and Ofuya, 2015; Iloba *et al*., 2016), to our knowledge, studies focusing on the oviposition deterrent property of the stem-bark powder of *J. curcas* are still scarce and possibly non-existent. In this study, all the concentrations (1.0, 2.0, and 3.0g) of *J. curcas* stem-bark powder used demonstrated some degrees of anti-ovipositional activity (44.46 – 65.60%) against *C. maculatus* following 120 hours of mating and oviposition. This result is in accordance with the findings of Iloba *et al*., (2016) where the authors revealed a significant reduction in the oviposition rate of *C. maculatus* at all the concentrations of *Greenwayodendron suaveolens* (Engl. and Diels) Verdc. (Annonaceae) leaf powder used. In addition, the remarkable reduction in the oviposition rate of *C. maculatus* observed in this study further concurs with the findings of Adebowale and Adedire (2006) who examined the effect of *J. curcas* seed oil on the egg laying capacity of *C. maculatus*. The authors documented a significant reduction in fecundity of *C. maculatus* females when cowpea seeds were treated with seed oil of *J. curcas.*

A number of explanations might exist for the results (i.e. high mortality and reduced oviposition) observed in this study. Firstly, the sequence of behaviour of insect pest especially in females while ovipositing makes them prone to acquiring toxic residues from treated surfaces (Ogunwolu and Idowu, 1994). Secondly, plant powders are characterized by the presence of fine particles which might block the spiracles of the insect thus leading to death by suffocation (Denloye, 2010). Thirdly, plants are characterized by the presence of bioactive compounds which have been documented to alter the physiology and metabolism of insect pests consequently, reducing their egg laying capacity (Aku *et al*., 1998; Kedia, 2015). Despite all of these, we attribute the high mortality of, and reduced oviposition in *C. maculatus* to the presence of secondary metabolites (=phytochemicals) such as saponins, steroids, tannins, glycosides, alkaloids and flavonoids in the stem of *J. curcas* (Igbinosa *et al*., 2009; Nayak and Patel, 2010; Ahirrao *et al*., 2011) as these compounds have been documented to be toxic to insect pests including those of stored products (see Chaieb, 2010; Ekeh *et al*., 2013; Agaba and Fawole, 2014). In summary, this present study has clearly demonstrated that the stem-bark powder of *J. curcas* possesses insecticidal and anti-oviposition properties that can be employed in the management of *C. maculatus* infestation on stored cowpea seeds.

References

Abdoul, H.Z., Haougui, A., Basso, A., Adam, T., Haubruge, E. and Verheggen, J.F. 2014, "Insecticidal effect of *Jatropha curcas* L. seed oil on *Callosobruchus maculatus* (Fab.) and *Bruchidius atrolineatus* (Pic.) (Coleoptera: Bruchidae) on stored cowpea seeds (*Vigna unguiculata* L. Walp) in Niger", African Journal of Agricultural Research **9(32),** 2506 – 2510.

Adebowale, K.O. and Adedire, C.O. 2006, "Chemical composition and insecticidal properties of the underutilized", *Jatropha curcas* seed oil. *African Journal of Biotechnology* **5(10),** 901 – 906.

Adesina, J.M. and Ofuya, T.I. 2015, "Oviposition deterrence and egg hatchability suppression of *Secamone afzelii* (Schulf) K. Schum leaf extract on *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomelidae)", Jordan Journal of Biological Sciences **8(2),** 95 – 100.

Agaba, T.A. and Fawole, B. 2014, "Phytochemical constituents of Siam weed (*Chromolaena odorata*) and African custard apple (*Annona senegalensis*)", International Journal of Food, Agriculture and Veterinary **6(1):** 35 – 42.

Ahirrao, R.A., Patel, M.R., Sayyed, H., Patil, J.K., Suryawanshi, H.P. and Tadavi, S.A. 2011, "*In vitro* anthelmintic property of various herbal plants extracts against *Pheritima posthuma*", Pharmacologyonline **2,** 542 – 547.

Akinkurolere, R.O. 2012, "Comparative effects of three plant powders and primiphos-methyl against the infestation of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in cowpea seeds", SOAJ of Entomological Studies **1(2):** 108 – 117.

Aku, A.A., Ogunwolu, E.O. and Attah, J.A. 1998, "*Annona senegalensis* L. (Annonaceae): performance as a botanical insecticide for controlling cowpea seed bruchid, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in Nigeria", Journal of Plant Diseases and Protection **105(5),** 513 – 519.

Bassem, F., Larbi, K.M. and Hela, E.F. Q. 2014, "Larvicidal efficacy of *Jatropha curcas* L. (Euphorbiaceae) leaf and seed aqueous extracts against *Culex pipiens* L.", African Journal of Biotechnology **13(26),** 2641 – 2647.

Carvalho, G.S., Silva, L.B., Silva, L.S., Almeida, M.L.S., Carneiro, E., Candido, A.C.S. and Peres, M.T.L.P. 2016, "Insecticidal activity of plant extracts and essential oils of bleed water against the bean weevil", Journal of Stored Products and Postharvest Research **7(7),** 69 – 75.

Chaieb, I. 2010, "Saponins as insecticides: a review", Tunisian Journal of Plant Protection 5, 39 – 50.

Denloye, A.A. 2010, "Bioactivity of powder and extracts from garlic, *Allium sativum* L. (Alliaceae) and spring onion, *Allium fistulosum* L. (Alliaceae) *Vigna unguiculata* (L.) Walp (Leguminosae) seeds", Journal of Entomology **2,** 1 – 5.

Ekeh, F.N., Onah, I.E., Atama, C.I., Ivoke, N. and Eyo, J.E. 2013, "Effectiveness of botanical powders against *Callosobruchus maculatus* (Coleoptera: Bruchidae) in some stored leguminous grains under laboratory conditions", African Journal of Biotechnology **12(12),** 1384 – 1391.

FAO. (2012) "*Vigna unguiculata* (L.). Walp", Available at www.fao.org/ag/agp/AGPC/doc/gbase/data/pf000090.htm [Accessed 2nd May, 2017].

Igbinosa, O.O., Igbinosa, E.O. and Aiyegoro, O.A. 2009, "Antimicrobial activity and phytochemical screening of stem bark extracts from *Jatropha curcas* (Linn)", African Journal of Pharmacy and

Pharmacology **3,** 058 – 062.

Ileke, K.D., Oni, M.O. and Adelegan, O.A. 2014, "Laboratory assessment of some plants latex as biopesticide against Cowpea bruchid, *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae)", Journal of Agricultural Science **6(1),** 123 – 128.

Iloba, B.N., Adetimehin, A.D. and Uyi, O.O. 2016, "High mortality and reduced oviposition: efficacy of the leaf powder of *Greenwayodendron suaveolens* (Engl. And Diels) Verdc. (Annonaceae) against *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae)", Nigerian Journal of Life Sciences **6(2),** 51 – 59.

Islam, A.K.M.A., Yaakob, Z. and Anuar, N. 2011, "Jatropha: A multipurpose plant with considerable potential for the tropics", Scientific Research and Essays **6(13),** 2597 – 2605.

Juliet, S., Ravindran, R., Ramankutty, S.A., Gopalan, A.K.K. and Nair, S.N. 2012, "*Jatropha curcas* (Linn) leaf extracts- a possible alternative for population control of *Rhipicephalus (Boophilus) annulatus*", Asian Pacific Journal Tropical of Disease **2,** 225 – 229.

Kedia, A., Prakash, B., Mishra, P.K., Singh, P. and Dubey, N.K. 2015, "Botanicals as eco-friendly biorational alternatives of synthetic pesticides against *Callosobruchus* spp. (Coleoptera: Bruchidae) – a review. Journal of Food Science and Technology **52(3),** 1239 – 1257.

Kouninki, H., Hance, T., Djossou, J., Noudjou, F., Lognay, G., Malaissse, F., Ngassoum, M. N., Mapongmetsem, P.M., Ngama, T.K. and Haubruge, E. 2010, "Persistent effect of a preparation of essential oil from *Xylopia aethiopia* against *Callosobruchus maculatus* (Coleoptera: Bruchidae)", African Journal of Agricultural Research **5(14):** 1888 – 1891.

Kumar, A. and Tewari, S. K. 2015, "Origin, Distribution, Ethnobotany and Pharmacology of *Jatropha curcas",* Research Journal of medicinal plant **9(2):** 48 – 59.

Liu, S.Y., Sporer, F., Wink, M., Jourdane, J., Henning, R.L.Y. and Ruppel, A. 1997, "Anthraquinones in *Rheum palmatum* and *Rumexdentatus* (Polygonaceae), and phorbol esters in *Jatropha curcas* (Euphorbiaceae) with molluscicidal activity against *Schistosoma* vector snails *Oncomelania*, *Biomphalaria*, and *Bulinus*", Tropical Medicine and International Health **2,** 179 – 188.

Manzoomi, N., Ganbalani, G.N. Dastjerdi, H.R. and Fathi, S.A.A. 2010, "Fumigant toxicity of essential oils of *Lavanda officinalis, Artemisia dracunculus* and *Heracleum ersicum* on the adults of *Callosobruchus maculatus* (Coleoptera: Bruchidae)", Munis Entomology and Zoology Journal **5,** 118 – 122.

Mbaiguinam, M., Maoura, N., Bianpambe, A., Bono, G. and Alladoumbaye, E. 2006, "Effects of six common plant seed oils on survival, eggs lying and development of the cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)", Journal of Biological Sciences **6(2),** 420 – 425.

Musa, A.K. and Olaniran, J.O. 2015, "Studies on the efficacy of *Jatropha curcas* L. seed oil on Adult mortality and emergence of seed beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Chysomelidae) in cowpea", International Journal of Phytofuels and Allied Sciences **4(1),** 1 – 12.

Nayak, B.S. and Patel, K.N. 2010, "Pharmacognostic studies of the *Jatropha curcas* leaves", International Journal of Pharm. Tech. Research **2(1),** 140 – 143.

Ofuya, T.I. 2001, Biology, ecology and control of insect pests of stored legumes in Nigeria. In Ofuya, T.I. and Lale, N.E.S. (Eds.) *Pests of stored cereals and pulses in Nigeria: Biology, ecology and control*. Dave Collins publication. pp 24 – 58.

Ofuya, T.I., Zakka, U., Umana, E.K. and Enyi, N. 2015, "Potential synergism of diatomaceous earth and *Piper guineense* for management of *Callosobruchus maculatus* in stored cowpea", Journal of Entomology and Zoology Studies **3(6):** 366 – 372.

Ogunwolu, O. and Idowu, O. 1994, "Potential of powdered *Zanthoxylum zanthoxyloides* (Rutacae) root bark and *Azadirachta indica* (Meliaceae) seed for control of the cowpea seed bruchid, *Callosobruchus maculatus* (Bruchidae) in Nigeria", Journal of African Zoology **108,** 521 – 528.

Ojo, J.A., Olunloyo, A.A. and Akanni, E.O. 2013, "Efficacy of *Moringa oleifera* leaf powder against *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) on stored cowpea (*Vigna unguiculata* L. Walp). Researcher **5(12),** 240 – 244

Olufumilayo, E.A. 2015, "Toxicity and repellent activity of *Momordica charantia* (L.). Extracts againsts the cowpea weevil, *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae)", Jordan Journal of Agricultural Sciences, **11(3),** 649 – 600.

Omotoso, O.T. 2008, "Efficacy of extracts of some aromatic medicinal plants on cowpea bruchid, *Callosobruchus maculatus* in storage", Bulletin of Insectology 6**1(1),** 21 – 24.

Opuba, S.K., Adetimehin, A.D., Iloba, B.N. and Uyi, O.O. 2018, "Insecticidal and anti-ovipositional activities of the leaf powder of *Jatropha curcas* (L.) (Euphorbiaceae) against *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae)", Animal Research International **15,** 2971-2978.

Phillips, R.D., Mcwatters, K.H., Chinnan, M.S., Hung, Y.C., Beuchat, L.R., Sefa-Dedeh,S., Sakyi-Dawson, E., Ngoddy, P., Nnanyelugo, D. and Enwere, J. 2003, "Utilization of cowpeas for human food", Field Crops Research **82,** 193 – 213.

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),** 10 – 20.

Rahuman, A.A., Gopalakrishnan, G., Venkatesan, P. and Geetha, K. 2008, "Larvicidal activity of some Euphorbiaceae plant extracts against *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae)", Parasitology Research **102,** 867 – 873.

Ratnadass, A. and Wink, M. 2012, "The Phorbol Ester Fraction of *Jatropha curcas* seed oil: Potential and Limits for Crop Protection against insect pests", International Journal of Molecular Sciences **13(2),** 16157 – 16171.

Sabbour, M. M. and Abd-El-Raheem, M. A. 2013, "Repellent effects of Jatropha curcas, canola and Jojoba seed oil, against *Callosobruchus maculatus* (F.) and *Callosobruchus chinensis* (L.)", Journal of Applied Sciences Research **9(8),** 4678 – 4682.

Sharma, M. and Trivedi, P.C. 2002, "Screening of leaf extracts of some plants for their nematicidal and fungicidal properties against *Meloidogyne incognita* and *Fusarium oxysporum*", Asian Journal of Experimental Sciences **16,** 21 – 28.

Silva, G.N., Faroni, L.R.A., Sousa, A.H. and Freitas, R.S. 2012, "Bioactivity of *Jatropha curcas* L. to insect pests of stored products", Journal of Stored Products Research **48,** 111 – 113.

Singh, B.., Ehlers, J.D., Sharma, B. and Filho, F.F.R. 2002, "Recent progress in cowpea breeding". In: Fatokun, C.A., Tarawali, S.A. Singh, B.B., Kormawa, P.M. and Tamo, M. (Eds.) Challenges and opportunity for enhancing sustainable cowpea production. *Proceedings of the World Cowpea Conference III held at International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, IITA, Ibadan, Nigeria.*

Singh, R. 2011, "Evaluation of some plant products for their oviposition deterrent properties against the *Callosobruchus maculatus* (F.) on Chick pea seeds", Journal of Agricultural Technology 7(5), 1363 – 1367.

Suleiman, M., Kankia, I.H. and Sani, Z. 2014a, "Efficacy of *Euphorbia balsamifera* L. and *Jatropha curcas* L. leaf powders against *Callosobruchus maculatus* F. (Coleoptera: Bruchidae)", European Journal of Zoological Research **3(3),** 15 – 20.

Suleiman, M., Shinkafi, B.Y. and Yusuf, S.H. 2014b, "Bioefficacy of leaf and peel extracts of *Euphorbia balsamifera* L. and *Citrus sinensis* L. against *Callosobruchus maculatus* Fab. (Coleoptera: Bruchidae)", Annals of Biological Research **5(4),** 6 – 10.

Uddin II, R.O. and Abdulazeez, R.W. 2013, "Comparative efficacy of neem (*Azadirachta indica*), false sesame (*Ceratotheca sesamoides*) Endl. and the physic nut (*Jatropha curcas*) in the protection of stored cowpea (*Vigna unguiculata*) L. Walp against the seed beetle *Callosobruchus maculatus* (F.)", Ethiopian Journal of Environmental Studies and Management **6,** 827 – 834.

Uyi, O. O. and Igbinoba, O. G. 2016, "Repellence and Toxicological activity of the root powder of an invasive alien plant, *Chromolaena odorata* (L.) (Asteraceae) against *Callosobruchus maculatus* (Fab.) (Coleoptera: Chryomelidae)", *Animal Research International*, **13(3),** 2510 – 2517.

Uyi, O. O. and Obi, B. N. 2017, "The evaluation of the repellent and insecticidal activities of the leaf, stem and root powders of siam weed (*Chromolaena odorata*) against the cowpea beetle, *Callosobruchus maculatus*", Journal of Applied Science and Environmental Management **21(3),** 511 – 518.