Accepted manuscript

Adeboye, O.R., M.O. Oni, and J.M. Adesina. 2020. Comparative response of *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) to powders of *Momordica charantia* and *Acalypha wilkesiana* in stored cowpea (*Vigna unguiculata*) (Walp.). Revista Colombiana de Ciencias Hortícolas 14(2). Doi: https://doi.org/10.17584/rcch.2020v14i2.9840

Scientific Note

Comparative response of *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) to powders of *Momordica charantia* and *Acalypha wilkesiana* in stored cowpea (*Vigna unguiculata)* (Walp.)

Respuesta comparativa de *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) a polvos de *Momordica charantia* y *Acalypha wilkesiana* en caupí almacenado (*Vigna unguiculata)* (Walp.)

OYEWALE RUFUS ADEBOYE[1]

MERCY OLAYINKA ONI[1]

JACOBS MOBOLADE ADESINA[2, 3]

[1] Federal University of Technology Akure, Department of Crop, Soil and Pest Management, Akure (Nigeria). ORCID Adeboye, O.R.: https://orcid.org/0000-0002-4679-821X; ORCID Oni, M.O.: https://orcid.org/0000-0002-3053-3567

[2] Rufus Giwa Polytechnic, Department of Crop, Soil and Pest Management Technology, Owo (Nigeria). ORCID Adesina, J.M.: https://orcid.org/0000-0003-1174-9095

[3] Corresponding author. moboladesina@rugipo.edu.ng

Farmers examine cowpea seeds stored in PICS bags.
Photo: IITA and PRO

Accepted manuscript

Adeboye, O.R., M.O. Oni, and J.M. Adesina. 2020. Comparative response of *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) to powders of *Momordica charantia* and *Acalypha wilkesiana* in stored cowpea (*Vigna unguiculata*) (Walp.). Revista Colombiana de Ciencias Hortícolas 14(2). Doi: https://doi.org/10.17584/rcch.2020v14i2.9840

Last name: ADEBOYE / ONI / ADESINA

Short title: ***Callosobruchus maculatus*** **CONTROL ALTERNATIVE IN STORED COWPEA**

DOI: https://doi.org/10.17584/rcch.2020v14i2.9840

Received for publication: 27-07-2019 Accepted for publication: 11-06-2020

ABSTRACT

Post-harvest preservation of cowpea in developing countries has been a major challenge owing to *Callosobruchus maculatus* infestation. The study compares response of *C. maculatus* (F) to *Momordica charantia* and *Acalypha wilkesiana* powders in stored cowpea seeds under laboratory atmosphere. Five pairs of freshly emerged *C. maculatus* adults were introduced into Petri-dish containing 20 g of cowpea admixed with 0.2, 0.4, 0.6 and 0.8 g of each plant powder, replicated thrice and arranged in a complete randomization design. Adult mortality was recorded at 24 h interval for 5 days, oviposition was recorded after 48 h. While newly emerged insects were recorded 30-35 days after infestation and weight loss was also determined. The treatments showed significant increase in *C. maculatus* adult mortality as the time of exposure and dosage increases, with highest values (90 and 100% for *A. wilkesiana* and *M. charantia*, respectively) at 120 h of exposure and 0.8 g dosage level. At 0.8 g, *A. wilkesiana* (66.3) and *M. charantia* (63.0) treated seeds recorded significantly lower number of eggs laid. Similar trend was equally observed for adult emergence and percentage weight loss. The study revealed that both plants had significant insecticidal effects and clearly showed that *M. charantia* was more effective than *A. wilkesiana*, but did not show higher significant differences in all the parameters assessed. This indicated that these plant powders have prospective to safeguard cowpea seeds in store from *C. maculatus* infestation and damage. Therefore, these plant should be included in the Integrated Pest Management Strategies for cowpea storage by small scale farmers.

Additional key words: bio-insecticides; seeds; postharvest preservation; adult mortality; IPM.

Adeboye, O.R., M.O. Oni, and J.M. Adesina. 2020. Comparative response of *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) to powders of *Momordica charantia* and *Acalypha wilkesiana* in stored cowpea (*Vigna unguiculata*) (Walp.). Revista Colombiana de Ciencias Hortícolas 14(2). Doi: https://doi.org/10.17584/rcch.2020v14i2.9840

RESUMEN

La preservación poscosecha del caupí en los países en desarrollo ha sido un desafío importante debido a la infestación de *Callosobruchus maculatus*. El estudio compara la respuesta de *C. maculatus* (F) a los polvos de *Momordica charantia* y *Acalypha wilkesiana* en semillas de caupí almacenadas en atmósfera de laboratorio. Se introdujeron cinco pares de adultos de *C. maculatus* recién emergidos en una placa de Petri que contenía 20 g de caupí mezclados con 0,2, 0,4, 0,6 y 0,8 g de cada polvo de planta, replicados tres veces y dispuestos en un diseño completamente al azar. La mortalidad adulta se registró en un intervalo de 24 h durante 5 días, la oviposición se registró después de 48 h. Mientras que los insectos recién emergidos se registraron 30-35 días después de la infestación y también se determinó la pérdida de peso. Los tratamientos mostraron un aumento significativo en la mortalidad de adultos de *C. maculatus* a medida que aumenta el tiempo de exposición y la dosis, con valores más altos (90 y 100% para *A. wilkesiana* y *M. charantia*, respectivamente) a las 120 h de exposición y dosis de 0,8 g. Con 0,8 g, las semillas tratadas de *A. wilkesiana* (66,3) y *M. charantia* (63,0) registraron un número significativamente menor de huevos puestos. Se observó igualmente una tendencia similar para la emergencia de adultos y el porcentaje de pérdida de peso. El estudio reveló que ambas plantas tenían efectos insecticidas significativos y mostró claramente que *M. charantia* fue más eficaz que *A. wilkesiana*, pero no mostró diferencias significativas más altas en todos los parámetros evaluados. Esto indicó que estos polvos de plantas tienen posibilidades de proteger las semillas de caupí almacenadas de la infestación y el daño de *C. maculatus*. Por lo tanto, estas plantas deben incluirse en las Estrategias de Manejo Integrado de Plagas para el almacenamiento de caupí por parte de pequeños agricultores.

Palabras clave adicionales: bioinsecticidas; semillas; preservación poscosecha; mortalidad de adultos; IPM.

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp. is a multifunctional crop providing food for man and livestock. It is a valuable and dependable revenue generating commodity widely grown by farmers in all agro-ecological zones of Nigeria. Cowpea is a major staple food crop in sub-Saharan Africa and major source of inexpensive dietary proteins to compliment the expensive animal sources of protein in many developing nations.

In most developing countries, small scale cowpea cultivation constitutes a substantial part of rural economies. Small scale farmers are confronted by severe post-harvest problems from bruchids infestation particularly in storage of grains. Research has shown that developmental stages of bruchid (*Callosobruchus maculatus*) under field and laboratory environments include: incubation period, duration of the evolution of larvae stage, pupae duration and longevity of new adults. The whole life cycle takes optimum 27 d at 30°C and 80% relative humidity (RH) (Kouninki *et al*., 2009).

Farmers who want to keep their produce from bruchids infestation result to the use of synthetic pesticides if they can afford them. The misuse of these chemicals frequently occurs since majority of small-scale farmers in many African countries are illiterate. The chemicals contaminate stored food commodity, leaving behind harmful residue, especially when application dosages are not properly followed (Parugrug and Aurea, 2008). Synthetic pesticides are not only expensive but may also have harmful effects in the health of the consumers. Moreover, some pests have developed some resistance to some of the synthetic pesticides; hence, it is necessary to find alternative natural solutions to the problem of bruchids in cowpea.

The objective of this study is to compare the response of *Callosobruchus maculatus* to powders of *M. charantia* and *A. wilkesiana* in stored cowpea.

MATERIALS AND METHODOLOGY

Location of the experiment

The study was carried out in the Department of Crop, Soil and Pest Management Laboratory, Federal University of Technology, Akure (Ondo state, South-west Nigeria).

Insect culture *(Callosobruchus maculatus)*

The adult of *Callosobruchus maculatus* used for the experiment were obtained from infested cowpea seeds which were bought from Oja-Oba market, Owo, Ondo State. The cowpea seeds were put in a kilner jar covered with muslin which prevented the insects from fleeing and allowed for ventilation (Adesina *et al*., 2016). The jar was kept at room temperature (28°C and 75% RH) for the insects to breed and multiply and emerged insects were used for the experiment.

Collection of cowpea seeds for bioassay

The seeds of cowpea drum variety used as bioassay were obtained from the same market. These were properly hand-picked and sieved, thus ensured that only wholly and uninfected seeds were used. These was kept in a deep freezer for a week to kill any immature stage of the insect (if any); followed by air drying in the laboratory for 24 h to prevent mustiness (Adesina and Mobolade-Adesina, 2020), then stored in cool dry place (Iloba and Ekrakene, 2006).

Collection and preparation of plant materials

Fresh leaves of *M. charantia* and *A. wilkesiana* were obtained from Rufus Giwa Polytechnic, Owo, Ondo state and identified at the Department of Forestry and Wood Technology of the institution. The plant leaves washed with clean water clean water to remove dirt and later air dried under a room temperature for 15 d. Thereafter, the dried leaves were grounded into powder using hammer mill and later sieved before been stored in tight lid cover container prior use.

Application of plant materials

Twenty grams of clean un-infested and disinfected cowpea seeds were weighed using digital weighing balance model TS 400D (precision standard) into Petri-dishes of 9 cm diameter. Thereafter, 0.2, 0.4, 0.6 and 0.8 g of each pulverized plant leaves was thoroughly mixed with the seeds inside each Petri-dish. Another Petri-dish containing 20 g of untreated cowpea seed was also prepared to serve as a control. Five pairs (10) of freshly emerged *C. maculatus* adults were introduced into each Petri-dish. Each treatment level was replicated three times and arranged in a complete randomization design on the laboratory workbenches.

The number of adult weevils that died were observed and recorded at 24 h interval for a period of 120 h (5 d). Insects were jabbed using a blunt dissecting probe as stated by Obeng-Oforie *et al.* (1997) and insects were considered as dead, on failure to respond to three probing. Thereafter, all insects were removed and the experiment was allowed to stay until adults (first filial generation) started to emerge. Oviposition was recorded at 48 h; number of eggs laid on the seeds (usually whitish in colour). The number of adults that emerged were counted and recorded after a period of 30-35 d; the newly emerged insects were removed after counted. Seed weight loss was determined after the experiment.

Statistical analysis

Data collected from the replicates were analyzed using the analysis of variance. Mean separation was achieved using Tukey's Honest Significance Test. Prior to analysis, data in percentage were arc sine transformed while those in count were square root transformed respectively.

RESULTS

Comparative effect of *M. charantia* and *A. wilkesiana* powders on adult mortality of *C. maculatus*

Table 1 shows the adult mortality of *C. maculatus* in cowpea seeds treated with powders of botanical plants (*M. charantia and A. wilkesiana*). At the lowest dosage of 0.2 g at 24 h of exposure, both treatments showed the lowest mortality (3.3%) with no mortality recorded for control. The treatments further showed increase in the adult mortality of *C. maculatus* as the time of exposure and dosage increases with highest values (90 and 100% for *A. wilkesiana* and *M. charantia*, respectively) at 120 h of exposure and 0.8 g dosage level.

It was obtained from the result that *M. charantia* and *A. wilkesiana* powders were potent against *C. maculatus* because they recorded higher percentage of beetle mortality (Tab. 1).

Table 1. Comparative effect of *M. charantia* and *A. wilkesiana* powders on adult mortality of *C. maculatus*.

	Period of exposure (h)				
Treatment	24 h	48 h	72 h	96 h	120 h
0.0 g (Control)	0.0±0.00 a	0.0±0.00 a	0.0±0.00 a	0.0±0.00 a	6.7±3.33 a
0.2 g (*A. wilkesiana*)	3.3±3.33 ab	13.3±3.33 b	23.3±3.33 b	36.7±3.33 b	53.3±3.33b
0.2 g (*M. charantia*)	3.3±3.33 ab	23.3±3.33 bc	36.7±3.33 bc	53.3±3.33 bc	63.3±3.33b
0.4 g (*A. wilkesiana*)	10.0±0.00 bc	30.0±0.00 cde	43.3±3.33 cd	56.7±3.33 c	66.7±3.33bc
0.4 g (*M. charantia*)	13.3±3.33 c	33.3±3.33 cde	46.7±3.33 cde	66.7±3.33 c	6.7±3.33 bcd
0.6 g (A. wilkesiana)	13.3±3.33 c	33.3±3.33 cde	56.7±3.33 cde	70.0±5.77 cd	0.0±0.00bcd
0.6 g (*M. charantia*)	16.7±3.33 c	40.0±0.00 de	66.7±3.33 fg	83.3±3.33 d	90.0±5.77cd
0.8 g (*A. wilkesiana*)	20.0±0.00 c	40.0±0.00 de	60.0±0.00 ef	83.3±3.33 d	90.0±0.00cd
0.8 g (*M. charantia*)	20.0±0.00 c	46.7±3.33 e	76.7±3.33 g	100.0±0.00 e	100.0±0.00d

Each value is the mean ± standard error of the three replicates. Values in the same column with same letter(s) do not differ significantly at P>0.05 using Tukey's honest significance test.

Adeboye, O.R., M.O. Oni, and J.M. Adesina. 2020. Comparative response of *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) to powders of *Momordica charantia* and *Acalypha wilkesiana* in stored cowpea (*Vigna unguiculata*) (Walp.). Revista Colombiana de Ciencias Hortícolas 14(2). Doi: https://doi.org/10.17584/rcch.2020v14i2.9840

Comparative effect of *M. charantia* and *A. wilkesiana* powders on the oviposition suppression of *C. maculatus*.

Table 2 shows oviposition suppression activity of *M. charantia and A. wilkesiana* powders in stored cowpea seeds. It was shown that untreated seeds (control) have the highest oviposition (175.0). The treatments showed significant effects on the oviposition of the insect (*C. maculatus*) compared with the control. It was shown that at 0.2 g dosage level, *Acalypha wilkesiana* treated seeds had 107.7 eggs laid by the insect. While, *M. charantia* had 105.7 eggs laid by the insects. At 0.4 g dosage level, *A. wilkesiana and M. charantia* showed 97.0 and 88.3 eggs laid respectively. At 0.6 g dosage level, *Acalypha. Wilkesiana* recorded 84.7 eggs laid on the stored cowpea seeds and *M. charantia* recorded 70.3 eggs laid on the stored cowpea seeds. At 0.8 g dosage level, *A. wilkesiana* treated seeds shows 66.3 eggs laid by the insect, while *M. charantia* shows 63.0 eggs laid by the insect.

Table 2. Comparative effect of *M. charantia and A. wilkesiana* powders on oviposition of *C. maculatus.*

	Plants powders	
Concentration	*A. wilkesiana*	*M. charantia*
0.0 g	162.3±0.10 a	175.0±2.40 a
0.2 g	107.7±1.20 b	105.7±0.13 bc
0.4 g	97.0±0.09de	88.3±2.65 cd
0.6 g	84.7±1.86 f	70.3±0.20 e
0.8 g	66.3±0.00 g	63.0±0.00 g

Each value is the mean ± standard error of the three replicates. Values with same letter(s) do not differ significantly at *P*>0.05 using Tukey's honest significance test.

Comparative effect of *M. charantia* and *A. wilkesiana* powders on the adult emergence of *C. maculatus*

Table 3 shows the activity of the plants powder (*M. charantia* and *A. wilkesiana*) on the adult emergence of *C. maculatus* on the stored cowpea seeds.

The result showed that there was significant effect of the plants powder on the adult emergence of the cowpea weevil in the stored seeds compared with the control. The control recorded the highest number of *C. maculatus* adult emergence (114.3), while *M. charantia* powder at 0.8 g dosage level shows the least number of adult emergences (40.0). At 0.2, 0.4 and 0.6 g dosage levels, there was no significant difference between the two plants powders.

Adeboye, O.R., M.O. Oni, and J.M. Adesina. 2020. Comparative response of *Callosobruchus maculatus* (Fab.) (Coleoptera: Chysomelidae) to powders of *Momordica charantia* and *Acalypha wilkesiana* in stored cowpea (*Vigna unguiculata*) (Walp.). Revista Colombiana de Ciencias Hortícolas 14(2). Doi: https://doi.org/10.17584/rcch.2020v14i2.9840

At 0.8 g dosage level, there was a significant difference between *M. charantia* (40.0) and *A. wilkesiana* powders (48.7) respectively.

Table 3. Comparative effect of *M. charantia and A. wilkesiana* powders on adult emergence of *C. maculatus*.

Plants powders Concentration	*A. wilkesiana*	*M. charantia*
0.0 g	114.3±0.18 a	113.7±3.53 a
0.2 g	79.0 ± 0.33 b	67.0 ± 1.15 b
0.4 g	66.3 ± 1.20 c	60.7 ± 0.33 c
0.6 g	57.0 ± 0.33 de	51.0 ± 0.33 de
0.8 g	48.7 ± 0.00 d	40.0 ± 0.00 e

Each value is the mean ± standard error of the three replicates. Values with the same letter(s) do not differ significantly at *P*>0.05 using Tukey's honest significance test.

Comparative effect of *Momordica charantia and Acalypha wilkesiana* powders on the activity of *C. maculatus* on weight loss of stored cowpea seeds

Table 4 revealed the effect of *M. charantia and A. wilkesiana* powders on the weight loss in stored cowpea seeds caused by cowpea weevils. The result shows that the seeds without treatment powder (control) has the highest percentage weight loss (17.2%) which was a result of insect infestation, followed by seed treated with 0.2 g dosage level of *M. charantia and A. wilkesiana* (12.3%), followed by 0.4 g dosage level of the treated seeds with *M. charantia* (10.8%) and *A. wilkesiana* (10.0%) respectively, followed by 0.6g dosage level of treated seeds with the two plants powders (8.0%). 0.8 g dosage level of treated seeds with the two plants powders has the least percentage seed weight loss (6.7%).

Table 4. Comparative effect of *M. charantia and A. wilkesiana* powders on activity of *C. maculatus* on weight loss of stored cowpea seeds.

Plant powders Concentration	***A. wilkesiana*** (%)	***M. charantia*** (%)
0.0 g	17.2 ± 0.05 d	17.2 ± 0.00 d
0.2 g	12.3 ±0.3 d	12.3 ± 0.02 d
0.4 g	10.0 ± 0.05 bc	10.8 ± 0.05 bc
0.6 g	8.0 ± 0.32 b	8.0 ± 0.08 b
0.8 g	6.7 ± 0.13 a	6.7 ± 0.12 a

Each value is the mean ± standard error of the three replicates. Values with same letter(s) do not differ significantly at *P*>0.05 using Tukey's honest significance test.

DISCUSSION

The main tactic for controlling storage insect pest had centred on the use of synthetic insecticides and fumigants, but these were observed to be linked with several drawbacks. Thus the alternative of embracing botanicals is a panacea to the resultant problems from the use of synthetics insecticides and fumigants. The high insecticidal effect of *M. charantia* and *A. wilkesiana* recorded in this study may be due to their insecticidal properties. In addition, the powders may block the spiracle of the beetles, thereby resulting to suffocation and death of the insect (Oni, 2014; Oni *et al*., 2018a; Ileke and Olotuah, 2012). The efficacy and effectiveness of these plants powders (*M. charantia* and *A. wilkesiana*) may also be as a result of phytochemical such as glycosides, alkaloid, sapon, and tannis among others present in the plant. Since almost these compounds had been reported to cause insect mortality, therefore, high mortality of *C. maculatus* to plant powders of *M. charantia* and *A. wilkesiana* can be associated with the presence of one or more compounds (Obembe and Ogungbite, 2017).

The study revealed that, maximum oviposition suppression was observed in *M. charantia* and *A. wilkesiana* while the minimum oviposition suppression was found in control (untreated seeds) and increase in dosage levels suppress the ovipositions as shown in table 2; this was in agreement with Olaifa and Erhun (1998), Oni *et al*. (2018b), Adesina *et al*. (2012) who found that higher concentration of the powder of *Piper guineense* and *M. charantia* significantly reduced oviposition rate and that these plants powder might possess repellent and/or oviposition suppression properties. Oviposition suppression may be due to changes induced in physiology and behavior in the adults of *C. maculatus* as reflected by their eggs laying capacity.

The significant effects of the plants powder in inhibiting adult emergence could be attributed to the plant biocidal property in suppressing *C. maculatus* oviposition in the stored cowpea seeds. A significant reduction in adult emergence was observed between the treatments. It is added that efficacy of these selected plant powders (*M. charantia* and *A. wilkesiana*) was much stronger against F1 than egg laying (oviposition). The finding is supported by Jayakumar *et al*. (2003) who reported that plant products have obvious effect on postembryonic survival of insect and resulting reduction in adult emergence in all the concentration of the plant powders. Raja *et al*. (2001) also supported this finding by stated that botanicals inhibited adult emergence in *C. maculatus* in cowpea. He further stated that, when eggs are laid on treated seeds, the toxic substance present in the plant products may enter into the eggs through chorion and suppressed their embryonic development. It is in agreement with the present study that adult emergence was greatly reduced in treated seeds than control seeds (untreated seeds).

The significant reduction in weight loss of treated cowpea grains may be as a result of the ability of the plant powders (*M. charantia* and *A. wilkesiana*) to suppress the oviposition and adult emergence rate of cowpea weevils in the stored cowpea seeds. This result of study is evidently in support of Adesina *et al*. (2012) who claimed that leaf powder of *M. charantia* has a great potential for use as admixture with cowpea seeds in storage at small holding farmers' level to reduce insect pest infestation damage; increased mortality, suppressed oviposition, adult emergent and weight loss.

CONCLUSION

The results of this finding show that the effectiveness of the plants powder (*M. charantia* and *A. wilkesiana*) was dependent of the dosages and time of exposure bring about significant effects in all the parameters accessed and have proofing entomocidal potential in conferring protection on stored cowpea grains against *C. maculatus* infestation. Therefore, due to their relative availability, easy to prepare, easy application, cheaper, nontoxic, greater ability and higher influence on *C. maculatus* infestation on stored cowpea seeds, it is recommended that *M. charantia* and *A. wilkesiana* powders can be used as parts of the components in Integrated Pest Management especially among small holding farmers or shop retailer for short term storage of cowpea against *C. maculatus* infestation in stored cowpea seeds. Further studies are recommended to determine the mode of action responsible for the plant insecticidal activities and the phytochemical profiling of the plant materials.

Conflict of interests: this manuscript was prepared and reviewed with the participation of the authors, who declare that there exists no conflict of interest that puts the validity of the presented results at risk.

BIBLIOGRAPHIC REFERENCES

Adesina, J.M., L.A. Afolabi, and T.I. Ofuya. 2012. Evaluation of insecticidal properties of *Momordica charantia* in reducing oviposition and seed damage by *Callosobruchus maculatus* (Fab.) J. Agric. Technol. 8(2), 493-499.

Adesina, J.M. and T.E. Mobolade-Adesina. 2020. *Callosobruchus maculatus* (Fab.) Coleoptera: Chrysomelidae) Infestation and Tolerance on Stored Cowpea Seeds Protected with *Anchomanes difformis* (Blume) Engl. Extracts. J. Hortic. Post-Harvest Res. 3(2), 367-378.

Adesina, J.M., T.I. Ofuya, and Y. Rajashekar. 2016. Efficacy of some plant extracts against cotton strainers, *Dysdercus superstitious* (Herrich Schaffer) (Hemiptera: Pyrrhocoridae). J. Entomol. Zool. Stud. 4(4), 170-174.

Ileke, K.D. and O.F. Olotuah. 2012. Bioactivity of *Anacardium occidentale* (L.) and *Allium sativum* (L.) powders and oils extract against cowpea bruchid, *Callosobruchus maculatus* (Fab.). [Coleoptera: Chrysomelidae]. Int. J. Biol. 4(1), 96-103. Doi: https://doi.org/10.5539/ijb.v4n1p96

Iloba, B.N. and T. Ekrakene. 2006. Daily mortality responses of Callosobruchus maculatus and Sitophiltus zeamais to change in the concentration of *Azadirachta indica*, *Ocilmum gratissium* and *Hyptis svaveolens*. J. Entomol. 3(4), 271-276. Doi: https://doi.org/10.3923/je.2006.271.276

Jayakumar, M., N. Raja, and S. Ignacimuthu. 2003. Efficacy of crude extracts of *Hyptis suaveolens* and *Melochia corchorifolia* on pulse beetle *Callosobruchus maculatus*. pp. 218-221. In: Ignacimuthu, S. and J. Eyaraj, (eds.). Biological control of insect pests. Phoenix Publishing House, New Delhi.

Kouninki, H., S. Ngamo, T. Hance, and M.B. Ngassoum. 2009. Potential use of essential oils from local Cameroonian plants for the control of red flour weevil *Tribolium castaneum*. Afr. J. Food Agric. Nutr. Dev. 7, 1-15.

Obembe, O.M. and O.C. Ogungbite. 2017 Comparative insecticidal activities of some botanical powders and pirimiphos-methyl against *Callosobruchus maculatus* Fab. (Coleoptera: Bruchidae) infesting cowpea seeds. MOJ Biol. Med. 2(4), 305-309. Doi: https://doi.org/10.15406/mojbm.2017.02.00063

Obeng-Oforie, D., C.H. Reichnuth, J. Bekele, and A. Hassan-Ali. 1997. Biological activity of 1, 8 cimeole a major component of essential oil of *Ocimum kenyense* (Ayobamgia) against stored product beetle. J. Appl. Entomol. 121, 237-243. Doi: https://doi.org/10.1111/j.1439-0418.1997.tb01399.x

Olaifa, J.I. and W. Erhun. 1998. Laboratory evaluation of *Piper guineense* for the protection of cowpea against *Callosobruchus maculatus*. Int. J. Trop. Insect Sci. 9(1), 55-59. Doi: https://doi.org/10.1017/S1742758400010031

Oni, M.O. 2014. Entomotoxic efficacy of cayenne pepper, sweet pepper and long cayenne pepper oil extracts against *Sitophilus zeamais* infesting maize grain. Mol. Entomol. 5(5), 37.

Oni, M.O., O.C. Ogungbite, and T.I. Ofuya. 2018a. Biotoxic efficacy of different fractions of *Acalypha godseffiana* oil extracts against *Callosobruchus maculatus* infesting stored cowpea. Med. Plant Res. 8(2), 8-13. Doi: https://doi.org/10.5376/mpr.2018.08.0002

Oni, M.O., B. Oyawoye, R.A. Adebayo, T.I. Ofuya, and O.C. Ogungbite. 2018b. Entomocidal efficacy of crude oil and fractions of *Mormodica charantia* (L) oil extract against cowpea bruchid *Callosobruchus maculatus* (Fab) infesting stored cowpea seeds. Appl. Trop. Agric. 23(1), 120-125.

Parugrug, M.L. and C. Aurea. 2008. Insecticidal action of five plants against maize weevil, *Sitophilus Zeamais* Motsch. (Coleptera: Curculionidae). KMITL Sci. Tech. J. 8(1), 24-38.

Raja, N., A. Babu, S. Dorn, and S. Ignacimuthu. 2001. Potential of plants f or protecting stored pulses from *Callosobruchus maculatus* (Coleoptera: Bruchidae) infestation. Biol. Agric. Hortic. 19, 19-27. Doi: https://doi.org/10.1080/01448765.2001.9754906