Journal of Biopesticides and Environment
ISSN: 2449-1284 (Online); 2449-1292 (Print)
http://www.biopjournal.com

REPELLENCY POTENTIAL OF THREE PLANT POWDERS AGAINST *Callosobruchus maculatus* F. [COLEOPTERA: CHRYSOMELIDAE]

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ABSTRACT

Experiments were conducted with the aim of assessing repellency potentials of some botanical powders against adult *C. maculatus*. Leaf powders of *Euphorbia balsamifera* L., *Jatropha curcas* L., and *Lawsonia inermis* L. were evaluated for their repellency potentials against *C. maculatus* in the Laboratory 1 of the Department of Biology of Umaru Musa Yar'adua University, Katsina (UMYUK), Nigeria. Doses of 0.1, 0.2 and 0.3 g each of the test powders were placed at one end of plastic tubings (12 x 1.5 cm), while the other end was plugged with fine cotton wool, serving as a control. Among the leaf powders applied, *E. balsamifera* was observed to have the highest (6.78 ± 0.02) repellency rating after 1 hour of exposure (HOE) when applied at the dose of 0.3g on 7 point rating scale, while the least (0.79 ± 0.01) was from the application of 0.1g of *J. curcas* after 72 HOE. All the botanical powders tested were repellent against *C. maculatus*. All the tested powders had significant ($P < 0.05$) repellent effects against *C. maculatus* adults at all doses. It is recommends that leaf powders of *E. balsamifera*, *J. curcas* and *L. inermis* could serve as botanical components of integrated pest management (IPM) of *C. maculatus* on stored cowpea.

Key words: Botanicals, *Callosobruchus maculatus*, Plant powders, Repellency

1. INTRODUCTION

Cowpea [*Vigna unguiculata* L. (Walp)] is known to be attacked by insect pests both in the field and during storage. *Callosobruchus maculatus* L. is a very serious pest of stored cowpea which attacks the stored pulses. This insect is dispersed throughout the tropics and subtropics through the medium of commerce and now has become a real menace (Kshirsagar, 2010). Initial infestation of cowpea seeds occurs in the field just before harvest and the insects are carried into the store where their population builds up rapidly. The female beetle lays eggs on the seed surface and the larva bores into the seed immediately after hatching. When it reaches the adult stage it consumes the seed cotyledons (Kshirsagar, 2010). Damaged seeds are riddled with emergence holes, spoiled with egg covers and have reduced viability. Heavy attack causes severe powdery and weight loss. In Nigeria alone, the dry weight loss due to *C. maculatus* exceeds 2900 tonnes each year (Ajayi, 2012).

Various forms of botanical plants have been used to control pests in the field and in storage, and some of them have been investigated and found effective (Suleiman *et al.*, 2011). The use of botanical products in the control of insect pests is more prevalent in storage systems, because farmers can grow them and are cheaper and easier to use than the synthetic insecticides (Govindan *et al.*, 2010). Plant materials with insecticidal properties are one of the most important locally available, biodegradable and inexpensive methods for the control of pests of stored products (Jayakumar, 2010).

There have been thorough investigations on plant secondary compounds for the past 20 years in an effort to discover new sources of botanical insecticides, repellents and antifeedants (Akhtar and Isman, 2004). Secondary plant compounds are therefore recognized as important components of plant defense system against herbivores and pathogens, as well as shaping the diet of herbivores. They are the by-products of plant metabolism and sometimes referred to as volatile plant secondary metabolites (Ukeh, 2009).
In the tropics, several plant products have been employed in subsistence agriculture for the protection of stored grains against a number of storage insects and their success rate has been encouraging (Lale, 2006). Repellent actions of

some plant materials against *C. maculatus* infesting stored cowpea have recently been reported by some researchers (Ajayi, 2013; Sabbour and Abd-El-Raheem, 2013; Bruno *et al.*, 2015; Uyi and Igbinoba, 2016).

Suleiman *et al.* (2012) reported that leaf powders of *E. balsamifera* and *L. inermis* were strong repellents against *S. zeamais*. It has been shown that the repellent action of some plant products might be due to volatility of pungent smell that causes reversible action in insects (Asawalam and Emosairue, 2006).

The objective of this research is to evaluate the repellency potential of *E. balsamifera*, *J. curcas*, and *L. inermis* leaf against adult *S. zeamais* in the store.

2. MATERIALS AND METHODS

Collection and Preparation of Plant Powders

Leaves of *J. curcas*, *E. balsamifera* and *L. inermis* were collected from the bushes around Bindawa town (12°40′11″N 7°48′19″E), Katsina State. All the plant leaves were dried under shade, for two weeks, in a well-ventilated area in the Laboratory 1 of the Department of Biology, UMYUK, before grinding into fine powders using laboratory blender (Model 8010ES) and sieved using 80 µm laboratory sieve. The powders were separately kept in glass containers and stored at room temperature (Parugrug and Roxas, 2008).

2.1 Repellency Bioassays

The repellency potential of selected plants against *C. maculatus* was conducted following the method described by Parugrug and Roxas (2008). Transparent plastic tubings (12 x 1.5 cm) were utilized. Each the tubes was plugged at one end with fine mesh tulle containing 0.1 g, 0.2 g and 0.3 g of each of the plant powders, respectively, while the other end of the tube was plugged with clean cotton ball which served as control. The tubes were replicated 3 times and arranged in a Completely Randomized Design (CRD). Five pairs of adult beetles were introduced at the centre of each tube through a hole created at the middle of the cylinder. The hole was covered with nylon mesh to retain the insects inside the cylinders and allow exchange of gases between the insects and atmosphere. The tubes were left undisturbed and the number of beetles that moved towards the untreated halves of the cylinders were counted and rated after 1, 24, 48, and 72 hours of exposure (HOE). Repellency rating was calculated as follows:

$$\text{Repellency Rating} = \frac{n(1) + n(3) + n(5) + n(7)}{N}$$

Where:

n = Number of insects stayed 0, 1 – 2, 3 – 4, and 5 – 6 cm from the centre of the cylinder towards the untreated cotton plug, respectively.

1, 3, 5 and 7 = rating scale on the reaction of the insects on different test materials.

N = Total number of insects introduced per cylinder.

The degree of repellency of each test powder is based on the following scale shown in Table 1.

2.2 Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using Graph Pad Prism (Version 7.01) and significantly different means were separated using Bonferroni Multiple Comparisons Test at 5% level ($P < 0.05$) of significance.

3. RESULTS

The results obtained on the repellency effects of the test powders on adults *C. maculatus* are shown in Figures 1 – 3. Figure 1 shows that when 0.1g powders were applied separately, *J. curcas* had the highest (6.29 ± 0.01) repellency rating after 1 HOE while *L. inermis* had the least (3.60 ± 0.01). The repellency rating of the test botanicals reduced with extension of exposure periods. At 24 HOE the repellency rating decreased to 2.31 ± 0.01 (*L. inermis*), 1.59 ± 0.01 (*E. balsamifera*) and 1.46 ± 0.01 (*J. curcas*). At 48 HOE highest (2.33 ± 0.01) repellency was observed in *L. inermis* followed by 1.30 ± 0.01 (*E. balsamifera*), while the least (1.23 ± 0.01) was by *J. curcas*. Prolonging the exposure period to 72 hours reduced repellency rating of *J. curcas* to the least (0.79 ± 0.01), while *E. balsamifera* and *L. inermis* had 1.04 ± 0.01 and 1.77 ± 0.01 repellency rating against *C. maculatus* (Figure 1). The repellency rating of was significantly different (ANOVA; F = 1434.00, df = 2, 4, P < 0.0001) between leaf powders of *E. balsamifera*, *J. curcas* and *L. inermis* applied at 0.1 g against *C. maculatus*. Similarly, a significantly (P < 0.0001) different repellency was observed between exposure periods.

Increase in dose of the plant powders to 0.2 g increased repellency effects of the tested powders. *E. balsamifera* had the highest (6.67 ± 0.02) repellency rating within the first hour of exposure, followed by *L. inermis* (6.52 ± 0.04), while *J. curcas* had the least (5.87 ± 0.02) repellency rating (Figure 2). At 24 HOE, *E. balsamifera* repellency was the highest (4.57 ± 0.02) followed closely by *J. curcas* (4.28 ± 0.02), while *L. inermis* had the least (4.18 ± 0.02). There was a general decrease in repellency of the botanicals against *C. maculatus* at 48 HOE at the dose of 0.2 g and both *E. balsamifera* and *J. curcas* had highest (3.78 ± 0.02) repellency rating, while *L. inermis* showed the least (3.50 ± 0.04). Increase in exposure time to 72 hours further decreased repellency ratings to 3.28 ± 0.02, 2.80 ± 0.03 and 2.49 ± 0.02 for *J. curcas*, *E. balsamifera* and *L. inermis*, respectively (Figure 2). There was significant difference (ANOVA; F = 382.00, df = 2, 4, P < 0.0001) between repellencies of the tested botanical powders against *C. maculatus*.

When the dose of powders applied was increased to 0.3 g, the repellency effect increased, and *E. balsamifera* was found to have the highest (6.78 ± 0.02), while *J. curcas* had the least (6.65 ± 0.03) repellency rating after 1 HOE (Figure 3). At 24 HOE, highest (5.27 ± 0.02) repellency was obtained in *J. curcas*, while the least (5.15 ± 0.03) was shown by *E. balsamifera*. The repellency continued to decrease with increase in time which resulted in 5.10 ± 0.03, 4.93 ± 0.04 and 4.45 ± 0.03 ratings for *J. curcas*, *L. inermis* and *E. balsamifera*. *L. inermis* had the highest (4.60 ± 0.03) repellency rating against *C. maculatus* at 72 HOE, while *J. curcas* leaf powders had the least (4.39 ± 0.03). There was significant difference (ANOVA; F = 548.60, df = 2, 4, P < 0.0001) between repellency ratings of the different botanical powders tested at 0.3 g against *C. maculatus*.

4. DISCUSSION

Repellents are desirable chemicals because they offer protection to our stored produce against insect pests and they have the advantage of minimal impact on the ecosystem. They reduce insect pest population in treated materials. Repellency actions of some plant materials against insect pests of stored products have been tested by some researchers (Asawalam and Emosairue, 2006; Parugrug and Roxas, 2008; Ajayi, 2013; Bruno *et al.*, 2015; Uyi and Igbinoba, 2016). In the tropics, for example, several plant products have been employed in subsistence agriculture for the protection of stored grains against a number of storage insects and their success rate has been encouraging (Lale, 2006). The leaves powder of *E. balsamifera*, *J. curcas* and *L. inermis* in this study showed their effectiveness in repelling adult *C. maculatus* when used in varying doses and for different exposure periods. *E. balsamifera* was reported to be of strong repellent effect against *S. zeamais* elsewhere (Suleiman *et al.*, 2012). The findings are also supported by Zorloni (2007) who found that 5% hexane extracts of related species, *E. candelabrum* and *E. tirucalli* resulted in 0% repellency against tick (*Rhipicephalus pulchellus*), while 10% of the same plant extracts gave 46 and 45 repellency index, respectively. Findings of this study have revealed that *L. inermis* showed a strong repellent activity against *C. maculatus* at all doses within the experimental periods. This is in agreement with Suleiman *et al.* (2012) who reported that leaf powders of *L. inermis* strongly repelled *S. zeamais* after 1 hour when applied at the dose of 0.3 g. Results on repellency of *J. curcas* against *C. maculatus* in this study agrees with the findings of Sabbour and Abd-El-Raheem (2013) who recorded a high repellent action of *J. curcas* seed oil against the beetles. Repellency potentials of some other botanicals like *Morinda lucida* (Benth.) *Simmondasia chinensis* (Link) and *Chromolaena odorata* (L.) were also tested against *C. maculatus* and found to be promising (Ajayi, 2013; Sabbour and Abd-El-Raheem, 2013; Uyi and Igbinoba, 2016).The findings indicated that as the dose increased, repellency increased for almost all the plant powders. The repellency effects also decreased with increase in the period of exposure in *J. curcas* at all rates. This agrees with the findings of Parugrug and Roxas (2008) who reported a decrease in repellency rating of *A. indica* against *S. zeamais* from 7.00 after 1 hour to 3.53 after 96 hours. They also reported a decrease in repellency rating of *T. erecta* from 6.90 to 1.13 after 96 hours of exposure. Similarly, Ajayi (2013) reported increase in repellent action of *M. lucida* against *C. maculatus* with increase in concentrations. All the plants leaf powders tested showed high repellency actions after the first 4 hours at higher dose and then the effect declined with time to moderately repellent actions. The declining action could be attributed to the fact that the active repellent components of the plant powders became weak as the exposure period was prolonged. The repellent action observed could be due to the action of essential oils from the leaves glandular trichomes which rupture to release the volatile oils on maceration.

The repellency activities of the selected botanicals in different formulations could be due to the presence of non-host volatile odour components of plants that repel insects as reported by Kuhns *et al.* (2016). Active ingredients such as alkaloids, flavonoids, saponins, phenolics and tannins, have been identified in *E. balsamifera*, *L. inermis* and *S. obtusifolia* by some researchers (Doughari *et al.*, 2008; Kamba and Hassan, 2010; Raja *et al.*, 2013). The bioactive compounds were suggested to confuse the olfactory receptors so that the insects could not smell the host (Effiom *et al.*, 2012). Adesina *et al.* (2016) also suggested that the toxic secondary metabolites present in extracts were responsible for repellent action against insect pests like *Dysdercus superstitious* (Herrich Schaffer).

5. CONCLUSION

From the findings of this study, it can be concluded that the selected plant powders had repellent activities against adults of *C. maculatus* which could be used in reducing grain damage that might have been caused by the beetle during storage for a short period of time. Since plant derived pesticides are biodegradable and safer to higher animals, they could be used as a control option and serve as a component of integrated pest management (IPM) strategies.

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Table 1**:** Repellency Rating Scale

Rating	Distance (cm) from the centre of the cylinder towards the untreated plug	Description
1	0	Ineffective
3	1 – 2	Slightly Repellent (SR)
5	3 – 4	Moderately Repellent (MR)
7	5 – 6	Highly Repellent (HR)

Source: Parugrug and Roxas (2008)

Table 2: Repellency Rating Scale

Rating	Distance (cm) from the centre of the cylinder towards the untreated plug	Description
1	0	Ineffective
3	1 – 2	Slightly Repellent (SR)
5	3 – 4	Moderately Repellent (MR)
7	5 – 6	Highly Repellent (HR)

Source: Parugrug and Roxas (2008)

Table 3**:** Repellency rating of some botanical powders applied at varying amounts against *C. maculatus*

Test powder	Amount used (g)	Mean repellency rating ± S. E /Duration of exposure (hours).			
		1	24	48	72
E. balsamifera	0.1	5.45 ± 0.00	1.59 ± 0.01	1.30 ± 0.01	1.04 ± 0.01
	0.2	6.67 ± 0.02	4.58 ± 0.02	3.78 ± 0.02	2.80 ± 0.03
	0.3	6.78 ± 0.02	5.15 ± 0.03	4.45 ± 0.03	4.39 ± 0.03
J. curcas	0.1	6.29 ± 0.00	1.46 ± 0.01	1.23 ± 0.01	0.79 ± 0.01
	0.2	5.87 ± 0.02	4.28 ± 0.02	3.78 ± 0.02	3.28 ± 0.02
	0.3	6.65 ± 0.03	5.28 ± 0.02	5.10 ± 0.03	4.42 ± 0.02
L. inermis	0.1	3.60 ± 0.01	2.31 ± 0.01	2.33 ± 0.01	1.77 ± 0.01
	0.2	6.52 ± 0.04	4.18 ± 0.02	3.50 ± 0.04	2.49 ± 0.02
	0.3	6.69 ± 0.02	5.25 ± 0.03	4.93 ± 0.04	4.60 ± 0.03

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