PEEL AND LEAF POWDERS OF THREE FRUITS AND A VEGETABLE AS PROMISING BOTANICALS AGAINST CALLOSBRUCHUS MACULATUS (F.)

Abdulrasak K. Musa* and Samuel O. Adewale

Department of Crop Protection, P.M.B. 1515, University of Ilorin, Ilorin, Nigeria

Abstract: The aim of this study was to examine the insecticidal activities of powders of bitter leaf, cashew leaf, orange peel and pawpaw leaf against Callosobruchus maculatus (F.) (Coleoptera: Bruchidae). These were tested at 2.5%, 5.0% and 7.5% (w/w) for their insecticidal activities against the insect. Results showed that the ovicidal and adulticidal activities of the plant powders depended on dosages and exposure time. Mortalities of 16.28% and 18.75% were observed in bitter leaf powder applied at 7.5% (w/w) dosage within 24 and 48 hours post infestation (HPI), respectively. In grains treated with 7.5% orange peel powder, 12.50% and 16.28% mortalities were observed within 24 and 48 HPI, respectively. Each of bitter leaf and orange peel powders was significantly different (p<0.05) in causing adult mortality at the highest dosage compared with the control. Oviposition was inhibited at the highest dosage of the plant powders, but the percentage of oviposition in the lower dosages was three-fold lower than the control. The plant powders also significantly reduced progeny emergence and grain damaged by the beetle. No beetle emergence was recorded in grains treated with bitter leaf powder at 27 DPI. Adult beetles in grains treated with cashew and pawpaw leaf powders caused grain damage of 46.3–54.7% and 44.7–60.7%, respectively during the study period. There was a noteworthy decrease in insecticidal effects of the plant powders as indicated: bitter leaf > orange peel > cashew leaf > pawpaw leaf. It is recommended that incorporating these plant parts in pest management of stored products will guarantee user safety, reduce environmental pollution and suppress insect infestation.

Key words: Callosobruchus maculatus, botanicals, damage, mortality, progeny.

*Corresponding author: e-mail: akmusa2013@gmail.com
Introduction

Cowpea is a household name in Nigeria where it is commonly called ‘wake’ in Hausa or ‘ewa’ in Yoruba. It is rich in amino-acids, especially lysine and tryptophan, making it a preferred plant protein (20–40%) for human consumption. The production areas are particularly in the middle belt and drier northern region (Ojuederie et al., 2009).

Insect pests constitute the most visible and important constraint to cowpea production, infesting mature pods and accounting for post-harvest reduction of grains (Musa, 2012). Cowpea is infested by bean beetle, *Callosobruchus maculatus* (F.) between harvest and storage leading to quantitative and qualitative losses of grains. The larvae feed within the grains and consume endosperm. The adults leave neat circular exit holes in the grains after emergence. The use of synthetic insecticides for controlling stored product insects is associated with problems such as their persistent toxicity in grains, development of resistance in insect populations and effects on non-target organisms (Iram et al., 2013). For these reasons, there is a steady increase in the use of plant products as an easier and safer means of protecting small-scale stored products against insect infestation. The objectives of this study were to examine the insecticidal activities of powders of bitter leaf, cashew leaf, orange peel and pawpaw leaf against bean beetle, *C. maculatus* in stored cowpea.

Material and Methods

Insect culture

About 50 unsexed adults of *C. maculatus* were picked from existing stock in the Crop Protection Laboratory, University of Ilorin, Nigeria and used to infest susceptible cowpea grains in a 500-ml kilner jar. These insects were allowed to oviposit and then they were removed 7 days after introduction. Freshly emerged adults (1–2 days old) were used in the study.

Collection and preparation of plant powders

Bitter leaf, *Vernonia amygdalina* Dileli (Compositae), cashew, *Anacardium occidentalis* L. (Anacardiaceae) leaves, sweet orange, *Citrus sinensis* L. (Rutaceae) peels and pawpaw, *Asimina triloba* (L.) Dunal (Annonaceae) leaves were removed from their parent plants, washed, air-dried and separately ground in an electric blender. The powders were then passed through a sieve of mesh of 0.01 mm to obtain uniform particles. The powders were kept in separate plastic containers and stored at ambient temperature and relative humidity of 28±3°C and 71±4%, respectively.
Source and preparation of cowpea grains

Cowpea grains (variety IT96k-610) properly wrapped in a brown envelope were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The grains were poured in a polythene bag and kept in a deep freezer for 7 days to rid them of any insidious infestation, and later allowed to air-dry to assume ambient temperature and relative humidity.

Sex determination

The method of Blumer and Beck (2008) was adopted in identifying the sexes. The female beetle has an enlarged and dark plate covering the end of the abdomen on both sides while the male beetle has a smaller plate which lacks stripes.

Adult mortality

Cowpea grains were treated with 2.5, 5.0 and 7.5% (w/w) of bitter leaf, cashew leaf, sweet orange peel and pawpaw leaf powders before they were infested with two females and one male of *C. maculatus* in their respective containers. The containers were thoroughly agitated for 3 min. to obtain uniform spread of the extracts before infestation. The open top of the containers was covered with muslin cloth held in place with a rubber band and then arranged in a completely randomized design on a laboratory desk. Each treatment was replicated three times including the control. Adult mortality of beetle was assessed at 24 and 48 hours post infestation (HPI).

Fecundity and progeny emergence

Powders of bitter leaves, cashew leaves, sweet orange peels and pawpaw leaves were separately mixed in three dosages of 2.5, 5.0 and 7.5% (w/w) per 20 g of cowpea grains and gently shaken in their respective Petri dishes. The mixture was then infested with two couples of freshly emerged (teneral) adults of *C. maculatus* and allowed to settle on the laboratory desk after preparing three replications of each treatment including the control. Fecundity was calculated as the percentage of eggs laid in all treatments at 5 days post infestation (DPI). Progeny emergence was calculated as the percentage of adults that emerged in all treatments at 27 and 32 DPI.

Grain damage

The number of grains damaged per 100 grains was counted at 3 months post infestation (MPI). This was carried out by counting the number of grains with
emergent holes divided by the total number of grains and then expressed as percentage of grain damaged.

Data analysis

Data collected were subjected to analysis of variance (ANOVA) using Genstat Statistical Package (Discovery Edition 3). Where significant differences were recorded in the ANOVA, means were separated using Least Significant Difference at p=0.05 level of significance.

Results and Discussion

Adult mortality

The mean percentage of adult mortality of *C. maculatus* exposed to different dosages of plant powders is shown in Table 1. Mortality of the beetles ranged between 6.25% and 16.28% for bitter leaf, between 4.65% and 6.98% for cashew leaf, between 6.25% and 12.50% for orange peel and between 0.0% and 4.65% for pawpaw leaf powders at 24 HPI. Each of bitter leaf and orange peel powders was significantly different (p<0.05) in causing adult mortality at the highest dosage compared with the control which had no mortality. At 48 HPI, the 7.5% dosage of bitter leaf powder caused 18.75% of adult mortality, which was not significantly different (p>0.05) from the orange peel powder which caused 16.28% of adult mortality. Results also showed that there was no significant difference in mortality recorded in 5.0% and 7.5% dosages of bitter leaf powder at 24 and 48 HPI, suggesting that the bitter leaf powder can be applied at lower dosage. It was also observed that mortality increased with an increase in dosage of plant powders and exposure. In this study, a higher dosage of plant powder treatment had more inhibitory action on the *C. maculatus* than a lower dosage. It was observed that mortality was dependent on dosage, type of plant powder and exposure period. The mortality in bitter leaf was dose- and time-dependent due to the presence of hydrocyanic acid and oxalic acid (Kabeh and Jalingo, 2007). Bitter leaf powder has been reported to have insecticidal potential and feeding deterrent effects on *C. maculatus* in stored cowpea. Insecticidal properties of pawpaw have been reported by Mulungu et al. (2007).

Fecundity and progeny emergence

The relationship between percentage oviposition and progeny emergence of *C. maculatus* can be deduced from Table 1. Results showed that the plant powders applied at the highest dosage (7.5%) inhibited egg-laying. There, percentage fecundity significantly (p<0.05) reduced by three-fold in the treated grains when
compared to the untreated grains. The reduction rates in fecundity either reduced or inhibited progeny emergence of *C. maculatus* in the study. No progeny emergence was recorded at different dosages of bitter leaf powder. Emergence was significantly \((p<0.05)\) reduced by 0.0–95.8% in cashew and orange peel powders, by 0.0–88.0% in pawpaw leaf powder compared with the control (58.1%) at 27 DPI. At 32 DPI, emergence was reduced by 0.0–96.7% in bitter leaf powder, by 0.0–87.2% in cashew leaf powder, by 0.0–93.6% in orange peel powder, by 0.0–90.0% in pawpaw leaf powder and by 73.2% in the control at 32 DPI. The highest progeny emergences of 6.98% and 7.31% recorded at the lowest dosage of pawpaw leaf powder were significantly lower than the control at 27 and 32 DPI, respectively. Progeny emergence decreased with an increase in dosage of the plant powders even though the emergences at different dosages compared favourably with one another. Bitter leaf powder was most effective in reducing beetle population, fecundity, progeny emergence and grain damage among different treatments applied. This study has shown that the plant powders interfered with the developmental process of the insect by reducing the number of eggs laid and exerting ovicidal effects on the insect. In addition, more grain damage occurred at the lower dosages as a result of increased progeny emergence. This may be attributed to increased feeding and behavioural activities of *C. maculatus*. Fecundity and progeny emergence may have been affected by seed size, appearance and variety. The mechanical effects of large quantities of powders themselves could have an effect on oviposition (Rajapakse, 2006). An increase in progeny emergence apparently resulted in an increase in percentage grain damaged. Worldwide reports indicate that when mixed with stored grains, leaf, bark, seed powder, or oil extracts of plants reduce oviposition rate and suppress adult emergence (Bakkali et al., 2008; Tripathi et al., 2009). Reduction in oviposition may have been induced by the change in appearance of the treated grains thus making the grains unattractive to the insect. Egg-laying inhibition, which is significant, is responsible for low grain damage, probably due to egg-laying deterrent effects of some plant powders.

**Grain damage**

Table 1 also reveals the percentage grain damaged by *C. maculatus* in the treated and untreated grains. There was a significant difference \((p<0.05)\) in grain damaged ranging between 5.3% and 5.7% in bitter leaf powder, between 46.3% and 54.7% for cashew leaf powder, between 6.3% and 11.0% for orange peel powder and between 44.7% and 60.7% in grains treated with pawpaw leaf powder. All treatments were significantly different in grain damaged by *C. maculatus* compared to the control. The least grain damage was observed in bitter leaf powder which was not significantly different \((p>0.05)\) from orange peel powder. The percentage grain damaged by the beetle increased significantly \((p<0.05)\) as dosage
of pawpaw leaf powder decreased. However, there was no significant difference in grain damage among the values obtained at various dosages of bitter leaf and orange peel powders. Cashew and pawpaw leaf powders caused significantly higher grain damage at different dosage levels compared with dosage levels of other plant powders. It was observed that grains treated with cashew and pawpaw leaf powders were severely damaged during the 3 months of the study. In this study, bitter leaf and orange peel powders played an observable role in suppressing bean beetle population in stored grains, although it was observed that packaging, winnowing, sorting, seed disinfection carried out at the start of the experiment may have contributed to reduced damage.

Table 1. Evaluation of insecticidal potential of powders of plant parts against *Callosobruchus maculatus* in stored cowpea grains.

| Plant powder | Dosage (%) | % of adult mortality (HPI) | % of oviposition (DPI) | % of progeny emergence (DPI) | % of grain damaged |
|--------------|------------|---------------------------|-----------------------|----------------------------|-------------------|
|              | 24 48 5 27 32 3 MPI |
| Bitter leaf  | 2.5 6.25c 9.30b 9.09b 0.0b 2.44b 5.7e |
|              | 5.0 12.50ab 13.95ab 9.09b 0.0b 2.44b 5.3e |
|              | 7.5 16.28a 18.75a 0.0c 0.0b 0.0b 5.3e |
| Cashew leaf  | 2.5 4.65d 6.25cd 9.09b 2.44b 9.30b 54.7b |
|              | 5.0 4.65d 6.25cd 9.09b 2.44b 9.30b 53.3c |
|              | 7.5 6.98cd 12.50b 0.0c 0.0b 0.0b 46.3c |
| Orange peel  | 2.5 6.25cd 6.98c 9.09b 2.44b 4.65b 11.0e |
|              | 5.0 9.30b 9.30bc 9.09b 2.33b 2.44b 8.7e |
|              | 7.5 12.50a 16.28a 0.0c 0.0b 0.0b 6.3e |
| Pawpaw leaf  | 2.5 0.0e 2.33d 9.09b 6.98b 7.31b 60.7b |
|              | 5.0 0.0e 2.33d 9.09b 2.44b 4.65b 52.7c |
|              | 7.5 4.65d 6.25cd 0.0c 0.0b 0.0b 44.7d |
| Control      | 0.0 0.0e 0.0d 27.28a 58.13a 73.17a 81.7a |

HPI=Hours post infestation; DPI=Days post infestation; MPI=Months post infestation; Numbers followed by different letters in the same column are significantly different (p=0.05).

*Callosobruchus maculatus* is definitely a great threat to stored cowpea grains in the tropical region of the world, including Nigeria. The current trend is to manage the population of the pest by seeking regulatory approaches that would reduce food shortage. Belmain and Stevenson (2001) opined that plant powders are abrasive and sometimes adhere to grains depending on particle size. The use of these plants is acceptable to farmers because of general safety and ease of handling.
Peel and leaf powders of three fruits and a vegetable as promising botanicals

Heaps of orange peels are sources of environmental pollution (Emeasor and Okorie, 2008) and converting them into useful pesticide would help reduce pollution. Orange peels contain secondary metabolites that show insecticidal activity against several coleopterans and dipterans (Belmain and Stevenson, 2001; Salvatore et al., 2004; Shrivastava et al., 2010). Most insects breathe through the trachea, which usually leads to the opening of their spiracle. These spiracles might be blocked by the powders and extracts, thereby leading to suffocation (Komabonta and Falodu, 2013).

Conclusion

The study shows that bitter leaf powder was most effective in suppressing beetle population with a consequent reduction in cowpea grain damage. The insecticidal action of orange peel powder compared favourably with bitter leaf powder. The incorporation of the former will help reduce heaps of waste capable of causing environmental pollution. These crops are indigenous to Nigeria, easy to apply, affordable and produce no detrimental effects on the health of the user. They will, therefore, form a sustainable alternative to imported and hazardous synthetic insecticides. Efforts are being made to evaluate the synergistic effects of these plant powders in protecting stored products from insect pests.

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Abdulrasak K. Musa* and Samuel O. Adewale

Odsek za zaštitu ratarskih useva, P.M.B. 1515, Univerzitet u Ilorinu, Ilorin, Nigerija

R e z i m e

Cilj ovog rada je bio da se ispitaju insekticidalne aktivnosti praha gorkog lista, lista indijskog oraha, pomorandžine kore i lista papaje protiv *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Ovi prahovi su testirani u rastvorima od 2,5%, 5,0% i 7,5% (w/w) radi svojih insekticidalnih aktivnosti protiv ovog insekta. Rezultati su pokazali da ovičidne i adulticidne aktivnosti ovih biljnih prahova zavise od doza i vremena izlaganja. Smrtni ishodi od 16,28% i 18,75% su uočeni kod primene praha gorkog lista pri dozi od 7,5% (w/w) do 24 odnosno 48 sati posle infestacije (SPI). Kod zrna koja su tretirana sa 7,5% prahom pomorandžine kore, smrtnosti od 12,50% i 16,28% su uočene unutar 24 odnosno 48 SPI. Svaki od prahova gorkog lista i pomorandžine kore je bio značajno različit (p<0,05) pri uzrokovanj smrtnosti odraslih jedinki pri najvećoj dozi u poređenju sa kontrolom. Ovipozicija je bila inhibirana pri najvećoj dozi biljnih prahova, ali je procenat ovipozicije pri nižim dozama bio trostruko niži nego kod kontrole. Biljni prahovi su takođe značajno smanjili nastanak potomstva i % zrna koja su insekti oštetili. Nije zabeležena pojava insekata u zrnima koja su tretirana prahom gorkog lista na 27 DPI. Odrasli insekti u zrnima koja su tretirana prahom indijskog oraha i papaje su uzrokovali štetu na zrnima od 46,3–54,7% odnosno 44,7–60,7%, tokom perioda ispitivanja. Bilo je takođe značajnog smanjenja insekticidalnog uticaja biljnih prahova kao što je iznaldo: gorki list > pomorandžina kora > list indijskog oraha > list papaje. Predpostavlja se da će inkorporiranje ovih biljnih delova u upravljanje štetočinama skladištenih proizvoda garantovati bezbednost korisnika, smanjiti zagadenje životne okoline i suzbiti infestaciju insektima.

Ključne reči: *Callosobruchus maculatus*, biljni preparati, šteta, mortalitet, potomstvo.

*Autor za kontakt: e-mail: akmusa2013@gmail.com*