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# Bioactivity and toxicity Effect of imidacloprid insecticide against *Rhyzopertha dominica* (Coleoptera: Bostrychidae) in Stored Cowpea (*Vigna unguiculata* (L.) (Walper)) Seeds

**[1]Bukar, A.; [2]Kabir, B.G.J.; [2]Gaya, S. S.; & [2]Gambo, F. M.**

[1]Department of Agricultural Technology, Mohamet Lawan College of Agriculture, P. M. B. 1427, Maiduguri, Borno State, Nigeria. [2]Department of Crop protection, Faculty of Agriculture, University of Maiduguri, P. M. B. 1069, Maiduguri, Borno State, Nigeria.

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Imidacloprid .Exposure .Mortality .Progeny inhibition .cowpea

## Abstract

Laboratory experiment was carried out in Entomology Laboratory of Department of Crop Protection Faculty of Agriculture, University of Maiduguri to evaluate the efficacy of imidacloprid insecticide against *Rhyzopertha dominica* (Fab.) (Coleoptera: Bostrychidae) on stored cowpea. Temperature and relative humidity during the study were range from 35$^{o}$c and 68-72 %. The experiment was laid out in Completely Randomized Design (CRD). The insecticide was tested at application rates of 0 (untreated control) 2.0, 4.0, 6.0, 8.0 and 10 mg/kg. For each treatment combination and control, 50 g grain samples in 5 replicates were place in 250 ml capacity jars, and 30 adults insects were place into each replicate. Adult mortality was observed after 7, 14 and 21days exposure. After additional 56 and 112 days intervals the jars were opened and examined for adult progeny emergence. The result shows that higher application dose rate of 10.0 mg/kg of imidacloprid insecticides gave appreciable adult mortality after 7 days of exposure interval, after continuous exposure to 21 days, complete 100% adult mortality were noticed at 10.0 mg/kg application rate. Progeny production was considerably suppressed after 56 and 112 days storage period. Where >97% progeny suppression where observed at the lowest dose rate of 2.0 mg/kg, complete progeny inhibition was noticed at the highest application rate of 10.0 mg/kg when compared with untreated controls. Also, based on the study reveal that, *R. dominica* is considered to be susceptible to the imidacloprid insecticide treatment. Furthermore, no damaged kernel and weight loss were recorded, also 98.2% seed germination potential were observed at the application rate of 10.0 mg/kg. Based on the findings of this study, it is possible to recommend 10.0 mg/kg of imidacloprid insecticide against management of *R. dominica* in stored cowpea.

## Introduction

Cowpea, (*Vigna unguiculata* L.) Walp) is a leguminous crop widely cultivated in tropical and subtropical region of the world (Boukar *et al.*, 2019). It is one of the most economically important cash crop (Togola *et al.*, 2017). It assumes a staple position in crop food in Africa and especially in Nigeria (Jayathilake *et al.*, 2018). It has become a food security crop and an important source of protein and carbohydrate in the diets of many rural and urban households, particulary poorer people who cannot afford to buy expensive animal protein (Jayathilake *et al.*, 2018). It production and consumption do not occur simultaneously, producers and trader need efficient storage system to ensure all round availability to consumers (Ndong *et al.*, 2012). However, insect pests are well-known problem during storage of cowpea, especially lesser grain borer, *Rhyzopertha dominica* (Fab.) which is very destructive pest of stored cowpea especially in dry areas, though its activity on cowpea is overshadowed by *C. maculatus* and much research were devoted to the later (Anderson and Major, 2002). *R. dominica* (Fab) is one of the major insect pests of stored grains that is observed among several commodities in Nigeria and other parts of the world (Diganggana, 2013). It is one of the most destructive insect pests of stored grains (Manal *et al.*, 2015). It infests other stored food items such as *Triticum*, beaten rice (Poha), millet, maize, dry fruits etc. (Edde, 2012). The adults are sturdy fliers, which fly from warehouse to warehouse, causing severe infestation and convert the stored grains to mere frass (Manal *et al.*, 2015). The larvae and adults both infest and produce frass and cause weight losses by feeding on grains (FAOSTAT, 2011). This insect pest may cause considerable economical losses if not adequately controlled because it has a very high rate of population increase (Sabbour, 2015).

It was observed that the use of residual insecticides is becoming less desirable because of the development of resistance in major insect pests. Regulatory restrictions on the use of insecticides, awareness of environmental pollution, the increasing cost of storage, erratic supplies, worker safety, and consumer desire for a pesticide-free product have led to pest management specialists to evaluate alternative methods for the pest control of stored products (Athanassiou *et al*., 2005 & 2006).

Imidacloprid (1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylidene-amine) is broad spectrum systemic neonicotinoid insecticides that have been widely used worldwide for broad spectrum insect control (Liu et al., 2005), which acts as an insect neurotoxin and belongs to a class of chemicals called the neonicotinoids which act on the central nervous system of insects with much lower toxicity to mammals. The chemical works by interfering with the transmission of stimuli in the insect nervous system. Specifically, it causes a blockage in the nicotinergic neuronal pathway (Zhang *et al*., 2008). This blockage leads to the accumulation of acetylcholine, an important neurotransmitter, resulting in the insect's paralysis, and eventually death. It is effective on contact and via stomach action (PIP, 2012). Because imidacloprid binds much more strongly to insect neuron receptors than to mammal neuron receptors, this insecticide is selectively more toxic to insects than mammals (Gervais *et al*., 2010). It has a low mammalian toxicity but is highly effective as an insecticide (Fossen 2006), it has a high efficacy, even at low field application rates (Aajoud *et al*. 2003). These advantages have contributed to the rise it popularity as insecticides for use in field and storage application (Daglish and Nayak, 2012). The objective of the study was to evaluate the efficacy of imidacloprid on the management of *R. dominica* on stored cowpea.

## Materials and methods

### Experimental Site

The experiment was conducted in Entomology Laboratory of the Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, Nigeria. Latitude $11^{o}$ 50ˈ N, $13^{o}$ 9ˈE. The experiment was conducted under ambient laboratory conditions. Temperature and relative humidity during the study was measured using hygrometer. The temperature and relative humidity, during the experiment were $35^{o}$C and 68-72%, respectively.

### Sources of Experimental Materials

### Maintenance of stock culture

Parent *R. dominica* used in this study was obtained from laboratory stock culture, which has been maintained for over a year. The culture was maintained in 1.5L capacity bottles containing cowpea seeds in order to maintain a stock culture for continuous fresh supply of large number of insects required for the experimentation. Fresh broken seeds was introduced periodically for proper development of the beetles.

Dead adult beetles and frass was periodically removed to avoid storage mite infestation.

**The cowpea seeds**

The cowpea seed (var: Borno brown) and local cultivars was obtained from Borno state Agricultural Development Programme (BOSADP) Maiduguri.

**The insecticides**

The insecticides Imidacloprid was obtained from a certified pesticide vendor in Kano, Kano state.

**Preparation of Cowpea seed**

The cowpea seed were cleaned and disinfested for10days using refrigerator and equilibrated and kept in plastic buckets covered with lids until commencement of the experiment

**Grain Treatments**

The grain was treated at the following application rates 0.0 (Control), 2.0, 4.0, 6.0,8.0 and 10mg/kg. For each treatment combinations 250g of clean disinfested cowpea grain was placed in 1 liter capacity jar and the appropriate amount of insecticides was added to each samples. The jars was capped and then shaken manually to achieve uniform distribution of insecticide on the entire grain.

**Bioassay Procedure**

All experiment was laid out in Completely Randomized Design, with six treatments replicated five times. Fifty gram (50g) of cowpea seeds per 250 ml capacity jar was prepared per each treatment. Cowpea seeds was infested using 30 pairs of unsexed 1-2 days old adult *R. dominica*. Five other 50g replicates was prepared and left uninfested which was served as untreated control. The following parameters was observed at course of the experiment, adult mortality after 7, 14 and 21 days of exposure, while weight loss, seed damage and percentage seed germination were also observed. Content of each jars were emptied on to a plastic tray, dead and live insects were recorded and dead insect was removed from the jars, while the live insects was returned into their respective jars and recounted, at which both the dead and live insects was removed. The grain and dust was returned to their respective jars and kept on the shelf at the same conditions. After additional 60 and 90 days intervals the jars was opened and examined for $F_1$ adult progeny emergence.

## Germination Losses

Germination losses was evaluated on each replicates for all treatment. Each replicates was set to germinate on top of non-toxic whatman filter paper moistened and placed in a plastic seed box. Germination was judged by the appearance of the radicle, was counted daily up to eight (8) days. At the final count, the number of normal and dead seedling was assessed. The SGP was calculated as follows

$$SGP\ (\%) = \frac{\text{number of germinated seeds}}{\text{Total seed number}} \times 100$$

## Data Analysis

Data obtained on mortality were first corrected for control using the Abbott's (Abbott, 1925) formula and together with data on grain damage, weight loss were arcsine transformed. Data relating to number of F1 progeny were square root $\sqrt{(x+1)}$ transformed. All transformed data subjected to a one-way Analysis of Variance (ANOVA) procedure using the statistical software Statistix 8.0 (Statistix, 2007). differences between the means were separated using Tukey-Kramer's Honestly Significant Difference (HSD) test at ($p \le 0.05$) (Zar, 1999).

## Results and Discussion

### Effect of Imidacloprid on Mortality of *R. dominica* Adults After 7, 14 and 21 Days of Exposure

The effectiveness of various level of imidacloprid against *R. dominica* at different periods after treatment was presented in Table 1. The results revealed that in each treatment, the mortality of *R. dominica* increased gradually with time of exposure. The contact toxicities of these insecticide increased with increase in dosage as well as increase in the period of exposure to the different treatments. At rate of 2.0mg/kg observed mortality after 7, 14 and 21days were 44.6, 90.0 and 96.7% respectively. However, as the dose rate increase the mortality increases thus at 6.0mg after 14days of exposure 100% mortality were recorded. Moreover, at rate 10mg/50kg of cowpea seeds, 100% mortality was obtained in sample even at 7days of exposure (Table 1).

Table 1: Mean (SE±) mortality of *R. dominica* adults after 7, 14 and 21 days of exposure to Cowpea Treated with Imidacloprid Insecticide

| Mortality (%±SE) | | | |
|---|---|---|---|
| Dose (mg/kg) | 7days | 14days | 21days |
| 0.0 | $1.3\pm0.8^{d}$ | $2.6\pm1.2^{c}$ | $3.3\pm1.5^{c}$ |
| 2.0 | $44.6\pm5.8^{c}$ | $90.0\pm2.9^{b}$ | $96.7\pm1.5^{b}$ |
| 4.0 | $76.0\pm7.9^{b}$ | $96.7\pm1.0^{a}$ | $98.7\pm1.3^{a}$ |

| | | | |
|---|---|---|---|
| 6.0 | 88.7±3.2[ab] | 100.0±0.0[a] | - |
| 8.0 | 96.7±1.5[a] | 100.0±0.0[a] | - |
| 10.0 | 100.0±0.0[a] | 100.0±0.0[a] | - |

Mean within columns and within treatment group followed by same letter (s) are not significantly different ($p<0.05$) from each other: Tukey-Kramer's HSD Test

*S.E= Standard Error

**Effect of Imidacloprid on Progeny Production and Percent Progeny Inhibition of *R. dominica* Adults on Treated Cowpea**

The data on progeny development and progeny inhibition of *R. dominica* showed significant differences among the different level of imidacloprid after 56 and 112 days of storage Table 2. The results show that there were very few $F_1$ progeny 3.6 and high progeny inhibition of 97.3% was achieved at dose rate of 2.0 mg/kg of imidacloprid after 56 days of storage. At the dose rate of 4.0mg/kg no $F_1$ progeny were developed. After 112days of storage, the result reveal that at the least dose rate of 2.0 mg/kg only 3.8 adults developed and inhibition of 97.7% adult progeny emergence was recorded. As the dose rate increases, progeny development decreases even at 4.0 mg/kg, no $F_1$ Adult progeny were developed (Table 2). When compared with 133.0±15.5 in the untreated control and the inhibition rate of 97.3% after 56days of storage. However, in some instance an ordered pattern was observed after 112days of storage (Table 2).

Table 2: Mean number (%±SE) of Progeny, Percent Dead Progeny and Progeny Inhibition of *R. dominica* Adults Exposed to Cowpea Treated with Imidacloprid Insecticide

| | 56days | | | 112days | | |
|---|---|---|---|---|---|---|
| Doses (mg/kg) | Mean no. of Progeny | % Dead Progeny | % Progeny Inhibition | Mean no. of Progeny | % Dead progeny | % Progeny Inhibition |
| 0.0 | 133.0±15.5[a] | 9.8±1.7[a] | - | 168.6±14.5[a] | 15.4±4.6 | - |
| 2.0 | 1.4±0.7[b] | 3.6±1.5[b] | 97.3 | 2.2±1.7[b] | 3.8±2.2 | 97.7 |
| 4.0 | 0.0±0.0[b] | - | - | 0.0±0.0[b] | - | - |
| 6.0 | 0.0±0.0[b] | - | - | 0.0±0.0[b] | - | - |
| 8.0 | 0.0±0.0[b] | - | - | 0.0±0.0[b] | - | - |
| 10.0 | 0.0±0.0[b] | - | - | 0.0±0.0[b] | - | - |

Mean within columns and within treatment group followed by same letter (s) are not significantly different ($p<0.05$) from each other: Tukey-Kramer's HSD Test

*S.E= Standard Error

**Effect of Imidacloprid on Percentage Grain damage, Weight loss and Germination loss caused by *R. dominica***

The result presented in Table 3 show that the percentage of insect damage kernel (IDK) was significantly affected by imidacloprid concentration. There were significant differences in the number of damage kernel among dose rates (Table, 3). In the untreated control after 112 days of storage complete kernel damage was recorded and this was significantly higher value in all other treatments. Significantly, at the lowest dose rate of 2.0 mg/kg of imidacloprid (2.0%) kernel damage were recorded; and as the concentration rate increases the rate of kernel damage decreased, thus very few (0.8%) were damaged at 10.0 mg/kg.

Similarly, highest weight loss was also recorded on untreated control with 87.6%, at the least concentration rate of 2.0mg/kg 6.2% weight loss were observed; and as the concentration rate increases even at 8.0mg/kg 0.0% weight loss was recorded. Furthermore, the result indicates that germination percentage was affected by different treatment concentration and highest germination percentage was recorded on different treatment concentration when compared with the untreated control thus at 2.0mg/kg 74.0±4.6% germinated grain was recorded, at 10.0mg/kg 98.2±0.6% was observed when compared with 8.0±1.4% on untreated control (Table, 3).

Table 3: Mean (SE±) Percent Grain Damage, Weight Loss and Percent Germination Caused by *R. dominica*

| Doses (mg/kg) | Damage (%) | % Weight loss | % Germination |
|---|---|---|---|
| 0.0 | 100.0±0.0a | $87.6{\pm}3.8^{a}$ | $8.0{\pm}1.4^{d}$ |
| 2.0 | $2.0{\pm}0.7^{b}$ | $6.2{\pm}1.1^{b}$ | $74.0{\pm}4.6^{c}$ |
| 4.0 | $1.4{\pm}0.9^{b}$ | $1.2{\pm}0.6^{b}$ | $82.6{\pm}1.3^{ab}$ |
| 6.0 | $1.0{\pm}0.6^{b}$ | $0.4{\pm}0.4^{b}$ | $90.6{\pm}1.6^{ab}$ |
| 8.0 | $0.8{\pm}0.6^{b}$ | $0.0{\pm}0.0^{b}$ | $96.2{\pm}0.8^{ab}$ |
| 10.0 | $0.0{\pm}0.0^{b}$ | $0.0{\pm}0.0^{b}$ | 98.2±0.6a |

Mean within columns and within treatment group followed by same letter (s) are not significantly different ($p<0.05$) from each other: Tukey-Kramer's HSD Test

## Discussion

There has been some research on the insecticidal activity of imidaclorid insecticide against insect pests of stored products (Daaglish and Nayak, 2012). However, there is limited published literature on the use of Imidacloprid insecticide against *R. dominica* on stored cowpea. Athanassiou *et al.* (2013) showed the potential of using imidacloprid insecticide against many stored product insects. The result of the present study has showed that imidaclorid could be used with success against *R. dominica* in stored cowpea. For all treatments efficacy increased with concentration rate and exposure period. However, Imidacloprid has been evaluated as a grain protectant by Daglish and Nayak (2012) for control of a wide range of stored-product beetle species. In that study, the authors reported that imidacloprid was effective for control of *R. dominica*, on cowpea, and progeny production was completely suppressed at 10 mg/kg. The results are in agreement with those reported by (Athanassiou *et al.*, 2013) the present study showed increased mortality of exposed insect (beetles) with increasing time interval as mentioned by (Waqas *et al.*, 2021) the death of insects caused by imidaclopríds is attributed by interfering with the transmission of stimuli in the insect nervous system. The development *R. dominica* progeny and their subsequent survival was significantly reduced by imidacloprid insecticide treatment. The fact that higher number of emerged progeny were dead affirms their residual activity in the treated commodity. *R. dominica* are highly susceptible to imidacloprid treatment, this fact was in agreement with the findings of Yue *et al.* (2003).

## Conclusion

The present study clearly showed that imidacloprid seed treatments have the potential to provide significant protectant against *R. dominica* in cowpea. It has been found that using the Imidacloprid insecticide had an excellent means for managing R. *dominica* on cowpea. However, efficacy varies with dose, exposure period. Furthermore, it is evident from this study that treatment doses have potential level of being used as grain protectant. However, dose rate 10.0 mg/kg gave 100% mortality after 14 days of exposure and inhibited progeny production after 56 and 112 days of storage period. However, at 10.0 mg/kg completely stopped grain damage and weight loss.

## Recommendation

Based on the findings of this study, it is possible to recommend 10.0 mg/kg of imidacloprid insecticide against management of *R. dominica* in stored cowpea. Moreover, further study is needed to investigate minimum effective dosage in controlling other stored product insects under large scale storage and field conditions.

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