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Persistence and Effectiveness of Diatomaceous Earth and Spinosad® Against *Sitophilus zeamais* (Coleoptera: Curculionidae) on Stored Rice

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Abstract

The insecticidal and residual effectiveness of Diatomaceous Earth (DE) (Nigeria-derived) and Spinosad® against *Sitophilus zeamais* on stored rice were evaluated under laboratory temperature (30 ± 2°C) and relative humidity (70 ± 5%). Adult mortality and progeny emergence were studied at three dose rates of DE and Spinosad® (0.1g/kg, 0.5g/kg, and 1g/kg). Spinosad® at 0.1-1.0 g/kg dose rates demonstrated significant results in mortality compared to DE and control groups at 14 d post-treatment and after the 2nd month of storage treatment. Spinosad® treated grains at the same dose rates also resulted in a significant reduction ($P<0.05$) in the emergence of progeny. Unlike DE, Spinosad® showed some insecticidal efficacy against *S. zeamais* on storage

Keywords: Insecticidal, Residual, Adult mortality and Progeny emergence.

INTRODUCTION

Rice is a strategic cereal and important household food in West Africa which accounts for over 20% of global calorie intake (Togola *et al*., 2013; Onu, 2018). Nigeria is Africa's leading consumer of rice (Food and Agriculture Organization – FAO, 2020). During storage, rice like other cereals is infested by pests including the maize weevil. The maize weevil, *Sitophilus zeamais* Motschulsky is the most important insect pest of maize, however, this insect can also infest rice during storage (Pires *et al*., 2008; Carvalho *et al*., 2013; Suleiman *et al*., 2015). Infestation by the maize weevil usually result in a decrease in the quality and quantity of grains and damage is usually extreme in the sub-tropical and tropical zone (Carvalho *et al.*, 2013; Ribeiro *et al.*, 2014). For the control of storage insect pests, fumigants, and other synthetic insecticides are frequently used (Chaube, 2008). However, this has resulted in toxic residue in grains. In addition, there is the development of resistant insect populations (Memon and Gilbert, 2013; Sparks and Nauen, 2015). As a result, research on a safer and more environ-

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mentally friendly approach has expanded rapidly.

Over the years, Diatomaceous earth (DE) (composed of fossils of phytoplankton) (Shah and Khan, 2014) and Spinosad (a metabolite from the actinomycete *Saccharopolyspora spinosa*) (Thompson *et al*., 1997) have demonstrated promising insecticidal activity against stored product pests (Nayak *et al*., 2005; Huang *et al*., 2007; Khashaveh et al., 2009; Athanassiou *et al*., 2014; Nwaubani *et al*., 2014; Otitodun *et al*., 2015; Korunic *et al*., 2016). Hence, this present study was conducted to further substantiate their insecticidal activity and it is aimed at evaluating the insecticidal activity of Diatomaceous Earth (Nigeria-derived) and Spinosad® as well as their residual effect against *S. zeamais* on stored rice.

MATERIALS AND METHODS

Cultures of *S. zeamais* was obtained from the insectary of Nigerian Stored Products Research (NSPR) Lagos, Nigeria; reared on rice grain and kept in the laboratory at 30±2°C and 70±5% relative humidity (r.h). The Diatomaceous Earth (Nigeria-derived) as described by Otitodun *et al*. (2015) and Spinosad® powders were obtained from the Department of Zoology, University of Lagos, Nigeria. Concentrations of 0.1, 0.5, and 1 g each of the powder were thoroughly mixed with 1 kg of a rice grain, to have stock samples. Rice grains without the powders served as control (negative). On the first day of treatment, from the respective stock samples (0.1g/kg, 0.5g/kg, and 1g/kg), 10 g each of the treated and untreated rice grain was measured and put into a vial, each of the vials was replicated three times. The experiment was conducted in a completely randomized design. Twelve (12) insects, 0 to 2-day old unsexed adult maize weevil were introduced into each of the replicates. The stock samples were stored for subsequent use. Two months later (after the initial treatment), from the respective stored stock samples, 10 g each of the treated and untreated rice grain was measured and put into a new vial, new sets of adult maize weevils were introduced. Adult mortality was assessed after 14 days of exposure. Insects were confirmed dead when they did not react when probed with a moistened camel brush as described by (Anese *et al*., 2018). Progeny emergence was checked 30 days after the removal of the parents. Results were analyzed using SPSS 16 software and differences between means were determined using Tukey's test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The mean mortality of adult maize weevil after exposure to the three-dose rates of DE and Spinosad® is presented in (Table 1). The DE treatments demonstrated insecticidal activity that was statistically similar ($P > 0.05$) to the control group. At 14 d post-treatment, the mean mortality was 1.33 ± 0.88, and 0.67 ± 0.67 after the 2nd month of storage treatments at 1.0 g/kg. However, a significant difference ($P < 0.05$) in mortality was observed in the treatments of 0.1 - 1.0 g/kg of Spinosad® compared to DE and control groups, with values ranging from 7.33 ± 1.45-11.33 ± 0.67 at 14 d post-treatment, and 5.00 ± 1.00-10.00 ± 0.58 after the 2nd month of storage treatments.

Spinosad® treated grains at 0.5-1.0 g/kg dose rates also resulted in a significant reduction ($P < 0.05$) in the emergence of progeny compared to DE and control groups (Fig. 1).

Table 1: Mean mortality of *S. zeamais* after exposure to the three-dose rates of DE and Spinosad®

		Treatment		
Conc (g/Kg)	Period of grain storage	Control	DE	Spinosad®
0.1	Initial	0.00±0.00[a]	0.33±0.33[a]	7.33±1.45[b]
	2nd month	0.00±0.00[a]	0.00±0.00[a]	5.00±1.00[b]
0.5	Initial	0.00±0.00[a]	0.67±0.33[a]	10.67±0.67[b]
	2nd month	0.00±0.00[a]	0.33±0.33[a]	10.67±0.88[b]
1.0g	Initial	0.00±0.00[a]	1.33±0.88[a]	11.33±0.67[b]
	2nd month	0.00±0.00[a]	0.67±0.67[a]	10.00±0.58[b]

*Mean ± Standard error of unlike letters in the same row are significantly different at P<0.05

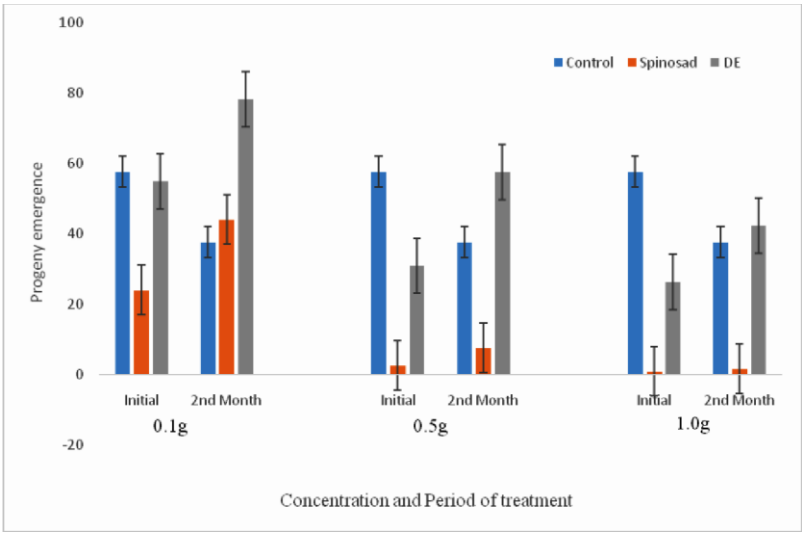

Figure 1: Progeny emergence of maize weevil after the initial and 2nd month of treatment

The results of this present study revealed the insecticidal efficacy of Spinosad® especially at a dosage of 0.5 g/kg and 1 g/kg against *S. zeamais* in rice grain for up to 2 months. Kemabonta *et al*. (2009) reported that Spinosad® dust (1 g/kg) was effective in protecting kolanuts from *Balanogastris kolae* infestations for up to 90 days. Similarly, Khashaveh *et al*. (2009) reported that prolonged exposure and high dosage of Spinosad® dust are required to completely control *Tribolium castaneum* in different oilseeds. It has been suggested that insects ingesting Spinosad® experience paralysis caused by hyperexcitation through binding to the nicotinic acetylcholine receptors (nAChRs)/or GABA receptors resulting in the interference of acetylcholine neurotrans-mission/or γ-amino-butyric acid (GABA) neurotransmission (Sparks *et al*., 2001; Salgado, 1998).

Although Spinosad® demonstrated high adult mortality, it could not completely check the emergence of progeny after 30 d. Huang and Subramanyam (2007) reported an almost complete reduction of progeny emergence of *Rhyzopertha dominica*, *Cryptolestes ferrugineus*, *Sitophilus oryzae*, *Oryzaephilus surinamensis*, and *S. zeamais* on corn treated with Spinosad® after 49 days. Spinosad®

was found to be effective in preventing progeny emergence in *R. dominica* but could not completely reduce progeny emergence in *T. castaneum*, *O. surinamensis*, and *S. oryzae* (Nayak *et al*., 2005).

In the present study, DE (Nigeria-derived) treatment demonstrated low efficacy against *S. zeamais* in all the dose rates and exposure period. This result is in contrast with the findings of Nwaubani *et al*. (2014) in which it was reported that DE (Nigeria-derived) exhibited insecticidal efficacy against *S. oryzae* and *R. dominica*. In this study, at a dose rate of 0.1% w/w, treatment with Bularafa DE was effective against *S. oryzae* and *R. dominica* in relation to mortality and progeny production suppression (Nwaubani *et al*., 2014). Likewise, a study by Otitodun *et al*. (2015) also demonstrated the efficacy of DE (Nigeria-derived) against *S. oryzae* and *R. dominica*. The low efficacy of DE in this present study is likely due to the surface area on which the dust covers, the concentration used, the storage period, source of the DE, insect species used, grain type, grain moisture content and temperature and, method of application, as these factors have been reported to greatly influenced the efficacy (Fields and Korunic, 2000; Nwaubani *et al*., 2014; Shah and Khan, 2014).

CONCLUSION

Unlike DE, Spinosad® showed some insecticidal efficacy against *S. zeamais* in storage. Further research focusing on the possible integration of Spinosad® with other control measures for *S. zeamais* management is needed.

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