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Entomocidal activity of some botanical powders and their mixes against adults of *Lasioderma serricorne* Fabricius and *Stegobium paniceum* Linnaeus (Coleoptera: Anobiidae)

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Abstract

The study investigated the lethality of powders made from rice husk ash (RHA), dry flower buds of *Eugenia aromatica* (L.) Baill. (EAP), and dry seeds of *Piper guineense* Schumach. (PGP), to adults of *Lasioderma serricorne* Fabricius and *Stegobium paniceum* Linnaeus, at 25 ± 2 °C and 65 ± 3% relative humidity. The powders were tested singly, and in binary and ternary combinations at the dosages of 0.02, 0.04, 0.06, 0.08 and 0.1 g/10 g of grain in glass Petri dishes. The constituents of binary and ternary combination of powders were mixed in equal proportions. There was a control involving no powder. Adult mortality of 20 individuals was observed 3, 5 and 7 days post treatment. ANOVA of data indicated significant differences among treatment means. Adult mortality increased with increase in dosage of powders and period of exposure. When applied singly the three insecticidal powders generally showed decreasing lethality to the adults beetles in this order RHA > EAP > PGP with respect to *S. paniceum*, but EAP > RHA > PGP with respect to *L. serricorne*. In the binary and ternary combinations of equal proportions the less toxic powders were more enhanced in lethality. The use of the binary and ternary combinations may be favoured for use in mitigating *S. paniceum* and *L. serricorne* damage to stored products for reasons of affordability, sustainability and durability which is discussed.

Keywords: Botanical powders; Mixtures; Adult beetles; Mortality

1. Introduction

The cigarette beetles, *Lasioderma serricorne* Fab and the drugstore beetles, *Stegobium paniceun* L. are perhaps the most ubiquitous of all stored-product pests [1]. *L. serricorne* is a cosmopolitan pest that consumes a wide variety of dry foods, such as wheat, snacks, dried noodles, green tea leaves, and dry tobacco leaves [2, 3]. *S. panecium* is also distributed worldwide and consumes a wide variety of dried plant products and biological specimens in museum collections. Adults of both species enter food storage containers and lay eggs on the dry foods. The larvae infest the stored product and the dead beetles and other wastes remain inside, causing economic damage [3]. They are especially problematic to curators of museum collections feeding on dried fungi, dried plant specimens, paper and adhesives. Such detritus insects can be merely a nuisance, but at high numbers, can cause serious damage [4].

Research into the control *L. serricorne* and *S. panecium* has involved non-chemical as well as chemical methods. The use of high and low temperatures can be effective in the control of these insects [4, 5, 6, 7]. The most popular and effective methods of controlling *L. serricorne* and most other stored products insects is by fumigation with phosphine gas, but control may also be achieved by applying contact insecticides such as methoprene and prethroids or pyrethrins [7]. Concern for the environment and the problem of insect resistance to chemical insecticides is restricting their use

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globally. Additionally, there are technical limitations to use of chemical insecticides and deployment of high or low temperatures, especially in developing countries of the tropics and sub-tropics. The use of plant derived insecticidal materials for the control of storage insect pests is thought to be simple, cheap, benign and environment friendly [8], and may be attractive to stakeholders in developing countries. However, there appears to be dearth of research or at best inadequate reports in literature on use of botanicals for the control of *L. serricorne* and *S. paniceum*. In this paper, results of an investigation of lethality of some botanical powders and their mixes against adults of these two storage beetles are presented.

2. Material and methods

The study was carried out at the Federal Research Centre for Cultivated Plants (Julius Kuehn Institute – JKI), Institute of Ecological Chemistry, Plant Analysis and Stored Product Protection, Berlin, Germany, under controlled conditions of 25 ± 2 °C and 65 ± 3% relative humidity.

2.1. Beetles

Adults of *L. serricorne* and *S. paniceun* (< than 2 weeks old) were used in this study. Their cultures are maintained at JKI, Berlin, Germany, using standard procedures [5].

2.2. Insecticidal Plant Powders

The insecticidal plant powders were prepared from rice husks (*Oryza sativa* L.), dry flower buds of *Eugenia aromatica* Baill. (EAP) and dry seeds of *Piper guineense* Schumach (PGP). Rice husk was converted to ash (RHA) following the method described by Ofuya and Adler [9]. All the powders were sieved to a particle size of 300 µm and were separately kept in air-tight plastic containers for subsequent use within six months of preparation.

2.3. Experimental Protocol

The powders were tested singly, and in binary and ternary combinations at the dosages of 0.02, 0.04, 0.06, 0.08 and 0.1 g/10 g of grain in glass Petri dishes. In combinations, the powders were mixed in equal proportions. Each dosage of powder/powder mixture and 20 adult beetles was shaken with grain in a Petri dish. There was a control involving no powder, but grain and adult beetles. The experiment was the completely randomized design with three replications. Adult mortality was observed 3, 5 and 7 days post treatment based on previous reports [10].

2.4. Data Analysis

Mortality data was corrected as recommended by Abbott [11], and the calculated percentage mortality data subjected to one-way analysis of variance (ANOVA). Where the ANOVA indicated significant difference between treatments, Fisher's least significant difference method was used to separate means at 5% level of probability.

3. Results

Irrespective of beetle species, there were significant differences among treatment means of adult mortality with respect to dosage and period of exposure (Tables 1 and 2). Adult mortality increased with increase in dosage of powder/powder mixture and period of exposure. For adults of *L. serricorne*, at 3 days period of exposure, EAP produced significantly highest mortality at 0.02 and 0.04 g of dosages; RHA at 0.06 g, and RHA + EAP + PGP at 0.08 and 0.1 g dosages. (Table 1). At 5 days period of exposure, RHA + EAP + PGP produced significantly highest mortality at 0.02, 0.04 and 0.08 g dosages; and EAP at 0.06 g dosage. With the 0.1 g dosage, RHA, EAP, RHA + EAP and RHA + EAP + PGP produced 100% mortality of adult *L. serricorne*. At 7 days period of exposure, RHA + EAP and RHA + EAP + PGP produced 100% mortality of adult *L. serricorne* irrespective of dosage. RHA and EAP produced 100% adult beetle mortality at all dosages except the 0.02 g dosage. For adults of *S. paniceum*, at 3 days period of exposure RHA produced significantly highest mortality, irrespective of dosage, followed by RHA + EAP + PGP, except at the 0.06 g dosage when both treatments produced 100% mortality (Table 2). At 5 and 8 days period of exposure respectively, RHA produced significantly highest mortality, irrespective of dosage, followed by RHA + EAP + PGP, except at the 0.06 g dosage when both treatments produced 100% mortality, and in addition, EAP, RHA + EAP and RHA + PGP at 0.08 and 0.1 g dosages.

Table 1 Mean percentage mortality of *L. serricorne* adults exposed to some botanical powders and their mixes applied at different rates overtime

Rate: g/10 g of grain	**Plant powder (s)**	**Computed Abbott mortality in:**		
		3 days	5 days	7 days
0.02	RHA	13.3	20.0	28.3
	EAP	55.0	66.7	88.3
	PGP	0.0	10.0	23.3
	RHA + EAP	30.0	80.0	100.0
	RHA + PGP	8.3	18.3	26.7
	EAP + PGP	18.3	33.3	41.7
	RHA + EAP + PGP	26.7	85.0	100.0
0.04	RHA	38.3	78.3	100.0
	EAP	50.0	75.0	100.0
	PGP	0.0	15.0	33.3
	RHA + EAP	38.3	86.7	100.0
	RHA + PGP	16.7	30.0	36.3
	EAP + PGP	25.0	76.7	93.3
	RHA + EAP + PGP	41.7	80.0	100.0
0.06	RHA	61.7	83.3	100.0
	EAP	41.6	86.7	100.0
	PGP	11.7	21.7	30.0
	RHA + EAP	43.3	78.3	100.0
	RHA + PGP	40.0	75.0	100.0
	EAP + PGP	46.7	80.0	100.0
	RHA + EAP + PGP	48.3	78.3	100.0
0.08	RHA	80.0	85.0	100.0
	EAP	68.3	83.3	100.0
	PGP	31.7	46.7	65.0
	RHA + EAP	68.3	86.7	100.0
	RHA + PGP	38.3	63.3	80.0
	EAP + PGP	58.3	80.0	100.0
	RHA + EAP + PGP	91.3	100.0	100.0
0.1	RHA	88.3	100.0	100.0
	EAP	81.7	100.0	100.0
	PGP	40.0	55.0	68.3
	RHA + EAP	88.3	100.0	100.0
	RHA + PGP	60.0	81.7	100.0
	EAP + PGP	66.7	86.7	100.0
	RHA + EAP + PGP	95.0	100.0	100.0
LSD (0.05)		0.00	0.00	0.00

RHA = Rice husk ash; EAP = *Eugenia aromatica* powder; PGP = *Piper guineense* powder

Table 2 Mean percentage mortality of *S. paniceum* adults exposed to some botanical powders and their mixes applied at different rates overtime

Rate: g/10 g of grain	**Plant powder (s)**	**Computed Abbott mortality in:**		
		3 days	**5 days**	**7 days**
0.02	RHA	23.3	55.0	65.0
	EAP	1.7	6.7	13.3
	PGP	0.0	0.0	0.0
	RHA + EAP	11.7	18.3	41.7
	RHA + PGP	10.0	31.7	50.0
	EAP + PGP	0.0	0.0	3.3
	RHA + EAP + PGP	15.0	26.7	53.3
0.04	RHA	100.0	100.0	100.0
	EAP	10.0	28.3	55.0
	PGP	0.0	3.3	8.3
	RHA + EAP	16.7	56.7	78.3
	RHA + PGP	40.0	65.0	80.0
	EAP + PGP	0.0	5.0	11.7
	RHA + EAP + PGP	43.3	66.7	83.3
0.06	RHA	100.0	100.0	100.0
	EAP	43.3	70.0	83.3
	PGP	16.7	30.0	36.7
	RHA + EAP	68.3	85.0	100.0
	RHA + PGP	68.3	81.7	100.0
	EAP + PGP	8.3	13.3	40.0
	RHA + EAP + PGP	100.0	100.0	100.0
0.08	RHA	83.3	100.0	100.0
	EAP	60.0	100.0	100.0
	PGP	30.0	33.3	40.0
	RHA + EAP	80.0	100.0	100.0
	RHA + PGP	76.7	100.0	100.0
	EAP + PGP	6.7	20.3	46.7
	RHA + EAP + PGP	73.3	100.0	100.0
0.1	RHA	100.0	100.0	100.0
	EAP	83.3	100.0	100.0
	PGP	36.7	45.0	51.7
	RHA + EAP	100.0	100.0	100.0
	RHA + PGP	98.3	100.0	100.0
	EAP + PGP	13.3	30.0	50.0
	RHA + EAP + PGP	96.7	100.0	100.0
LSD (0.05)		0.00	0.00	0.00

RHA = Rice husk ash; EAP = *Eugenia aromatica* powder; PGP = *Piper guineense* powder

4. Discussion

The results of this study have shown that there may be good prospects in mitigating damage by *S. paniceum* and *L. serricorne* to stored products by using insecticidal plant powders. RHA, EAP and PGP applied in single, binary and ternary applications were observed to be lethal to adults of the two beetles. In line with reports of many previous workers [12]. Adult mortality increased with increase in dosage of powders/powder combinations as well as period of exposure. When applied singly the three insecticidal powders generally showed decreasing lethality to the adults beetles in this order rice husk ash > *E. aromatica* > *P. guineense* with respect to *S. paniceum*, but *E. aromatica* > rice husk ash > *P. guineense*, with respect to *L. serricorne*. In the binary and ternary combinations of equal proportions the less toxic powders were more enhanced in lethality. Clearly, PGP was generally enhanced in lethality to the two beetles in binary and ternary combinations with RHA and EAP. Lethality of RHA, EAP and PGP applied singly and in binary and ternary combinations to some other storage beetles have also been observed and reported by researchers [13, 14, 15, 16, 17]. The lethality of these plant powders to storage beetles is believed to be due to their bioactive chemical constituents. The insecticidal activity of EAP has been attributed mainly to the chemicals eugenol and caryophylene by many workers [18, 19], whilst that of RHA is said to be due to the high silica content [20, 13]. Lale [21] lists Chavicine and piperine as the probable active principles in PGP.

Oil extracted from shiso, an aromatic herb, *Perilla frutescens* (Thunb.) H. Deane have been reported to exhibit repellency to *L. serricorne* due to its unique content of Perillyl aldehayde and Perillyl alcohol imparting a riveting fragrance [22]. Similarly, β-thujaplicin (hinokitiol) found in the heartwood of naturally durable trees belonging to the Cupressaceae family exhibits repellency to *L. serricorne* [23]. The repellent behavioural response of *L. serricorne* to some other plant products such as citronellal, citral and rutin as reported in [24] is further indicative of the possibility of using botanicals for the mitigation of infestation of stored products by *L. serricorne*.

This paper is probably the first pioneering effort at mitigating *S. paniceum* and *L. serricorne* infestation by using a combination of botanicals. Combining insecticidal plant materials that are cheaply and easily obtainable by reason of relative abundance like rice husk ash, with *Eugenia* powder which may be more difficult to obtain in sufficient quantity, may have the advantage of affordability and sustainability by different categories of stakeholders [17]. Putatively, because of the complex of chemicals being presented, it may be more difficult for insects to develop resistance or tolerance to botanical cocktails thereby ensuring durability in efficacy in pest management.

5. Conclusion

Single, binary and ternary combinations of powders made from rice husk ash, dry flower buds of *Eugenia aromatica* and dry seeds of *P. guineense* have been proven to be sufficiently lethal to adults of *S. panecium* and *L. serricorne* that may warrant their use for mitigating the damage of the beetles to stored products. The use of the binary and ternary combinations may however be favoured for use for reasons of enhanced efficacy, affordability, sustainability and durability.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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