ARTIGO ORIGINAL

The insecticidal activity and repellency of the *Andira paniculata* (Fabaceae) extract against *Sitophilus zeamais* (Coleoptera: Curculionidae)

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ABSTRACT: *Sitophilus zeamais* is among the main pests affecting stored maize grains. The aim of the current study is to assess the mortality and repellency of organic extracts from *Andira paniculata* leaves against maize weevil, *Sitophilus zeamais*. The experiments were conducted at the Agricultural Entomology Laboratory of Instituto Federal Goiano - Urutaí Campus. A completely randomized experimental design was adopted to assign the mortality and repellency in 17 treatments in four replications. *Andira paniculata* leaves were oven dried, grounded and subjected to exhaustive extraction using ethanol. Hexane (APFE-H), Dichloromethane (APFE-D), Ethyl Acetate (APFE-A) and Hydroalcoholic (APFE-W) extracts were used at the concentrations 0.01%, 0.1%, 0.5% and 1 %, respectively. BIOMATRIX BM 3061 hybrid grains were treated with the plant extracts and, subsequently, infested with *Sitophilus zeamais*. The mortality was assessed 24, 48 and 72 h, as well as 30, 60 and 90 days after exposed to the plant extracts. The ethyl acetate (1.00%) showed the highest mortality (95%). The ethyl acetate (0.01 - 0.5%) also showed the similar performance after 48 h in the repellency test. Dichloromethane presented the lowest LD_{50} (0.2115%), and showed a highest mortality of *Sitophilus zeamais*. Thus, *Andira paniculata* has potencial for future studies on the control of *Sitophilus zeamais* in stored maize grains.
Keywords: *Zea mays*, botanic insecticide, *Sitophilus zeamais*, stored-grain pests.

RESUMO: **Atividade inseticida e repelência de extrato de *Andira paniculata* (Fabaceae) contra *Sitophilus zeamais* (Coleoptera: Curculionidae).** *Sitophilus zeamais* está entre as principais pragas que afetam os grãos de milho armazenados. O objetivo do presente estudo foi avaliar a mortalidade e repelência de extratos orgânicos das folhas de *Andira paniculata* em *Sitophilus zeamais*. Os experimentos foram realizados no Laboratório de Entomologia Agrícola do Instituto Federal Goiano - Campus Urutaí. O delineamento experimental adotado foi inteiramente casualizado (DIC) com 17 tratamentos e quatro repetições para a mortalidade e repelência. As folhas de *Andira paniculata* foram secas em estufa com circulação de ar a temperatura de 50 °C por 120 h, moídas e expostas ao processo de extração exaustiva com etanol. Os extratos de hexânico (APFE-H), diclorometano (APFE-D), acetato de etilila (APFE-A) e hidroalcoólico (APFE-W) foram utilizados nas concentrações de 0,01%, 0,1%, 0,5% e 1%, respectivamente. Sementes do híbrido BIOMATRIX BM 3061 foram tratados com os extratos e, posteriormente, infestados com *Sitophilus zeamais*. A mortalidade foi avaliada 24, 48 e 72 h, e aos 30, 60 e 90 dias após a exposição aos extratos vegetais. Acetato de etila (1,00%) causou a maior mortalidade (95%). A fração acetato de etila (0,01 - 0,5%) também desempenho similar após 48 horas para a repelência. A fração diclorometano apresentou a menor DL50 (0,2115%), com a maior mortalidade de *Sitophilus zeamais*. Assim, *Andira paniculata* tem potencial para estudos futuros no controle de *Sitophilus zeamais* em grãos de milho armazenado.
Palavras-chave: *Zea mays*, inseticida botânico, *Sitophilus zeamais*, pragas de grãos armazenados.

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INTRODUCTION

Stored maize grains and other cereals are often infested by several insect pests. *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) stands out among the pest in maize grains in the field and in storage facilities, due to its high biotic potential and is able to survive at great depths in the grain mass (Lorini 2008; Lorini et al. 2010; Lorini et al. 2015).

The adult infests the maize grain in the field (cross-infestation) or in storage (Marsaro Júnior et al. 2008; Lorini et al. 2010). Both *Sitophilus zeamais* larvae and adults are harmful to grains and seeds, since they feed on the seed reserve tissue and enable the introduction of other deteriorating agents (Lorini et al. 2010). After the egg laying, the larvae hatch, develop into pupae and become adults while they are still in the grain. The damage results from reduced grain weight and quality (Lorini 2008; Lorini et al. 2015).

The most commonly used method to control *S. zeamais* is conventional insecticide. However, it is important to develop alternatives to chemical control methods due to the problem of pesticide resistance to *S. zeamais* (Kavallieratos et al. 2015). The use of plant-based substances has become a promising strategy to control stored grain pests (Procópio et al. 2003).

Botanical Insecticides do not always kill the insects, but they cause direct and indirect damage such as dietary inhibition, reduced motility, chitin biosynthesis and growth inhibition, pupae deformation and reduced fecundity. In addition, they mainly affect the population growth and may interact with other control methods (Coitinho et al. 2006; Estrela et al. 2006; Ayvaz et al. 2010; Chu et al. 2010).

Andira paniculata (Fabaceae) show potential to control stored grain pests. *A. paniculata* is described as a poisonous tree used as insecticide in Brazilian countryside communities (Silva Júnior 2005; Pereira 2012). Leaf extracts of *A. paniculata* were toxic to *Atta sexdens rubropilosa* (Hymenoptera: Formicidae) (Pereira et al. 2010). Sousa Netto et al. (2018) showed high mortality on *Helicoverpa armigera* (Lepidoptera: Noctuidae) feeding on soybean leaves treated with *A. paniculata* extract in fractions of hexane (0.01% and 0.1%), ethyl acetate (0.01% and 0.5%) and hydroalcoholic (0.01% and 0.5%).

The aim of the current study was to assess the mortality and repellency of organic extracts of *Andira paniculata* (Fabaceae) against *Sitophilus zeamais* on stored maize grains.

MATERIALS AND METHODS

The experiments were carried out at the Agricultural Entomology Laboratory of Instituto Federal Goiano, Urutaí Campus, Urutaí, Goiás, Brazil, under controlled conditions (T 25 ± 2 ºC, RH 70 ± 10% and 12-h photoperiod).

Infestation Suppression and Grain Moisture Equilibrium

Cleaned and dried maize grains used in *S. zeamais* breeding processes and bioassays were stored in plastic bags and kept in a freezer at -10 °C, for 7 days, in order to eliminate insect infestations from the field. After, the grains were transferred to glass vials and kept in the laboratory at room temperature for 10 days in order to reach hygroscopic equilibrium.

Sitophilus zeamais rearing

The adult of *S. zeamais* fed on BIOMATRIX BM 3061 grains and were stored in glass containers (2 l). The insects were kept in confinement for 30 days in order to lay eggs. Posterioly, it were discarded and the containers were stocked until the emergence of the F1 generation. The entire procedure was carried out through successive generations to assure the number of adults necessary to perform the bioassays.

Plant material and plant extract preparation

Andira paniculata leaves were collected in the Cerrado preservation area located at Anápolis Air Base (BAAN), Anápolis, Goiás, Brazil. The species was identified and the exsiccates deposited in the Herbarium of Goiás State University, under the registration number 7176. Healthy leaves were selected after collection and all the material was placed in an oven with air circulation at 50 °C for 120 h The leaves were ground and subjected to extraction process using ethanol. The solution resulting from the extraction process was collected and the organic solvent was evaporated at 40 ºC to obtain the crude ethanolic extract.

The crude ethanolic extract from the leaves was fractionated through liquid-liquid extraction and resuspended in ethanol-water solution (3:1) in increasing polarity order: hexane, dichloromethane, ethyl acetate and hydroalcohol in order to find the fractions of hexane (APFE-H), dichloromethane (APFE-D), ethyl acetate (APFE-A) and hydroalcoholic (APFE-W).

The extracts were prepared using 1.0 g of the hexane, ethyl acetate and hydroalcoholic fractions and 0.46 g of the dichloromethane fraction. The APFE-H, APFE-D and APFE-A fractions were dissolved in acetone and water (1:1), whereas the

APFE-W fraction was dissolved in ethanol and water (1:1), all at 1% concentration. The other concentrations were fractionated based on the initial concentration.

Mortality bioassay

An experiment consisting of Sixteen treatments plus one control, each replicated four times, was conducted to determine *Sitophilus zeamais* mortality (fractions - APFE-A: 0.01%, 0.1% and 0.5%; APFE-D: 0.01%, 0.1%, 0.5% and 1%; APFE-H: 0.01%, 0.1%, 0.5% and 1%; APFE-W: 0.01%, 0.1%, 0.5% and 1%).

Each plastic container (100 ml) was added with 20 g of maize grains (BIOMATRIX BM 3061) and 1 ml of *A. paniculata* extract at their respective fractions and concentrations, except for the control (distilled water). Each container was manually stirred for two minutes and left to rest for one hour to evaporate the solvents. Afterwards, ten adults of *S. zeamais* was released per container.

The first assessment has quantified the dead weevils after 24, 48, 72 confinement hours. The counting was also performed after 30, 60 and 90 confinement days and the following parameters were analyzed: number of dead *Sitophilus* (NDS); number of live *Sitophilus* (NLS); damaged seed weight (DSW); undamaged seed weight (USW); number of damaged seeds (NDSe); and number of undamaged seeds (NUS). All live insects returned to the plastic containers at the end of each assessment.

Repellency bioassay

The experiments conducted to determine the repellency of *A. paniculata* extracts against *S. zeamais* used the same treatments adopted in the mortality experiment, with six replications. Each replication was conducted as follows: 10 g of maize grains (BIOMATRIX BM 3061) (right side: untreated maize - left side: treated maize) were placed on Petri dishes, thus totaling 20 adult weevils per dish. After 12, 24 and 48 hours, the insects were counted on both sides.

Statistical analysis

The mortality means and the parameters concerning the maize grain damages caused by *S. zeamais* exposed to *A. paniculata* plant extracts were compared through the Scott-Knott test ($P < 0.05$) in the R software, using the package ExpDes. The $LD_{50\%}$ (lethal dose) of *A. paniculata* extract concentrations (%) for *S. zeamais* mortality was determined through LOGIT analysis in the R software (package bda), whereas the binomial test was adopted to determine the significance of repellency rate (RR) of *A. paniculata* plant extracts over *S. zeamais* (R core team, 2016).

RESULTS

There were significant differences in the mortality of adult *Sitophilus zeamais* exposed to different *A. paniculata* plant extract concentrations after 72 h (Table 1).

TABLE 1. Mortality of *Andira paniculata* extracts against *Sitophilus zeamais* (Coleoptera: Curculionidae).

Fractions	Concentration (24 h)			
	0,01	**0,1**	**0,5**	**1**
APFA	5.0	7.5	30.0	20.0
APFW	15.0	12.5	12.5	15.0
APFEH	10.0	30.0	20.0	2.5
APFED	12.5	7.5	17.5	10.0
Control		7.5		
P value		0.7772		
F		0.70		

Fractions	Concentration (48 h)			
	0,01	**0,1**	**0,5**	**1**
APFA	7.5	15.0	35.0	45.0
APFW	17.5	15.0	22.5	22.5
APFEH	27.5	35.0	37.5	27.5
APFED	20.0	15.0	37.5	20.0
Control		12.5		

Continua...

TABLE 1. *Continuação*

P value	0.6095			
F	0.86			
Fractions	**Concentration (72 h)**			
	0,01	**0,1**	**0,5**	**1**
APFA	30.0 b	40.0 b	67.5 a	95.0 a
APFW	32.5 b	25.0 b	40.0 b	72.5 a
APFEH	47.5 b	75.0 a	85.0 a	32.5 b
APFED	42.5 b	45.0 b	67.5 a	60.0 a
Control	25.0 b			
P value	0.0002			
F	2.55			

Means followed by the same letter do not statistically differ from each other in the Scott-Knott test at 5% probability. APFA - Ethyl Acetate Fraction; APFW - Hydroalcoholic Fraction; APFEH - Hexane Fraction; and APFED - Dichloromethane Fraction.

The highest mortality of *S. zeamais* to different *A. paniculata* concentrations for 72 h were: 1.0% APFA (95.0%); 0.5% APFEH (85.0%); 0.1% APFEH (75.0%); 1.0% APFW (72.5%); 0.5% APFA (67.7%); 0.5% APFED (67.5%) and 1.0% APFED (60.0%).

The adult of *S. zeamais* fed on maize treated with different *A. paniculata* extract concentrations at 30, 60 and 90 days, and the number of damaged seeds (NDSe), number of undamaged seeds (NUS), damaged seed weight (DSW) and undamaged seed weight (USW) were assessed (Table 2).

The NDSe, DSW and USW showed a significant difference ($p < 0.05$) at 30th day of exposure to *A. paniculata* extract. The highest NDSe index was found in individuals exposed to 1.0% APFED, whereas the lowest were found in 0.01% APFA and 0.5% APFW. The highest DSW value was found in individuals exposed to 0.1% APFEH, whereas the lowest were found in 0.01% APFA and 0.5% APFW.

The variables NDSe, DSW and USW showed a significant difference ($p < 0.05$) at 60th day of exposure to *A. paniculata* extract. The highest NDSe value was found in individuals exposed to 1% APFEH, whereas the lowest were found in 0.1% APFA and 0.01% APFA. The highest DSW index was found in individuals exposed to 1.0% APFEH, whereas the lowest were found in 0.5% APFW, 0.1% APFED, 0.5% APFA, 1% APFW, 1.0% APFA, 0.01% APFA and in the control. The highest USW values were found in individuals exposed to 0.01% APFA, 1.0% APFA, 1% APFW, 0.5% APFA, 0.1% APFED, 0.5% APFW and in the control, whereas the lowest was found in 1.0 % APFEH.

TABLE 2. Duration of *Sitophilus zeamais* (Coleoptera: Curculionidae) feeding on maize grains treated with different *Andira paniculata* extract concentrations (%). Urutaí, Goiás, Brazil.

Fractions	**30 d**				**60 d**				**90 d**			
	NDSe	**NUSD**	**DSW**	**USW**	**NDSe**	**NUS**	**DSW**	**USW**	**NDSe**	**NUS**	**DSW**	**USW**
Hexane												
0,01	3.00ab	57.75	1.46ab	18.53a	10.25ab	50.50	3.76a	16.24ab	18.00ab	42.75ab	8.33	11.66
0,10	5.00ab	56.75	1.97a	18.02a	7.00ab	54.5	3.55a	16.44ab	17.25ab	44.25ab	6.24	13.75
0,50	5.50ab	59.00	1.79ab	18.21a	13.25ab	51.25	3.73a	16.27ab	39.75ab	26.75b	11.86	8.13
1,00	5.75ab	60.25	1.45ab	18.54a	18.00a	48.00	7.01a	12.98b	51.00a	15.00b	15.16	4.83
Dichloromethane												
0,01	5.25ab	59.75	1.41ab	18.58a	8.25ab	56.5	3.59a	16.40ab	23.75ab	41.25ab	6.29	13.70

Continua...

TABLE 2. *Continuação*

Fractions	30 d				60 d				90 d			
	NDSe	NUSD	DSW	USW	NDSe	NUS	DSW	USW	NDSe	NUS	DSW	USW
0,10	3.50ab	61.25	1.93ab	18.07a	9.00ab	55.75	2.47b	17.52ab	13.00b	51.75ab	4.53	15.46
0,50	6.25ab	57.75	1.43ab	18.56a	13.00ab	51.00	3.71a	16.28ab	35.25ab	28.75ab	9.74	10.25
1,00	6.50a	56.00	1.21ab	18.78a	12.25ab	50.25	4.64a	15.35ab	37.75ab	23.50b	10.47	9.52
Ethyl acetate												
0,01	2.50b	62.50	0.73b	18.26a	3.50b	62.75	1.04b	18.95a	8.00b	57.00a	4.30	15.69
0,10	3.25ab	63.25	1.02ab	18.97a	4.00b	62.00	2.98a	17.02ab	10.25b	56.25a	3.60	16.39
0,50	4.00ab	58.25	1.37ab	18.62a	5.00ab	57.25	2.38b	17.61a	15.25ab	47.00ab	5.21	14.79
1,00	4.25ab	60.00	1.45ab	18.55a	5.50ab	58.75	1.78b	18.21a	14.75ab	51.50ab	4.65	15.35
Hydroalcohol												
0,01	3.50ab	59.50	1.18ab	18.81a	10.25ab	52.5	2.92a	17.07ab	18.75b	42.75ab	5.87	14.12
0,10	3.25ab	61.25	1.15ab	18.84a	7.25ab	57.25	3.25a	16.75ab	26.75ab	37.75ab	7.13	12.87
0,50	2.50b	65.25	0.89b	19.10a	6.00ab	61.25	2.61a	17.39a	23.50ab	42.75ab	6.99	13.00
1,00	3.50ab	61.50	1.17ab	18.83a	8.75ab	56.25	2.29b	17.70a	36.25ab	28.75ab	8.99	11.00
Control	3.00ab	59.75	1.07ab	18.92a	4.75ab	58.00	2.42b	17.58a	37.00ab	25.75b	9.88	10.11
F	2.5275	1.0415	1.6543	1.6543	1.8864	1.4991	2.293	2.2931	1.8444	1.9433	1.561	1.561
P	0.062	0.432	0.088	0.088	0.04432	0.1368	0.01282	0.01282	0.05027	0.03733	0.114	0.114

Means followed by the same letter do not statistically differ from each other in the Scott-Knott test at 5% probability. Number of damaged seeds (NDSe); number of undamaged seeds (NUS); damaged seed weight (DSW) and undamaged seed weight (USW).

The NDSe and NUS showed significant difference ($p < 0.05$) at 90th day of exposure to *A. paniculata* extract. The highest NDSe value was found in individuals exposed to 1% APFEH, whereas the lowest were found in 0.01% APFA, 0.1% APFA and 0.1% APFED. The highest NUS value was found in individuals exposed to 0.01% APFA, whereas the lowest were found in 0.5% APFEH, 1% APFED, 1% APFEH and in the control.

TABLE 3. The $LD_{50\%}$ (Lethal Dose) to *Sitophilus zeamais* (Coleoptera: Curculionidae) feeding on maize grains treated with different *Andira paniculata* extract concentrations (%). Urutaí County, Goiás State, Brazil, 2016.

Fractions	$LD_{50\%}$
APFA	0.2447
APFW	0.5760
APFEH	0.6047
APFED	0.2115

APFA - Ethyl Acetate Fraction; APFW - Hydroalcoholic Fraction; APFEH - Hexane Fraction; and APFED - Dichloromethane Fraction.

The LD_{50} (lethal dose) of hexane fraction (APFEH) was estimated at 0.6047%. This fraction had the weakest effect on weevil mortality; it was followed by the hydroalcoholic (0.5760%) and ethyl acetate (0.2447%) fractions. The dichloromethane fraction showed the lowest LD_{50} (0.2115%), indicating a highest mortality of *Sitophilus zeamais* (Table 3).

The repellency rate was determined 12, 24 and 48 hours after the insects were subjected to treatments with and without plant extracts. Increased repellency was considered a positive result, whereas decreased repellency was considered a negative result (Table 4). The fraction of hexane (APFEH) used at concentrations 0.01%, 0.1% and 0.5% showing the best performance in the 12-hour. However, all ethyl acetate fraction (APFA) concentrations showed positive repellency against *S. zeamais* in the 24 and 48-hour periods.

DISCUSSION

Studies have shown that insecticide plants are promising in the control of pests affecting stored grains (Estrela et al. 2006). Demissie et al. (2008)

TABLE 4. Repellency rate (RR) of *Andira paniculata* extracts against *Sitophilus zeamais* (Coleoptera: Curculionidae).

Fractions	Concentration (12 h)			
	0,01	**0,1**	**0,5**	**1**
APFA	-7.5	25 (0.1539)	5 (0.8746)	-5
APFW	-30	-10	-5	-15
APFEH	25 (0.1939)	0	5 (0.8746)	-15
APFED	-45	20 (0.2682)	-5	-10
Fractions	**Concentration (24 h)**			
	0.01	**0.1**	**0.5**	**1**
APFA	30 (0.0807)	15 (0.4296)	35 (0.0385)	5 (0.8746)
APFW	-35	0	-25	-25
APFEH	35 (0.0385)	25 (0.1539)	40 (0.0166)	-35
APFED	-10	15 (0.4396)	20 (0.2682)	15 (0.4296)
Fractions	**Concentration (48 h)**			
	0.01	**0.1**	**0.5**	**1**
APFA	60 (0.0001)	50 (0.0022)	60 (0.0001)	45 (0.0064)
APFW	-30	0	30 (0.0807)	-5
APFEH	-50	35 (0.0385)	-45	-25
APFED	20 (0.02682)	-15	-35	10 (0.6358)

[a]RR values referring to 40 insects per treatment. Significant difference in the control (P <0.05), according to the binomial test. APFA - Ethyl Acetate Fraction; APFW - Hydroalcoholic Fraction; APFEH - Hexane Fraction; and APFED - Dichloromethane Fraction.

have used *Eucalyptus globulus* (Myrtaceae) oils against *S. zeamais* and found 100% mortality among adult during the initial storage period; the eugenol compound, as well as *Lippia gracilis* (Verbenaceae), *Azadirachia indica* (Meliaceae) and *Caryocar brasiliense* (Caryocareceae) have also efficiently controlled these pests. This result was also found in the current study, wherein fractions of *A. paniculata* extracts caused up to 95% mortality among adult of *S. zeamais*, thus confirming the potential in studies about the control of stored grains pests.

Few studies have explored the species' potential to be used as an insecticide plant. Sousa Netto et al. (2018) have found up to 85.0% larval mortality and 66.0% pupal mortality of *H. armigera* treated with fractions of *A. paniculata*. Pereira (2012) has found 100% larval mortality of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) feeding on artificial diet containing *A. paniculata* ethyl acetate and dichloromethane fractions.

Promising results were also found in other plant species showing insecticidal potential. Chu et al. (2010) have found that the essential oil from *Artemisia vestita* (Asteraceae) has effectively controlled *Sitophilus zeamais*. Ayvaz et al. (2010) have found that the essential oil from *Origanum onites* (Lamiaceae) and *Satureja thymbra* (Lamiaceae) led to 100% mortality in *Plodia interpunctella* (*Lepidoptera*: Pyralidae) and *Ephestia kuehniella* (*Lepidoptera*: Pyralidae), respectively.

The treatments with ethyl acetate (APFEA) were the most promising with respect to the damages caused by *S. zeamais* after *A. paniculata* extracts were applied to the stored maize grains. These treatments resulted in the smallest number and lowest rate of seeds damaged by *S. zeamais*. Other studies have reported the insecticidal effect of plant by-products extracted with ethyl acetate against agricultural pests (Baskar et al. 2011; Vendum et al. 2009; Baskar and Ignacimuthu 2012). Pavunraj et al. (2011) reported 65% deterrence caused by the quinone compound isolated with *Pergularia daemia* (*Asclepiadaceae*) ethyl acetate against *H. armigera*. Rheina derived from ethyl acetate extracted from *Cassia fistula* (*Caesalpiniaceae*) presented 76% deterrence on *H. armigera* (Duraipandiyan et al.,

2011). Sousa Netto et al. (2018) found that the 0.01% and 0.5% ethyl acetate fractions of *A. paniculata* showed antifeedant effect on *H. armigera*. The lower damage caused by *S. zeamais* in maize treated with these fractions may be associated with the fact that the chemical compound affected the insect's mouthparts or its chemoreceptors, thus preventing it from feeding (Baskar and Ignacimuthu 2012).

The extracts with the highest repellency levels on *S. zeamais* were hexane (APFEH) and ethyl acetate (APFA) fractions. Several studies have shown the repellency of insecticide plants against *S. zeamais*. Powder of *Capsicum frutescens* (Solanaceae) have shown repellency to adult of *S. zeamais* (Procópio et al. 2003). Nerio et al. (2009) have found the repellent effect of essential oils on *Sitophilus zeamais*; the essential oil from *Lippia origanoides* (Verbenaceae) was the most effective. However, *Eucalyptus citriodora* (Myrtaceae) and *Tagetes lucida* (Asteraceae) have also presented a repellent effect when they were used at doses ranging from 0.063 to 0.503 ml/cm^2.

These results show the possibility of developing botanical insecticides to be used in the control of agricultural pests as an IPM strategy to enable repellent or bioinsecticidal effect. The use of insecticide plants to control stored grains pests has important applications, mainly in regions of the world where insecticides are expensive or scarce and where these plants are readily available to be used by small farmers. In addition, repellents used to protect stored maize grains may potentially minimize the use of broad-spectrum toxic insecticides, therefore reducing the selection of pest resistant to insecticides.

CONCLUSION

The *A. paniculata* extract in the ethyl acetate fraction (1.0%) caused up to 95.0% mortality on *S. zeamais*. The ethyl acetate (APFEA) fraction in different concentrations provided the highest protection to stored maize grains, whereas the hexane (APFEH) and ethyl acetate (APFA) fractions provided repellency against adult of *S. zeamais*. This plant shows potential for studies as a new botanical insecticide with the potential to be used to control stored grain pests.

Conflict of interest

The authors declare that they have no conflicts of interest.

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