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Control of the Mexican bean weevil *Zabrotes subfasciatus* with kaolin

Controle do caruncho-do-feijão *Zabrotes subfasciatus* com caulim

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ABSTRACT

The Mexican bean weevil ***Zabrotes subfasciatus*** *(Coleoptera: Chrysomelidae: Bruchinae) is an important pest of stored beans in tropical regions. The efficiency of kaolin [with or without neem (****Azadirachta indica****) oil] and diatomaceous earth (DE) (standard treatment) was studied in laboratory aiming to obtain alternatives for chemical control of this insect. Insects were confined in plastic vials containing beans treated with kaolin (2, 4 and 8g kg^{-1}), kaolin + neem [2g kg^{-1}(5% neem oil)], diatomaceous earth (1g kg^{-1}) and control. Mortality of adult insects, number of eggs and F1generation beetles emergency were assessed. Kaolin caused mortality of* ***Z. subfasciatus,*** *however higher periods and doses than DE were necessary to promote high mortality (100% or close). Kaolin treatments also affected female behavior because many eggs were placed in the vials walls. Number of emerged adults (F1) was similar between DE and kaolin; hence, kaolin constitutes a promising tool to the management of* ***Z. subfasciatus.*** *The mixture of kaolin and neem oil was not efficient in the control of* ***Z. subfasciatus.***

Key words: *bruchids, inert dusts,* ***Phaseolus vulgaris****.*

RESUMO

O caruncho-do-feijão ***Zabrotes subfasciatus*** *(Coleoptera: Chrysomelidae: Bruchinae) é uma importante praga de grãos de feijão armazenado nas regiões tropicais. A eficiência do caulim [com ou sem óleo de nim (****Azadirachta indica****)] e terra diatomácea (TD) (tratamento padrão) foi estudada em laboratório com o intuito de obter alternativas para o controle químico deste inseto. Insetos foram confinados em frascos de plástico com feijão tratado com caulim (2, 4 e 8g kg^{-1}), caulim + nim [2g kg^{-1}(5% óleo de nim)], terra diatomácea (1g kg^{-1}) e controle. Mortalidade de insetos adultos, número de ovos e emergência da geração F1 foram avaliados. Caulim causou a mortalidade de* ***Z. subfasciatus****, porém foram necessários maiores períodos e doses que a TD para promover elevada mortalidade (100% ou aproximadamente). Os tratamentos com caulim também afetaram o comportamento da fêmea, pois muitos ovos foram colocados nas paredes dos frascos. O número de adultos emergidos (F1) foi similar entre a TD e o caulim; portanto, caulim constitui uma ferramenta promissora para o manejo de* ***Z. subfasciatus****. A mistura de caulim e óleo de nim não foi eficiente no controle de* ***Z. subfasciatus.***

Palavras-chave: *bruquídeos,* ***Phaseolus vulgaris,*** *pós inertes.*

INTRODUCTION

The weevil ***Zabrotes subfasciatus*** (Boheman, 1833) (Coleoptera: Crysomelidae: Bruchinae) is an important pest of beans (***Phaseolus vulgaris*** L.). This insect damages the stored legume seeds in tropical regions (SPERANDIO, 2001). Larvae develop in the cotyledons until reach adult stage, causing reduction of weight, nutritional quality (CREDLAND & DENDY, 1992; GALLO et al., 2002), germination and vigor (HOHMANN & CARVALHO, 1989) and also contributing to the development of fungi and mycotoxins in the grains. The quality of seeds is also reduced. Plants from seeds with one hole of ***Z. subfasciatus*** presented a reduced number of seeds, weight of 100 seeds and yield; plants from seeds

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with four holes presented 3 and 2.5 times less germination and weight of 100 seeds, respectively, in comparison with the control (CHIPUNGAHELO et al., 2001).

Inert dust and botanical extracts have been studied as substitutes to chemical insecticides due to insect resistance, increasing costs and suitability for small farmer conditions (GARCIA et al., 2000; ALMEIDA et al., 2005). Neem plant (***Azadirachta indica*** A. Juss) derivatives are referred as effective to more than 300 species of insects (SCHMUTTERER, 1990). OLIVEIRA & VENDRAMIM (1999) found that the neem oil repelled ***Z. subfasciatus*** weevils from beans. BARBOSA et al. (2002) obtained protection during 150 days using 3mL of neem oil kg^{-1} of beans seed.

Diatomaceous earth (DE) also has been used to control insects in stored grains. This material acts physically on insects, destroying the cuticle by abrasion and absorbing lipids, causing insect death by desiccation (GOLOB, 1997). DE is the fossilized sediments of microscopic diatomaceous algae mainly composed of hydrated silica in the shape of disordered crystals (PINTO JÚNIOR et al., 2005) and may be associated with insecticides (BARROS, 1999; CERUTI & LAZZARI, 2005); has no toxic effect for humans or animals (ATUI et al., 2003). LAZZARI (2005) obtained satisfactory control of ***Z. subfasciatus*** using diatomaceous earth (0.75 and 1.00g kg^{-1} of beans) at different temperatures (15, 20, 27 e 30°C).

Kaolin is an aluminum silicate, nonabrasive dust that when activated by acid and heat treatments has a high specific surface that absorbs the wax in the epicuticle of insect pests of stored grains (EBELING, 1971). In addition, it has been referred as effective in the control of some plant pests such as aphids (COTTRELL et al., 2002), olive fruit flies (SAOUR & MAKEE, 2004) and pear psyllids (GLENN et al., 1999). Thus, the efficiency of kaolin (with or without neem oil), compared with diatomaceous earth, on ***Z. subfasciatus*** in common beans was studied in laboratory.

MATERIAL AND METHODS

Experiments were conducted in the Entomology Laboratory, Department of Agronomy, Universidade Estadual de Londrina, Londrina, PR, Brazil. A rearing facility of ***Z. subfasciatus*** was maintained in the laboratory. Common bean cv. Carioca was used both in rearing and experiments. Treatments were kaolin (Protesyl®) (Fertirico, Curitiba, PR, Brazil) (2, 4 and 8g kg^{-1}), kaolin + neem [2g kg^{-1} (5% neem oil)] (Fertirico, Curitiba, PR, Brazil); diatomaceous earth (DE) (KeepDry®) (Vet Química, Campinas, SP, Brazil) (1g kg^{-1}) and control. The dusts were placed in plastic bags containing the grains and mixed during two minutes. The grains (30g) were put in 100mL vials containing five holes of 0.5mm in the cover. Five couples of ***Z. subfasciatus*** beetles were placed in each vial. Vials were maintained in environmental chambers (T 25$\pm$2°C; RH 70$\pm$10%; 12h Photophase).

Weevils' mortality was evaluated daily. Insects were considered dead when no movements were observed after be touched by a brush. After the assessment, died insects were recorded, sexed and discarded, and the alive insects were replaced in the vial. Eight days after experiment onset, all adults were removed and eggs quantified. The vials remained in the environmental chamber until total emergency of the F1 generation.

The completely randomized design was used. Proportion data (mortality) were transformed using arc sen (square root sen/100). ANOVA was performed on data and means compared using Tukey's test ($P<0.05$).

RESULTS AND DISCUSSION

In general, from second day after treatment, higher mortalities were found in the treatment with DE in which total mortality was observed in the third day for females and fourth day for males (Tables 1, 2). On the other hand, in the treatment using kaolin, 100% of mortality was observed in the fourth (4 and 8g kg^{-1}) and seventh (2g kg^{-1}) days for females; and 100 and 96% of mortality was found in the sixth (2g kg^{-1}) and eight (4 and 8g kg^{-1}) days for males, respectively. Higher doses of kaolin did not improve significantly the mortality.

In the treatment in which kaolin was mixed with neem oil, the efficiency was lower in the first assessments. Mortality was similar to the other treatments using kaolin just in the seventh and eight days for females and males, respectively (Table 1, 2). These results corroborate previous information about the relatively fast time of action of DE. Total mortality of ***Acanthoscelides obtectus*** (Coleoptera: Bruchinae) in common bean grains was referred at three and four days after treatment in the same dosage used in the present study (PINTO JÚNIOR et al., 2005; BAVARESCO, 2007).

The higher number of eggs in the grains was found on the control treatment (Table 3). In the treatment with kaolin + neem, values were intermediate. The lowest number of eggs was found

Table 1 - Cumulative mortality(%) of ***Zabrotes subfasciatus*** females in common beans grains treated with kaolin, kaolin + neem and diatomaceous earth in the laboratory (25±2ºC, 70% RH; 12: 2 L: D).

Treatments	-----------------------------Cumulative mortality[1] (Days after treatment) -----------------------------							
	1	2	3	4	5	6	7	8
Kaolin (2g kg^{-1})	16 C ab	28 C bc	64 B bc	84 AB a	92 A a	96 A ab	100 A a	100 A a
Kaolin (4g kg^{-1})	8 C ab	44 B bc	84 A ab	100 A a	100 A a	100 A a	100 A a	100 A a
Kaolin (8g kg^{-1})	36 B a	76 A a	92 A a	100 A a	100 A a	100 A a	100 A a	100 A a
Kaolin + neem [2g kg^{-1}(5% neem oil)]	4 E b	8 DE c	40 CD cd	48 BC b	64 ABC b	76 AB b	84 A b	92 A a
Diatomaceous earth (1g kg^{-1})	24 C ab	76 B a	100 A a	100 A a	100 A a	100 A a	100 A a	100 A a
Control	4 C b	16BC bc	24 BC d	28 BC b	36 AB c	40 AB c	56 A c	56 A b

[1] Means followed by the same letter did not differ using Tukey's test (P<0.05) (capital letters in the lines and lower case in the columns).

in the higher doses of kaolin. Except for the control, females deposited eggs in the vials walls.

Higher number of emerged adults was observed in the control. In the kaolin + neem treatment values were intermediate (Table 3). DE and mostly kaolin probably changed the oviposition behavior because females placed their eggs in the walls of the vials. This behavior probably disabled larvae survival because when larvae hatch, they penetrate directly inside the grains without contact with the outside [CARVALHO & ROSSETTO (1968) apud SPERANDIO (2001)]. Activated kaolin was also used for paddy rice treatment and suppressed progeny of some insect species for 250 days (PERMUAL & PATOUREAL, 1992). Insecticidal proprieties of DE and activated kaolin are attributed mostly by the thin dust proprieties that absorbs the lipids of the insect cuticle what promotes its desiccation (EBELING, 1971; GOLOB, 1997). Although the kaolin formulation used in this study was not heat or acid activated, protection of the grains was found. Another probable explanation for this efficiency is the physical action of the dusts on the surface of the grains affecting beetles behavior. According to HEADLEE (1924), when beans are treated with some kinds of inert dusts, larvae slips have no adherence to on the grain surface and difficulties to drill into the bean. Kaolin (hydrated aluminum silicate) formulation, when applied to the plants, constitutes a protective barrier (Particle Film Technology) that acts by repellence or physical barrier which difficult movements, feeding and oviposition (GLENN & PUTERKA, 2005). The results obtained in this study confirm for a pest of stored grains the previous results in which kaolin formulation reduced insect infestations in cultivated plants (EL-WAKEIL & SALEH, 2007; COTTRELL et al., 2002). Apparently, the protective barrier was effective because, when bean grains were treated with kaolin, the majority of eggs were placed in the vials walls (Table 3).

Other inert dusts also have been proposed for the common bean beetles management. However, hydrated lime and mostly dolomitic lime and wood ash are used in higher concentration than the present study (6; 200 and 200g kg^{-1}, respectively) (BAVARESCO, 2007).

Although neem oil is reported as effective against ***Z. subfasciatus*** (BARBOSA et al., 2002; SILVA et al., 2007), antagonistic effects probably

Table 2 - Cumulative mortality (%) of ***Zabrotes subfasciatus*** weevils males in common bean grains treated with kaolin, kaolin + neem and diatomaceous earth in the laboratory (25±2ºC, 70% RH; 12: 2 L: D).

Treatments	-------------------------------Cumulative mortality [1] (Days after treatment) -------------------------------							
	1	2	3	4	5	6	7	8
Kaolin (2g kg^{-1})	8 D a	32 CD bc	56 BC b	84 AB a	96 A a	100 A a	100 A a	100 A a
Kaolin (4g kg^{-1})	4 D a	40 C bc	72 B ab	92 AB a	92 AB ab	92 AB a	92 AB a	96 A a
Kaolin (8g kg^{-1})	0 C a	52 B ab	92 A a	96 A a	96 A a	96 A a	96 A a	96 A a
Kaolin + neem [2g kg^{-1}(5% neem oil)]	4 D a	12 D bc	24 CD c	48 BC b	68 AB b	80 A a	96 A a	96 A a
Diatomaceous earth (1g kg^{-1})	24 B a	84 A a	96 A a	100 A a	100 A a	100 A a	100 A a	100 A a
Control	4 A a	4 A c	4 A c	8 A c	16 A c	20 A b	32 A b	40 A b

[1] Means followed by the same letter did not differ using Tukey's test (P<0.05) (capital letters in the lines and lower case in the columns).

Table 3 - Means number of eggs (± SE) and emerged beetles of ***Zabrotes subfasciatus*** in common beans grains treated with kaolin, kaolin + neem and diatomaceous earth in laboratory (25±2ºC, 70% RH; 12: 2 L: D).

Treatments	Number of eggs [1]			Emerged adults [1]		
	Grains	Vials	Total	Females	Males	Total
Kaolin (2g kg^{-1})	10.4 ± 2.4 bc	14.4 ± 4.4 a	24.8 ± 5.4 b	3.6 ± 0.9 bc	3.8 ± 1.4 b	7.4 ± 1.9 b
Kaolin (4g kg^{-1})	8.8 ± 1.7 bc	11.4 ± 2.4 a	20.2 ± 2.6 b	2.8 ± 1.0 bc	3.4 ± 1.1 b	6.2 ± 1.6 b
Kaolin (8g kg^{-1})	0.8 ± 0.8 c	10 ± 6.5 a	10.2 ± 6.4 b	0.4 ± 0.2 c	0.4 ± 0.2 b	0.8 ± 0.4 b
Kaolin + neem [2g kg^{-1}(5% neem oil)]	26 ± 4.1 b	8.6 ± 4.1 a	34.6 ± 6.4 b	9.8 ± 1.5 ab	11 ± 1.3 a	20.8 ± 2.2 a
Diatomaceous earth	7.8 ± 2.7 bc	1.6 ± 0.5 a	9.4 ± 2.8 b	4.4 ± 1.8 bc	2.4 ± 0.9 b	6.8 ± 2.6 b
Control	64.2 ± 9.8 a	0 ± 0.0 a	64.2 ± 9.8 b	15.4 ± 3.8 a	16.8 ± 3.0 a	32.2 ± 6.2 a

[1] Means followed by the same letter did not differ using Tukey's test (P<0.05) (capital letters in the lines and lower case in the columns).

occurred when it was mixed with kaolin (Tables 1, 2 and 3). The oil may have affected the sorptive effect and the physical characteristics of kaolin and the protective layer would be negatively influenced. Further investigations using other neem derivatives (extracts or powders) can be conducted to test this hypothesis.

CONCLUSION

Kaolin treatment constitutes a suitable candidate for ***Z. subfasciatus*** management because the F1 generation been similar to DE although higher periods and doses than DE is necessary to promote high mortality. The mixture of kaolin and neem oil is not efficient in the control of ***Z. subfasciatus.***

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