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Use of caffeine for the management of rice weevil *Sitophilus oryzae* (L.)

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ABSTRACT

Caffeine, a naturally occurring alkaloid was tested in the laboratory for its efficacy against rice weevil *Sitophilus oryzae (L.)*, a devastating primary pest of stored grains. The chemical was found to be effective at 1.5 and 2.0% and resulted in >80% cumulative mortality with in a period of 5 days after its application. Total mortality was observed in two-week period.The nutritional indices RGR, RCR and ECI were high at 1.5 & 2.0% caffeine concentrations. The FDI index was negative for all the doses of caffeine confirmed the stimulant nature of the chemical to rice weevil. The filter paper method did not show any significant repellency of the chemical. However it can be recommended for alternation with other chemicals and as synergist in stored product pest management.

Key words: Rice weevil, Caffeine, Mortality, Whole kernel bioassay, Nutritional indices, Repellency studies.

INTRODUCTION

Rice weevil, *Sitophilus oryzae.L*. is a serious pest of large grain storage areas having world-wide distribution (Cotton, 1963). The insect damage to stored grains and their products amounts to 5-10% in temperate zone and 20-30% in tropical zone (Nakakita, 1998) in addition to the quality deterioration. Many countries, such as Australia, Canada and France, impose zero tolerance for imported grains.

This problematic pest is generally managed using synthetic insecticides. However, increased concern by consumers over insecticide residues in processed cereal products and the occurrence of insecticide resistant insect strains (Subramanyam and Hagstrum, 1995) new and alternative approaches are gaining momentum.

Many phytochemicals from plant sources are used in many parts of the world from ancient days and these ethno botanicals are easily available to farmers, less expensive and compatible with international trade and regulations. Hence they continue to be a valuable tool in integrated and biological pest management programs. Many plant secondary metabolites play an important role in plant–insect interactions and therefore such compounds may have insecticidal, hormonal or antifeedant activity against insects (Camps, 1988).

Caffeine (1, 3, 7-trimethylxanthine), is one such phytochemical in the plants like coffee, tea, and cacao found to have pestistatic and pesticidal action (Nathanson, 1984), It also causes sterility in some insects and possess antibacterial and antifungal properties. It also acts as repellent or toxicant for slugs and snails (Hollingsworth *et al.,* 2002) and an effective bird repellent (Avery and Cummings, 2003: Avery *et al.,* 2005).

Based on these considerations, the current study was undertaken to assess the potential and effectiveness of caffeine and to explore the possibilities of utilizing this as an alternate chemical for rice weevil, a treaded primary pest of stored cereals.

MATERIALS AND METHODS

Rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae) culture obtained from Agriculture and Agri-Food Canada, Winnipeg, maintained in the laboratory at Bio systems engineering department of McGill University, Canada was used for conducting experiments. Insects were reared on Hard Red Spring wheat variety at 13-14% moisture content at 25° C and 55±5%R.H. The chemical caffeine (1, 3, 7-trimethylxanthine) purchased from Sigma Chemicals was used for the experiments.

Whole kernel bio assay :

Caffeine was mixed with whole wheat kernel at varying concentrations of 0.1, 0.5, 1.0, 1.5, 2.0, 5.0 and 10.0g/100g of grain and the untreated one was maintained as control to eliminate mortality due to other factors. Each treatment was replicated five times. Twenty gram of grain was weighed and treated with the chemicals thoroughly for about two minutes. The treated grain was placed in a paper cup and covered using a muslin cloth for free air circulation. Ten unsexed adults from mixed age population were released into each cup.

Observations were made after 1, 3, 5,7,14 days of treatment and at each observation dead insects were

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removed after counting.

Cup bio assay technique :

The repellency of the chemical was tested using the cup bioassay technique developed by Mohan and Fields (2000), with modification. Small paper cups were used to hold about 50g of grains with holes of 2mm size to allow the insect to pass through and not the grains. The beetles moving out of the cup from sideways were captured using a plastic Petri plate smeared with white petroleum jelly to arrest insect movement. Untreated grains were used as control to eliminate the influence of natural movement.

Fifty gram of whole wheat grain was treated with caffeine to get different concentrations of 0.1, 0.5, 1.0, 1.5, 2.0 and 5.0%. Each treatment was replicated thrice with ten unsexed rice weevil adults per replication. The insects were released in the centre of each cup. The experimental setup was maintained in dark and the observations were made after 1, 6, 24 and 48 hours of commencement of the experiment. The repellency of caffeine was measured in terms of the percentage of insects moving out from the treated grain and trapped in the collection devices and compared with those from untreated grain.

Filter paper method :

The effect of caffeine on adult movement was assessed by filter paper as described by Tripathi et al. (2000). Caffeine was dissolved in acetone: distilled water mixture (1:1) and stirred thoroughly using a teflon coated bar in a magnetic stirrer (Fisher Scientific). From the stock solution of 5% further dilutions were made to get 0.1, 0.5, 1.0, 1.5 and 2.0.The filter paper of 9.0cm diameter was divided into two equal halves and one half was treated with 0.25ml of each dilutions. The other half was treated with acetone alone. The treated filter paper was air dried and ten unsexed adults were released in the middle of the petriplate. Each treatment was replicated three times and observations were made on number of insects on treated and untreated half of the filter paper after 1 and 4 h. of treatment.

Flour disk method :

Flour disks were prepared with some modifications as described in earlier methods (Xif *et al*., 1996: Huang *et al.,* 1997) using Hard red spring wheat (Canadian all purpose) flour. Five replicates were maintained with ten group weighed, unsexed adult insects each treatment. The insects were allowed to feed and the experimental setup was maintained in dark. The flour disks and the insects were weighed before release and were again weighed after 3 days.

The nutritional indices like relative growth rate, relative consumption rate, efficiency of conversion of ingested food were calculated as described by Huang *et al.,* (1997). An antifeedant index (C-T/C+T) was calculated from the mass eaten of control (C) and test (T) disks/squares, respectively. A potent antifeedant would have a positive index greater than 0.5 and negative index indicates stimulant nature.

Statistical Analysis

The mortality responses across the whole assessment period were analyzed using analysis of variance test (ANOVA) for a completely randomized design and the means were compared by least significant difference (LSD). The nutritional indices were calculated as per the formulas and subjected to ANOVA and the means are compared by Duncan's Multiple Range Test at P=0.01.The data collected from repellency tests were presented as percentage.

RESULTS AND DISCUSSION

The per cent mortality of rice weevil was less than 10% on one day after treatment and the maximum per

Table 1 : Effect of caffeine on mortality of adult *S. oryzae* at different time intervals.

Treatment		Mean Mortality					
		1	3	5	7	14	Total
T_1	Caffeine 0.1%	7.19a	15.92b	19.33d	38.35a	16.61a	97.40
T_2	Caffeine 0.5%	8.58a	29.95a	31.64c	23.29b	8.28b	100.00
T_3	Caffeine 1.0%	9.92a	17.90b	43.88b	19.47b	10.95a	100.00
T_4	Caffeine 1.5%	8.19a	27.55a	54.43a	8.44c	2.67c	100.00
T_5	Caffeine 2.0%	9.77a	23.43ab	55.21a	9.78c	2.67c	100.00
T_6	Untreated control	0.00	0.00	0.00	0.00	5.78c	5.78

Means followed by same letter within columns indicate no significant difference (P>0.01) by LSD. The data is a mean of three replications.

cent mortality of 54.43 and 55.21 was noted after 5 days at 1.5 and 2.0% caffeine, respectively (Table 1). The chemical resulted in total mortality of rice weevil adults in a period of two weeks and no surviving insects were observed at the end of experiment.

In the cup bioassay technique insect movement was more during one and 24 h. after treatment rather than on 12 and 48h. of treatment. The caffeine treatment resulted in 27.0 to 50.5% of insects to move out from the treated grain (Table 2).

Filter paper method showed no significant difference on the number of insects in each treated and untreated surfaces and there is no influence of caffeine on insect aggregation. Most of the insects were seen moving on the top of the lid as non-respondants.

The studies on Nutritional indices showed maximum growth rate in 1.5, 5.0 and 10.0% which is on par with 2.0 and 0.1% . The food ingestion is maximum at higher concentrations and is significant at 10.0%.At 5&10% RGR&RCR are significantly high implying increased consumption of treated food and relative growth. ECI is the maximum at 1.5% and is lower at 0.5 and 1.0%. The FDI or the repellent index is negative for all doses of caffeine except at 10.0%, revealing the stimulant nature of caffeine. The stimulant effect is significant at 1.5% as shown by significant RGR, ECI and RCR values (Table2).

Few reports only are only available for the effect of caffeine on stored products showing its toxicity. Mondal and Akhtar, (1992) reported the toxic effect of caffeine to adults and larvae of *Tribolium castaneum* when compared to castor oil and the toxicity depended on ingestion of the treated medium.

Caffeine was found to reduce feeding by tobacco hornworms and reproductive potential in several species of moths (Nathanson, 1984: Mathavan et al. 1985)) . It also exhibited synergistic effect with microbial and chemical insecticides against insect pests of crops (Morris *et al*., 1994: Farag, 2000).

Table 2 : Repellency of caffeine to *S. oryzae* by cup bioassay method

Treatment		Mean Percentage of insects				
		1h	12h	24h	48h	Total
T_1	0.1%	0.00	2.50	27.50	5.00	35.00
T_2	0.5%	5.00	7.50	22.50	2.50	37.50
T_3	1.0%	10.00	5.00	12.50	0.00	27.50
T_4	1.5%	15.00	2.50	15.50	2.50	35.50
T_5	2.0%	15.00	5.00	20.00	2.50	47.50
T_6	5.0%	22.50	5.00	27.50	2.50	50.50
T_7	10.0%	20.00	5.00	17.50	5.00	47.50
T_8	Control	0.00	0.00	5.00	0.00	5.00

Mean of five replications

Table.3 : Repellency of caffeine to *S. oryzae* - Filter paper method .

Caffeine		Control	Treated	Control	Treated
	%	1 h.	1h.	4 h.	4 h.
T_1	0.1	1.09a	1.32a	1.158	0.927
T_2	0.5	1.32a	1.39a	1.158	0.395
T_3	1.0	0.36a	1.37a	1.158	1.503
T_4	1.5	1.27a	0.74a	1.380	0.283
T_5	2.0	1.08a	1.79a	1.271	0.937
T_6	5.0	1.33a	0.25a	1.318	1.629
T_7	10.0	1.52a	1.52a	1.131	0.613

Means followed by same letter within columns indicate no significant difference (P>0.01) by DMRT. The data is a mean of three replications.

Table 4 : Nutritional and feeding deterrence indices for *S. oryzae* adults fed on caffeine treated flour disk

Treatment		RGR	RCR	ECI	FDI
T_1	0.1%	0.121ab	0.606b	17.835ab	-84.553cde
T_2	0.5%	0.003b	0.337b	0.466b	-88.580bc
T_3	1.0%	0.011b	0.498b	1.422b	-53.030bc
T_4	1.5%	0.324a	1.103ab	28.542a	-16.623b
T_5	2.0%	0.210ab	1.727ab	11.743ab	-97.620de
T_6	5.0%	0.348a	1.786ab	18.366ab	-60.308cd
T_7	10.0%	0.364a	3.624a	17.243ab	117.243a
T_8	control	0.081ab	0.410b	21.872ab	-

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The FDI index calculated showed the stimulant nature of the chemical to rice weevil. The increased adult mortality at 1.5 & 2.0% can be interpreted based on higher values of RGR, RCR and ECI, in comparison to other doses. Muthukrishnan, et al.(1979) reported the higher assimilation efficiency of *Danaus* larvae fed on leaves treated with 0.5% caffeine and failure of normal metamorphosis.

The results of present study explicitly indicate the stimulant effect of caffeine on rice weevil in spite of its delayed mortality effect. Caffeine has a place in stored product pest management as alternate chemical in rotation to routine chemicals in insecticide resistance management. The stimulant nature exhibited against rice weevil paves way for using the as synergist with other chemicals. Further in depth study is required to establish strong evidence for insecticidal properties of caffeine and methods of use in stored product management.

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