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THE FUMIGANT TOXICITY OF FOUR PLANT BASED PRODUCTS AGAINST THREE STORED PRODUCT PESTS

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ABSTRACT

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The fumigant effect of emulsified petroleum ether extract of *Acorous calamus* rhizome alone and three separated mixtures of different plants materials (*A. calamus* rhizome + *Corchorus capsularis* seed, *A. calamus* + *Thevetia neriifolia* seed and *A. calamus* + *Zingiber cassumunar* rhizome) were evaluated against adults of *Sitophilus oryzae* (L.), *Callosobruchus chinensis* (L.) and 13 days old larvae of *Tribolium castaneum* (Herbst.). The fumigant toxicity of different combination of plant materials with *A. calamus* extracts were assessed at four doses *viz*. 10, 20, 30 and 40 mg/100 ml volume and for *A. calamus* alone was 5, 10, 20 and 30 mg/100 ml volume in space fumigation. Emulsified of *A. calamus* rhizome extract was found to be the most effective against *T. castaneum* larvae and *C. chinensis* adults at 24 and 48 hours. The LD_{50} values for *T. castaneum* larvae were 19.63 and 4.08 mg/100 ml volume whereas in case of *C. chinensis* the LD_{50} values were 4.63 and 1.04 mg/100 ml volume at 24 and 48 hours respectively. Combination of *A. calamus* with *Z. cassumunar* extract was found to be the most effective fumigant against *S. oryzae* adult (16.48 mg/100 ml volume) at 24 hours but it varied at 48 hours where *A. calamus* with *C. capsularis* was the most effective against the beetle (4.08 mg/100 ml volume).

***Key words**: plant products, fumigant toxicity, S. oryzae, C. chinensis and T. castaneum*

INTRODUCTION

The global post-harvest grain losses caused by insect damage and other bio-agents range from 10-40% (Raja *et al.* 2001; Ogendo *et al.* 2008). Most of them have the habit of destroying more than what they eat. *Stophilus* and *Tribolium* species respectively are major pests of stored grains and grain products in the tropics and cause considerable economic losses of stored wheat grain (Farideh *et al.* 2008). *Callosobruchus chinensis* (L.) is a serious pest of chickpea, mung bean, peas, cowpeas, lentil and arhar. The most efficient method of controlling these insect pests relies on the use of insecticides either directly applied to grains or by gas fumigation, many of which act on the insect nervous system.

Rice weevil and pulse beetle are being an internal feeder can not be controlled with insecticides. Fumigation is the most effective method in insect pest elimination in stored products. Currently, phosphine and methyl bromide are the two common fumigants used for stored product protection world over. However, because of its ozone depletion potential, methyle bromide is being phased out completely (Rajendran and Sreanjini, 2008).

Recently, there has been a growing interest in research concerning the possible use of plant extracts as alternatives to synthetic insecticides. Plant essential oils may act as fumigants, contact insecticides, repellents, deterrents and antifeedants (Weaver and Subramanan, 2000; Kim *et al*. 2003; Negahban *et al*. 2007). Plant products are receiving greater attention as prophylactics against stored-product pests, mainly because of their presumed safety to non-target organism. *A. calamus* rhizomes, *C. capsularis* seed, *T. neriifolia* seed and *Z. cassumunar* rhizomes have been reported as effective protectants against several stored product pests (Kim *et al.* 2003; Yao *et al.* 2008; Hassan *et al.* 2006). Toxicity studies on mixtures of different essential oils or their constituents against stored-product insects to demonstrate additive, synergistic or antagonistic effects are rare. Don-Pedro (1996) noted an additive effect of individual components of citrus peel oil {(+)-limonene, g-terpeneol, terpinolene, a-terpeneol, n-decyl alcohol} against *C. maculatus* adults. Therefore, the following investigation was undertaken to evaluate the fumigant action of different emulsified mixtures of plant essential oils (*A. calamus, C. capsularis, T. neriifolia* and *Z. cassumunar*) against *S. oryzae, C. chinensis* and 13 days old larvae of *T. castaneum*.

MATERIALS AND METHODS

The experiment was conducted in research laboratory of Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratories, Rajshahi, Bangaladesh during the month of January to March, 2010. Seeds of White Jute *Corchorus capsularis*, Karabi, *Thevetia neriifolia*, rhizomes of Bonada, *Zingiber cassumunar* and white Boch, *Acorus calamus* were procured from the different areas of Rajshahi. All the parts were dried in a shade and finally dried in an oven at 40^0C. After drying these parts were crushed in a mortar and pestle and extracted by petroleum ether separately. After extraction, extracted liquid were dried in a rotary evaporator and then collected in a small reagent bottle, preserved at 4^0C in a refrigerator. 5ml *A. calamus* extract were mixed with 5ml of other plant extract separately. Then 5ml of 2.6% Sodium hydroxide solution in distil water were added and was stirred vigorously for 15 minutes. In case of *A. calamus*, 10ml extract were mixed with 5ml Sodium hydroxide solution (2.6%) in distil water and stirred vigorously. Finally 15ml of emulsified product of

A. calamus + *T. neriifolia*, *A. calamus* + *C. capsularis*, *A. calamus* + *Z. cassumunar* and *A. calamus* alone were prepared.

Stock culture of *C. chinensis* and *S. oryzae* were maintained in separate 1000ml beaker on sterilized cowpea and maize at 30^0C ± 0.5^0C in an incubator respectively. A standard mixture of whole wheat flour with powdered dry yeast in a ratio of 19:1 was used as food medium in case of *T. castaneum*.

The method used to determine the fumigant activity of tested four emulsified product based on the method described by Sahaf *et al.* (2007) with some modification. 5, 10, 20, 30 and 40 mg of each plant product was dissolved in two drop of water and applied to filter papers (2cm diameter of Whatman No. 1) uniformly with the help of a pipette. The treated filter papers were then air dried for 10 minutes to evaporate the solvent completely then attached to the under surface of the screw cap of a glass vial (4.5 cm diameter, 10.5 cm height, volume 100 ml) where it was inaccessible to insects. The caps were screwed tightly on the vial containing 10 adults (5-10 days old) of each species of insect and 13 days old larvae of *T. castaneum* separately. The doses of the combined plant based products were 10, 20, 30 and 40 mg/100 ml and for *A. calamus* alone were 5, 10, 20 and 30 mg/100 ml volume. Each dose was replicated five times. Control insects were kept under the same conditions without any products. Mortality was assessed after 24, and 48 hours of the exposure period. When no leg or antennal movements were observed, insects were considered dead. The mortality was corrected by using Abbott's formula (Abbott 1925) and LD_{50} values were determined by probit analysis (Busvine 1971). The experiments were performed in the laboratory at ambient temperature 30^0C ± 0.5^0C.

RESULTS AND DISCUSSION

The results of fumigant toxicity of different plant based products on the adults of *S. oryzae, C. chinensis* and 13 days old *T. castaneum* larvae are shown in Table 1, 2 and 3. LD_{50} values and fiducial limits of the products were determined. All plant based products were toxic to these adults and larvae. Our results showed that the mortality of the pests increased with the increasing exposure time. Boch + Bonada product exhibited the lowest LD_{50} value (Table 1) on *S. oryzae* adults after 24 hours where Boch + Jute were found to be the most effective toxicant against the beetle at 48 hours. The calculated LD_{50} values of Boch + Bonada, Boch alone, Boch + Karabi and Boch + Jute products were 16.48, 18.55, 23.74 and 26.79mg/100ml volume respectively against *S. oryzae* adults after 24 hours. At 48 hours intervals Boch + Jute, Boch alone, Boch + Bonada and Boch + Karabi were 6.69, 7.94, 9.41 and 12.92 mg/100ml volume respectively against the same species. The order of efficacy at 24 hours was Boch + Bonada > Boch alone > Boch + Karabi > Boch + Jute products and at 48 hours was Boch + Jute > Boch alone > Boch + Bonada > Boch + Karabi products.

Highest mortality was recorded with the Boch emulsified product in *C. chinensis* adults after 24 and 48 hours treatment. Where LD_{50} values were 4.63 and 1.04 mg/100ml volume at the respective time intervals. LD_{50} values of Boch + Bonada were 7.56 and 1.99mg/100ml volume, Boch + Karabi product were 7.65 and 1.99mg/100ml volume and Boch + Jute product were 9.29 and 4.14 mg/100ml volume after 24 and 48 hours exposure time respectively. During 24 hour treatment their efficacy followed the order Boch > Boch + Bonada > Boch + Karabi > Boch + Jute. After 48 hours, Boch + Karabi and Boch + Bonada showed the same level of toxicity.

In case of *T. castaneum* larvae, these products showed fumigant toxicity at all the duration (Table 3). The results indicate the highest mortality with Boch emulsified product at 24 and 48 hours treatment. The LD_{50} values of Boch product were 19.63 and 4.08 mg/100 ml volume, Boch + Jute product were 36.07 and 7.52 mg/100ml volume, Boch + Bonada were 35.66 and 19.31mg/100ml and Boch + Karabi emulsified product were 31.04 and 13.50 mg/100ml volume at 24 and 48 hours respectively. After 24 hours treatment their efficacy followed the order Boch alone > Boch + Karabi > Boch + Bonada > Boch + Jute and at 48 hours the order of efficacy was Boch alone > Boch + Jute > Boch + Karabi > Boch + Bonada.

The present results are in conformity with the results of Sahaf *et al.* (2008) who reported that *T. castaneum* and *S. oryzae* adults were significantly susceptible to the fumigant toxicity of the essential oil of *Vitex pseudo-negundo*. Results of the present study are in agreement with the results of Rajendran and Sriranjini (2008), who reported that *Tribolium castaneum*, *Rhyzopertha dominica*, *Sitophilus oryzae* and *S. zeamais* were generally susceptible to the fumigant toxicity of essential oil of plants mainly belonging to the families Apiaceae, Lamiaceae, Lauraceae and Myrtaceae and their components. Lee *et al.* (2004) reported the fumigant toxicity of six out of 42 essential oils extracted from species of the family Myrtaceae against three major stored-grain insects, *S. oryzae*, *T. castaneum* and *R. dominica*. Negahban *et al.* (2007) observed the fumigant toxic effect of different essential oils of *Artemissia sieberi* against 7days old adults of *Callosobruchus maculatus, Sitophilus oryzae* and *Tribolium castaneum* by using the doses from 37 to 928μl/L. Arabi *et al.* (2008) found that the fumigant toxicity of essential oil of *Perovskia abrotanoides* caused 100% mortality on *Tribolium castaneum* and *Sitophilus oryzae* at 32μl/L of air after 15 and 8 hours exposure time respectively. Tembo and Murfitt (1995), reported that treatment with vegetable oils of groundnut, rape seed and sunflower combined with pirimiphos-methyl were effective than the pirimiphos methyl alone. He also observed that the vegetable oils and pirimiphos-methyl when applied alone at reduced rate were less effective than combined treatment.

Table 1. Fumigation toxicity of four plant based product against *Sitophilus oryzae* adults

Hours after treatment	Plant materials	χ^2 values for hete-rogeneity	Regression equation	LD_{50} ($\mu g/cm^2$)	Fiducial limits	
					Lower	Upper
24	*Boch + Jute*	*1.20*	*Y = 3.08 + 1.34*	*26.79*	*13.48*	*53.24*
	Boch + Karabi	2.70	Y = -0.77 + 4.19X	23.74	19.29	29.21
	Boch + Bonada	2.95	Y = 1.52 + 2.85X	16.48	12.73	21.33
	Boch (alone)	*5.13*	*Y = 3.31 + 1.33X*	*18.55*	*10.83*	*31.78*
48	*Boch + Jute*	3.31	Y = 3.44 + 1.89X	6.69	4.14	10.82
	Boch + Karabi	2.65	Y = 1.54 + 2.92X	12.92	10.21	16.34
	Boch + Bonada	*0.936*	*Y = 2.15 + 2.92X*	*9.41*	*7.18*	*12.33*
	Boch (alone)	*5.31*	*Y = 3.52 + 1.64X*	*7.94*	*4.86*	*12.96*

Table 2. Fumigation toxicity of four plant based product against *Callosobruchus chinensis* adults

Hours after treatment	Plant materials	χ^2 values for hete-rogeneity	Regression equation	LD_{50} ($\mu g/cm^2$)	Fiducial limits	
					Lower	Upper
24	*Boch + Jute*	*1.70*	*Y = 2.60 + 2.47X*	*9.29*	*6.83*	*12.65*
	Boch + Karabi	0.056	Y = 3.20 + 2.04X	7.65	5.09	11.50
	Boch + Bonada	1.35	Y = 2.92 + 2.30X	7.56	5.28	10.82
	Boch (alone)	*0.191*	*Y = 3.82 + 1.77X*	*4.63*	*3.04*	*7.06*
48	*Boch + Jute*	0.147	Y = 3.81 + 1.91X	4.14	2.09	8.20
	Boch + Karabi	0.217	Y = 4.59 + 1.35X	1.99	0.415	9.61
	Boch + Bonada	*0.218*	*Y = 4.59 + 1.35X*	*1.99*	*0.42*	*9.60*
	Boch (alone)	*3.67*	*Y = 4.97 + 1.25X*	*1.04*	*0.22*	*4.97*

Table 3. Fumigation toxicity of four plant based product against 13 days old *T. castaneum* larvae

Hours after treatment	Plant materials	χ^2 values for hete-rogeneity	Regression equation	LD_{50} ($\mu g/cm^2$)	Fiducial limits	
					Lower	Upper
24	*Boch + Jute*	*0.188*	*Y= 2.171 + 1.81X*	*36.07*	*22.26*	*58.46*
	Boch + Karabi	0.209	Y=1.65 + 2.24X	31.04	22.09	43.62
	Boch + Bonada	2.53	Y=1.43 + 2.29X	35.66	24.41	52.10
	Boch (alone)	*1.25*	*Y= 2.75 + 1.74X*	*19.63*	*13.33*	*28.92*
48	*Boch + Jute*	0.718	Y=3.92 + 1.23X	7.52	2.26	25.03
	Boch + Karabi	0.121	Y=1.77 + 2.85X	13.50	9.85	18.50
	Boch + Bonada	1.77	Y= 2.07 + 2.28X	*19.31*	*14.26*	*26.16*
	Boch (alone)	*0.572*	Y= 4.11 + 1.45X	*4.08*	*0.767*	*21.75*

CONCLUSION

Our observation showed that fumigation action of plant based products were characterized by rapid knocked down effect, convulsion and also showing that in some cases mixture of plant extract was more toxic than the individual products. Our results indicate the same activity of essential oils and emulsified products. These results would indicate a significant potential as a possible source of natural products that could be used as an alternative to synthetic insecticides. Use of plants in controlling insect infestation would offer desirable solutions, especially in developing tropical countries, where plants are found in abundance everywhere, throughout the year

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