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Alternative Materials for the Control of Pulse Beetle, *Callosobruchus maculatus* (F.)

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ABSTRACT. *Dried plant powders and acetone extracts of Tridax procumbans, Eucalyptus camaldulensis and Lantana camara, paddy husk ash, activated kaolin clay and untreated kaolin clay were tested for their insecticidal and ovicidal effects on the pulse beetle, Callosobruchus maculatus (F.) reared on stored green gram seeds. Acetone extracts of the three plant species caused adult mortality ranging from 43.75 to 96.25%, reduced egg laying capacity by 46.7 to 91% and egg hatchability by 22.13 to 47.5 % at 10% level indicating a high potential of these plant species for the extraction and formulation of botanical insecticides. Dried plant powders also showed an effect in the control of the pulse beetle. Out of the three non - chemical products, activated kaolin clay reduced the population levels of the pulse beetle by more than 90% at a low dose of 2%. Paddy husk ash showed a population reduction of 54% at a dose of 5%. Thus activated kaolin clay could be considered as highly effective and paddy husk ash as moderately effective insect control agents for the pulse beetle, Callosobruchus maculatus.*

INTRODUCTION

Callosobruchus maculatus (F.) is a serious pest of pulses causing heavy losses under storage (Wolfson *et al.*, 1991). Certain synthetic organic pesticides and fumigants are being used against the stored grain pests which are costly and involve the risk of health hazards to consumers (Fernando and Nawarathna, 1984). As an alternative, Plant derivatives can be used to control these pests effectively. *Lantana camara* was observed to be highly effective against *C. chinensis* in pulses (Saxena *et al.*,1992). *Tridax procumbans* and *Eucalyptus* species were suggested by Muralikrishna *et al.* (1990), as antifeedants for several agricultural pests.

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Inert materials such as kaolin clay and paddy husk ash have also been used to control storage pests. Activated kaolin clay was found to show insecticidal properties (Perumal and Patourel, 1990). Activation of kaolinitic clays increases their adsorptive capacity sufficiently to make them effective desiccants for a number of insect species, including stored product pests. The low cost of the activation process together with the negligible mammalian toxicity of the finished product make it a suitable alternative agent to control stored product pests.

Mixing of paddy husk ash in varying quantities with grains has been an age old practice in Sri Lanka to prevent deterioration of pulses during storage. Insect controlling effect of ash is due to physical injury of the epicuticle and absorption of epicuticular wax of the insect by the ash resulting in death due to desiccation (Fernando and Nawarathna, 1984; Wolfson *et al.*, 1991).

MATERIALS AND METHODS

Leaves of *L. camara, T. procumbans* and *E. camaldulensis* collected were washed thoroughly and dried under the shade for one week. The powdered material of the plant was "Soxhleted" with alternative solvent extraction treatment using acetone. Crude extracts were obtained after complete removal of the solvents with vacuum evaporation below 60°C. These extracts were diluted with acetone as required for the laboratory bioassays. Four different concentrations (2.5%, 5%, 10% and 20%) of the crude extracts were screened against laboratory-cultured pulse beetle on green gram seeds. Contact toxicity of above mentioned plant leaf extracts and dried plant powders was assayed by grain treatment. In grain treatment method, 1, 0.5, 0.25 and 0.125 g of the extract was dissolved separately in 5 ml of acetone. 2.5 ml aliquot of these solutions were then added to the 40 g of chemical free MI 5 green gram seeds (Ahangama and Kurundukumbura, 1993). The mixture was stirred continuously until all the acetone had evaporated. Treated grain samples were divided into four sub samples, which were transferred to small jam bottles and covered with muslin cloth. Same quantity of untreated grains and grains treated with acetone alone were used as control and control 1. Batches of 10 pairs of day old *C. maculatus* adults were introduced into each sample. Adult mortality (counted after 4 days), number of eggs laid on seeds and emergence of adults were recorded.

Acid and heat activated kaolinitic clay, completely burnt paddy husk ash (white ash) and untreated kaolin clay were separately passed through 100

mesh (cm^2) sieve (Kameswar *et al.*, 1990; Prakash and Jegadiswari, 1989) and then nixed thoroughly with 10 g portion of green gram seeds at 2%, 3% and 5% level by weight in small jam bottles. Ten pairs of adults of *C. maculatus* were introduced into each jam bottle and the mouth was covered with muslin cloth (Bandara and Saxena, 1995). Untreated grain was kept as the control. The treatments were replicated four times. Adult mortality, after 4 days, number of eggs laid on seeds and adult emergence were recorded.

RESULTS AND DISCUSSION

E. camaldulensis, L. camara and *T. procumbans* caused a significantly high mortality of adult pulse beetle, *C. maculatus* 4 days after treatment showing their insecticidal properties (Table 1). *E. camaldulensis* extract showed the highest insecticidal activity causing 75, 84, 96 and 100% mortalities at 2.5, 5, 10 and 20% concentrations, respectively (Figure 1). The oviposition by the pulse beetle was significantly reduced by acetone extracts of all the three plant species tested at concentrations above 5% (Figure 2). In green gram seeds treated with *T. procumbans* extract at concentrations of 5, 10 and 20% the oviposition rate was reduced by 61%, 91% and 95%, respectively. While similar concentrations of acetone extract of *E. camaldulensis* showed 34%, 66%, and 88% reduction in egg laying. The values for *L. camara* were 22%, 37% and 62%, respectively. Similar results were obtained by Saxena *et al.*, (1992). This reduction in egg laying may be due to a repellent action of the extracts or due to antihormonal activity of the plant compounds or may be due to alteration of the surface of seeds by the formation of a film showing nonpreference by the insect for egg laying.

Acetone extracts of the three plant species showed ovicidal effect by significantly reducing the egg hatchability. *T. procumbans* extract showed the highest effect resulting in 46, 22 and 7% egg hatchability by treatments with extract at 5, 10 and 20% concentrations compared to 76% hatchability of eggs on control and control 1. Similar reduction in egg hatchability was observed in seeds treated with similar concentrations of acetone extracts of *E. camaldulensis* and *L. camara*. Emergence of adult beetles after completion of the generation was significantly reduced in seeds treated with all the three plant extracts compared to the coltrol and control 1 (Figure 3). This reduction in emergence of adults may be due to the reduction of oviposition rate, reduction in hatchability or may be due to inability of larvae to complete the life cycle on treated seeds.

Table 1. **Effect of acetone extracted botanicals, paddy husk ash, activated kaolin clay and untreated kaolin clay on the development of *Callosobruchus maculatus*.**

Treatment (in %)	Mean % of adult mortality (after 4 days)	Mean No. of Egg deposited per 10 gm of greengram	Mean % of Hatchability	Mean No. of adult emergence
T. procumbans (w/v)				
2.5	16.5	307.5	70.5	231.5
5.0	30	124.5	46	26.5
10.0	52.5	28.75	22.13	6.5
20.0	87.5	15	7.12	1
Control	0	317.5	76.5	288.5
Control 1	0	319.25	76.6	302.25
M.S.D.	18.23	49.447	18.23	34.9
E. camaldulensis (w/v)				
2.5	75	243.75	68.5	187.25
5.0	83.75	212	66	142
10.0	96.25	107.5	44	49
20.0	100	39.25	30.25	10.5
Control	0	319.5	73	294
Control 1	0	330.5	73.5	311
M.S.D.	6.55	34.206	17.036	40.05
L. camara (w/v)				
2.5	48.75	213.75	62.5	121
5.0	55	199	65.5	73.5
10.0	43.75	142.75	47.5	53.5
20.0	61.25	85	36.5	17.25
Control	0	225.5	74.5	202.25
Control 1	0	236.75	73.5	215.75
M.S.D.	9.556	94.99	3.9603	102.16
Paddy Husk Ash (w/w)				
2.0	0	393.5	60.5	205.75
3.0	0	301.5	60	150
5.0	0	147.5	64	128
Control	0	390.75	73	276.75
M.S.D.		41.75	7.764	57.336
Activated Kaolin Clay (w/w)				
2.0	100	11.75	75	10.25
3.0	100	10.75	25.6	2.75
5.0	100	09.25	8.3	0.75
Control	0	155.25	83.5	141.25
M.S.D.	3.70	20.474	51.5	17.702
Untreated Kaolin clay (w/w)				
2.0	0	194.75	194.75	175
3.0	0	168.25	168.25	148.25
5.0	0	195	195	168
Control	0	204.25	204.25	188.75
M.S.D.		48.57	48.57	44.613

M.S.D. - Minimum Significant Difference
(w/w) - Weight/Weight
Control 1 - Solvent treatment only
(w/v) - Weight/Volume

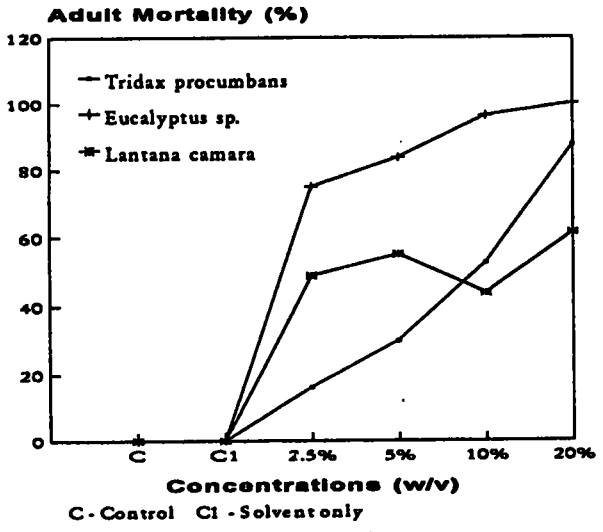

Figure 1. **Effect of acetone extracted botanicals on the adult mortality of *Callosobruchus maculatus* on green gram seeds.**

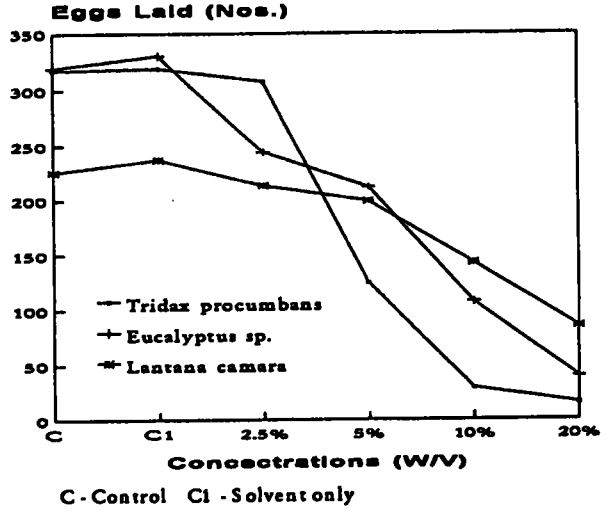

Figure 2. **Effect of acetone extracted botanicals on the oviposition of *Callosobruchus maculatus* on green gram seeds.**

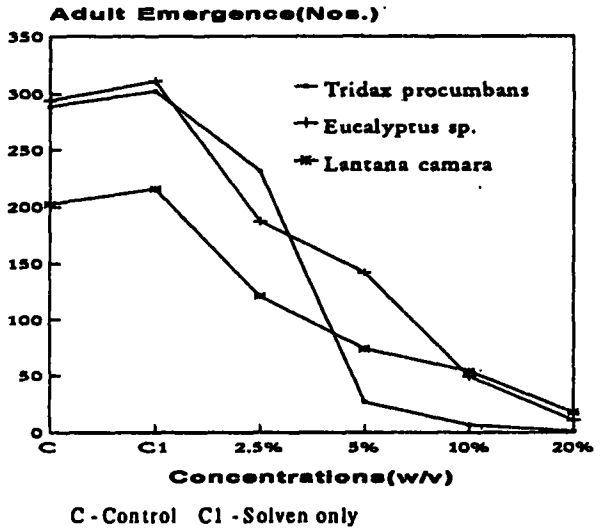

Figure 3. Effect of acetone extracted botanicals on the emergence of adults of *Callosobruchus maculatus* on green gram seeds.

Plant powders of the three plant species also showed significant reduction of oviposition rate, egg hatchability and emergence of fresh adult beetles (Table 2) indicating the effectiveness of dried plant powders in the control of *C. maculatus*. The use of dried plant powders is a convenient and practical method to be adopted by rural farmers. The insecticidal and ovicidal properties of acetone extracts of the plant species, *T. procumbans; E. camaldulensis* and *L. camara* shown in this study indicates that these plant species could be used for extraction and formulation of effective botanical insecticides for the control of pulse beetles.

In the bioassay conducted to determine the contact toxicity of paddy husk ash, activated kaolin clay and untreated kaolin clay, 100% mortality of adult pulse beetles was observed 3 days after treatment when the green gram seeds were treated with activated kaolin clay at the rates of 2, 3 and 5% (Table 1). No adult mortality was observed in seeds treated with paddy husk ash and untreated kaolin clay at the same doses. Above 90% reduction in oviposition rate was observed on green gram seeds treated with activated kaolin clay at concentrations above 2%. In seeds treated with paddy husk ash at 5% concentration a 62% reduction in egg laying capacity was found. Similar results have been shown by Ahangama *et al.*, (1992) Fernando and Navarathne

Table 2. Effect of plant leaf powders against *Callosobruchus maculatus*.

Plant powders 5% w/w dose	Adult Mortality (%)	Eggs laid (Nos.)	Hatchability (%)	Adult emergence (Nos.)
T. procumbans	48.75	151 (49.4%)	70	118
E. Camaldulensis	42.50	133.5 (37.26%)	62	65
L. Camara	12.50	106.2 (34.7%)	62	98
Control	2.50	305.7 (100%)	74	151
C.V.	33.5	21.46	3.38	26.56
M.S.D.	16.662	74.813	4.55	61.15

C.V. - Coefficient of Variation
M.S.D. - Minimum Significant Difference

(1984) and Walfson *et al.* (1991). However, untreated kaolin clay did not show any effect on the oviposition rate of the pulse beetle (Figure 4). Activated kaolin clay showed ovicidal effects by reducing the hatchability of eggs on treated seeds by 70% and 90% at rates of 3% and 5%, respectively. Reduction in egg hatchability found on seeds treated with paddy husk ash at the rate 3% was only 18%. Untreated kaolin clay did not show any ovicidal effects on *C. maculatus* eggs. Adult emergence in seeds treated with activated kaolin clay at the rates of 2, 3 and 5% was reduced by 90, 97 and 100%, respectively compared to the untreated control (Figure 5). In seeds treated with paddy husk ash at doses of 3 and 5% adult emergence was reduced by 45% and 54%, respectively. Untreated clay was ineffective. This observed reduction in fresh adult emergence could be attributed to the reduction in oviposition rate, egg hatchability and growth and development of immature stages of the pulse beetle. These results show the moderate effectiveness of paddy husk ash and the high effectiveness of activated kaolin clay in the control of the pulse beetle on green gram seeds. As paddy husk ash is freely available in paddy growing areas, this product could be considered as a cheap controlling agent to be incorporated in insect management programmes for stored grains. Kaolin clay is freely available in Sri Lanka though the activation process could add to the cost. As these products do not show any adverse effects on other animals they

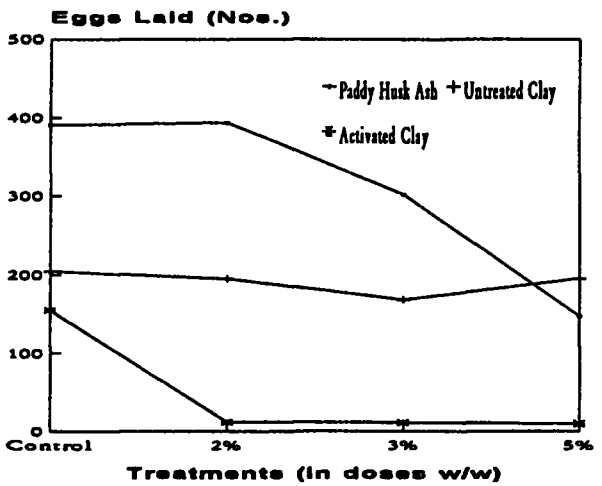

Figure 4. **Effect of paddy husk ash, activated kaolin clay and untreated kaolin clay on egg laying capacity of *Callosobruchus maculatus*.**

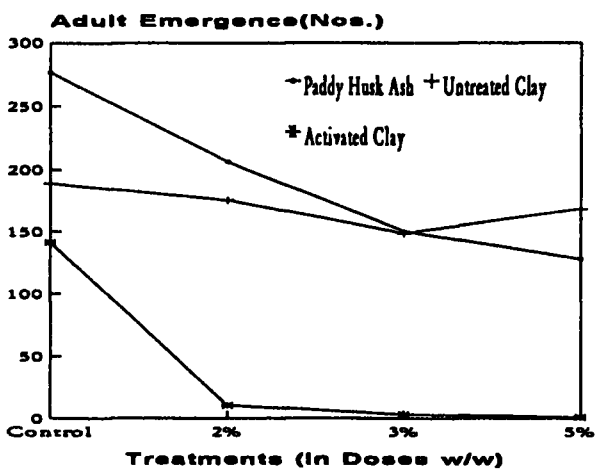

Figure 5. **Effect of paddy husk ash, activated kaolin clay and untreated kaolin clay on adults emergence of *Callosobruchus maculatus*.**

could be considered as safe materials to be used in pest management programmes. As paddy husk ash and activated kaolin clay particles could be easily removed by washing the seeds, chances of the particles being consumed by consumers is prevented.

CONCLUSIONS

Dried plant powders and Acetone extracts of the three plant species *Lantana camara, Eucalyptus camaldulensis* and *Tridax procumbans* were found to be showing insecticidal and ovicidal properties causing adult and egg mortality and reducing egg laying capacity of *C. maculatus*. Thus these three plant species could be used for extraction and formulation of botanical insecticides for the protection of grains in storage from insects. Out of the three non chemical products tested, activated kaolin clay showed very high degree of effectiveness in controlling the pulse beetle. Paddy husk ash was found to be moderately effective in the control of the pulse beetle.

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