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Journal of Stored Products Research 37 (2001) 85–91

Journal of STORED PRODUCTS RESEARCH

www.elsevier.com/locate/jspr

Effect of some Ghanaian plant components on control of two stored-product insect pests of cereals

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Accepted 14 January 2000

Abstract

In an attempt to find natural and cheaper methods for the control of stored-product pests of cereals, some traditionally useful Ghanaian plant materials were evaluated. Hexane + isopropyl alcohol extract of leaves of *Ocimum viride* proved most effective in the control of *Tribolium castaneum* (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (Coleoptera: Curculionidae), followed by that of *Chromolaena odorata*. *O. viride* showed strong repellent activity and thus deterred the insects from feeding. It reduced survival of both insect pests to less than 25% after 10 days of treatment at concentrations of 0.1 mg ml^{-1} and above. The results show the potential of *O. viride* and *C. odorata* in the control of stored-product insects.

Keywords: Ghanaian plants; Stored-product insects; Control; Cereals

1. Introduction

The misuse and unaffordable cost of insecticides, especially in developing countries have necessitated the need to look for alternatives. One approach is to revisit traditional pest control methods. Though most of these methods are little used in developed countries, they still play significant roles in pest control programmes of developing countries. The use of plant parts and derivatives, for example wood-ash, etc. to control insect pests of stored products and backyard vegetables, as well as termites and mosquitoes, has been a long standing practice in

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0022-474X/01/$ - see front matter
PII: S0022-474X(00)00010-2

African agricultural culture. Unfortunately however, most of these methods, though effective, have not been fully utilized. Plants such as neem, leaves and seeds (Saxena, 1986; Lowery and Isman, 1993), as well as others (Shaaya et al., 1991; Owusu, 1993; Talukder and Howse, 1993; Weaver et al., 1995), have been successfully used to control insect pests. However, there remains a vast array of unexplored natural sources of plant chemicals that can be utilized for food production and preservation. Studies on the feasibility of using certain plant materials and their associated ash components to control stored product pests of cereals have been in progress for some time. Results of studies on *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), serious pests of cereals, are reported in this paper.

2. Materials and methods

2.1. Collection and preparation of plant material

The common, family and scientific names of the plants used are as listed in Table 1. Leaves of test materials, as well as cocoa pod husks, were collected from local farms in Ghana, air dried under natural conditions and stored at 4°C before use.

Components from dried leaves were extracted with an hexane + isopropyl alcohol mixture (4 + 1 by volume), as described by Weaver et al. (1995) for dried leaves from rocky mountain plants.

2.2. Insect cultures

T. castaneum was reared on a diet of powdered rice, while *S. oryzae* was reared on whole grain rice. Cultures were maintained in 0.5 litre jars held in a controlled temperature chamber at 28 ± 1°C, relative humidity (r.h.) of 75–85%, and photoperiod of LD 16:8 (hours light:dark). Cultures were changed every month and newly emerging *T. castaneum* larvae were transferred into fresh jars containing fresh food medium.

Table 1
List of plants used in the study

Family name	Local/common name	Scientific name	Plant part
Labiatae	Akoko besa	*Ocimum basilicum* L.	Leaves
Labiatae	Nunum	*Ocimum viride* Wild	Leaves
Compositae	Siam weed	*Chromolaena odorata* (L.)	Leaves
Rutaceae	Lemon	*Citrus limon* L.	Leaves
Meliaceae	Neem	*Azadirachta indica* A. Juss	Leaves
Sterculiaceae	Cocoa	*Theobroma cacao* L.	Pod husk

2.3. Intact dried plant component test

In line with the normal practices carried out traditionally by small scale farmers, 1 g of dried plant parts as stated in Table 1, were mixed with 10 g of rice in plastic cups and allowed to stand for 24 h. After that, 10–20 mixed-sexed adults (1–4 days old) of *T. castaneum* or *S. oryzae* were introduced into the cups and allowed to feed. Dead insects were counted daily until all members of the cohort died. Mortality was assessed by the inability of the insect to respond to probes by a pin. Each treatment was replicated six times.

2.4. Repellency test

Fifty microlitres of acetone-dissolved plant extract was pipetted on to filter paper disks (d = 12 mm) (treated). Two treated disks and two disks treated with acetone alone (controls) were arranged alternately 5 cm from each other in Petri dishes. Four grains of rice were deposited evenly on each of the filter paper disks. Ten adult insects (previously starved for 24 h) were released into the middle part of each Petri dish and covered. Dishes were placed in either dark or light (28 ± 1°C; 75% r.h.) and the numbers of insects that settled after 1 h were counted. There were four replicates for each treatment, and positions of treated and control were changed in each replicate. Mean counts were expressed in percentage repulsion (% R) as: $R = 2 \times (X\text{-}50)$, where X = percentage of insects on rice (McDonald et al., 1970).

2.5. Effect of extracts on adult feeding

Five grammes of rice were placed in Petri dishes and mixed with 5 ml of 50 mg ml^{-1} concentration of previously prepared plant extracts in acetone for 1 h. The control was treated with acetone alone. The dishes were then infested with 20 previously starved adult insects which were allowed to feed for 30 days. Extracts were applied at biweekly intervals. After the feeding period, grains were reweighed and a feeding ratio (Fr) was calculated as follows: $Fr = 1-FW/5$, where FW represents the final grain weight after the 30-day feeding period.

2.6. Dose response test

Acetone solutions (ranging from 0.01 to 100 mg ml^{-1}) of hexane : isopropyl alcohol extracted dried leaves were used. Portions of prepared plant concentrations (0.1 μl) were topically applied to the ventral thorax of adult insects (0–4 day-old, mixed sex). Treated insects (10 per concentration) were placed in plastic cups containing food held at 28 ± 1°C, 75% r.h., and L:D 16:8 (hours light:dark). Experiments were replicated three times for each concentration used. Control insects were treated with acetone alone. Mortality was assessed 48 h later and insects that could not respond to a probe by a pencil or pin were considered dead. Mortality data were corrected for control mortality by Abbott's formula.

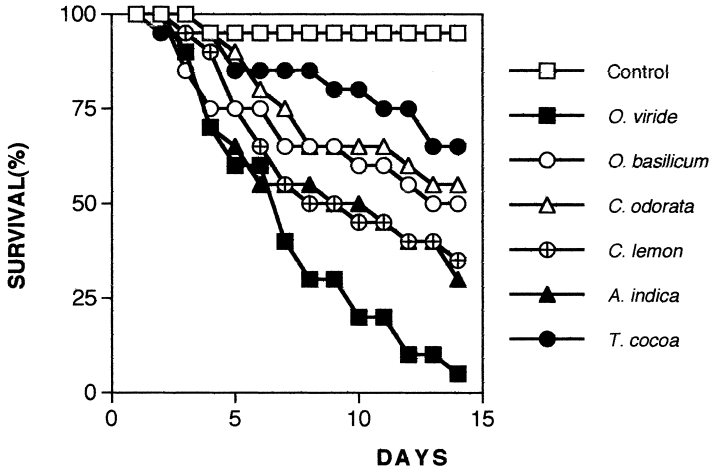

Fig. 1. Effect of intact dried plant components on survival of *T. castaneum*.

3. Results

Figs. 1 and 2 give the effects of the various intact dried plant components on survival of adult *T. castaneum* and *S. oryzae* up to 15 days post-treatment respectively. In both cases, *O. viride* which is highly aromatic in nature, proved very effective as a control agent as compared with the others, including *A. indica* and *C. limon* both of which have been widely explored and universally accepted as effective agents of pest control. While survival of *T. castaneum* declined to less than 25% after a 10-day treatment with *O. viride*, that of *S. oryzae* declined to approximately 40%. Additionally, treatment with the other plant components gave about 50–

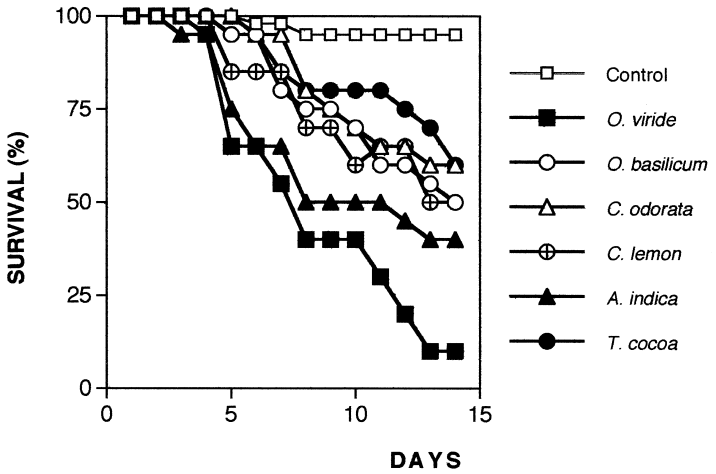

Fig. 2. Effect of intact dried plant components on survival of *S. oryzae*.

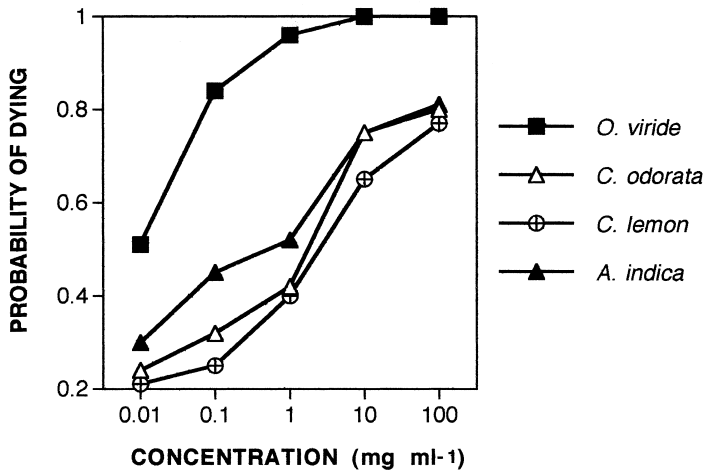

Fig. 3. Response of *T. castaneum* to various concentration of plant component extracts (0.1 μl) applied topically after 48 h exposure.

80% survival after the same period. However, in general, the effect of the various plant components was more pronounced on *T. castaneum* than on *S. oryzae*.

Plant extract concentration effects on control of both insect pests are depicted in Figs. 3 and 4. As noted in Figs. 1 and 2, the effect of *O. viride* on both insects was more pronounced than effects of the others. In *T. castaneum*, concentrations of 0.1 mg ml^{-1} and above gave less than 80% probability of survival. However, in *S. oryzae* higher concentrations were found to be essential for effective control. While *A. indica* gave about the same level of control as *O. viride* for *S. oryzae*, it was less effective for *T. castaneum*.

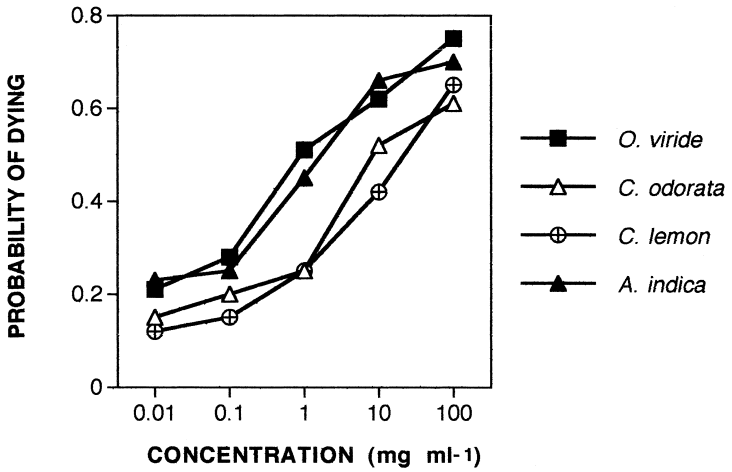

Fig. 4. Response of *S. oryzae* to various concentration of plant component extracts (0.1 μl) applied topically after 48 h exposure.

Table 2
Effect of plant extracts on feeding of *T. castaneum*

Plant	Percentage repulsion (% *R*)		Feeding ratio (*Fr*)
	Light	Dark	
O. viride	98.4 ± 6.3	94.3 ± 6.9	0.00
O. basilicum	80.8 ± 5.4	80.2 ± 8.9	0.14
C. odorata	50.5 ± 4.9	62.7 ± 3.1	0.20
C. limon	90.8 ± 7.8	85.5 ± 9.5	0.10
A. indica	50.9 ± 5.6	45.9 ± 7.8	0.04
T. cacao	10.2 ± 2.9	-10.5 ± 2.2	0.50
Control	–	–	0.64

The effects of plant extracts on feeding behaviours of *T. castaneum* and *S. oryzae* are shown in Tables 2 and 3 respectively. *O. viride* extract gave better results for control of *T. castaneum*. This is because it was highly repellent in both light and dark, as well as preventing feeding (Table 2). It also proved effective against *S. oryzae* though in dark, in common with most extracts, repulsion was 50% or less.

4. Discussion

The misuse of insecticides especially in developing countries and its concomitant problems, has necessitated the examination of alternative traditionally oriented methods of pest control. Grainge and Ahmed (1988) list a wide range of plants with pest control properties. However, the use of these materials is limited to small scale traditional farming, and not large scale commercial crop protection.

Of the six plant species used in the present study *A. indica* is the most widely explored as an antifeedant of insect pests (Saxena, 1986; Lowery and Isman, 1993). Nonetheless, a number of

Table 3
Effect of plant extracts on feeding of *S. oryzae*

Plant	Percentage repulsion (% *R*)		Feeding ratio (*Fr*)
	Light	Dark	
O. viride	90.2 ± 9.7	50.5 ± 7.9	0.08
O. basilicum	80.8 ± 8.7	42.9 ± 6.6	0.20
C. odorata	65.6 ± 5.9	23.3 ± 8.1	0.34
C. limon	70.8 ± 4.3	17.7 ± 3.9	0.50
A. indica	70.1 ± 8.2	28.5 ± 6.1	0.20
T. cacao	20.2 ± 3.9	15.4 ± 2.3	0.64
Control	–	–	0.80

other candidate plant materials, including *C. odorata* have been used in stored product pest management (Shaaya et al., 1991; Talukder and Howse, 1993; Regnault-Roger et al., 1993; Niber, 1994; Weaver et al., 1995; Obeng-Ofori and Reichmuth, 1997). However, the potential of *O. viride* for the control of pests has not formally been reported. *O. viride* is used traditionally for the treatment of stomach upsets and fever, while *C. odorata* is used as a blood clotting and antibacterial agent. Control of *T. castaneum* by these plant materials was greater than for *S. oryzae*. This phenomenon can be explained by the fact that *Tribolium* spp react more strongly to antifeedants than other stored product pests (Nawrot et al., 1986). Generally, feeding repellent activities of *O. viride* and *C. odorata* were found to be higher than that of the well known *A. indica*, though it is not clear whether differences in activity of the extract reflect differences in concentration of the same active component or if they are due to the presence of different compounds.

Acknowledgements

This work is supported by funds from Toyota Foundation (grant No. 94-A-008). The author thanks Mr. E.O. Okyere of Mpraeso-Kwahu, Ghana for technical assistance with sample survey, test, and collection.

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