PHYTO-OILS AS ALTERNATIVES TO METHYL BROMIDE FOR THE CONTROL OF INSECTS ATTACKING STORED PRODUCTS AND CUT FLOWERS

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Fumigation is still one of the most effective methods for the protection of stored grain and dry food from insect infestation. At present only two fumigants are still in use, phosphine and methyl bromide. There have been repeated reports that some insects have developed resistance to phosphine. Methyl bromide has been identified as a major contributor to ozone depletion which casts doubts on its future use in insect control. Thus, there is an urgent need to develop safe alternatives with the potential to replace the toxic fumigants. Aromatic plants contain volatile compounds winch are known to possess insecticidal activities. These allelo chemical compounds are mainly essential oils. This study is aimed at evaluating the potential of essential oils as fumigants for the control of stored-product insects and cut flowers.

The test insects were laboratory strains of *Sitophilus oryzae, Rhyzopertha dominica, Oryzaephilus surinamensis, Tribolium castaneum*, and also two quarantine insects attacking cut flowers, whitefly *Bemisia tabaci* and thrips *Frankliniella occidentalis*.

The essential oils were obtained from fresh plants, leaves and stems, by steam distillation. Three types of tests were performed to evaluate the activity of the oils:

1. The first screening of the essential oils was space fumigation in chambers of 3.44 glass flasks.

2. The highly active oils were then assayed in 600-ml glass chambers filled to 20% or 70%, by volume, with wheat (11% moisture content). To each fumigation flask, 20 adults of each of the test insects were introduced.

3. Pilot tests were carried out in simulation glass columns 10 cm in diameter x 120 cm in height, filled to 70% volume with wheat (11% m.c.). The insects were introduced in cages with each holding 20 insects of the same species along with food. Groups of four cages were suspended by a steel wire at different heights from the bottom of the column.

Screening a large number of essential oils in space fumigation showed that the oils ZP51 and SEM76 were most active against stored-product insects, and that S. *oryzae* and *T. castaneum* had the highest tolerance to the oils tested. For most of the oils, a concentration of over 15 µl/l air was needed to obtain LC_{50} of these two insects. However, for ZP51 only 1.4-4.5 µl/l air was high enough to obtain 90% adult mortality of all species tested with an exposure time of I day. The eggs and pupae of *Tibolium castaneum* were found most tolerant to ZP51 compared to the larvae and adults.

Studies to evaluate the activity of ZP51 against *S. oryzae and T. castaneum* in 600fumigation chambers filled to 20% or 70% volume with wheat were carried out. With 20% fill, a concentration of 3 and 10 µl/l and an exposure time of I day were enough to cause 100% mortality of S. oryzae and *T. castaneum*, respectively. With 70% fill, a concentration of 30 and 20 µl/l and an exposure times of 2 and 3 days, respectively, was required to obtain 100% mortality for *S. oryzae*; to obtain 100% mortality of *T. castaneum* both a higher concentration of 40µl/l and longer exposure time of 4 days were needed.

Studies with columns 70% filled with wheat showed that in order to obtain 100% mortality of *S. oryzae* and *T. castaneum*, a concentration of 50 µl/l and 5 days' exposure were needed (Table 1). For *R. dominica* and *0. surinamensis*, a longer exposure time (~7 days) was needed (Table 1). If the concentration was increased to 70 µl/l an exposure time of 4 days was enough to obtain 85-100% mortality of all insect species studied (Table 1).

By measuring the concentration of the essential oils in the wheat at various times after treatment, we could show that the concentration of the essential oil decreased gradually and only negligible amount was measured three months after treatment.

The possible involvement of the enzyme acety1cholinesterase in the susceptibility of stored-product insects to monoterpenes was examined. This study leads to postulate that this enzyme is not the main site of action of the monoterpenes.

A number of essential oils were also found active against cut flower insects. Against the whitefly a concentration of 10 g/m^3 and exposure time of 2 h were enough to obtain 100% mortality (Fig. 2). In the case of thrips a higher concentration of 20 g/m^3 and exposure time of 4 h were needed to obtain 100% mortality (Fig. 3). The phytotoxicity of the oils was also recorded after fumigation

In conclusion in this study we reported on two essential oils which are potential fumigants for the control of stored-product insects. A concentration as low as 40g oil/m^3 gram is enough to obtain effective control of the insects, as compared with the recommended concentration for methyl bromide of 30-50 g/m^3. Also a number of oils were found active at low concentrations against thrips and whitefly attacking cut flowers. The high activity of the test compounds could render them potential substitutes for methyl bromide in agriculture.

Table 1. Fumigant Activity of ZP51 against Four Stored-Product Insects on Winter Wheat; in Columns 70% Filling, in Pilot Tests

Concentration (PM)	Exposure time (days)	Mortality (%) *S. oryzae*	T. *castaneum*	*0. surinamensis*	*R. dominica*
50	3	95	87	70	69
	4	99	97	70	71
	5	100	100	85	72
	7	-	-	94	99
70	3	100	94	80	81
	4	-	97	90	85

Table 2. Toxic Activity of Plant Volatiles on *Bemisia tabaci (whitefly)* in Dianthus

Compound	Concentration (g/m3)	Exposure time (h)	Mortality (%)	Phytotoxicity after *7* days
C-72	10	2	100	0
0-89	10	2	100	0
C-31	15	2	100	0

Table 3. Fumigant Activity of Essential Oils against the Thrips *Frankliniella occidentalis* on Roses in Comparison to Methyl Bromide

	Concentration (g/m3)	20°C 6h	20°C 4h	30°C 4h
C-31	20	100*	96*	100*
0-3	20	-	-	100
C-72	20	92	30	94
Methyl bromide	20	-	100*	100*
	20	-	-	100 (2.5h)

*Low phytotoxicity