

EFFECT OF CINEOLE FUMIGATION OF SPACE DIFFERENTLY OCCUPIED WITH STORED PEST INFESTED WHEAT

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Abstract: These investigations aimed to determine effective concentration of cineole fumigation against *Tribolium castaneum* (Herbst.), *Rhyzopertha dominica* (F.) and *Chryptolestes ferrugineus* (L.) in spaces differently occupied with wheat (empty space, 50% and 95% occupied). Concentration of cineole of 50g m⁻³ in empty space induced nearly 100% mortality in all three tested insect species. However, fumigation in space 50% occupied with wheat was absolutely effective against *C. ferrugineus*, with 89.5% efficacy against *R. dominica*, and only 11% against *T. castaneum*. In space 95% occupied with wheat mortality of *C. ferrugineus* was 88%, *R. dominica* 64% and *T. castaneum* only 4.5%.

Keywords: fumigation, cineole, *Tribolium castaneum*, *Sitophilus oryzae*, *Rhyzopertha dominica*, *Chryptolestes ferrugineus*

Introduction

The primary cause of food contamination and environmental pollution arising from agriculture are chemical pesticides (Jolánkai et al., 2006). Also, the pesticide residues in grain arising from postharvest treatments (Fishwick, 1988) come from their non-selective and uncritical application causing the toxic effects in the food and contamination of the environment (WMO, 1995). Therefore, the use of botanical pesticides is one of the solutions to protect crops, their products and the environment from pesticide pollution (Prakash and Rao, 1997). Many of them degrade rapidly and do not accumulate in the body and environment; while some are very pest specific and do little or no damage to other organisms. One of them is cineole, the active component of many essential oils such as eucalyptus. It is a cyclic ether with empirical formula C₁₀H₁₈O and systematic name 1,3,3-trimethyl-2-oxabicyclo[2.2.2]octane. Sometimes is traded commercially as "eucalyptol". It is readily biodegradable, unreactive and relatively non-toxic (Haley, 1982). Cineole has been investigated as a fumigant against stored-product insects (Shaaya et al., 1991; Singh and Upadhyay, 1993; Lee et al., 2003; Rozman et al., 2006; 2007; 2007a). Also, it inhibits the enzyme acetylcholinesterase (Ryan, 1988), it interferes with sonic communication and mating in leafhoppers (Saxena and Kumar, 1984), and it is a mosquito feeding and ovipositional repellent (Klocke et al., 1987). Cineole, therefore, has a future as an industrial and commercial solvent as well as the potential to control insects in an environmentally acceptable manner, in addition to its existing use in pharmaceuticals. All these observations suggest that cineole has a potentially large-scale use as a benign agricultural bioagent. For this reason, our investigation describes the effect of cineole fumigation in spaces differently occupied with wheat (empty space, 50% and 95% occupied) against three stored pests.

Materials and methods

Experiment was carried out in the laboratory of Diatom Research and Consulting Inc. in Canada with objective to determine the effect of cineole fumigation of space differently occupied with wheat grain. The used method was a modified procedure described by Lee et al., 2004.

Chemical: 99% cineole ($C_{10}H_{18}O$) was purchased from "Sigma-Aldrich" (Export Division Grünwalder Weg 30 D-82041 Deisenhofen, Germany, EC No: 207-431-5).

Test insects: cultures of the *Chryptolestes ferrugineus* (L.) - rusty grain beetle, *Rhyzopertha dominica* (F.) - lesser grain borer and *Tribolium castaneum* (Herbst.) - red flour beetle were reared in the laboratory of Diatom Research under controlled laboratory conditions: temperature $30 \pm 1^\circ C$, $70 \pm 5\%$ r. h. in darkness. Adults of mixed sex were 2 to 4 weeks old. Each test insect runs separately.

Replications: 4 with 100 test insects in each jar.

Jar: 450 ml volume.

Wheat: Canadian Western Hard red wheat, clean, with 14% m.c.

Combinations:

- Empty jars 450 ml in volume with 0.5 grams of flour and 10 wheat kernels at the bottom with introduced test insects (control).
- Uninfested grains 200 grams in 450 ml jars (50% occupied space) with introduced test insects (control).
- Uninfested grain 360 grams in a 450ml jar (95% occupied space) with introduced test insects (control).
- Empty jars with 0.5 grams of flour and 10 wheat kernels at the bottom with introduced test insects. A piece of filter paper was taped on the metal lid and treated with 0.05 gram of cineole (50 g m^{-3}). Jar was tightly closed with this lid with treated side of lid inside the jar.
- Uninfested 200 grams of grain in a 450ml jar (50% occupied space) with introduced test insects. A piece of filter paper was taped on the metal lid and treated with 0.05 gram of cineole (50 g m^{-3}). Jar was tightly closed with this lid with treated side of lid inside the jar.
- Uninfested 360 grams of grain in a 450ml jar (95% occupied space) with introduced test insects. A piece of filter paper was taped on the metal lid and treated with 0.05 gram of cineole (50 g m^{-3}). Jar was tightly closed with this lid with treated side of lid inside the jar.

Conditions: $30 \pm 1^\circ C$ and $70 \pm 5\%$ r.h., 24 hours dark.

Number of replications (jars) in experiment: 72 replications in total

Assessment after 2 days (48 hours). After the assessment the aeration started. One species was assessed per day (assessments during 4 days).

Statistical analysis - data were subjected to one-way analysis of variance (ANOVA) according to the GLM (general linear model) and LSD test entered in the table. Data processing was conducted by the SAS System for Windows 98. The figure that represents mean values was made by Microsoft Excel 2003.

Results and discussion

In comparison to the control fumigation with cineole at the dose of 50 g m^{-3} proved to be absolutely effective in empty space with achieved mortality of 100% in all three insect species. Fumigation in space 50% occupied with grain was absolutely effective against *C. ferrugineus*, with obtained mortality for *R. dominica* of 89.50%, and *T. castaneum*, of only 11%. *C. ferrugineus* had very good response to cineole fumigation in 95% occupied space (88% mortality), *R. dominica* showed mortality of 64%, whilst application to *T. castaneum* proved to be ineffective (4.5%). Similar results were described by Lee et al. (2004) with the cineole dose of 42 g m^{-3} for LD_{50} for *S. oryzae*, *R. dominica* and *T. castaneum* species.

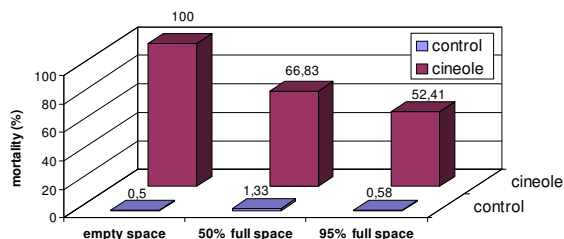
Table 1. Adults' mortality (%) after 48 hours induced by application of 50 g m^{-3} cineole

<i>Chryptolestes ferrugineus</i> *	Mortality (%) of adults after 48 hours			
	Control		Cineole 50 g m^{-3}	
	Mean	SD.	Mean	SD.
in empty space	0.50 ^b	0.57	100.00 ^a	0.00
in 50 % full space	1.50 ^b	1.73	100.00 ^a	0.00
in 95 % full space	1.50 ^b	1.73	88.00 ^a	4.96
<i>Rhyzopertha dominica</i> *	Mortality (%) of adults after 48 hours			
	Control		Cineole 50 g m^{-3}	
	Mean	SD.	Mean	SD.
in empty space	1.00 ^b	0.81	100.00 ^a	0.00
in 50 % full space	2.50 ^b	1.29	89.50 ^a	3.69
in 95 % full space	0.25 ^b	0.50	64.75 ^a	4.50
<i>Tribolium castaneum</i> *	Mortality (%) of adults after 48 hours			
	Control		Cineole 50 g m^{-3}	
	Mean	SD.	Mean	SD.
in empty space	0.00 ^b	0.00	100.00 ^a	0.00
in 50 % full space	0.00 ^b	0.00	11.00 ^b	1.41
in 95 % full space	0.00 ^b	0.00	4.50 ^b	1.29

* means in the same row followed by the same letters are not significantly ($P>0.05$) different as determined by the LSD-test.

Moreover, the effect of cineole fumigation was observed to gradually decline with the space being more occupied with grain mass (Figure 1). In other words, to gain as similar results as obtained with the application of standard fumigants like phosphine, cineole doses should be $200\text{-}250 \text{ g m}^{-3}$ to control all tested species.

Figure 1. Average test insect mortality (%) in cineole fumigation (50 g m^{-3})



Conclusions

Cineole proved to have fumigant effect particularly expressed against *C. ferrugineus* and *R. dominica* species while its efficacy against *T. castaneum* did not prove to be significant in practice. Very good results were gained in fumigation of empty space, while results of fumigation of space occupied with wheat (50% and 95%) did not prove to be successful and acceptable. Probable cause could be found in considerable sorption of cineole in wheat grains and poor permeability of cineole vapours into seed interspace and into grains, which largely lessen fumigation effect.

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