Post-fumigation Productivity of Some Stored Products Insects

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The effect of fumigants and atmospheric gases on the rate of multiplication or productivity of insects varies between species. Studies were made of the multiplicative potential of the survivors of populations exposed either at LD50 or to a range of fumigant concentrations as larvae (*Trogoderma granarium* Everts), pupae (*Callosobruchus chinensis* L. and *Sitophilus oryzae* L.), and adults (*S. oryzae*, *Tribolium castaneum* Herbst, *Oryzaephilus surinamensis* L., *Rhyzopertha dominica* F.).

Reduced productivity was noted in *S. oryzae* and *T. castaneum* exposed as adults to LD50 doses of ethylene oxide, chloropicrin, and ethylene dibromide (Table 1). Phosphine had an adverse effect on *S. oryzae* at LD50, on *T. granarium* at a dose causing 52% kill, on *R. dominica* (Table 2), and on a phosphine-resistant strain of *O. surinamensis* at higher lethal concentrations (Table 3). A significant reduction in multiplication of *T. castaneum* and *S. oryzae* was observed following exposure to dichlorvos vapour causing more that 86% kill (Table 4). Trichloroethylene and a mixture of trichloroethylene and acrylonitrile caused an increase in productivity of *T. castaneum* (Table 5).

A nitrogen atmosphere causing 90% mortality of *R. dominica* in 72 hours affected its productivity, and enriched carbon dioxide atmospheres had a similar effect in *T. castaneum* but not in *S. oryzae*, *R. dominica*, or *T. granarium*.

Table 1. Doses of fumigants inhibiting the multiplicative potential of some stored product insects when exposed for 24 hr at 25°–30°C.

Fumigant/mixture	Species and life stage exposed *T. castaneum* adult	*S. oryzae* adult	*R. dominica* adult	*T. granarium* larva
Ethylene dibromide	0.72(40.3)	1.49(31.9)	1.40(95.5) 1.60(98.2)	1.00(83.7) 1.25(81.0)
Ethylene oxide	3.39(49.8)	1.06(38.8)	1.00(11.1) 1.25(59.0) 1.50(76.6)	N.E.
Chloropicrin	1.08(70.0)	0.57(57.7)	–	–
Acrylonitrile	N.E.	0.40(68.1)	–	–
Carbon tetrachloride	N.E.	N.E.	–	50.00 (90.8) 60.00 (97.2)
Methyl iodide	N.E.	N.E.	–	N.E.
Methyl bromide– Ethylene dibromide 1:1 w/w	1.00–3.00 (26.4–98.1)	–	–	–
Acrynolitrile– Carbon tetrachloride 36:65 w/w	N.E.	N.E.	–	–
Acrylonitrile– 8% carbon dioxide	0.46(67.5)	0.19(54.4)	–	–
Nitrogen	–	–	99.9%/72 hr (89.7)	–

Doses in mg/L with % kill achieved in parenthesis.
N.E. No effect on the productivity.

Table 3. Mean±SD productivity of phosphine-resistant* *Oryzaephilus surinamensis* adults exposed to phosphine for 24 hr at 26 ±1°C.

Dose (mg/L)	No. of replicates	Corrected final mortality (%)	Productivity (progeny produced/adult-day) during first 12 days	later 22 days
Control	6	(20.7)	0.50±0.07	0.51±0.05
0.01	6	5.0	0.49±0.11	0.54±0.02
0.02	6	6.7	0.44±0.08	0.52±0.03
0.04	6	45.4	0.49±0.17	0.57±0.16
0.06	12	79.3	0.38±0.19	0.58±0.17
0.08	12	78.3	0.34±0.19	0.53±0.23
0.20	12	97.1	0.14±0.20†	0.55±0.60
0.40	12	100.0	-	-

* × 94 at LD99.9
†Significant from control after Duncan's new multiple range test ($P<0.05$).

Table 2. Effect of phosphine, methyl bromide, and carbon dioxide on the productivity of some stored product insects exposed for 24 hr 25–30°C.

Species	Life stage exposed	Phosphine			Methyl bromide			Carbon dioxide		
		No effect*	Inhibitory*	Percent inhibition	No effect*	Inhibitory*	Percent inhibition	No effect*	Inhibitory*	Percent inhibition
T. granarium	larva	0.002–0.008 (0.7–22.7)	0.016 (40.4)	39	1.0–2.0 (16.0–43.5) 3.0 (98.6)	0.5 (10.9) 100	18	8–64 (5.0–44.)	–	–
R. dominica	adult	0.002–0.016 (2.2–79.4)	–	–	0.6–0.9 (6.3–77.3)	1.0 (95.2)	68	40–80 (8.6–95.7)	–	–
S. oryzae	adult	–	0.006 (35.7)	50	–	1.14 (60.5)	14	–	23.2 (38.3)	16
T. castaneum	adult	0.008 (71.0)	–	–	–	2.65 (65.5)	22	–	49.7 (32.0)	23

* Doses in mg/L or % CO_2 with per cent mortality achieved in parenthesis. Values are means of three replicates in *S. oryzae* and six in others.

Table 4. The productivity of *S. oryzae* and *T. castaneum* adults surviving exposure to dichlorvos vapour for 24 hr at 26±1°C.

Insect	Dose (mg/m^3)	Corrected final mortality (%)	Productivity* (mean±SD)
S. oryzae	2.8	0	$1.25^{\pm}0.31^{a}$
	5.7	0	$1.29^{\pm}0.25^{ab}$
	8.5	34.7	$1.30^{\pm}0.35^{ab}$
	14.2	86.9	$0.67^{\pm}0.66^{b}$
	19.8	92.4	$0.46^{\pm}0.80^{c}$
	25.6	99.5	0
	Control	(12.5)	$1.40^{\pm}0.24^{a}$
T. castaneum	3.5	18.3	$1.89^{\pm}0.66^{ab}$
	7.1	62.8	$2.52^{\pm}0.82^{a}$
	14.2	78.1	$2.36^{\pm}1.90^{ab}$
	21.2	87.9	$1.21^{\pm}1.39^{b}$
	28.2	93.0	$0.57^{\pm}0.99^{c}$
	35.3	100	0
	Control	(3.4)	$1.71^{\pm}0.45^{ab}$

* Progeny produced/adult-day during the post-fumigation holding period of 14 days.
Each value is mean of eight replicates.
Means followed by different letters differ significantly at 1% (*S. oryzae*) and 5% (*T. castaneum*) levels by Duncan's new multiple range test.

Table 5. Increased productivity of *T. castaneum* adults surviving exposure to the LD_{50}s of trichloroethylene and 35:65 w/w acrylonitrile-trichloroethylene mixture for 24 hr at 25°–30°C.

Fumigant	LD_{50} (mg/L)	Actual mortality recorded (%)	Productivity (Mean* and range of progeny)	
			Control	Fumigant
Trichloroethylene	30.2	47.2	3914 (3743–4200)	5230 (4800–5501)
Acrylonitrile-Trichloroethylene	3.3	36.0	3914 (3743–4200)	5105 (4520–5500)

* Each value is mean of three replicates.