ETHYL FORMATE: AUSTRALIAN FIELD TRIALS AND A NEW FORMULATION - VAPORMATE^{Ò}

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A new ethyl formate formulation - VAPORMATE^{Ò} (ETHYL FORMATE+CO_2)

Laboratory studies

VAPORMATE^{TM} formulated by BOC Ltd is a cylinderised mixture of ethyl formate (EF16.7% by weight) in carbon dioxide and is being evaluated as a fumigant for the rapid disinfestation of grain. Insect mortality achieved with a 3 hour dynamic (forced flow) application versus a static application of the EF formulation was investigated. In the dynamic application, gaseous VAPORMATE^{TM} was pumped through grain in a 65 L model silo at 6 L min^{-1}. In the static application, 2.7 L desiccators were dosed with equivalent concentrations of the EF formulation applied to the headspace. The mortality of mixed age cultures of the species most tolerant insect of EF, *Rhyzopertha dominica (F.), Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst), were compared in the two systems over a range of EF concentrations. The mortality of *S. oryzae* was also compared after a 3 or 24 h dynamic application of VAPORMATE^{TM}.

An application of VAPORMATE^{TM} at 147 g(EF) t^{-1} grain by forced flow fumigation (figure 1) gave very high control (>99% mortality) of a phosphine-resistant strain of *Rhyzopertha dominica* and the *T. castaneum* but lower control (82% mortality) of *S. oryzae.* Extending the fumigation time to 24 hours and reducing the applied amount of EF to 100 g t^{-1} grain resulted in a small improvement of the mortality of *S. oryzae* to 86%. The dynamic application gave higher mortality than the static application.

Seed store disinfestations trials with VAPORMATE^{TM}

In December 2002, a semi sealed seed store (260m^3 capacity), 30% loaded with newly harvested seeds of barley, wheat and sorghum, was treated with VAPORMATE^{TM}. In total, 40 kg of VAPORMATE^{TM} containing 6.85 kg of ethyl formate was applied in four doses (within 24 hours) to achieve a relatively constant ethyl formate concentration of about 16-26g/m^3 for slightly more than two days (figure 2). Two hours after application the ethyl formate was evenly distributed through out the seed store space and had penetrated into seed bags. All tested mixed aged insects such as *Callosobruchus phaseoli, Tribolium castaneum, Rhyzopertha dominica* and *Bruchus pisorum* were controlled, but the egg stage of *Sitophilus oryzae* was not completely controlled (Table 1). During the fumigation period, the concentrations of ethyl formate in the adjacent stores and 1m and 3m from the front door of the fumigated store were 5-25ppm lower than that TLV of

100ppm. Ethyl formate residues declined to natural of fumigation in sealed conditions. VAPORMATE™ had no effect on the germination of the stored seeds.

The results indicate that VAPORMATE™ is a highly effective formulation of ethyl formate for seed store disinfection, because of its fast application, even distribution in the space and seed bags, and absence of effect on germination and the working environment.

Field trials on the application of liquid ethyl formate to on-farm storage

Trials in Australia using ethyl formate on wheat (Harden, NSW), sorghum (milo) (Warwick, QLD) and split faba beans (Two Wells, SA) were conducted in unsealed farm bins. The liquid ethyl formate was applied as a pulsed, or double dose, to the top of the grain through a specially designed PVC probe (ϕ 4cm $\times$ 1.2m). This method of application was chosen to: maintain ethyl formate concentrations below the flammability level; reduce vaporisation and maintain an effective concentration of ethyl formate for >10 hours; and avoid liquid ethyl formate accumulating at the bottom of the bin. With wheat, the concentration of ethyl formate was maintained at effective levels for about 2 days, all insects at all stages were killed rapidly (Table 2), and after another 3-5 days, the residues reduced to natural levels without aeration. Faba beans sorbed ethyl formate strongly and the residues persisted longer, but full control of all bioassays was achieved. Control though high was not not 100% in the sorghum trials. Residues in the sorghum at 10ºC persisted significantly longer than at 20ºC. During application and fumigation, the levels of ethyl formate in the working environment did not exceed the worker safety level of 100 ppm (TLV). These trials show that ethyl formate has good potential as a fumigant in unsealed farm bins. Unlike phosphine, which takes days to kill insects, ethyl formate kills rapidly and residues reduce to natural levels without aeration degrading to non-poisonous and naturally-occurring products (formic acid and ethanol).

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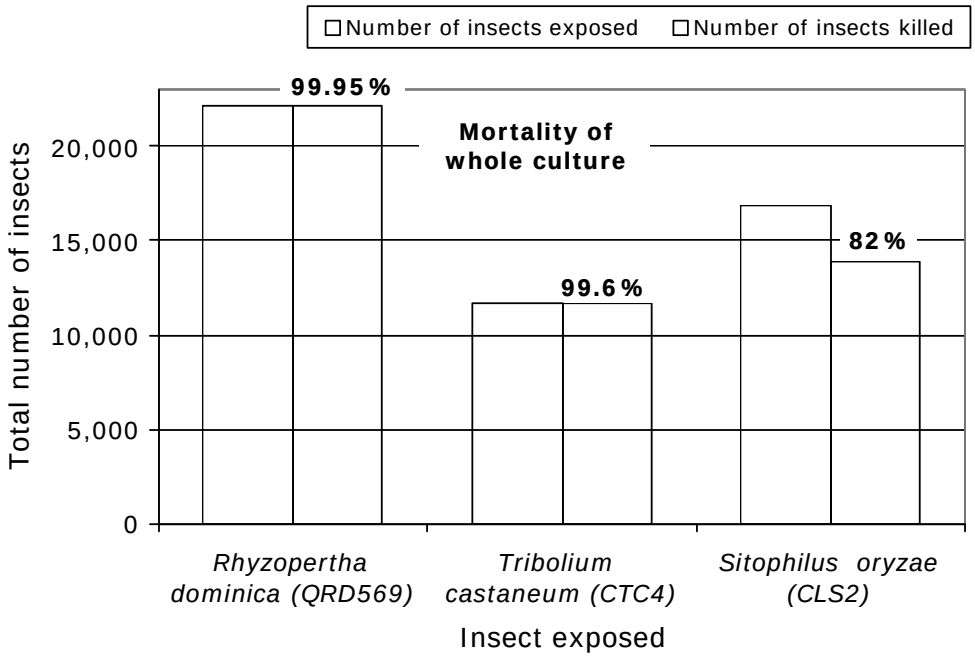

Figure 1. Mortality of whole cultures after a 3 hour exposure to VAPORMATE™ applied at 147g ethyl formate/t grain.

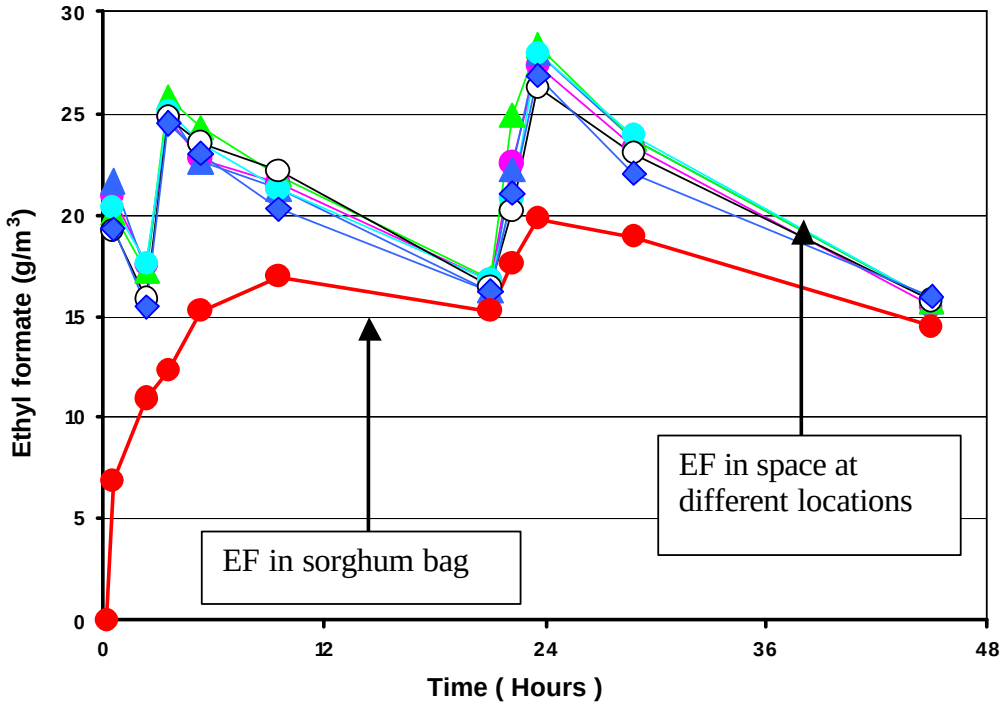

Figure 2. The concentration of ethyl formate at different locations in seed store and inside seed bag.

Table 1. Insects emerging after treatment with VAPORMATE®.

Strain	Insect	Before fumigation	After fumigation		Further live insects emerging after holding for (days):		
		Live	Live	1 day	7	28	56
QOS301	Sawtooth	124	0	124	0	0	0
QRD569	Lesser grain borer	102	0	102	0	0	0
QRD369	Lesser grain borer	67	0	67	0	0	0
QTC931	Flour beetle	54	0	54	0	0	0
QNCF037	Flat grain beetle	45	0	45	0	0	0
QSO335	Grain weevil	14	0	14	9	5	7
Bruchids	Cow pea weevil	224	0	224	0	0	0

Table 2. Control (%)of insects using ethyl formate in farm bins containing different commodities

	Bin	*Sitophilus oryzae*	*Rhyzopertha dominica*	*Tribolium castaneum*	*Callosobruchus phaseoli*
Wheat	1	100	100	100	-
	2	100	100	100	-
Faba bean	1	100	100	100	100
	2	100	100	100	100
Sorghum	1	84(68-100)	99(97-100)	100	-
	2	96(84-100)	100	100	-