

# EFFICACY OF ETHYLENE DICHLORIDE AND CARBON TETRACHLORIDE MIXTURE FOR FUMIGATION OF IMPORTANT ANIMAL FEEDS

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## ABSTRACT

It has been found that animal feeds like crushed barley, crushed gram and wheat bran can be effectively disinfested by fumigation with 3 : 1 mixture of ethylene dichloride and carbon tetrachloride at a dosage of  $2\frac{1}{2}$  gallons per 1,000 cu ft†. The lowest average atmospheric temperatures, at which the fumigation for 48 hours and for 72 hours was found effective, were 28.6 and 24.15°C respectively. It was also found that the order of susceptibility of the three test insects, viz. *Tribolium castaneum* Herbst, *Trogoderma granarium* Everts and *Latheticus oryzae* Waterh and their various stages varied considerably. In all cases, adults and pupae were found to be more susceptible than larvae.

## INTRODUCTION

Ethylene dichloride and carbon tetrachloride 3 : 1 mixture (EDCT 3 : 1) is the most commonly used fumigant for insect infested grains<sup>1,2</sup> and some other food-stuffs.<sup>3</sup> In Defence Services, grains and dals whole and split are disinfested by this fumigant at the rate of  $2\frac{1}{2}$  gallons per 1000 cu ft. The period of fumigation is 48 hours in summer and 72 hours in winter; in hill stations the period of fumigation is 72 hours throughout the year. But no such instructions exist about the crushed grains like crushed gram, crushed barley and bran, used as animal feeds. In practice, however, they have been fumigated, with varying results. Various details (such as the type of the chamber used, type of the commodity fumigated, ambient temperature, etc.) when the fumigation has failed, have not been available. The present investigation was, therefore, undertaken to find out the effectiveness of this fumigant for disinfestation of these animal feeds, the duration of the fumigation being 48 and 72 hours as for grains.

## MATERIALS AND METHODS

### *Fumigation chamber*

All fumigation trials were carried out in a mild steel chamber 5' × 5' × 5'. The chamber is provided with a door, size 5' × 4'-8", on one side and a perspex window, size 6" × 6", at the opposite side. A hole (with a cover) is provided in the centre of the top for pouring the fumigant. The door and the cover of the top hole are provided with felt lining and nuts and bolts for tight closing. The chamber is provided with four wheels for easy shifting. It was tested for leakproofness before being taken into use, and was kept under cover in a verandah, about 7 ft. wide, facing south.

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† Metric equivalent will be 4 litres per 10 cu m.

### Animal feeds

Animal feeds viz. wheat bran, crushed barley and crushed gram contained in standard size jute bags were used.

### Fumigant

EDCT 3 : 1 was procured from a Service installation.

### Test insects

Insects normally found in the animal feeds in question are *Tribolium castaneum* and *Trogoderma granarium*. Sometimes, moths such as *Corcyra* sp., *Ephestia* sp. and beetles such as *Tenebrio* sp., *Latheticus* sp. and *Oryzaephilus surinamensis* Linn. are also present in very small numbers. Of these insects, cultures of only *T. castaneum*, *T. granarium* and *L. oryzae* are maintained in this laboratory. Therefore only these three species of insects were used as test insects. Twenty numbers of each insect stage i.e. eggs, larvae, pupae and adults of each of the three test insect species were introduced (in separate test tubes/cages) in each bag.

### Containers for test insects inside the bags

In the first two fumigation trials, glass tubes 2"  $\times$   $\frac{1}{2}$ ", covered with muslin at both ends were used, for holding the test insects inside the bags. In later trials the glass tubes were replaced by wire gauze (40 mesh) cages, half an inch smaller in length than the glass tubes. Test insects were introduced in these tubes/cages and then placed in the middle of each bag before fumigation.

## EXPERIMENTAL

The bags, when received, showed slight infestation of *Tribolium*, *Calandra*, *Rhizopertha*, *Tenebrio*, *Latheticus*, and some moth species. Prior to each fumigation, large population of the three test insect species viz. *T. castaneum*, *T. granarium* and *L. oryzae* was introduced in the bags left for several weeks to establish a good degree of infestation in the bags. This artificial infestation was introduced upto the 5th trial. After the 5th trial, this was not possible because fumigations had to be done at short intervals to catch up with the quickly rising atmospheric temperatures. In each trial, nine bags, three replicates of each commodity were taken. Test insects in tubes/cages were introduced in the middle of each bag. The bags were stacked in the chamber in three tiers in such a way that each tier contained one bag of each commodity in a different position, as given in the plan shown below:

Top tier	B	G	Br
Middle tier	G	Br	B
Bottom tier	Br	B	G

NOTE—B, G and Br stand for Barley, Gram and Bran respectively.

A large shallow enamelled tray, size 20" × 17" × 3" was kept on the top of the stack in the centre. The door of the chamber was closed tightly and sealed with cowdung and mud plaster. 1422 cc of EDCT 3 : 1, calculated @ 2½ gallons per 1000 cu ft, was poured through the top hole in the chamber, into the dish kept over the stack. The hole was then closed tight and sealed with cowdung and mud plaster. Constant vigilance was maintained during fumigation to ensure the gas tightness of the chamber.

A minimum maximum thermometer was placed near the chamber for record of atmospheric temperature.

Two replicates of each commodity were kept in a separate room to serve as control.

Fumigation trials were carried out at various atmospheric temperatures for 48 or 72 hours. After each trial, the amount of the fumigant left over in the tray was measured. The chamber was kept open for about 15 minutes to allow the fumigant vapours to escape before any observations on insect mortality were recorded.

#### *Assessment of efficacy of fumigation*

At the end of fumigation, test insects were taken out of the bags and mortality recorded except that of eggs and pupae of all insects and larvae of Khapra beetles, mortality in which case was recorded about a week after<sup>4</sup>. In the first few trials, mortality of insects in the bags was also recorded. For this purpose, the size of the sample drawn from the bags in a trial was such as would contain not less than 20 insects of a single species and 40 of all the species. The fumigation was considered effective if all the test insects in all the fumigated bags were killed (except an odd one sometimes) as against nil or a few natural deaths in control bags.

## RESULTS AND DISCUSSION

Summary of results is given in Table 1. It will be seen from these results that the lowest temperatures, at which all the stages of all the test insects were killed as a result of fumigation for 48 hours and 72 hours, were 28·6°C and 24·15°C respectively. It is also seen that all the stages of all the three test insects, except larvae of *T. granarium* were killed at lower temperatures. This indicates that the larvae of *T. granarium* are more resistant than the larvae and other stages of the insects tested.

It will be seen from Table 1 that the susceptibility of various insects and of the various stages of the same insect varies. The lowest temperatures at which fumigation for 72 hours produced effective kill of the various stages of test insects are given in Table 2. It will be seen that adults and pupae are more susceptible than larvae in all cases. Of all the insect stages, eggs are least susceptible except in the case of *T. granarium*, where the eggs are more susceptible than pupae and larvae. These findings are in general conformity with those of the other workers summarised by Brown<sup>5</sup>, who states that in holometabolous insects, generally larva is the most susceptible stage to the toxic effects of fumigants and pupae the least susceptible. Egg stage of the same insect is either the most susceptible stage or most resistant, depending upon the fumigant.

Taking into account all the stages of the test insects, it is noticed that *L. oryzae* is most susceptible, followed by *T. castaneum* and *T. granarium*.

Selection of mild steel fumigation chamber was necessary for this preliminary investigation, with a view to prevent otherwise loss of fumigant vapours into the material of the chamber and to have a chamber of fixed dimensions for all the fumigation trials, which would have had otherwise slight variations if a gasproof cover was used. Conclusions and recommendations based on the results of this investigation will be applicable to only those fumigations which will be conducted in a non-gas-absorbent material such as gasproof covers. Brick and cement concrete structures with or without plaster would absorb fumigant vapours and therefore, in such structures fumigant used at the rate as in this investigation may or may not be effective in fumigating animal feeds. Experiments in various types of structures are necessary to find out the dosage of the fumigant required for fumigation in those structures.

#### CONCLUSIONS

Animal feeds such as crushed gram, crushed barley and wheat bran can be effectively disinfested by fumigation with EDCT 3 : 1 at the dosage of 2½ gallons per 1000 cu ft. in a gas-tight non-gas-absorbent fumigation chamber, duration of the fumigation being:

- (a) 48 hours at the average atmospheric temperature of not less than 28·6°C.
- (b) 72 hours at the average atmospheric temperature of not less than 24·15°C.

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TABLE 1

SUMMARY OF RESULTS OF FUMIGATION OF ANIMAL FEEDS, WITH EDCT 3:1

Duration of fumigation	72 hours					48 hours		
	4.4°C	12.8°C	17.2°C	20.85°C	24.15°C	26.1°C	28.6°C	35°C
Average atmospheric temperature during fumigation	4.4°C	12.8°C	17.2°C	20.85°C	24.15°C	26.1°C	28.6°C	35°C
Residual quantity of the fumigant after fumigation	625 cc	325 cc	100 cc	7 cc	1 cc (approx.)	6 cc	Nil	Nil
Sequence of the trial	(3)	(4)	(5)	(6)	(2)	(7)	(8)	(1)

*T. castaneum*—

Adults	N.E	E	E	E	E	E	—	E
Pupae	N.E	N.E	E	E	E	E	—	E
Larvae	N.E	N.E	E	E	E	E	—	E
Eggs	N.E	N.E	N.E	E	E	E	—	E

*T. granarium*—

Adults	—	—	E*	E	E	E	E	E
Pupae	—	—	N.E	—	E*	—	—	E*
Larvae	N.E	N.E	N.E	N.E	E	N.E	E	E
Eggs	—	N.E	E	E	E	E	E	—

*L. oryzae*—

Adults	N.E	E	E	E	E	E	—	E
Pupae	E	—	—	—	E	—	—	E*
Larvae	N.E	E	E	E	E	E	—	E
Eggs	N.E	N.E	—	—	E*	E	—	—

Key: E—Fumigation effective. No eggs hatched and 100% test insects died (except an odd one sometimes).

N.E—Fumigation not effective. One or more eggs hatched and two or more insects survived.

— Insects not available for the test.

\* Effective kill may have been obtained at lower temperature(s) if the insects were available.

TABLE 2

LOWEST TEMPERATURES AT WHICH EXPOSURE FOR 72 HOURS PRODUCED EFFECTIVE KILL OF THE VARIOUS STAGES OF THE TEST INSECTS

Temperature	<i>T. castaneum</i>	<i>T. granarium</i>	<i>L. oryzae</i>
4-4°C			Pupae
12-8°C	Adults		Adults and larvae
17-2°C	Pupae and larvae	Adults and eggs*	
20-25°C	Eggs		
24-15°C		Pupae and larvae*	Eggs*

\* May have been susceptible even at a lower temperature, if these stages were available for use in the temperature trial.