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Ethylene dichloride-carbon tetrachloride[†]: a fumigant for disinfestation of germplasm under exchange against insect pests

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ABSTRACT

Ethylene dichloride-carbon tetrachloride (EDCT) mixture (3:1) was used as a fumigant at 320 mg L⁻¹ for 48 h or at 640 mg L⁻¹ for 24 h under normal air pressure to disinfest germplasm/trial material meant for import and export against insect pests. During 2014 and 2015, a total 1,096 imported samples of different crops, i.e. *Oryza sativa* L. (608), *Triticum aestivum* L. (279), *Triticum durum* Desf. (5), *Lens culinaris* Medik. (91), *Vicia faba* L. (76), *Pisum sativum* L. (19), *Hordeum vulgare* L. (13) and *Lathyrus sativus* L. (5), were found infested by immature stages of bruchid, *Bruchus dentipes* (Baudi), *B. lentis* (Frolich), *Acanthoscelides obtectus* (Say), *Rhyzopertha dominica* (Fabricius), *Tribolium castaneum* (Herbst), *Trogoderma granarium* (Everts), *Sitophilus oryzae* (L.), *Sitotroga cerealella* (Olivier) and *Cryptolestes ferrugineus* (Stephens). All the 1,096 infested germplasm/trial material samples were successfully disinfested against insect pests by EDCT fumigation at the given dosage. However, a total 13,012 imported germplasm samples of various crops were also given prophylactic treatment with EDCT fumigation during 2014 and 2015.

Key words: Crops, Ethylene dichloride-carbon tetrachloride (EDCT), Fumigation, Germplasm, Quarantine

About 500 species of insect pests have been found associated with stored grain products and about 100 species of insect pests cause economic losses. Fumigation is a method of pest control in buildings, soil, grain and produce. It is also used during exchange of germplasm (imported or exported) to prevent introduction of exotic insect pests. Fumigation of export cargo is essential because there are possibilities of hidden infestation in the cargo.

There are number of factors which increase infestation risk of cargo. These include high moisture level in the cargo, the place where cargo has been stored prior to shipment and during the time of transit, previous residues that would be present in cargo, container and ship. The infestation rapidly develops during the voyage period and when cargo reaches the port of discharge, it is re-fumigated again

at the cost of exporter or the buyer. Fumigation is generally carried out prior to export to avoid huge fumigation expenditure and handling cost at the port of discharge. Fumigation operation is effective and a better option than other methods of pest control because in fumigation process, the fumigant circulates and spreads to all areas of infestation where spraying operation or other methods of pest control would be less effective.

Methyl bromide, aluminium phosphide and ethylene dichloride-carbon tetrachloride (EDCT) mixture (3:1) are registered fumigants in India to mitigate the pest problem in stored commodities, plants and plant products meant for import and export including germplasm under exchange. However, methyl bromide has been designated as an ozone-depleting substance in the Montreal Protocol (1987) and was to be eventually phased out globally by 2015. In case of aluminium phosphide-based fumigation, comparatively longer duration is required to get effective results.

[†]Carbon tetrachloride is a banned substance under the control measures of the Montreal Protocol.

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Ethylene dichloride-carbon tetrachloride (EDCT) is a liquid fumigant consisting a mixture of two chemicals, namely ethylene dichloride and carbon tetrachloride, in the ratio of 3 : 1 by volume. However, carbon tetrachloride has been identified as an ozone depleting substance and banned for non-feedstock applications under the Montreal Protocol but it is continues to be useable under the protocol as a chemical feedstock and for specific, approved laboratory uses. A very limited quantity of this substance is used with ethylene dichloride carbon tetrachloride (EDCT) mixture is employed for fumigation of cereals, pulses and seeds. The fumigant is not employed for products rich in fat or milled products, nursery stocks, living plants or vegetables. Mixtures of ethylene dichloride and carbon tetrachloride at the rate of 1 L for 20 quintals (2 tonnes) of grain or 35 litres per 100 m³ of space with exposure period of 4 d is recommended. In the past, several workers have used EDCT fumigation against a number of insect pests in various commodities (Khalsa et al., 1964; Singh et al., 2003; Bhargava and Kumavat, 2010).

MATERIALS AND METHODS

A total 1, 79,024 germplasm/trial material samples meant for import were processed in Plant Quarantine Division of NBPGR, New Delhi, during 2014 and 2015 to detect insectpest infestation and for salvaging infested samples. The germplasm samples included *Triticum aestivum* L. (69,676), *T. durum* Desf. (432), *Oryza sativa* L. (4126), *Lens culinaris* Medikus (3,417), *Vicia faba* L. (762) and *Lathyrus sativus* L. (701) processed during 2014, while germplasm processed during 2015 were *T. aestivum* (67,843), *O. sativa* (17,075), *Hordeum vulgare* L. (15768) and *Pisum sativum* L. (224). Insect pests intercepted in both

the years included *Bruchus dentipes* (Baudi), *B. lentis* (Frolich), *Acanthoscelides obtectus* (Say), *Rhizopertha dominica* (Fabricius), *Tribolium castaneum* (Herbst), *Trogoderma granarium* (Everts), *Sitophilus oryzae* (L.), *Sitotroga cerealella* (Olivier), *Cryptolestes ferrugineus* (Stephens) and immature stages of bruchids. Infested samples were salvaged by fumigation with EDCT (3:1) mixture at 320 mg L⁻¹ for 48 h or at 640 mg L⁻¹ for 24 h. Fumigation with EDCT was carried out in a fumigation chamber containing the seed material packed in small packets/boxes. The liquid fumigant was applied on the bags/packets of seed. Vigorous circulation with a fan or blower was used during the treatment for complete volatilization of the liquid and even distribution of the gas, which is heavier than air. The size of chamber in which fumigation was carried out was 4' × 3' × 3' (120 cm × 90 cm × 90 cm), about 1 m³. The chamber is provided with a door, size 4.5' × 3.5' (35 cm × 105 cm). The door is provided with nuts and bolts for airtight closing.

RESULTS AND DISCUSSION

During 2014, a total 79,114 germplasm/trial material samples included *Triticum aestivum* (69,676), *T. durum* (432), *Oryza sativa* (41,26), *Lens culinaris* (3,417), *Vicia faba* (762) and *Lathyrus sativus* (701) were processed to detect insect pest infestation. Out of these, 79,114 processed germplasm samples, 1,048 samples of various crops, i.e. *T. aestivum* (267), *T. durum* (5), *O. sativa* (604), *V. faba* (76), *L. culinaris* (91) and *L. sativus* (5) imported from Mexico, Lebanon, Nepal and Morocco were found infested by *R. dominica*, *T. castaneum*, *T. granarium*, *S.oryzae*, *C. ferrugineus* and *A. obtectus* (insects of quarantine significance to India), *Sitotroga cerealella*, *B. dentipes* (not reported from India), *B. lentis* and

Table 1 Salvaging of infested samples of imported germplasm by EDCT fumigation during 2014

Name of crop	Origin country	Sample processed (Nos.)	Insect-pests interception	Infested/ salvaged samples (Nos.)
<i>Lathyrus sativus</i> L.	Lebanon	701	<i>Acanthoscelides obtectus</i> [#]	5
<i>Lens culinaris</i> Medikus	Lebanon, Morocco	3,417	Immature stages of bruchid, <i>B.lentis</i>	91
<i>Oryza sativa</i> L.	Nepal	4,126	<i>R.dominica</i> , <i>S.oryzae</i> , <i>Sitotroga cerealella</i> , <i>Tribolium castaneum</i>	604
<i>Triticum aestivum</i> L.	Mexico	69,676	<i>Cryptolestes ferrugineus</i> [#] , <i>Rhizopertha dominica</i> , <i>Sitophilus oryzae</i> , <i>Tribolium castaneum</i> , <i>Trogoderma granarium</i>	267
<i>T. durum</i> (Desf.)	Lebanon	432	<i>Rhizopertha dominica</i>	5
<i>Vicia faba</i> L.	Lebanon	762	<i>Bruchus dentipes</i> [*]	76

[#]Insects of quarantine significance to India, ^{*}Insect not reported in India

Table 2 Salvaging of infested samples of imported germplasm by EDCT fumigation during 2015

Name of crop	Origin country	Sample processed (Nos.)	Insect-pests interception	Infested/salvaged samples (Nos.)
<i>Hordeum vulgare</i> L.	Morocco	15,768	<i>R. dominica</i> , <i>T. castaneum</i>	13
<i>Pisum sativum</i> L.	Australia	224	Immature stages of bruchids	19
<i>Oryza sativa</i> L.	Bangladesh	17,075	<i>R. dominica</i> , <i>S. oryzae</i> , <i>Sitotroga cerealella</i> , <i>T. castaneum</i>	4
<i>Triticum aestivum</i> L.	Mexico	67,843	<i>Cryptolestes ferrugineus</i> [#] , <i>Rhizopertha dominica</i> , <i>Sitophilus oryzae</i> , <i>Sitotroga cerealella</i>	12

[#]Insect of quarantine significance to India

Table 3 Prophylactic treatment with EDCT fumigation given to imported germplasm during 2014 and 2015

Name of crop	Origin country	Number of germplasm given prophylactic treatment with EDCT fumigation		
		2014 (Year)	2015 (Year)	Cumulative
<i>Hordeum vulgare</i> L.	Morocco	-	2,825	2,855
<i>Lens culinaris</i> Medikus	Lebanon	126		126
<i>Trigonella foenum graecum</i> L.	USA	41	-	41
<i>Triticum aestivum</i> L.	Mexico	9,042	255	9,297
<i>T. durum</i> (Desf.)	Lebanon	143	-	143
<i>Vicia faba</i> L.	Lebanon	580	-	580
Total		9,932	3,080	13,012

immature stages of bruchid. All the infested samples were salvaged by EDCT mixture at 320 mg L⁻¹ for 48 hours or at 640 mg L⁻¹ for 24 hours under normal air pressure (Table 1). Similarly, during 2015, a total 100,910 germplasm/trial material samples including *T. aestivum* (67,843), *O. sativa* (17,075), *Hordeum vulgare* (15,768) and *Pisum sativum* (224) were processed to detect insectpest infestation. Out of these samples, only 48 germplasm samples of various crops, i.e. *T. aestivum* (12), *O. sativa* (4), *H. vulgare* (13) and *P. sativum* (19) imported from Mexico, Bangladesh, Morocco and Australia, respectively, were found infested by *R. dominica*, *S. oryzae*, *C. ferrugineus* (insect of quarantine significance to India), *T. castaneum*, *S. cerealella* and immature stages of bruchid. All the infested samples were salvaged by treatment with EDCT mixture (3:1) as above (Table 2). EDCT mixture (3:1) at the same rate was also used as prophylactic treatment against various insect-pests intercepted in imported germplasm during 2014, and 2015. During 2014, about 9,932 germplasm samples of *T. aestivum* (9,042), *T. durum* (143), *V. faba* (580), *L. culinaris* (126) and *Trigonella foenum-graecum* L. (41) imported from Mexico, Lebanon, Morocco and the USA were subjected to prophylactic treatment with

EDCT mixture (3:1). During 2015, with a total 3,080 samples of *T. aestivum* (255) and *H. vulgare* (2,825) imported from Mexico and Morocco respectively, subjected to prophylactic treatment with EDCT mixture (3:1) (Table 3). Pests free consignments were released to consignees after complete eradication of insect pests intercepted in germplasm under exchange during both the years.

The efficacy of EDCT mixture against various stored product insect pests and its safety has been studied earlier by a number of workers (Bond, 1984). Srivastava et al. (1966) used EDCT mixture against pink bollworm, *Pectinophora gossypiella* (Saunders) successfully. Bhatia and Tonapi (1975) observed that the postembryonic stage of *Corcyra cephalonica* (Stainton) larvae was most susceptible to fumigation with a mixture of ethylene dichloride and carbon tetrachloride. The larvae reared at 26–30°C on crushed sorghum [*Sorghum bicolor* (L.) Moench] were most susceptible during the first instar to fumigation, either because of their high metabolic rate or because of the permeability of their newly formed integument. Ishaque et al. (1982) obtained a varying degree of mortality of *R. dominica*, *T. castaneum* and *T. granarium* using of EDCT mixture. Singh et

al. (2003) studied the effect of phosphine and methyl bromide fumigants on chickpea (*Cicer arietinum* L.) and EDCT mixture on greengram [*Vigna radiata* (L.) R. Wilczek] seed germination and vigour during a storage period of 3.5 years in chickpea and 6.5 years in greengram. Infestation of legume crop seeds with pulse beetle *Callosobruchus* spp. (Coleoptera : Bruchidae) resulted in deterioration of seed quality during storage. Fumigation is carried out to control infestation of this bruchid in seed stores. Phosphine was found to be more deleterious to seed quality than methyl bromide in chickpea. The effect was relatively delayed in EDCT treatment of greengram. Khalsa et al. (1964) tested EDCT mixture (3:1) against *T. castaneum*, *T. granarium* and *Latheticus oryzae* Waterh. in various animal feed and found that animal feeds like crushed barley, crushed gram and wheat bran can be effectively disinfested by fumigation with EDCT (3:1) mixture at a dosage of 2.5 gallons per 1,000 ft³ (about 540 g m⁻³). The lowest average atmospheric temperatures at which the fumigation for 48 h and for 72 h 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. *T. castaneum*, *T. granarium* and *L. oryzae*, and their various developmental stages varied considerably. In all the cases, adults and pupae were found to be more susceptible than larvae.

Fumigation with EDCT helped in achieving the objective of disinfestation of insects during quarantine and release of pest free material to the indenters. It was found to be effective both as a prophylactic and

curative method of insect-pest management.

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