

DYNAMIC STUDIES ON MIXTURE OF ETHYL FORMATE AND CARBON DIOXIDE FOR DISINFESTATION OF GRAIN

Viorel Fătu^{*1}, Andrei Chiriloaie¹, Maria Ciobanu¹, Sonica Drosu¹, Florin Oancea²

¹Research Development Institute for Plant Protection Bucharest

²Scientific Research and Technological Development in Chemical and Petrochemical Industry Bucharest

*Correspondence address:

Research-Development Institute for Plant Protection

Bd. Ion Ionescu de la Brad nr. 8, CP 013813, S 1,

Bucharest, ROMANIA

Tel.: 004-021-2693234

Fax: 004-021-2693239

E-mail: fatu_viorel@yahoo.com

Abstract: Among the new technologies as alternative control methods for stored product pests is the mixture of ethyl formate (EF) and carbon dioxide (CO₂) for disinfestation of grain. This paper presents the results of dynamic studies on gaseous mixture consisting of EF and CO₂ in different doses introduced into the pest control of warehouses. The most effective recipe for composition of FE and CO₂ gas was dose of 5.7 ml EF/50 kg wheat + 20 l CO₂, with a period for 3 hours exposure to gas mixture. Larval lethal doses were in the range of 3.5425-5.6938 ml EF/50 kg wheat and adults lethal doses between 0.4249-4.5613 ml EF/50 kg wheat, larvae being more resistant to treatment with ethyl formate (LD 100 = 5.6938) compared with adults (LD 100 = 4.5613).

Key words: ethyl formate, carbon dioxide, fumigation, stored grain insects

INTRODUCTION

The restrictions on the use of fumigants have posed new global challenges to the food industry, and have resulted in efforts to found new technologies as alternative control methods for stored product pests. Ethyl formate (EF) has shown the efficacy against stored grain insects, being used for rapid disinfestation (Annis, P.C. and al., 2000, Damcevski and Annis, 2001). Ethyl formate is known as a solvent and is used as a flavoring agent in the food industry. It is naturally present in certain fruits, wine and honey. It decomposes slowly in water releasing formic acid and ethanol. In India, extensive laboratory tests against insect pests of food commodities and field trials on bagged cereals, spices, pulses, dry fruits and oilcakes have been carried out on the fumigant (Muthu et al., 1984).

The CO₂ has been added to eliminate the flammability of the EF and to enhance efficacy by its synergistic effect in reducing the time required to kill insects (Haristos Victoria and al., 2006, Damcevski et al., 2009, Dojchinov G. and al., 2010).

This paper presents the results of dynamic studies on gaseous mixture consisting of ethyl formate (EF) and carbon dioxide (CO₂) in different doses to achieve the most effective recipe for composition of FE and CO₂ gas introduced into the pest control of warehouses.

MATERIAL AND METHOD

Device for testing gas compositions to protect grain stored in closed silos (Fig. 1), (submitted patent nr. A/01289/2011) was used to evaluate the efficacy of the Ethyl Formate (EF) and CO₂ mixture against the main pests of the stored grains. It consists of one cylindrical chamber with a height of 160 cm and diameter 25 cm, which are connected air flow meter, an air pump, an evaporator cartridge and three double cages for insects.

Device was filled with 50 kg wheat. Using CO₂ cylinder it was introduced into wheat 20 l gas, and then all dosages tested, respectively 3.0 ml, 4.0 ml, 5.0 ml, 6.0 ml and 7.3 ml of EF, pumped in mass of wheat for 3 hours at a rate of 10 l/min, were placed on. Insect cages (300 adults and 150 larvae of *Tribolium castaneum*) were placed into the silo before experiments on the 3 levels (top, middle, and bottom).

Because the density of ethyl formate vapor is higher than that of CO₂, it is recommended that the mixture gas recirculation system will achieve a full cycle in five minutes.

After 3 hours the insects were removed and mortality was evaluated successively at 24 hours, 48 hours and 72 hours after exposure.

Statistical processing of the results was performed using BIOSTAT 2009 program.

RESULTS AND DISCUSSIONS

The results obtained in the Research Development Institute for Plant Protection (RDIPP) laboratory (static study), the use of gas compositions in protecting stored agricultural products have shown good efficacy of ethyl formate mixture of carbon dioxide (Sonica Drosu and al., 2011). Dynamic study were initiated using the device for testing gas compositions to protect grain stored in closed silos, made by RDIPP team (submitted patent nr. A/01289/2011).

Mortality values recorded after specified in method time intervals (24, 48 and 72 hours after exposure) showed no significant differences. For statistical analyzing were chosen the values recorded after 72 hours of exposure. Probit analysis results with coefficient $\alpha = 0.05$, are shown in Fig. 2 and Fig. 3 graphs.

Statistical analysis of the results was found that larval lethal doses are in the range of 3.5425-5.6938 ml/50 kg wheat and adults lethal doses between 0.4249-4.5613 ml/50 kg wheat (Table 1).

The results show that larvae are more resistant to treatment with ethyl formate (LD 100 = 5.6938) compared with adults (LD 100 = 4.5613). Because in the mass of wheat there are simultaneously both larvae and adults to control they it is recommended to use EF dose of 5.7 ml/50 kg wheat, with a period for 3 hours exposure to gas mixture, in order to avoid prolonged exposure, which would lead to an unwanted accumulation in grains.

CONCLUSIONS

- Dynamic study were initiated using the device for testing gas compositions to protect grain stored in closed silos;
- It is recommended to use ethyl formate dose of 5.7 ml/50 kg wheat+20 l CO₂, with a period for 3 hours exposure to gas mixture;
- Larval lethal doses are in the range of 3.5425-5.6938 ml/50 kg wheat and adults lethal doses between 0.4249-4.5613 ml/50 kg wheat;
- Larvae are more resistant to treatment with ethyl formate (LD 100 = 5.6938) compared with adults (LD 100 = 4.5613).

REFERENCES

- ANNIS, P.C., GRAVER, J.E., VAN, S., 2000, Ethyl formate - a fumigant with potential for rapid action. In: Obenauf, G.L., Obenauf, R. (Eds), Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, 6-9 November 2000, Orlando, FL, USA, pp. 70-1; 70-3.
- DAMCEVSKI KATHERINE A and P.C. ANNIS, 2001, Does ethyl formate have a role as a rapid grain fumigant? Preliminary findings, Proc. Int. Conf. Controlled Atmosphere and Fumigation in Stored Products, Fresno, CA. 29 Oct. - 3 Nov. 2000, Executive Printing Services, Clovis, CA, U.S.A. pp. 91-99
- DAMCEVSKI KATHERINE A, GREG DOJCHINOV, JAMES D WOODMAN and VICTORIA S HARITOS, 2009, Efficacy of vaporised ethyl formate/carbon dioxide formulation against stored-grain insects: effect of fumigant concentration, exposure time and two grain temperatures. *Pest Manag Sci* 66(4): 432-8
- DOJCHINOV GREG; DAMCEVSKI KATHERINE A; WOODMAN JAMES D; HARITOS, VICTORIA S, 2010, Field evaluation of vaporised ethyl formate and carbon dioxide for fumigation of stored wheat, *Pest Management Science*, Volume 66, Number 4, pp. 417-424(8)
- DROSU SONICA, MARIA CIOBANU, FL. OANCEA, V. FĂȚU , 2011, Preliminary studies on efficacy of vaporized Ethyl Formate and Carbon Dioxide formulations against stored-grain insects, *RJPP*, Vol. IV, <http://www.rjpp.ro/sites/rjpp.ro/files/>
- FĂȚU V., MARIA CIOBANU, RANETE D., SONICA DROSU, 2011, Dispozitiv pentru testarea de compozitii gazoase destinate protectiei cerealelor depozitate in silozuri inchise, Brevet nr. A/01289/2011
- HARITOS VICTORIA S, KATHERINE A DAMCEVSKI and GREG DOJCHINOV, 2006, Improved efficacy of ethyl formate against stored grain insects by combination with carbon dioxide in a 'dynamic' application. *Pest Manag Sci* 62(4): 325-33
- MUTHU, M., RAJENDRAN, S., KRISHNAMURTHY, T.S., NARASIMHAN, K.S., RANGASWARMY, J.R., JAYARAM, M. and MAJUMDER, S.K., 1984, Ethyl formate as a safe general fumigant. In: Ripp, B.E. et al., ed., *Controlled atmosphere and fumigation in grain storage*. New York, Elsevier, 369-393.

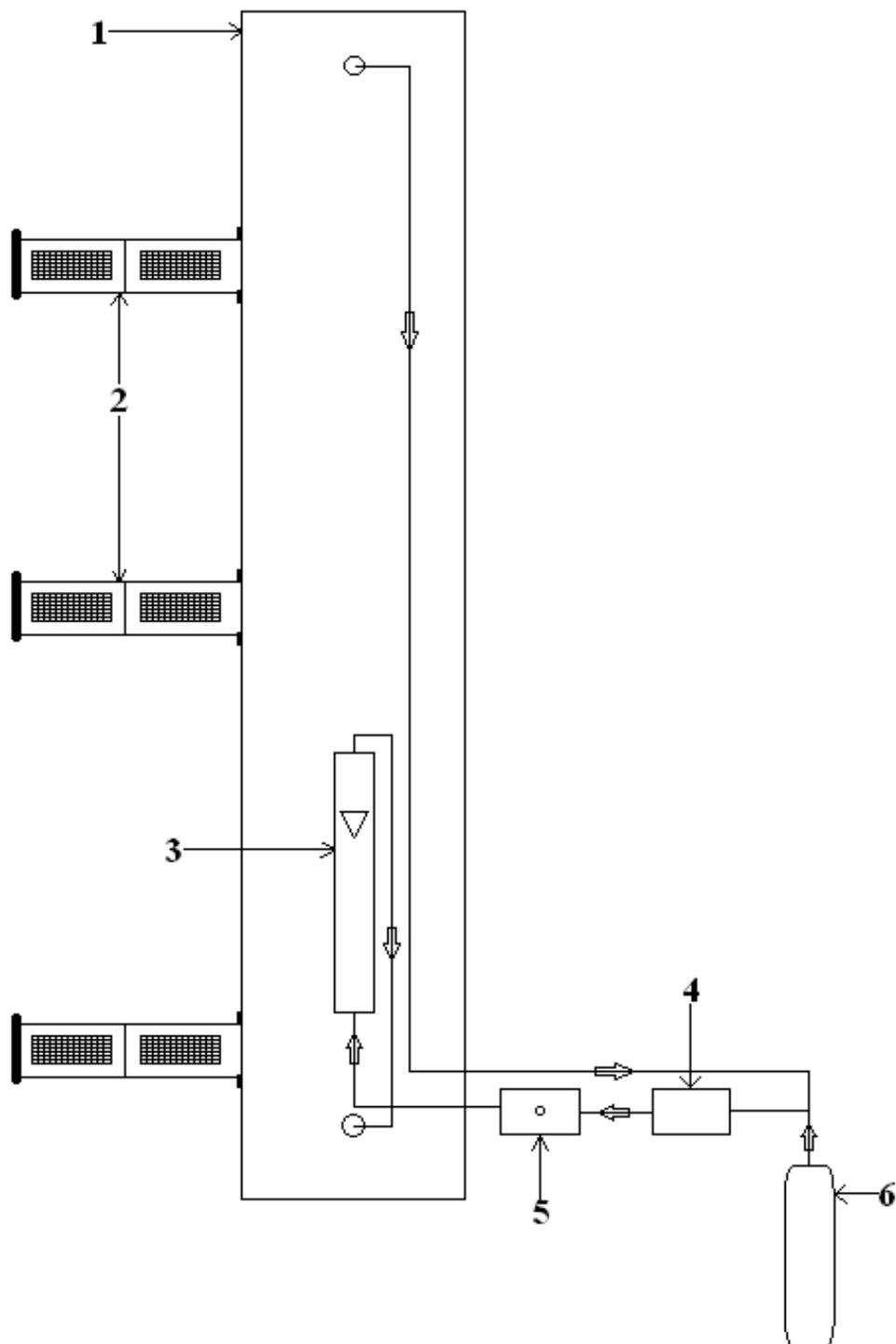


Fig.1 Device for testing gas compositions to protect grain stored in closed silos
1- Cylindrical chamber filled with cereal 2- Insect cages 3- Flowmeter 4- Air pump 5- Evaporator cartridge
6- CO₂ gas cylinder

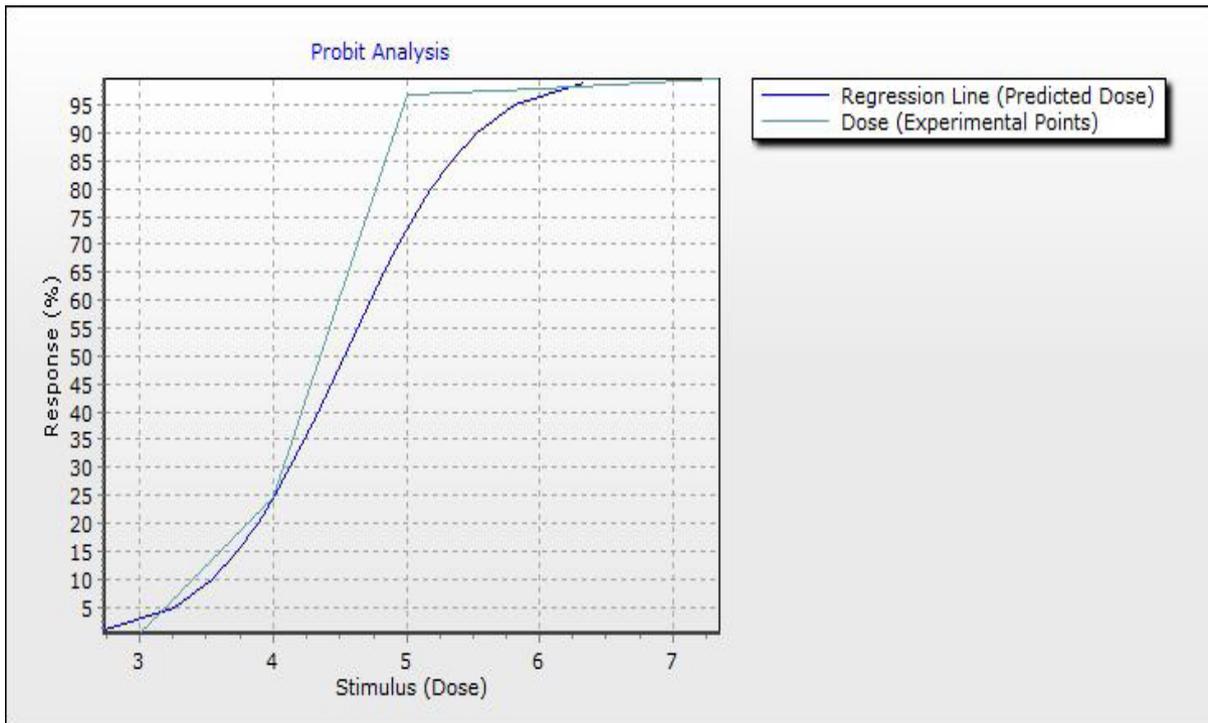


Fig. 2 Regression curve of *Tribolium castaneum* larvae mortality

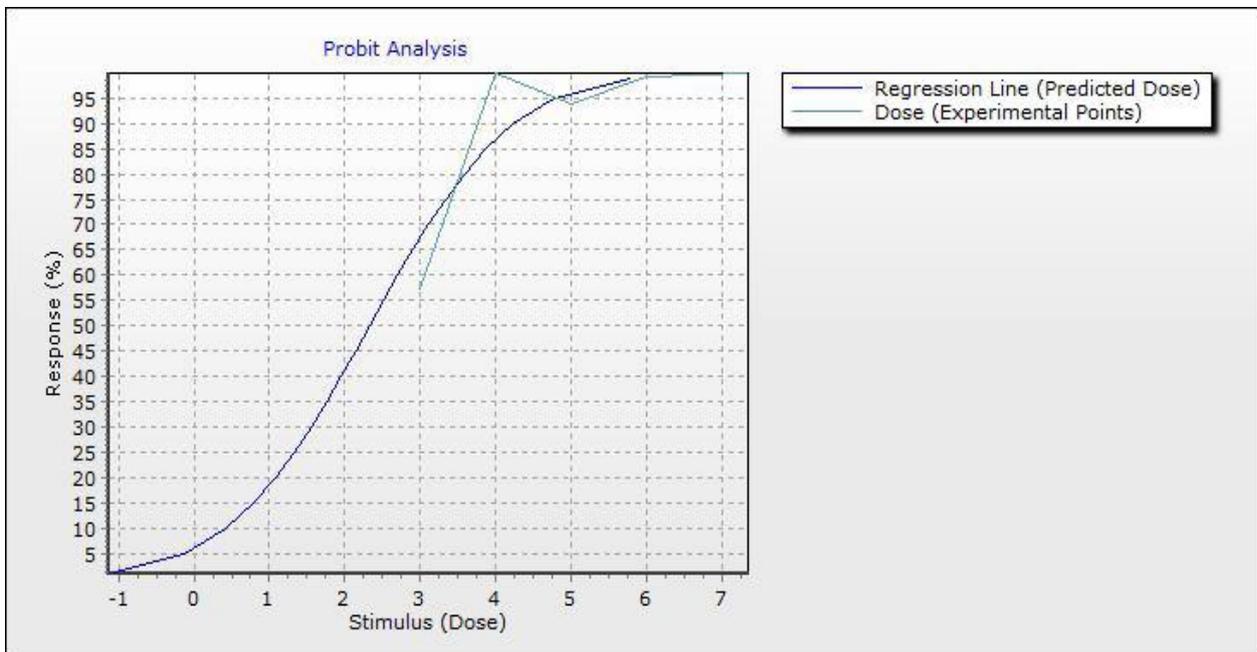


Fig. 3 Regression curve of *Tribolium castaneum* adults mortality

Table 1**Lethal doses of Ethyl Formate for *Tribolium castaneum* control**

Lethal doses (LD) ml EF/50 kg wheat	Adults <i>Tribolium castaneum</i>	Larvae <i>Tribolium castaneum</i>
LD 10	0.4249	3.5425
LD 16	0.8438	3.7604
LD 50	2.3308	4.5338
LD 84	3.8178	5.3072
LD 90	4.2368	5.525
LD 100	4.5613	5.6938