SULFURYL DIFLUORIDE TO CONTROL PREMATURE LIFE STAGES OF *EPHESTIA ELUTELLA* (HÜBNER)

D. Baltaci[1,2], D. Klementz[1]*, B. Gerowitt[2], M. Drinkall[3], Ch. Reichmuth[1]

[1] Federal Research Centre for Agriculture and Forestry (BBA), Institute for Stored Product Protection, 14195 Berlin, Germany, d.klementz@bba.de
[2] University of Rostock, Institute for Land Use, Crop Health, 18059 Rostock, Germany
[3] Dow AgroSciences, Latchmore Court, Hitchin, SG5 1BR, United Kingdom

1. Introduction

Sulfuryl difluoride (SF) currently registered as ProFume™ gas fumigant (Dow AgroSciences), is considered to be a feasible alternative to methyl bromide for fumigation of infested structures like flour mills and agricultural harvested products against storage insects (Drinkall et al., 1996; 2003; Reichmuth et al., 2003). Former studies have shown that extending exposure time improves efficacy of SF on insect eggs while the other life stages are considerably more susceptible (Bell et al., 1999; Schneider and Hartsell, 1999; Reichmuth et al., 1999). The warehouse moth (tobacco moth) *Ephestia elutella* belongs to the very important insect pests in grain storage and also in warehouses in moderate climates (Rees, 2004). There are no published data available on the efficacy of SF on this moth. To determine the optimal concentration and exposure time for the control of *E. elutella*, 1 to 4 days old eggs, larvae and pupae were treated at a temperature of 25°C and a relative humidity of 65% under normal atmospheric pressure (NAP) with about 10 g/m³ SF and three different exposures times (18 h, 24 h and 48 h).

2. Material and Methods

Ephestia elutella was taken from the long established culture of the Institute for stored product protection and cultivated at a temperature of 25°C and relative humidity of 65% on a mixture with yeast, glycerol, glucose and water. The 0-1, 1-2, 2-3 and 3-4 day old eggs were removed from the cultivating cells 3, 2 and 1 days, respectively, before the fumigation started. Only 0-1 day old eggs, 4 week old larvae and 5 week old pupae were removed from climatized chambers at the day of the beginning of the experiment. The counted samples of the different stages of *E. elutella* were treated in separate metal gauze cages (5 cm length and 1.5 cm width), with 5 ml of substrate in gas-tight Dressel flask. The cages were closed with a stop cock. About 11 g/m^3 of SF were applied for three exposure times for each premature life stage of *E. elutella* (50 eggs, 30 larvae and 30 pupae) for all 3 replications. The exposure times covered 18 h, 24 h and 48 h, respectively, at 25°C. In order to obtain the same gas concentrations, three flasks were linked with gas tight valves, PVC tubing and pieces of solid Nylon tubes. An extra flask with $NaNO_2$ in saturated salt water (Solomon, 1952) was used to regulate the relative humidity at 65% (Figure 1). A Fourier Transform Infrared Spectroscope (FT-IR) pumped the gas, which was injected through a septum during the circulation, and registered the SF concentration. The concentration was adjusted in steps with a first injection with an amount to achieve a value below the end concentration.

Additional gas was subsequently added in intervals after about 10 minutes waiting time until the concentration reached a stable plateau. The concentration of SF is shown in Table 2.
After the treatments, the valves were closed and the flasks separated by removing the Nylon tubes. The separated glass bottles were placed into the climatized room at 25°C and 65% rh. The flasks were aired after 18 h, 24 h and 48 h of exposure time, respectively. The caged samples were removed from the bottles, placed into glass vessels of 200 ml volume together with 20 ml substrate. The glasses were covered with cotton cloths and rubber bands. The treated eggs, larvae and pupae were checked once a week up to twelve weeks to determine the percentage of mortality or development.

Table 1: Experimental plan for the efficacy testing of sulfuryl difluoride against *Ephestia elutella* under NAP at 25°C and 65%rh

Exposure times (h)	Dose (g/m^3)		Number of individuals		
		Dosage (gh/m^3)	Eggs (0-4 day old)	Larvae	Pupae
18	11.6	209	12 × 50	3 × 30	3 × 30
24	11.6	278	12 × 50	3 × 30	3 × 30
48	11.6	557	12 × 50	3 × 30	3 × 30
Control	0	0	12 × 50	3 × 30	3 × 30

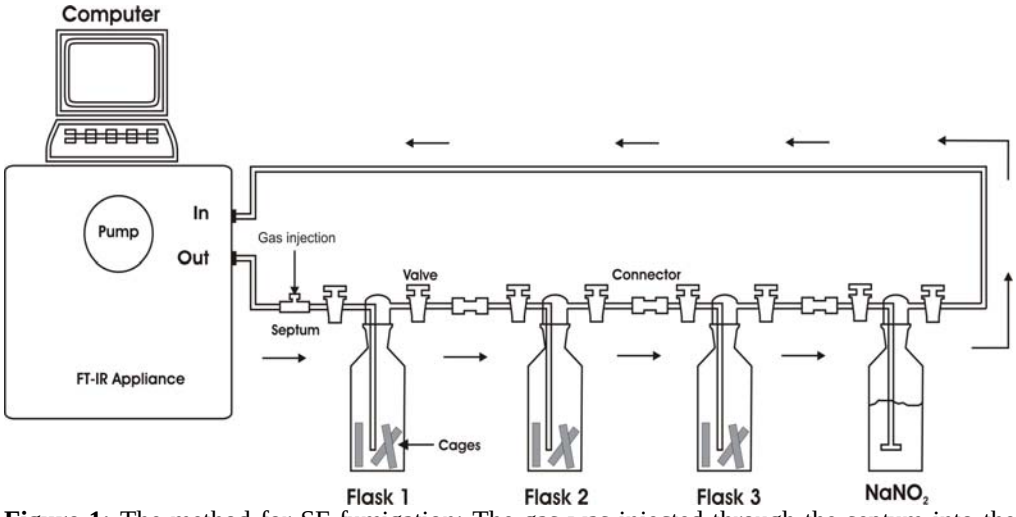

Figure 1: The method for SF fumigation: The gas was injected through the septum into the circulating air/gas-mixture. The mixture was re-circulated through the flasks by use of the pump within the FT-IR. The FT-IR apparatus determined the concentration of SF in the gas tight system and transferred the concentration data each 20 seconds into the linked computer.

3. Results

The applied dose (11.6 g/m^3 ± 1.3 g/m^3) at 18 h, 24 h and 48 h, respectively of sulfuryl difluoride at 25°C and 65% rh was sufficient for complete kill of all larvae and pupae. Additionally, more than 98% of the 1 to 4 days old eggs were killed within 48 h treatment. At the shortest exposure period of 18 h, about 75% of 3 day old eggs were killed, and the 24 h exposure times controlled over 85% of all of the eggs. 3 day old eggs were more tolerant at 18 h and 24 h treatment (Figure 3). The dosages accumulated (gh/m^3) in these treatments were less the 1500 gh/m^3 recommended by the ProFume

Fumiguide™ Program for control of insects (eggs, larvae and adults) as registered in Germany.

Table 2: The concentrations of sulfuryl difluoride (g/m³) during the SF fumigation at 25°C and 65% rh.

SF concentrations during the fumigation (g/m³)							
Start (0 h)		**18 h**		**24 h**		**48 h**	
Average	SD	Average	SD	Average	SD	Average	SD
11.6	1.3	10.5	0.2	10.3	0.3	10.7	0.3

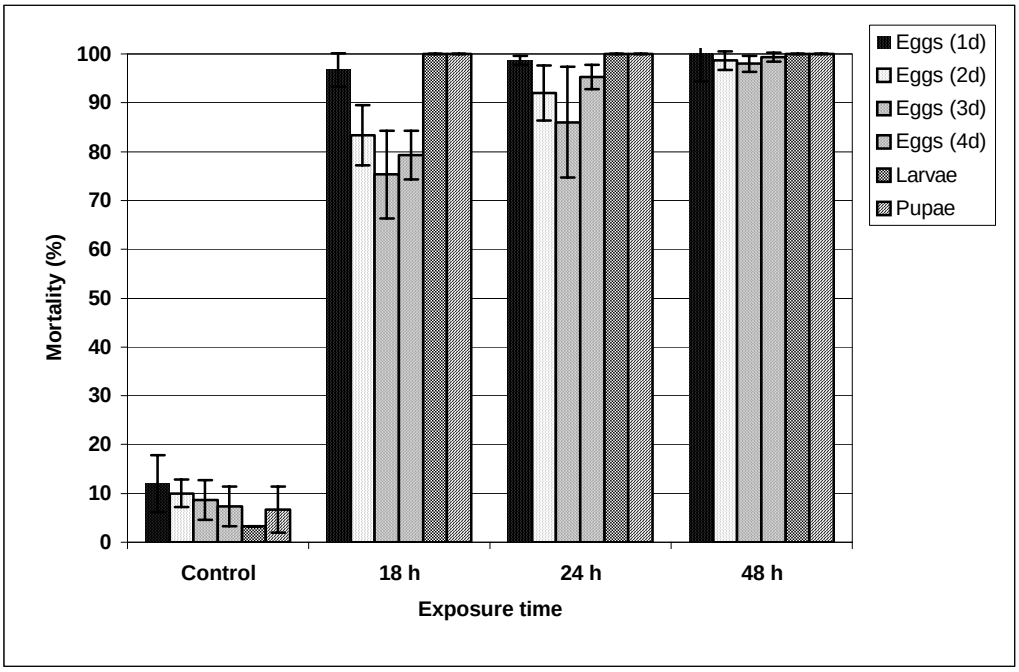

Figure 3: Mortality percentages of eggs, larvae and pupae of *Ephestia elutella* for different exposure times. The concentration of SF was always 11.6 g/m^3 at 25°C and 65% rh.

4. Discussion

The results indicated that the egg stage of *E. elutella* behave similar to the egg stage of other stored product pests insects (Bell et al. 1999; Reichmuth et al. 1999, Schneider and Hartsell, 1999) and some wood boring insects . All larvae and pupae of *E. elutella* were killed after the shortest exposure period (18 h) of sulfuryl difluoride fumigation. Even directly after the fumigation, the larvae and pupae did not show any signs of life.

It was not surprising that the 3 day old eggs were more tolerant to the SF fumigation after 18 h and 24 h exposure, respectively. Similar findings were presented for the closely related pyralid moths *E. kuehniella* (Bell et al., 1999) and *Plodia interpunctella*. (Schneider and Hartsell, 1999; Reichmuth et al., 1999). According to Bell et al. (1999) the 4 day old eggs of *E. kuehniella* were more susceptible than the other egg stages. Since the target of the fumigation is the complete control of all stages of pest insects, the dosage for the control of *E. elutella* must be higher than 557 gh/m³. It should be chosen to control at least the 2 and 3 days old eggs.

5. References

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