Effects of different speed of build up and decrease of pressure with carbon dioxide on the adults of the tobacco beetle *Lasioderma serricorne* (Fabricius) (Coleoptera : Anobiidae)

C. Ulrichs*

Abstract

The lethal effects of a sudden or slow increase and decrease of carbon dioxide pressure as a pest control technique were tested on adult tobacco beetles *Lasioderma serricorne*. The effect of exposure time and pressure change on the mortality was demonstrated. A quick build up and decay of the carbon dioxide pressure of 20 bar within 2 seconds resulted in higher mortalities than a slow increase and slow decrease within 2 minutes. When the pressure increase was slow and the decrease rapid, beetle mortality was higher, as when the increase was rapid and the decrease slow. It appeared that the decrease is more efficient than the increase for quickly obtaining mortality. The valance of increase and the valance of decrease were tested with 20 bar for 5 minutes and 25 bar for 4 minutes at 25°C.

Introduction

Using techniques with pressurised fumigants in pest control is a new field in pest management. In order to apply the technique economically, it is important to determine its effects on the target organisms. Little is known on the susceptibility of the tobacco beetle to high pressures of carbon dioxide, apart from the studies of Gerard et al. (1988) and Stahl and Rau (1985). According to Gerard et al. (1988), the tobacco beetle is one of the most tolerant pest species towards pressurised carbon dioxide and was therefore chosen in this study.

Lasioderma serricorne causes problems not only on dried tobacco leaf but also on drugs and spices. Because of this economic importance, experiments were carried out to determine in more detail the possibility of controlling *Lasioderma serricorne* with carbon dioxide under high pressure as a possible alternative to conventional pest control.

Material and methods

Beetles

Tobacco beetles were reared on dried tobacco leaves and wheat bran including glucose, yeast, glycerine and water. The female insects laid eggs into folds of the tobacco leaves Fig. 1. Damage to the product is caused by the larvae which usually hatch after 10 days. The development of the beetles depends strongly on temperature and humidity. The optimum for larval development is 32.5°C and 70% r.h. Under these conditions development takes about 16 days (Heinze 1983). Test insects were reared under constant conditions at 25°C and 65–70% r.h. Larval development took about 40 days. The biology of *Lasioderma serricorne* is described in detail by Asworth (1993).

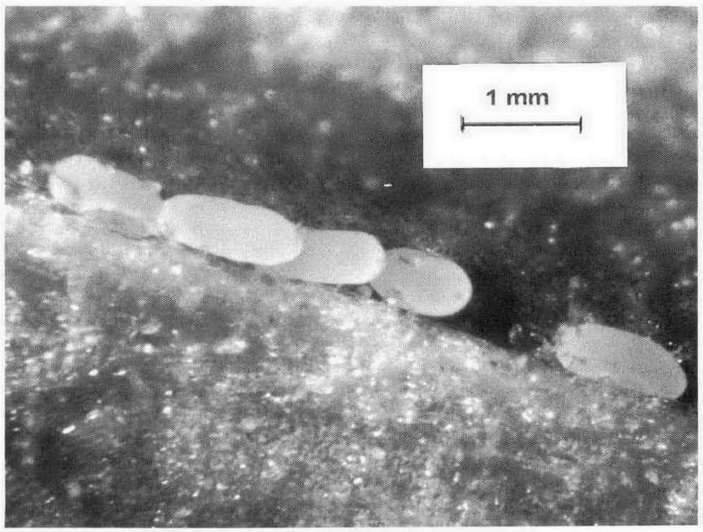

Fig. 1. Eggs of *Lasioderma serricorne* on a tobacco leaf

Treatment with carbon dioxide under high pressure

A small pressure chamber (Reichmuth and Wohlgemuth, these proceedings) was filled with carbon dioxide (Fig. 2). The volume of the chamber was 400 mL. The insects were inserted

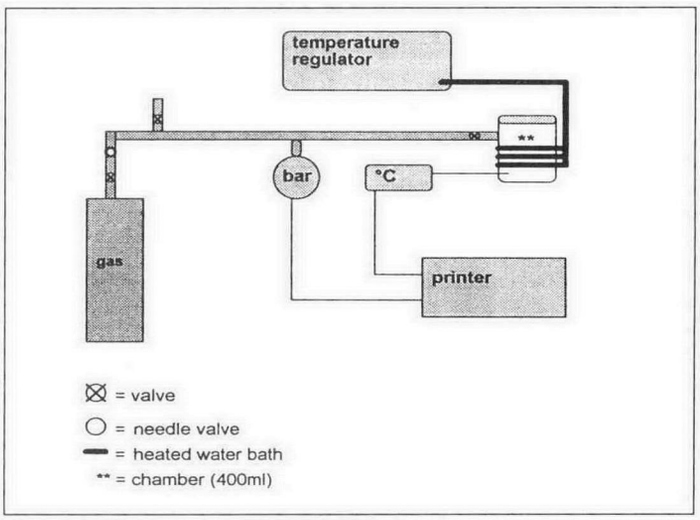

Fig. 2. Diagram of the apparatus used to treat insects with carbon dioxide under high pressure

* Federal Biological Research Centre for Agriculture and Forestry, Institute for Stored Product Protection Konigin–Luise–Straße 19, 14195 Berlin, Germany.

into the chamber in small glass vessels with a perforated plastic cap. Sensors were linked to a digital device and to a printer, recording changes in temperature and pressure. The temperature was controlled by a heated water bath.

The maximum pressure was 46 bar. The speed of building up or decreasing the pressure in the chamber was varied at constant temperature of 25°C.

- fast build–up of pressure : from 1 bar to 10 bar within 1 second
- slow build–up of pressure : from 1 bar to 10 bar within 60 seconds linear
- fast release of pressure : from 1 bar to 10 bar within 1 second
- slow release of pressure : from 1 bar to 10 bar within 60 seconds linear

Mortality tests

Fifty adult beetles were counted into a glass which was inserted into the pressure chamber. The pressure was built up at constant temperature. After the exposure time, the main valve was closed. Decompression was regulated with a needle valve. During the treatment, the beetles were exposed to maximum experimental pressure. The time for build up and decay of the pressure was not included in the exposure period. Three hours after treatment, the samples were bioassayed for survivors. Each test was carried out in four replicates. The control was kept at the same constant temperature without pressure.

Results

A fast build–up and decay of the pressure reduced the time needed to kill test insects. A comparison with slow pressure change is given in Figure 3. Slow increase and decrease of pressure and an exposure to 25 bar for 5 minutes resulted in 10% mortality. Mortality was 20% after 4 minutes at 25 bar. Higher mortalities of 40% and 45%, were achieved at the same pressure and exposure for 4 minutes by increasing the pressure quickly. Fast build-up and slow decay caused mortalities of 60% and 75%.

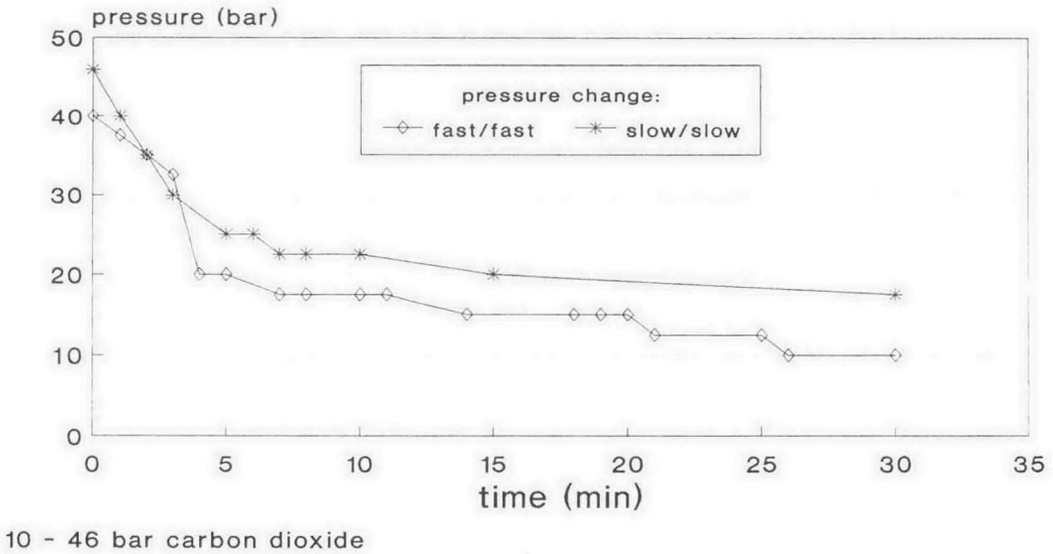

Fig. 3. Lethal dose for adult tobacco beetles at 25°C after treatment with carbon dioxide under pressure

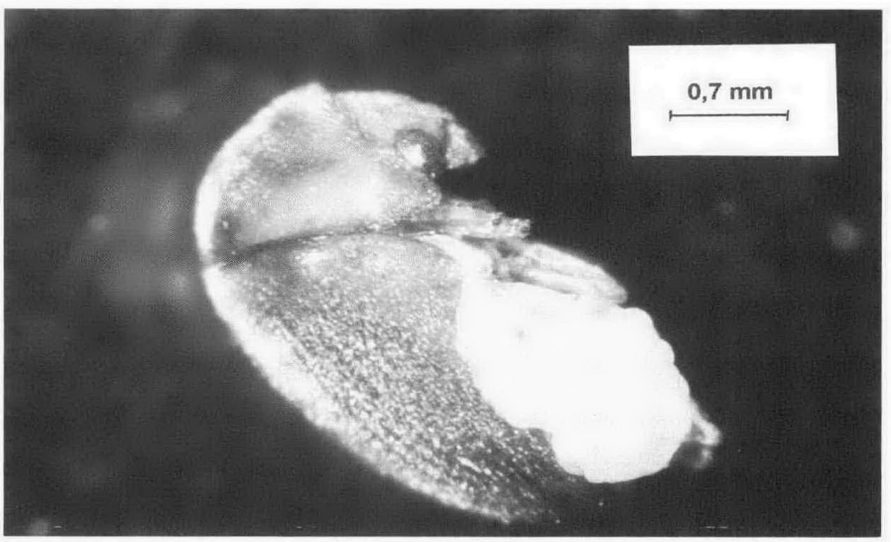

Fig. 4. Beetle with ruptured abdomen following pressure treatment

Independent of the speed of build-up of pressure, only fast decay led to physical disruption of the adult insects (Figure 4). When the beetles burst open, undestroyed eggs could be seen.

Discussion

The speed of increase and decrease of carbon dioxide pressure had a pronounced impact on the mortality. The more rapidly the changes in pressure occurred, the shorter was the time for complete kill of the adult insects. Carbon dioxide treatment at ambient pressure was required for 3 weeks to control the granary weevil *Sitophilus granarius* and the red flour beetle *Tribolium confusum* (Adler and Reichmuth 1989). A rapid build–up of pressure had less impact on mortality than rapid release of pressure (Fig. 5). Both rapid increase and rapid decrease led to higher mortalities than slow pressure increase and slow pressure decrease. In practice, the time for increasing and releasing the pressure is likely to be longer than under experimental conditions, because of the difference in size between a small laboratory autoclave and a large pressure chamber.

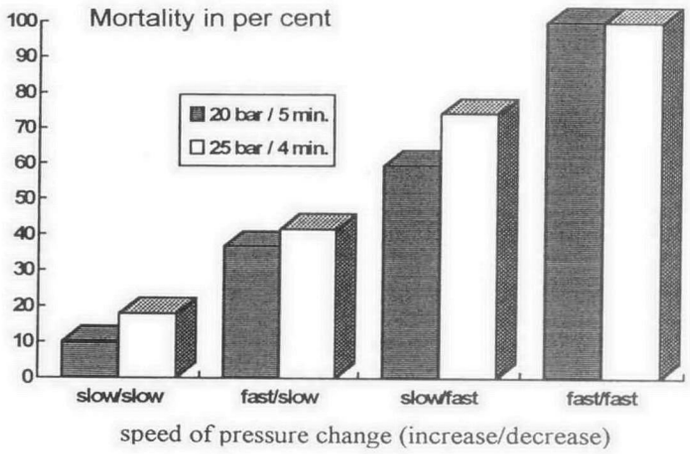

Fig. 5. Mortality of adult *Lasioderma serricorne* after treatment at different pressures and different speeds of pressure change (increase/decrease). Shaded columns, 20bar/5 minutes; open columns, 25 bar/4 minutes.

References

Adler, C. and Reichmuth, C.H. 1989. Zur Wirksamkeit von Kohlendioxid bzw. Stickstoff auf verschiedene vorratsschädliche Insekten in Stahl–Getreidesilozellen. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes, 41, 177–183.

Asworth, J. R. 1993. The biology of *Lasioderma serricorne*. Journal of Stored Products Research, 29, 291–303.

Gerard, D., Kraus, J., Quirin, K.-W. and Wohlgemuth, R. 1988. Anwendung von Kohlendioxid unter Druck zur Bekämpfung vorratsschädlicher Insekten und Milben. Pharm. Ind., 50, 1298–1300.

Heinze, K. ed. 1983. Leitfaden der Schädlingsbekämpfung, Vorrats– und Materialschädlinge. IV Wissenschaftliche Verlagsgesellschaft mbH Stuttgart, 348 p.

Stahl, E. and Rau, G. 1985. Neues Verfahren zur Entwesung. Anzeiger für Schädlingskunde, Pflanzenschutz und Umweltschutz, 58, 133–136.