Cooperation Centre for Scientific Research Relative to Tobacco

CORESTA Guide N° 9

Technical Guide for Freezing Parameters for the Control of Cigarette Beetle and Tobacco Moth

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Pest and Sanitation Management in Stored Tobacco Sub-Group

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1. Introduction

Two insects, the cigarette beetle, *Lasioderma serricorne,* and the tobacco moth, *Ephestia elutella*, are major pests of cured tobacco, infesting the commodity during storage, manufacture and distribution. Insect control in stored tobacco has relied on the use of fumigation and contact pesticides applied as space or surface sprays within structures (not directly on the tobacco). Increasing concerns over the use of toxic compounds, linked to health and environmental fears, as well as the ineffectiveness of fumigations below 16 °C (61 °F) and the development of phosphine resistant populations (Zettler and Keever, 1994; Savvidou et al., 2003), have fuelled the need to find alternative control methods. Two such alternatives are controlled atmosphere (the subject of CORESTA Guide N° 12) and deep freezing treatments (the subject of this guide).

These insects can be controlled by freezing although the parameters required to achieve 100 % mortality differ for each species and life stage (Anon, 1995). The cigarette beetle is thought to have originated in the warm climates of North Africa and thus is less cold tolerant than the tobacco moth which originated in temperate regions in the northern hemisphere (Howe, 1957; Cox and Bell, 1991). Laboratory studies have shown that immature stages of both species are the most tolerant of cold temperatures (Collins and Conyers, 2010). Larval activity of the cigarette beetle ceases when the temperature falls below 15 °C (59 °F) and these larvae can remain dormant for many months and may over-winter in this stage in cool climates (Runner, 1919; Howe, 1957; Childs et al., 1968). Not only is the tobacco moth well adapted to cooler climates, but it is further able to survive cold temperatures by the ability of fully-grown larvae to enter diapause in response to short day lengths and low temperatures (Bell, 1975; 1983). Diapause is a state of dormancy that allows insects to survive adverse conditions, such as extreme temperatures, with development resuming when conditions improve. Although, despite cold tolerance being an adaptation for insect survival under low temperatures, extreme cold conditions can cause mortality in even the most cold adapted species.

2. Background

The potential loss of phosphine as a control tool as a consequence of regulation and/or resistance development necessitates finding alternative control methods. The use of low temperatures for the control of storage pests is well documented and has been used to disinfest bulk tobacco and finished products (Runner, 1919; Swingle, 1938; Reed and Vinzant, 1942; Tenhet et al., 1957; Childs et al., 1968; Fletcher et al, 1973; Rassmann, 1980, Anon, 1995; Imai and Harada, 2006; Imai and Tsuchiya, 2007). Therefore, in 2004, the CORESTA The aim of the studies was to make a more realistic efficacy on Pest and Sanitation Management in Stored Tobacco (hereafter referred to as the Sub-Group) commissioned Fera Science Ltd. (Fera) (formerly the Food and Environment Research Agency and the Central Science Laboratory) of the UK to conduct a literature review to investigate the use of extreme temperatures as a control tool (Savvidou, 2004). The recommended treatment parameters, although not completely contradictory, differed from study to study. The review highlighted the difficulty in making comparisons between studies because of differences in strains, acclimation, temperatures, duration and methodologies (Fields, 1992). Therefore, the Sub-Group again commissioned Fera to conduct a number of studies between 2004 and 2013 to determine the exposure periods required to kill cigarette beetles and tobacco moths (Collins, 2006; Savvidou et al., 2006; Collins, 2008a; Collins and Conyers, 2008; Collins, 2013). These studies took into consideration the impact of cold tolerance, strains, stages, acclimation, and the insulating properties of the commodity. The aim of the studies was to make a more realistic efficacy assessment on insects than those reported in existing data sources by testing modified freezing treatments that mimicked practical conditions.

Although these experiments mimicked practical conditions, they were nevertheless conducted under controlled laboratory conditions and could therefore only approximate those observed in a practical situation. In order to validate the results, British American Tobacco with support of the Sub-Group, conducted experiments in practical settings using freezing to disinfest leaf and finished tobacco products of cigarette beetle (Collins, 2008b). One note of caution in interpreting the results from all of these experiments is that, although the strains used in these experiments were relatively recently collected in their natural habitat, they had been in laboratory culture for a few years. Any strains encountered in the natural environment may be more or less cold tolerant than those assessed in these experiments and therefore may require longer or shorter exposure periods (Fields, 1992).

There are factors that influence how quickly an insect may be exposed to lethal temperatures. Most of the treatment time in freezing tobacco consists of the time taken for the tobacco to be cooled to the target temperature and then returned to ambient conditions. The insulating effects of the commodity (initial temperature, size, volume, density, etc.) need to be taken into consideration. Larger bales may take longer to reach the target temperatures, which may affect the acclimation and survival of any insects contained within (Fields, 1992; Imai and Harada, 2006). A thorough recording of temperatures within the freezer apparatus used in the laboratory experiments mentioned above highlighted that the performance of the freezer (temperature differences within the freezer and operating fluctuations) is also a factor that should be taken into consideration.

There are many different freezer apparatuses that can be used for freeze treatments ranging from small household freezers to treat tobacco samples, to reefers (transport containers for land, sea or rail), to warehouse size cold storage facilities.

3. Freezing Parameters for Cigarette Beetles and Tobacco Moths

The laboratory and practical studies confirmed that four parameters must be considered for the effective use of freezing:

1) Tobacco temperature (the warmer the initial temperature of the commodity, the longer it will take to bring the commodity down to the target temperature)
2) Rate of temperature decline (faster temperature declines reduce the insect’s ability to acclimate)
3) Lethal temperature (see Table 1)
4) Time at lethal temperature (see Table 1)

It is vital that commodity temperatures are recorded continuously and accurately so that it is known when and for how long the tobacco has been at the lethal temperature. It is also important to monitor the temperature at the centre of the bale as this will take the longest time to reach the desired temperature. The rate of cooling can be increased by the use of air circulation.

The Sub-Group recommends the following freezing parameters for use in controlling cigarette beetle and tobacco moth infestations.

Table 1. Minimum conditions required to control all stages of cigarette beetle and tobacco moth AFTER commodity has reached the target temperature at the centre.

Tobacco Temperature (°C)	(°F)	Time (hours)
-18	-0,4	24
-25	-13	4

Note: The tobacco moth data are based on laboratory experiments and have not been corroborated with field studies.

4. Potential Changes and Impact

Previous freezing regimens that have been advocated will need to be modified to insist on monitoring of the temperature of the commodity to ensure that target temperatures are reached rather than assuming that a set number of days is sufficient for the commodity to reach the target temperature. Also there must be insistence that the commodity itself is monitored at the centre rather than relying on freezer temperature gauges.

In order to meet these standards it will be necessary to use equipment capable of achieving and holding these temperatures, and accommodating the load. Good airflow is important to ensure that the entire commodity has reached the target temperature. The commodity, therefore, should be placed on pallets with space between packages. A circulating fan may be beneficial.

Care must also be given when bringing the commodity out of the treatment. It should be gradually tempered to ambient conditions to avoid excess condensation. The follow tempering regime is recommended: Raise product temperature from below freezing to 0 °C (32 °F) 10 °C (20 °F) per day; Raise product temperature from 0 °C (32 °F) to ambient 5 °C (10 °F) per day. The handling of the tobacco while it is frozen should be kept to a minimum due to the fragility of the frozen product.

Not only is freezing an excellent control tool in itself, but using it as a part of an integrated pest management strategy could help the tobacco industry prolong the future usability of phosphine fumigations. It could be used in cold weather situations where phosphine fumigations are unacceptable and have the potential for promoting the development of phosphine resistance. It could also be used in combating phosphine resistance directly in situations where resistance has been identified, by using freezing instead of fumigating at ever increasing higher doses of phosphine, in the attempt to manage an ever increasingly resistant population.

In many countries, phosphine fumigations are the only acceptable criteria for the issuing of phytosanitary certificates. The Sub-Group recommends that proper freezing treatments should be added as a valid option.

5. Implementation

The use of freezing to control insect pests in tobacco is a non-toxic, chemical free alternative to phosphine fumigations. It also provides a means to address concerns of treating tobacco in cold weather and where there is phosphine resistance. The Sub-Group is conducting worldwide joint training sessions to share its knowledge and experience of this alternative for the control of cigarette beetle and tobacco moth with the Industry.

Further consideration will need to be given as to the best way to implement the use of freezing and which type of freezing apparatus is most suitable to each given situation. New technologies will need to be developed to expand the practicality of using freezing.

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