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INTEGRATION OF BIOLOGICAL CONTROL AND CO_2: AN ALTERNATIVE IN STORED PRODUCT PEST MANAGEMENT

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ABSTRACT

Control of stored product pests is based on fumigation and residual chemical treatments. Repeated use of these treatments contributes to toxicological and environmental problems and causes the rapid development of pest resistance. Moreover, methyl bromide (MB), which is one of the most widely used fumigant, will be phased out in developed countries by the year 2005. Carbon dioxide (CO_2) has been investigated as an alternative fumigant for grain and other durable commodities. Its advantages include good penetration, no residues, no safety interval following treatment, and it is environmental friendly. The disadvantage is in the long exposures required compared to MB. Several insect parasitoids and predators have been described as natural enemies of stored product pests. However, very few natural enemies are commercially available and they have not been used since residual chemical treatments are widely used by the agro-food industry. In order to study alternative control methods to MB, the combination of biological control and CO_2 applications (comprising modified atmospheres (MA) or high-pressure treatments) were proposed. Our preliminary results showed the potential for using two parasitoid species during storage and applying CO_2 at the end of processing for the control of *Sitophilus oryzae* and *Plodia interpunctella.*

INTRODUCTION

Chemical control is the most widely applied method for controlling pests in stored products that causes chemical residues problems when insecticide treatments are intensively applied. Biological control is recently receiving interest as an alternative in pest control, but there is not enough information on natural enemies of stored product pests to successfully apply it in IPM programs (Schöeller and Prozell 2003). Biological Control is the use of parasitoid, predator and pathogen populations to suppress a pest population, making it less abundant and thus less damaging than it would otherwise be (van Driesche and Bellows 1996). Biological control has several advantages among which we can mention that it is innocuous to users and consumers, and harmless to the environment. Natural enemies are very effective in locating the pest population; and, due to the long history of co-evolution with their host, they have no risk of becoming pest resistant. Nevertheless, there are also some disadvantages, such as the requirement of intensive surveillance of pest populations to release the natural enemy at the appropriate time, and the need to have a wide knowledge of pest biology for managing both populations. Also, these organisms usually have a limited shelf life and cannot be stored for medium or long periods of time. They also require specific environmental conditions of temperature and humidity in their transportation and storage. European regulations are not ready yet for insect releases in stored products, and it is not allowed to introduce organisms in products that may be considered as contaminants.

Carbon dioxide (CO_2) is a fumigant used as an alternative to many applications of methyl bromide. CO_2 causes desiccation to insects due to permanent opening of their spiracles, and produces pH changes affecting many important metabolic processes (Nicolas and Sillans 1989). At the release of high pressure CO_2, cellular cell walls are broken. The use of CO_2 has several advantages: there is no accumulation of toxic residues after the treatment has been performed, there is no need for a time period between the application of treatment and the consumption of the food product. Also CO_2 is accepted as a food additive (E-290), it is organolepticaly neutral on food, and it is recyclable when used at high pressure.

The objective of our study was to assess the possibility to combine biological control based on the release of parasitoids for the control of grain weevils during the storage period of the grain and for the control of flour moths pests in the milling facilities, and the subsequent application of a CO_2 treatment at the end of the manufacturing process to eliminate both the remaining pests and parasitoids.

MATERIAL AND METHODS

Experiments were carried out under laboratory conditions (25 ± 1ºC and 75 ± 10 % RH). We tested the parasitoids *Lariophagus distinguendus* (Föster) (Hymenoptera: Pteromalidae) for the control of the rice weevil *Sitophilus oryzae* (L.) and *Trichogramma evanescens* Westwood (Hymenoptera: Trichogrammatidae) for the

control of the Indian meal moth *Plodia interpunctella* (Hübner). CO_2 was tested at high pressure (20 atm.; 15 – 60 min.) and in Modified Atmospheres (90% CO2 – 3% O2; 4 – 12 days). A control with the same infestations of pests' ratios was included in order to see the effectiveness of the treatments.

RESULTS AND DISCUSSION

These laboratory experiments have shown the importance of combining biological control and CO_2, for both the reduction of the pest and preventing quality depreciation of the product during storage. Biological control alone was effective in reducing both of the pests used in the tests, but in combination with CO_2 the treatment was even more effective than applying it alone (Tables 1 and 2). After the treatment with CO_2, the presence of parasitoids, which could be considered as a contaminant for the product, was also eliminated. Other than the presence of insects, the loss of weight for the grain and the presence of webbing for the flour are important problems derived from the pests' action. In our experiment they were also reduced to a great extent (Tables 3 and 4).

TABLE 1
Percentage of reduction of insect population the control, after applying biological control, or in applying the combination of biological control and CO_2 (under pressure or by modified atmospheres).

	Biological control	Biological control + CO_2	
		Pressure	Modified atmospheres
S. oryzae	91	100	95
L. distinguendus	-	100	100

TABLE 2
Percentage of reduction of insect population *vs*. the control, after applying biological control or the combination of biological control and CO_2 (under pressure or modified atmospheres).

	Biological control	Biological Control + CO_2	
		Pressure	Modified atmospheres
P. interpunctella	91	100	95
T. evanescens	-	100	100

TABLE 3
Percentage of reduction of grain weight loss *vs.* the control, after biological control or the combination of biological control and CO_2 were applied (under pressure or modified atmospheres).

Biological	Biological Control + CO2	
Control	Pressure	Modified Atmospheres
75	90	81

TABLE 4
Percentage of reduction of Lepidoptera webs weight *vs.* the control, after biological control or the combination of biological control and CO_2 were applied (under pressure or modified atmospheres).

Biological Control	Biological control + CO_2	
	Pressure	Modified atmospheres
93	100	100

When long periods of time are considered, such as one year of storage, biological control could be a good alternative to maintain the pest population low. To keep the pest population low avoids important losses of weight for grain and the production of webbing for flour that contaminates the machinery and facilities.

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