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Observations on the Activity of Insect Pests inside and outside two Flour Mills

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Abstract: Two Italian mills were selected for fumigation with sulfuryl fluoride or methyl bromide. The impact of fumigations upon populations of flour beetles and moths was evaluated. Traps baited with aggregation pheromone lure and an oil-based food attractant were used to monitor populations of flour beetles. Sticky traps baited with a pheromone lure were used to monitor the Mediterranean Flour Moth and the Indian Meal Moth. Traps were placed inside the mill buildings, within the areas selected for fumigation, and outside. The purpose of monitoring outside the mill buildings was to detect possible sources of reinfestation.

After fumigation, several stored product insects were detected in traps placed outside the mill buildings. The results showed that sulfuryl fluoride performed similarly to methyl bromide and was therefore a suitable alternative to control stored product pests in Italian mills. The re – infestation of mills could be directly attributed to undetected foci of infestation outside the fumigated area or to infested products brought into the mill.

Key words: stored-product pests, monitoring, Indian Meal Moth, *Tribolium*, fumigation, sulfuryl fluoride, methyl bromide

Introduction

At this time, the need of replacing methyl bromide with other techniques or alternative products in the traditional annual mill fumigation is meeting several difficulties in Italy. This is due both to the need of organizing pest management in an innovative way, in food industries characterised by inadequate structures, and to the habit of relying exclusively on methyl bromide, wrongly considered to be the safest product for killing pest insects. Among the possible alternatives, sulfuryl fluoride is at present the only active ingredient usable in Italy for fumigation.

In this work, we examined in particular the possibility of reinfestation after a fumigation treatment, as a consequence of the presence of pests outside the mill. Our results emphasise that pest management treatments, carried out with fumigations, must be integrated, with prevention and monitoring practices and with localised treatments outside the fumigated buildings. In fact, many stored-product pest species can be trapped outside grain storage and processing structures[1,2,3,4]. Some authors found high numbers of some pest species immediately outside food processing facilities and speculated that immigration could be important in pest dynamics inside the mill[5,6]. Other authors have shown, with the mark-recapture technique, that *Plodia interpunctella* was capable of entering the building from outside, and that this movement is primarily at the basement, first and top floor levels[7]. It was also observed that rebound of stored-product insect populations detected during post-fumigation monitoring could be directly attributed either to infested product being brought into the mill or to undetected foci of infestation outside the mills[8].

Materials and Methods

Two mills (A and B), located in the North of Italy, were studied. In mill A, fumigation was scheduled traditionally with methyl bromide; in mill B, disinfestation was carried out with sulfuryl fluoride. The main characteristics of the mills are shown in Table 1.

Table 1. Main characteristics and treatments of the fumigated mills.

	Mill A	Mill B
Date of fumigation	24/05/07 – 27/05/07	14/07/07 – 16/07/07
Volume (m^3)	14,000	6,900
Building material	concrete	bricks, wooden floor
Fumigant	methyl bromide	sulfuryl fluoride
Dosage ($g\ m^{-3}$)	66.7	20

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	Mill A	Mill B
Exposure time(h)	48	56
Internal temperature(℃)	22 – 27	24 – 28

Efficaly Determination of Salfaryl Fluoride Fumigation

This was the first time that mill B had been treated with sulfuryl fluoride. To check the results of fumigation, twenty – six bioassays (with insects reared at the Institute of Agricultural Entomology, University of Milan) were placed in the mill prior to the fumigation. One untreated control was kept in a cool box in a non – fumigated area of the mill. Insect species included in the bioassays were *Tribolium confusum* (50 eggs, 10 larvae, 10 adults), *Plodia interpunctella* (50 eggs and 10 larvae), *Sitophilus oryzae* (10 adults and mixed population of eggs, larvae and pupae).

Insect cultures were contained in 50 – mL polystyrene jars closed with metallic mesh lids. Food consisted of: rice for *S. oryzae*; white flour for *T. confusum*; a laboratory diet made up of bran, wheat, yeast, corn flour, white flour, honey and glycerol for *P. interpunctella*. Following fumigation, the bioassays were removed and maintained at 26℃ and 65% r. h. in the laboratory of the Institute of Agricultural Entomology, University of Milan, for mortality assessment.

Monitoring

Dome™ Traps Design CFB/RFB (containing an aggregation pheromone lure and an oil-based food attractant) were used to monitor population of *Tribolium* spp. Pheronet Meal Moth traps (Russel IPM, UK) baited with an IMM + 4 pheromone lure were used to monitor the Mediterranean Flour Moth and the Indian Meal Moth.

Traps were placed inside the mill buildings, within the areas selected for fumigation, and outside (Table 2). Where possible, Pheronet traps were placed in approximately the same locations as Dome traps.

Table 2. Number of DOME and Pheronet traps inside and outside the treated mills.

Location	Number of traps – Mill A		Number of traps – Mill B	
	DOME	Pheronet	DOME	Pheronet
Inside mill	24	26	10	10
Outside mill	6	7	2	2

In mill A, infestation levels of the stored product pests were monitored 2 weeks prior to fumigation and 6 weeks post – fumigation, while in mill B 1 week prior and for a total of 7 weeks post – fumigation.

Results and Discussion

Mill A

The overall percentages of reduction in moths and *Tribolium* spp., after fumigation, were 94 and 91%, respectively.

However, a steady and high number of moths was present in an area external to the mill that contained milling by-products (Fig. 1). Some conveyors link this area with the internal part of the mill. This could explain the rapid recolonisation of the mill by *P. interpunctella* and *E. kuehniella*. The moth population decreased significantly in mill A after fumigation and then it gradually increased in the weeks following the treatment (Fig. 1).

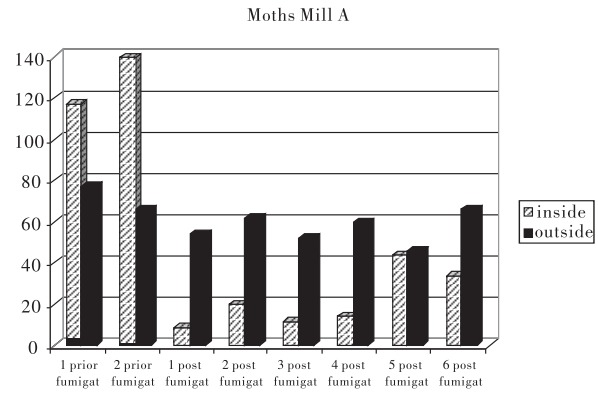

Fig. 1 Number of IMM and MFM trapped in and outside mill A, prior and after fumigation with methyl bromide.

Also, fumigation reduced the internal populations of *Tribolium* spp. remarkably, whereas their numbers remained almost constant outside the mill (Fig. 2). Campbell & Arbogast[7] pointed out that *Tribolium castaneum* trap captures tended to be lower outside compared to inside a mill. They suggested that population rebound after fumigation may result both from persistence of individuals within some patches within the mill and also the movement of new individuals into the mill either actively or in infested products. In mill A, after fumigation, we observed a gradual increase in *Tribolium* captures throughout the mill, whereas outside it, captures remained low.

Mill B

In mill B, it was not possible to estimate the reduction within the mill since no *Tribolium*

spp. and no moths were trapped inside the mill prior to fumigation. Since the owners had decided to test the use of sulfuryl fluoride as alternative to MB, bioassays were placed in the different areas of the building to verify fumigation efficacy. The results show the overall mortality of all the used species, in the different life stages (Table 3).

No infestation of *E. kuehniella* or *P. interpunctella* was detected inside mill B throughout the duration of the study (Fig. 3). *P. interpunctella* was detected only outside, namely in the trap placed near the loading area for flour into bulk flour trucks. Despite its continued presence in the external area, the mill itself never became infested. The loading area for flour is

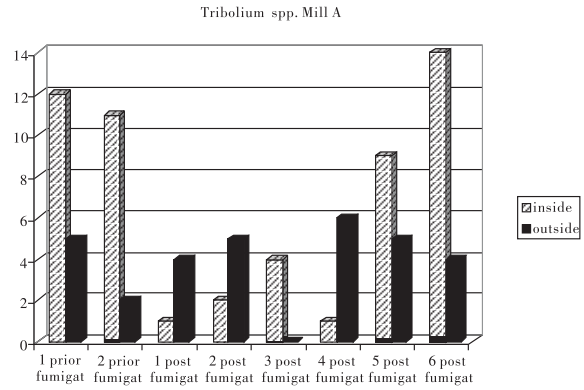

Fig. 2 Number of *Tribolium* spp. trapped in and outside the mill A, prior and after fumigation with methyl bromide.

Table 3. Mortality of bioassays used in the mill B to verify fumigation efficacy with sulphuryl fluoride.

Species	Life stage	Total number	Alive aftertreatment	Mortality rate (%)	Mortality rateof untreatedcontrol (%)
T. confusum	eggs	1300	000	100	36
	larvae	260		100	0
	adults	260		100	0
P. interpunctella	eggs	1300	0	100	6
	larvae	260	0	100	0
S. oryzae	adults	260	0	100	10

located adjacent to the mill. Mill doors and windows are kept closed when not in use. All the mill floors are thoroughly cleaned and polished every day. In such a situation, larvae of pest insects usually do not find food to grow.

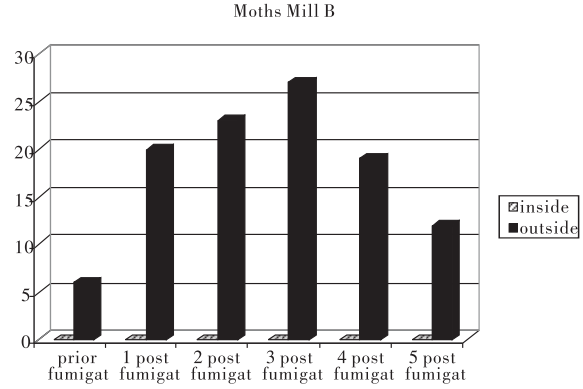

Fig. 3 Number of IMM trapped in and outside the mill B, prior and after fumigation with sulphuryl fluoride.

During inspections, neither present nor previous signs of infestation by Lepidoptera were detected inside the mill. As far as beetles are concerned, before fumigation, *Tribolium* spp. was not present either inside nor outside the mill. After fumigation, some individuals were occasionally found inside the mill (Fig. 4). As already mentioned, the cleaning conditions of the mill were excellent.

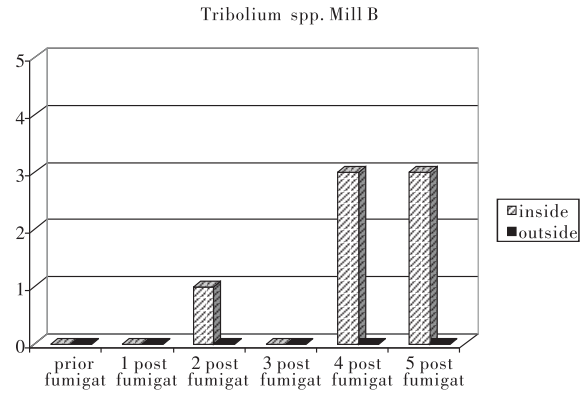

Fig. 4 Number of *Tribolium* spp. trapped in and outside the mill B, prior and after fumigation with sulphuryl fluoride.

Conclusions

Effectiveness of the sulphuryl fluoride fumigation of mill B was verified through use of bioassays. This supports the use of sulphuryl fluoride as an effective alternative to methyl bromide to control stored product pests in Italian mills.

It is important to underline that the distri-

bution of insects outside of food processing and storage facilities has a significant influence on the population dynamics and spatial distribution of pests inside facilities.

The collected data show how it is fundamental to monitor the external area to the mill itself for presence of pests. The area must be considered an integral part of the mill structure for pest control. It is thus necessary to include this area in the monitoring and infestation management program and when planning disinfestation treatments. Otherwise there is a risk that pest populations will not be eliminated, due to pest survival there. In only a few days, the presence of these foci of infestation would nullify the results of even a drastic disinfestation treatment such as fumigation with toxic gases. IMM and MFM populations will be difficult to destroy with fumigation unless better measures are taken to prevent entry of moths into the mill. This is what happened in mill A.

Furthermore, a good management of the mill is very important in terms of cleaning and rationalisation of any openings towards the outside. This prevents pests from entering the milling areas, despite the presence of insects in the field, as in mill B. In this mill there was a high risk of infestation by *P. interpunctella* in the mill products to be sold, because of a focus of infestation around the loading door for flour, which had been ignored by the miller.

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