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Alternatives to Methyl Bromide in Italian Food Industries Results of Two-year Practical Applications

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Abstract: In 2005 – 2006, the Italian Ministry of Environment gave a grant to the Institute of Entomology of the University of Milan for a research project. The goal was to find out several alternatives to the use of methyl bromide for the control of pests in food industries. The MB alternatives tested in Italy were fumigation with sulfuryl fluoride, heat treatments, automatic systems for the distribution of pyrethrins with the ULV method and integrated pest management.

Different food industries participated in the project and the results were reported in a special meeting in Italy. The general conclusion is that it is completely possible to replace methyl bromide to control pests. Every industry can choose the most appropriate alternative to methyl bromide.

Key words: sulfuryl fluoride, heat treatments, fogging, IPM

Introduction

Methyl bromide (MB) is widely spread all over the world, thanks to its broad spectrum of application, the possibility of doing treatments effectively, even at low temperatures, its easy-to-use versatility and its relatively low cost.

But as already well known, in 1992, MB was included in the Montreal Protocol on substances that deplete the ozone layer because of its ozone depletion potential. The reduction calendars were defined three years after its inclusion in the Protocol. This led to the elimination of MB as fumigant agent in food industries. Many alternatives have now been tested, and continue to be tested, as replacement for methyl bromide in the control of stored-product insect infestations.

In 2005 – 2006, the Italian Ministry of Environment gave a grant to the Institute of Entomology of the University of Milan for a research project. The goal was to test possible alternatives to methyl bromide in Italian food industries, particularly fumigation with sulfuryl fluoride (SF), heat treatments, the use of an automatic system for the distribution of insecticides with the Ultra-Low-Volume (ULV) method and the application of IPM. Different food industries participated in the project, allowing tests of alternative technologies to MB.

Material and Methods

Tests were carried out with different methods, according to the different needs. In particular:

Test Insects

Table 1. Test insects

Species	Life stage	Treatment
Tribolium confusum J. du val	Eggs, larvae, adults	ULV, heat treatment, sulfuryl fluoride
Tribolium castaneum (Herbst)	Eggs, larvae, adults	ULV, heat treatments, sulfuryl fluoride
Sitophilus oryzae (Linnaeus)	Eggs, larvae, pupae, adults	sulfuryl fluoride, heat treatment
Rhyzopertha dominica (Fabricius)	Eggs, larvae, pupae, adults	sulfuryl fluoride
Stegobium paniceum (L.)	Eggs, larvae, pupae, adults	sulfuryl fluoride
Plodia interpunctella (Hubner)	Eggs, larvae, pupae	sulfuryl fluoride, ULV, heat treatment
Ephestia kuehniella Zeller	Eggs, larvae, pupae	sulfuryl fluoride, ULV, heat treatment
Musca domestica Linnaeus	Adults	ULV

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Test Environments

Table 2. Test environments

Industry	Treatment
Confectionery industry	ULV
Mill	sulfuryl fluoride, heat treatment
Industrial bakery	heat treatment
Rice mill	heat treatment

Monitoring

- pheromone traps for moths
- traps baited with aggregation pheromone lure and an oil-based food attractant for beetles
- Oil-and water-filled traps for moths

The number of insects used for each test was different, according to the kind of test, the size of the area to be treated and the specific needs. Some details are given in the discussion of the results.

Results and Discussion

Fumigations with Sulfuryl Fluoride

The Institute of Agricultural Entomology onitored several applications directly, both in the mill industry and in pasta factories, through the installation of an adequate number of monitoring points in the areas to be treated. The bioassays were carried out with different life stages. Great attention was devoted to the gas action on insect eggs, particularly on *Tribolium* ones, since they represent the most resistant stage to treatments.

The following bioassays, shown in table 1, were used in the first test, carried out in a semolina mill, with an estimated volume of 16 250 m^3.

Table 3. Details of test insects introduced into the mill

Species	Life stage	Number of replicates	Number per replicate
Sitophilus oryzae	mixed population	1 single test for each location	5 adults + mixed population
Rhyzopertha dominica	mixed population	1 single test for each location	5 adults + mixed population
Plodia interpunctella	eggs pupae	1 single test for each location	50 20
Ephestia kuehniella	eggs pupae	1 single test for each location	50 20
Tribolium confusum	eggs adults	1 single test for each location	50 20
Tribolium castaneum	eggs adults	1 single test for each location	50 20
Stegobium paniceum	mixed population	1 single test for each location	5 adults + mixed population

During fumigation, the temperature ranged from approximately 28℃ to 31℃. The CT product with SF fumigation ranged from 1 101 g. h/m^3 to 1 501 g. h/m^3, with a mean of 1 353 g. h/m^3. At this CT product, 100% mortality was confirmed for all the insect species included in the bioassays: *S. oryzae*, *R. dominica*, *S. paniceum* (mixed life stage culture), *P. interpunctella*, *E. kuehniella* (eggs, pupae), *T. confusum* and *T. castaneum* (eggs, adults). Many of the test insects had been placed in protected and difficult-to-reach locations in the mill, providing an exacting test of efficacy for the fumigant[1].

Further tests, carried out in different mills, showed that sulfuryl fluoride could be considered as an effective disinfestation fumigant for food industries, provided that its use is assigned to qualified staff. In several cases, pests reappeared afterwards and quickly in the treated areas. This is due to the presence of insects in the industry yards which are not taken into account with adequate cleaning and disinfestation treatments. This situation is hence not due to ineffectiveness of the application but to a bad global management of the pest control. This occurs obviously with every kind of toxic gases[2,3,4].

Heat Treatments

The use of warm air was particularly interesting. Also for this method, there was the opportunity to follow and organize some applications in mills, industrial bakeries and in some departments of pasta factories and rice mills. Temperatures around 42℃ cause a reduction of oviposition; when 50℃ are reached, insects die in short time. The data at disposal show indeed that most species do not survive for more than 24 hours at 40℃, 12 hours at 45℃, 5 minutes at 50℃ and for more than a single minute at 55℃[5]. In practical applications, several parameters are to be taken into consideration; in fact, it is important not only to identify pests but it is absolutely necessary to consider the materials used to build the environments and the plants. The thermal conductivity of a concrete or plate wall, of a tiled or wooden floor, of metal removable coversor conveyor belts made of plastic materials is indeed very different. Furthermore, since the movement of warm air is upward, temperatures, even higher than those needed, can be reached quickly on the premises ceilings, whereas walls and floors still remain half – cold. In these cases, it is necessary to improve air circulation with fans, in order to uniform the environmental temperature as quickly as possible. Before dying, insects flee from overheated nesting points and they move where temperature is more tolerable.

In an industrial mill, tests were made in order to obtain a gradual warming of premises and plants up to 55℃, for 48 hours. Ten bioassays were arranged, each containing *P. interpunctella* (eggs, larvae, pupae), *E. kuehniella* (eggs, larvae, pupae), *Tribolium* spp. (eggs, larvae, adults), *R. dominica* and *S. oryzae* (mixed population).

The mortality rate of all the considered species, in all the life stages, turned out to be 100%. The production shutdown lasted as long as that necessary for a MB disinfestation.

In the case of an industrial bakery, the intervention lasted only 48 hours because of production needs. As table 4 shows, the mortality rate noted in the bioassays did not reach 100%.

Table 4. Details and mortality rate of insect bioassays introduced into the industrial bakery.

Species	Life stage	Total number	Alive after treatment	Mortality rate (%)
T. castaneum	eggs	40	2	95
	larvae	40	1	97.5
	adults	40	0	100
T. confusum	eggs	40	19	52.5
	larvae	40	10	75
	adults	40	16	60
E. kuehniella	eggs	200	0	100
	larvae	40	0	100

The present method, which is very interesting and also gradually spreading in Italy, requires PCOs with specific experience, sometimes flanked by conditioning technicians of industrial environments. In any case, the required temperatures, needed to kill insects, must be reached and maintained for the necessary time, in every point of each department and plant to be disinfested.

Space Spraying

Automatic systems to disinfest wide volume areas, employing only active ingredients with knock-down effect, have been used in different places. Space spraying devices are different and they are based on the micronization of the product which is distributed nearly as if it were fog. It is evident that the more the insecticide is distributed uniformly with an ultra-low volume treatment, the more the intervention is effective. The limit of these applications derives from the characteristics of the active ingredients at disposal, as natural pyrethrum or non-persistent synthetic pyrethroids. Since they are contact insecticides, they work essentially on adults but they are not effective on nested insects and on life stages characterized by reduced or no motion.

A similar system for insecticide distribution was already tested in Italy[6]; the obtained results were interesting but the method, called Turbocide GOLD (Trademark AgrEvo) was not further developed.

The present research was made with the use of a space spraying device called Nebbia Secca (Trademark GEA, Italy). Thanks to its very high insecticide micronization (droplets of about 12 μm, produced by collision), this method gives the advantage of determining an optimal distribution of the a. i., without smearing plants, as often occurs with thermofog. Each spray nozzle of Nebbia Seccacovers about 1000 m^3. Treatment times depend on premises volume and on the a. i. which is used.

In a test, carried out in a confectionery industry, a department of about 3 000 m^3 was treated in 8 – 10 minutes. In this industry, several applications were made using 200 g of AquaPy (Bayer) for each test(*). Immediately before each of the three tests, 36 containers had been placed in the environment to be treated (18 containing each 10 Indian Meal Moth adults and 18 containing each 10 *Musca domestica* adults). After space spraying, insect containers remained in the department for 14 hours before their collection and control. The mortality ratewas 100% of the bioassays.

This centralized insecticide spraying system can be a valid instrument for knocking down fly and moths adults. However, its use requires repeated and frequent applications to give completely positive results. This system is particularly effective in areas with low levels of infestation, where an accurate monitoring of pest flight can be done. Moreover, it is effective also in big goods stocking or distribution warehouses, where rational monitoring is extremely difficult or inapplicable. In this case, it is necessary to make frequent treatments.

Integrated Pest Management

Localized insecticide treatments, use of pheromones for monitoring, mass trapping and mating disruption are a good help for the IPM. If this method is used in food industries, it is necessary to consider that, at least in Italy, there is no tolerance threshold regarding the presence of pests. Integrated pest management is essentially based on prevention and on careful monitoring; these two aspects aim at reducing traditional pest treatments, since the general situation of the environments tends to be always under strict control. By implementing such practices it is also possible not to use toxic gases. Integrated pest management requires well technical trained users and a regular application. Implementing a pest management programme with this method determines for sure remarkable technical progress for the industries that want to adopt it. The results obtained in Italy in an IPM annual test were referred[7].

Conclusions

The general conclusion is that it is completely possible to replace methyl bromide in the control of pests and that every industry can choose the most appropriate alternative.

In fact, none of the considered IPM methods can totally solve each problem. Nevertheless, as already known, also the use of methyl bromide was not able to eradicate pest attacks in a definitive way. The transition towards new methods requires good willingness to come to alternative techniques; furthermore, it requires higher technical skills from both the people in charge of the food industries concerned and from PCOs. It can also require much time to be devoted to the pest problem but in this way, insects can be always kept under control. The appearance of serious infestations, which may cause surprise and worries to food safety supervisors, is thus prevented.

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* *AquaPy* ®: *natural pyrethrins* 3% ; *ppb* 13.5 %.