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Integrated Pest Management in the Italian Mill Industry

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Abstract: The efficacy of integrated pest management (IPM) in an Italian mill was evaluated as a substitute for annual fumigation with methyl bromide, an ozone-depleting pesticide which is now banned in developed countries for most of its uses.

Traps baited with aggregation pheromone lure and an oil-based food attractant were used to monitor populations of stored-product beetles. sticky traps baited with a pheromone lure were used to monitor the Mediterranean Flour Moth (MFM) and the Indian Meal Moth (IMM). In addition, several bins, oil-or water-filled and baited with a pheromone lure, were used to catch adults of the MFM and of the IMM in the most critical areas.

Monitoring and inspection were carried out weekly; cleaning was carried out more often than in the past; local treatments were made if necessary; and sometimes there were changes to the buildings to reduce insect hiding places. Several sources of infestation were detected and critical areas were more often monitored. The intent was to avoid fumigation in the following years.

Due to the IPM activities, it was possible to reduce the population peak to a lower level than recorded in the previous years. The frequent inspections led to the identification of foci of infestations and occasional pests, such as *Tineola bisselliella* Hummel, *Tetramorium caespitum* (Linnaeus), and *Blatta orientalis* Linnaeus.

IPM is a useful alternative to methyl bromide, but its application requires specialized knowledge by technicians who know the biology and the behaviour of stored-product pests, and are able to manage the monitoring program and to organize the most appropriate control strategies.

Key words: methyl bromide, alternative, IPM, trapping, monitoring, mill industry, stored-product pests.

Introduction

Pest management has been an established technique in agriculture for more than twenty years, whereas attempts to extend it also in the food industries are more recent. The acquisition of more knowledge about pest bioethology and the availability of pheromone lures and monitoring food traps contributed to this trend.

Another contribution was recently given by the necessity of finding the most effective alternative methods to methyl bromide for disinfesting production areas[1]. Among these ones, a pest management program was carried on in a mill where fumigation with methyl bromide and phosphine had been done for years.

The aim of the present work was to implement, where necessary, the monitoring already done by the mill in the past years, to follow the trend of pest captures and to localize the presence of infestation traces every week. In this way, it was possible to intervene by intensifying cleaning, with localized treatments and by realizing possible structural improvements. Finally, the effectiveness of integrated pest management was considered a valid alternative to the annual fumigation.

Materials and Methods

The industry is a soft wheat mill in the north of Italy. It extends on about 10 000 m^2 and has a productive capacity of 200 t/h.

The production area is placed in a 5 – floor building and it is near four warehousing areas (for raw materials, loose manufactured goods, packaged manufactured goods and by-products).

Pest management occurred according to a specific practice, contained in the Management and Quality Control Handbook. In the mill there were 33 funnel traps for Lepidoptera, baited with a pheromone lure for moth pests. They were controlled every month.

Every year, in summer, a pest control treatment with methyl bromide was scheduled and carried out in the production areas, whereas phosphine was used in the areas where raw materials and manufactured goods are stored.

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After fumigation, the funnel traps, already present in the mill (Mastrap), were restored, together with 13 Anobiidi Trapto monitor *Lasioderma serricorne* (F.) and *Stegobium paniceum* (L.), 5 Pantry Patrol, baited with different pheromone lures and an oil-based food attractant to monitor simultaneously *Tribolium* spp., *Oryzaephilus* spp., *L. serricorne*, *Plodia interpunctella* (H bner), *Sitophilus* spp., *S. paniceum* and *Trogoderma* spp.

Besides these ones, after having at disposal the monitoring data, also other traps were used to mass trapping moths. They were composed of plastic rectangular boxes (18 × 24, 5 × 12 cm), filled with water or seed oil and baited with pheromone lure for moth pests[2]. These traps (one for each type) were placed in the two areas of the mill which were considered to be the most critical (basement "wheat silos" and by-products area) because of an increase in the captures of *P. interpunctella* in the funnel traps present there.

During the whole period of experiment (July 2005, August 2006), monitoring had a weekly frequency: the captured insects were collected and classified and thanks to the direct comparison with the data referring to the previous weeks, every time it was possible to detect the areas which had to be taken under control or where it was necessary to intervene promptly.

Results and Discussion

Lepidoptera

The 2005 fumigation with methyl bromide eliminated the presence of the moths in the mill but it did not prevent their recolonization, since captures of moths were already noted in the weeks following the treatment, particularly in the by-products area and in the basement "wheat silos" (Fig. 1、Fig. 2). In this area the reinfestation was due to the losses of the wheat transportation redler, from the unloading hole to the pre-winnowing, and to the fact that the wheat silos area is linked to the outside.

The problem concerning sudden room infestations, even from the week following the fumigation, and due in particular to the presence of infestation foci outside the building, was highlighted in different works[3,4,5].

After the increased captures in the basement "wheat silos", some targeted interventions were implemented, such as extraordinary cleaning and mass trapping with water-and oil-filled traps, baited with a pheromone lure. Thanks to these interventions, population diminished (Fig. 2). At the end of October, captures ceased with the arrival of cold weather.

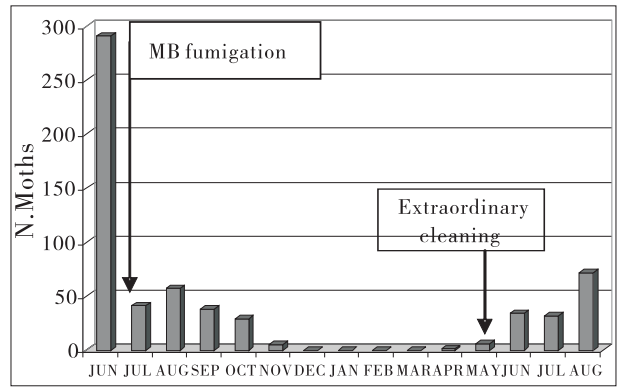

Fig. 1 Number of captured IMM and MFM in the mill, from June 2005 to August 2006.

Also the by-products area was involved in a targeted cleaning intervention (July, 25 2005) which made it possible to reduce captures for several weeks (Fig. 2).

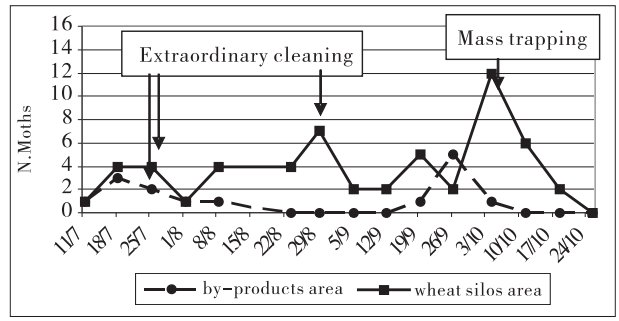

Fig. 2 Weekly captured moths in by – products area and "wheat silos" area and treatments to reduce moths population.

In the remaining mill departments, from July to November 2005, only some Lepidoptera captures were noted but they were not considered worrying. In winter, captures ceased and the presence of moths in the mill began again at the end of May 2006 (Fig. 1).

As a precautionary measure, during the second week of May, the winnowing area and the milling area of the entire building were completely cleaned because the monitoring data of the previous years showed a top of presence after the first spring captures. The extraordinary cleaning intervention aimed at eliminating infestation foci (in cracks and crevices, machinery, corners, overhead wires, etc.) from which new adults could flutter.

In fact, the weekly monitoring data showed that the population density in the mill remained at non-worrying levels for the rest of the warm season, thanks to the targeted cleaning and pest control interventions (Fig. 2).

Comparing the monthly captures of the

years 2004 – 2005 – 2006, the flight curve showed a peak in June 2004 and 2005 and then a fall due to the fumigation carried out in the first week of July (Fig. 3).

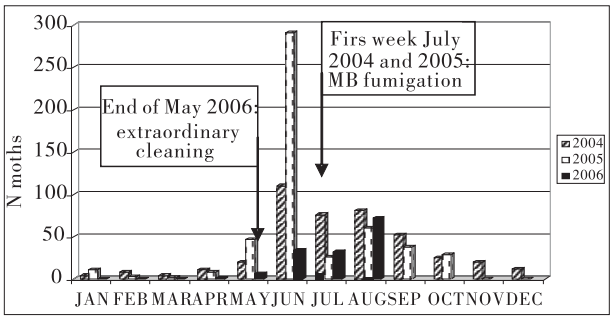

Fig. 3 Monthly captures of moths inside the mill in 2004, 2005, 2006.

In 2006, there was a foreseeable increase in the presence of Lepidoptera during the summer period. In June and in July, captures were strongly inferior compared with those of the same month, in the previous years, although fumigation was not done in 2006. In 2006, the peak of presence was noticed in August but it was inferior if compared with June 2004 and 2005. In these years, there was a boom in captures because of the absence of frequent monitoring and of targeted and prompt interventions. Captures decreased only with fumigation in July.

Beetles

Pantry Patroltraps, used to monitor beetles, captured also many *P. interpunctella* individuals, which turned out to be the main pest in the mill (Fig. 4). More than 20% of the noted captures was composed of insects coming from the outside and linked to the traps position, placed mostly on the ground floor and on transit areas with openings towards the outside. This data showed an inadequate structural prevention, linked to the presence of areas opened towards the outside, windows without the appropriate anti-insect net and because of the frequent habit of leaving the doors open in the transit areas. In the warehouse containing manufactured products in sacks, the introduction of pallets constituted another source of infestation from the outside.

In the mill, the sporadic captures of Anobidae showed that they are occasional pests, as proved also by the data collected with *Pantry Patrol* (Fig. 4).

However, *Anobiidi Trap*, especially those ones near doors and windows or placed in areas

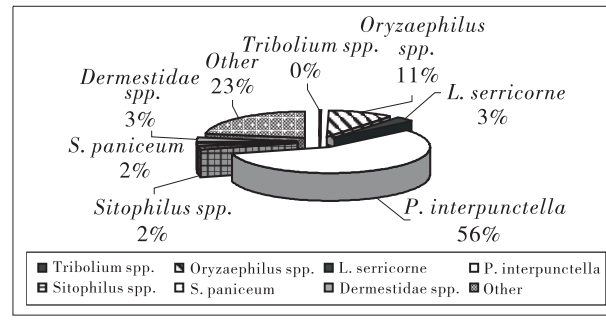

Fig. 4 Percentage of captured species with Pantry Patroltraps (July 2005 – August 2006).

opened towards the outside, captured a considerable number of occasional pests, coming from the outside, such as Hymenoptera and Diptera. This shows again the importance of prevention from the entrance of insects coming from the surrounding areas.

Water-and oil-filled traps

These traps, baited with a pheromone lure, were placed in some critical areas of the mill. The direct comparison among the captures data of the different traps (oil-filled, water-filled, funnel) showed that, especially in the by-products area, water-and oil-filled traps were more effective in capturing Lepidoptera than funnel traps (Fig. 5).

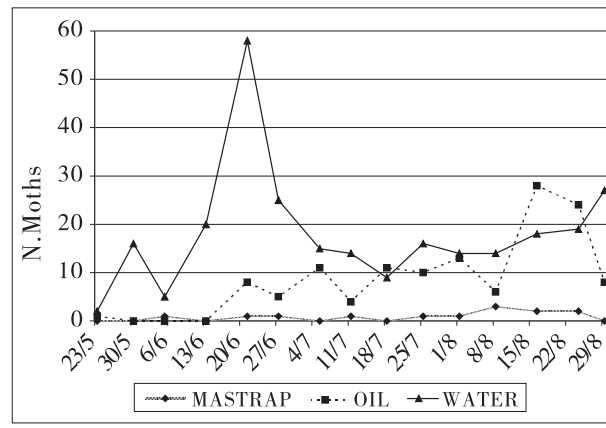

Fig. 5 Weekly captures of moths in by – products area with funnel traps (Mastrap), oil – and water – filled traps.

In general, it is known that there are different factors which can influence insect capture; these factors are linked to the trap, such as the structure and colour, the kind of lure, the capacity to detain insects after capture but they are also linked to the environment, such as placement, temperature, the kind of preserved goods and the way they are stored[6,7,8]. A study, in which four different traps to capture *P. interpunctella* were tested, showed that the funnel trap captures the lowest percentage of adults,

whereas "pagoda traps" were the most effective among sticky traps, followed by delta traps[9].

However, it is important to point out that in particular situations, such as in dusty environments like mills, funnel traps are the most appropriate. In fact, in these cases, sticky traps surfaces would be quickly inactivated by powders.

The strong attractiveness of water to Lepidoptera adults, observed in this study, had been already pointed out on *Ephestia cautella* Walker by Ryne *et al.* [2].

Trapped adults were sexed and the collected data showed that these traps were not only able to attract males, but also a small quantity of females (Fig. 6). Ryne *et al.* [2] analysed if water attractiveness varied between sexes of *E. kuehniella* Zeller and *E. cautella*. For the last one, they pointed out substantial differences in capturing individuals of both sexes with water-filled traps, either baited or not with a pheromone lure, compared to the same traps without water and to funnel traps. On the contrary, for *E. kuehniella*, females were not attracted, whereas males were captured only in the traps baited with a pheromone lure; once again, sack traps were less effective than water-filled traps, baited with pheromone lure. As for *P. interpunctella*, the percentage of captured females was small; more precisely, water-filled traps captured 3, 4% more females than oil-filled traps. (Fig. 6). Capture percentages of female individuals were not high but these traps proved to be more effective than funnel traps in mass trapping.

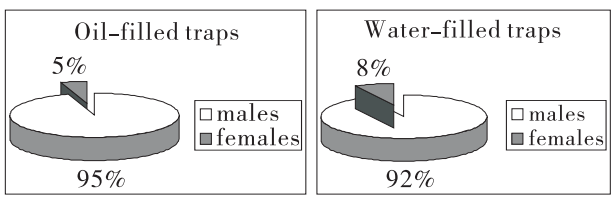

Fig. 6 Percentages of *P. interpunctella* males and females captured with oil – and water – filled traps.

Also some beetles showed their attractiveness to water-and oil-filled traps because a week after their placement, numerous captures of *Sitophilus oryzae*, *Oryzaephilus surinamensis*, *Cryptolestes* spp. were noticed in the basement area "wheat silos". In the following week, captures increased abnormally and this fact led to the identification of a considerable infestation in the raw materials stocking area above this room. A targeted intervention was hence scheduled with the use of phosphine in the stocking silos and deltamethrine on the walls of this area. After the interventions, captures diminished until they ceased after two weeks. These traps were therefore very useful to promptly identify a strong infestation existing in the stocking silos. A following and immediate intervention was hence possible.

Interventions against Accidental Insects

During this study, besides ordinary and extraordinary cleaning, made after real necessities, structural interventions and some treatments towards occasional pests, such as cockroaches, ants and tineids, were carried out.

The capture of some individuals of *Blatta orientalis* on the ground floor of the flour silos area (June, August 2006) was attributed to the presence of a manhole on the external yard of the mill which was linked to the urban sewerage system. The interventions regarded localized treatments in the interested area, with imidacloprid gel baits.

On the ground floor of the flour silos area, there was also the presence of *Tetramorium caespitum* coming from the outside. The interventions aimed at eliminating flour remains, at sealing crevices with concrete and at treating the area with a deltamethrine-and pyrethrum-based product.

In May 2006, an infestation of the clothing moth *Tineola bisselliella* was noticed on the cloth lid filters of the flour silos used for sacking. The filters were removed and cleaned. After this intervention, the infestation disappeared.

Intervention on the Flour Silos

An important structural intervention was sealing the flanges of the stocking silos containing flour to be packed. Product loss was in fact due to the lack of grip of the flanges because of the loading pressure of the flour silo; this problem determined not only an economic loss, but it constituted also an attractive source for insects (the presence of Dermestidae larvae was often noticed). All silos were therefore sealed with silicon: after this intervention, there were no more product losses and the presence of traces diminished considerably.

Conclusions

Thanks to the implementation of IPM program, with an increment in the control frequency and an increase in the number of traps, it was possible to detect infestation foci and to define critical areas in order to intervene promptly and in a specific area. In this way, infestations

can be eliminated and after that, the success of the intervention can be checked.

In 2006, the number of insects in the mill was inferior if compared to the previous years, thanks to all the interventions implemented. Fumigation with MB was hence unnecessary.

Using other kinds of traps (Pantry Patrol, Anobiidi Trap, water-and oil-filled traps), which in some cases proved to be more effective than the traps generally used in monitoring to attract and capture insects, it was possible to trap a greater number of pests. Infestations were consequently kept under control, particularly in the basement "wheat silos" and in the stocking area of milling by-products, which were considered to be the two most critical areas in the mill. In particular, although water-and oil-filled traps captured few female adults of *P. interpunctella*, the mass trapping technique was developed with the aim of capturing as many adults as possible. Female capture, besides lowering the mating possibilities between individuals, diminishes also the possibility of oviposition.

Thanks to the traps placed on the ground floor and near openings, the entrance of pests from the outside was monitored and the need to prevent it was stressed. To stop the entrance of pests, nets were installed where they lacked and doors were kept closed when not used.

Infestation foci, which were promptly removed, and occasional pests, such as Tineidae, ants and beetles, managed through targeted interventions, were detected during the weekly visual monitoring.

It is also important to monitor the presence of pests weekly and not monthly; to plan to clean more frequently and if necessary, extraordinarily and promptly; to invest money in structural improvements or new machinery; and to train the staff about stored-product pests and IPM techniques.

The obtained results show that infestation management in a mill industry can be realized through an integrated pest management program, leaving aside the annual fumigation.

However, it must be highlighted that this approach requires a more technically skilled staff able to organize and manage monitoring.

References

[1] Savigliano R, Minuto A, Camponogara A, et al. Bromuro di metile: eliminazione senza rimpianti. Informatore fitopatologico, 2006 (3): 31 – 35

[2] Ryne C, Ekeberg M, Olsson P O C et al. Water revisited: a powerful attractant for certain stored-product moths. Entomologia Experimentalis et Applicata, 2002, 103: 99 – 103

[3] Doud C W, Phillips T W. Activity of *Plodia interpunctella* (Lepidoptera: Pyralidae) in and around flour mills. Journal of Economic Entomology, 2000, 93: 1842 – 1847

[4] Campbell J F, Arbogast R T. Stored-product insects in a flour mill: population dynamics and response to fumigation treatments. Entomologia Experimentalis et Applicata, 2004, 112: 217 – 225

[5] Campbell J F, Mullen M A. Distribution and dispersal behaviour of *Trogoderma variabile* Ballion and *Plodia interpuctella* (H bner) outside a food processing plant. Journal of Economic Entomology, 2004, 97: 1455 – 1464.

[6] Levinson H Z, Hoppe T. Preferential flight of *Plodia interpunctella* and *Cadra cautella* (Phycitinae) toward figures of definite shape and position with notes on the interaction between optical and pheromone stimuli. Z. ang. Ent., 1983, 96: 451 – 500

[7] Trematerra P, Rotundo G, De Cristofaro A. Trapping stored – product insects using an unbaited multifunnel trap. In: Highley E., Wright E. J., Banks H. J., Champ B. R., ed., Proc. of the 6th Int. Working Conference on Stored Product Protection, 17 – 23 April 1994, Canberra, Australia: 451 – 454

[8] Mullen M A, Wileyoto E P, Arthur F H. Influence Trap Design and Location on the Capture of *Plodia interpunctella* (Indian Meal Moth) (Lepidoptera: Pyralidae) in a Release – Recapture Study. J. Stored Prod. Res., 1998, 34 (1): 33 – 36

[9] Savoldelli S. Evaluation of the efficacy of different kinds of pheromone traps for the monitoring of *Plodia interpunctella* Hbn. (Lepidoptera: Pyralidae). Proc. Working Group "Integrated Protection of Stored Products" IOBC/WPRS, Kusadasi (Turkey) 16 – 19 September 2003, Ed. S. Navarro, C. Adler, M. Sch ller, M. Emek i, A. G. Ferizli, L. Steng rd Hansen, 2004, 27 (9): 103 – 108