Mass trapping of *Ephestia kuehniella* Zeller in a traditional flour mill

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Abstract

Results obtained by mass trapping method, using the synthetic pheromone (*Z*,*E*)-9,12-tetradecadienyl acetate (TDA), to control the population of *Ephestia kuehniella* Zeller in a large traditional flour mill are reported. The surveys were carried out over a period of five years. Forty-two funnel traps, each baited with 2 mg of TDA, were placed in the mill on March 2004 and kept until November 2008. Eight additional traps were located around the exterior of the facility, especially in the wheat silo area and near loading equipment. In almost five years, the pheromone traps attracted a total of 54,170 male *E. kuehniella*. Considering only the catch data obtained from the traps located in the internal departments of the mill, 28,360 specimens were captured. Outside the plant, 1,975 males were trapped. From the trap counts obtained it was possible to identify the locations of the main foci of infestation. With regard to the pest control attained by mass trapping techniques, trap catches of *E. kuehniella* inside the mill revealed a conspicuous decrease in the population density (of about 92.2%) comparing the data obtained in 2008 with that from 2004. The population density of the pest outside the mill also decreased from the first until the last year of the surveys. The infestation was maintained at a low level, especially during the last two years of the study, when the Integrated Pest Management program applied in the plant did not include general fumigations but only localized insecticide treatments and careful cleaning of the various departments (wheat storage bins, processing and packaging areas, milling products warehouses and the loading zone) and the interior of all equipment.

Keywords: Mediterranean flour moth, Mass trapping, IPM, Flour mill, Italy.

1. Introduction

The Mediterranean flour moth, *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) is one of the major pests in European cereal warehouses and food processing industries. If not controlled in the flour mills its infestations, it can be so abundant as to clog the flow of products in equipment. Furthermore, the presence of larvae and webbing in the end product is unacceptable to consumers.

In Italy, before the Montreal Protocol that limited methyl bromide use, control of insect pests inside mills was typically realized by one or two general fumigations per year and several contact insecticide treatments, especially during the summer period (Trematerra and Gentile, 2006). Methyl bromide has usually been replaced by sulfuryl fluoride or, in only a small number of industrial facilities, by non-chemical alternatives, generally in combination with spot insecticide treatments. In this context, for the majority of flour mills the number of chemical treatments using contact insecticides (natural pyrethrins and synthetic pyrethroids but also organophosphates) has been increased, whereas preventive measures, such as good hygiene procedures, even if widely accepted as important in pest control, are often not adopted by mill managers.

Several studies have been carried out in the last two decades to find effective alternatives to methyl bromide and conventional chemical treatments or, in any case, of limiting their use. Among them have been investigation on the potential of pheromone-based methods (mass trapping, attract and kill or mating disruption techniques) to control indoor populations of *E. kuehniella* (Trematerra and Battaini, 1987; Trematerra, 1988, 1990, 1994a and 1994b; Süss et al., 1996 and 1999; Anderbrant et al., 2007; Ryne et al., 2007; Trematerra and Gentile, 2010). Considering the mass trapping method, Trematerra & Battaini (1987) demonstrated that integrated control of *E. kuehniella* can be achieved by this technique in limited environments. Furthermore, Trematerra (1988; 1990) reported results obtained in an entire large flour mill: the practical application of mass trapping to control the infestation of *E. kuehniella* led to a

reduction in chemical treatments, and as a consequence the mill obtained economic and qualitative advantages by protecting milling products from pesticide residues and improving the image of the firm.

In the present paper, the results of applying the mass trapping method to contain the Mediterranean flour moth infestation in a traditional flour mill are reported. Our researches focused on the effectiveness of mass trapping, combined with other pest control techniques, at improving the procedures applied to combat infestation by *E. kuehniella* in an Integrated Pest Management (IPM) approach.

2. Materials and methods

The surveys were carried out in a flour mill situated in Central Italy, over a period of almost 5 years, from March 2004 until November 2008. The plant is a building of 11,500 m3 with four floors, and it produces about 70 tons of flour per day from processing spring wheat or hard wheat.

Funnel traps (Mastrap type) with rubber dispensers baited with 2 mg of (Z, E)-9, 12-tetradecadienyl acetate (or TDA) (daily release of 13 µg) were used. The dispensers remained effective for about 2 months at which point they were replaced (traps and dispensers were supplied by Novapher, Italy). According with Trematerra and Battaini (1987), 42 traps were positioned in the mill, about one every 270 m3, placed 2 to 2.5 m above the floor and 3 to 3.5 m from the walls. Eight traps were located at the exterior of the mill, especially in the wheat silo area and near loading equipment, sectors that are frequently covered with grain, debris or dust. Trap captures were recorded weekly. Pipe joints were left open whenever processing was temporarily halted, i.e., during the holidays, so that the pheromone could act on moths inside machinery. On the occasion of structural fumigations and chemical treatments with contact insecticides, traps were removed and then reinstalled after 1 wk.

For every sampling date, visual inspections were carried out to observe the presence of E. kuehniella free adults, larvae, pupae or their traces, such as the larval silken webbing. These evidences, recorded as qualitative data, were reported every week to management personnel of the flour mill together with the number of the trapped moths. This was to assist them decisions making regarding measures to perform against any critical situation found. Moreover, these observations, in addition to the trap catch data, were also used in our study to evaluate the effect of mass trapping techniques and other IPM procedures applied in the mill.

3. Results and discussion

The environmental conditions found inside the flour mill (monthly mean temperatures between 15°C and 31°C from April to October, and between 8°C and 21°C from November to March) allowed the continuous development of the Mediterranean flour moth during eight to nine months every year, with approximately one generation every two months (Bell, 1975).

The captures obtained by the funnel traps positioned inside and outside the mill for every month throughout the five years of the trial are represented in Figure 1. In the entire survey period, pheromone traps attracted a total of 54,170 male Mediterranean flour moths. The insect pest was present in the mill on almost all sampling dates. The traps located in the internal departments of the mill trapped 28,360 specimens during 2004, 5,856 in 2005, 8,992 in 2006, 2,235 in 2007 and 2,218 in 2008. Outside the facility, 1,975 males were captured in 2004, 1,405 in 2005, 1,005 in 2006, 1,010 in 2007, and 1,114 in 2008.

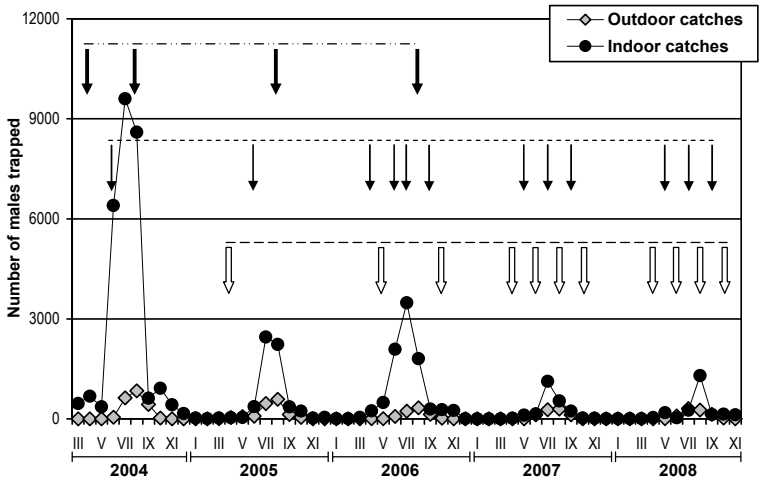

Figure 1 Cumulative monthly trap catches of *Ephestia kuehniella* males inside and outside the flour mill.

The main peaks occurred during the summer months, July or August, whereas the population remained at low levels from November until March, with few trap catches found. The increases recorded in the spring period, especially in May and June, are considered a consequence of emergence from the cocoon of the portion of the pest population that overwinters as mature larvae or pupae.

After structural fumigations with both methyl bromide (carried out twice in 2004: in April and in August, and once in August 2005) and sulfuryl fluoride (carried out in August 2006), trap catches were almost totally annulled for 2-3 weeks, however a rapid recolonization of the mill occurred, especially after of the spring fumigation of 2004.

The highest numbers of males were recorded in traps positioned near machinery with 'critical points', where fairly constant large amounts of food resources or favorable environmental conditions are to be found. High levels of infestation also occurred in rooms where silos of milling products (flour, semolina or bran) were located. Visual inspections confirmed this particular distribution of the pest. The position of the main infestation foci of *E. kuehniella* in critical areas could be due to various causes: microclimatic suitability, interaction with biotic factors, processing practices, presence of doors and windows and other physical attributes of a facility. The presence of the pest is a more frequent problem in all the departments where the possibility of finding flour, semolina, damaged grain, wheat debris or dust is regularly greater than that in other areas. Critical points such as the roll stands, the screen conveyors, the spouts, the plansichters, and the dust collectors, must be regularly and accurately inspected and cleaned. Other studies carried out in similar contexts indicate that there is a significant correlation between some of these factors and the spatial distribution of several insects in food processing facilities and in flour mills (Trematerra & Sciarretta, 2004; Trematerra and Gentile, 2006).

During the investigation, a higher presence of Mediterranean flour moth was observed on the ground floor compared to the other sectors of mill, especially in sampling dates following fumigations or contact insecticide chemical treatments. The assumption that the outdoor population might reinfest the flour mill seems to be well founded because in this sector of the plant, during the summer period, it is easier for insects to enter from outdoors and colonize the indoor departments. Investigations into the incidence of stored-product moths of the genera *Ephestia* and *Plodia* outside warehouses and food-processing factories were carried out at various locations (Wohlgemuth et al., 1987; Trematerra, 1988 and 1990; Süss et al., 1996; Doud and Phillips, 2000; Campbell and Mullen, 2004; Campbell, 2007). The results show that during summer adults fly in the outdoors near these types of structures. Several surveys suggest that a population of *E. kuehniella* outside storage facilities can potentially migrate inside.

Although *E. kuehniella* is primarily associated with stored foods and is not considered to be a pest in crop fields, the immediate areas outside warehouses or food processing factories can represent important

sources of infestation. Trematerra (1990) captured a great number of *E. kuehniella* males outside a flour mill in pheromone-baited traps. Trematerra (1990) and Süss et al. (1996) recorded rapid reinfestations by *E. kuehniella* in flour mills after fumigation with methyl bromide, and attributed these increases to immigration by the outdoor population. Campbell and Arbogast (2004) found similar results when assessing seasonal trends in *E. kuehniella* trap captures in a flour mill, the relationships between catch data inside and outside the plant, between the number of trapped moths and product infestation, and the impact of fumigation on the pest population.

In our case, immigration by outdoor adult specimens has to be a limited phenomenon, since infestation remained at low levels without further important increases. On the other hand, the exiguous number of *E. kuehniella* adults observed by means of visual inspections in the inner departments of the plant, and consequently, the low level of presence of free females, was in concordance with other mills controlled using a mass trapping method (Trematerra and Battaini, 1987; Trematerra, 1990). Indeed, the pheromonal substance present inside the structure could induce the Mediterranean flour moth females to leave the internal areas in favour of the outdoor zones, and the absence of males could also stimulate dispersal.

With regard to the pest control attained by mass trapping techniques, the trap catches of *E. kuehniella* inside the mill revealed a conspicuous decrease in the population density (of about 92.2%) comparing data obtained in 2008 with that from 2004. The population density of the pest outside the mill also decreased from the first until the last year of the surveys, even though this reduction was smaller being about 44.6%.

Further IPM strategies were employed in the flour mill during the hot seasons of the last three survey years. Mass trapping was accompanied by careful cleaning of the various departments (especially wheat storage bins, processing and packaging areas, milling product warehouses and loading zone) and of the equipment interiors (in May and October 2006; April, June, August and October 2007; April, June, August and October 2008). This was done in tandem with localized chemical treatments with contact insecticides of the critical sectors of the facility (in April, June, July and September 2006; May, July and September 2007; May, July and September 2008) (Figure 1). These chemical treatments consisted of spot surface spraying or space fogging of single infested rooms by means of synergized pyrethrum or, in areas with unusual problems, pyrethroids such as deltamethrin, permethrin or bioallethrin.

The mass-trapping method accompanied with other pest control procedures was able to remove so many *E. kuehniella* specimens as to ensure a low infestation level from the first year of the survey on. This prevented an increase in the residual population. It follows that the prolonged presence of funnel traps led to a drastic reduction of insect presence in the entire facility. As reported by Knipling and McGuire (1966), we can likewise assume that the effectiveness of mass trapping was such that about 85-90% of males were captured. The effectiveness of the IPM program carried out in the mill during our research rendered unnecessary the second general fumigation in 2005 and 2006. Afterwards, in 2007 and 2008, when the IPM program applied in the plant included regular cleaning procedures and localized insecticide treatments, no fumigation treatment was carried out; there was no increase in pest problems. Conversely, the fumigation treatments did not appear to impact trap captures of *E. kuehniella* for a long time, probably because of high rates of immigration from the exterior.

Considering the mass trapping method alone, its effectiveness is above all conditioned by the density of the population present in a structure. In our case assuming that a highly efficient trapping system has been designed and an adequate trapping regime established, the problem of accurately assessing the effects of the mass trapping treatment as a component of pest control still remains. IPM, in the strictest sense, includes the establishment of thresholds, at least at the level of economic injury. This is difficult to determine in any environment where it is neither possible to measure the exact size of the pest population nor to quantify the economic damage caused by a specific actual population size. In particular, for the Mediterranean flour moth, an independent measurement of population density is still lacking (Ryne et al., 2006). Furthermore the risks of attack by this pest are often underestimated (Süss et al., 1996; Campbell et al., 2002). This means that IPM strategies in flour mills, to a much higher degree than in other processing food plants or stored product areas, may be dependent on a strategy which includes a number of preventive elements.

The impressive reduction in the population density of *E. kuehniella* obtained in our surveys raises the question of whether "insectistasis" (Levinson and Levinson, 1985) can be obtained in a flour mill by mass trapping alone. Extrapolation of data recorded suggests that use of pheromone traps in a traditional mill for a longer time should dilute the population density of the Mediterranean flour moth even further. However, it was not possible to eliminate infestation, or even reduce the level of "insectistasis", if trapping was not accompanied by insecticide treatment and general cleaning of the mill, particularly in the corners and inside the machinery where the insects can hide and reproduce undisturbed. If such measures are not observed, the mass trapping will, at best, only reduce the number of insecticidal treatments.

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