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Management strategies for the control of *Tuta absoluta* (Lepidoptera: Gelechiidae) damage in open-field cultivations of processing tomato in Tuscany (Italy)

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Since its recent introduction into the Mediterranean area, *Tuta absoluta* (Meyrick) has become widespread and an important pest throughout the region, including in Tuscany, where it was first recorded in 2009. Although several studies have been conducted within controlled environments on the ecology and management of *T. absoluta*, limited information is currently available on the importance of this pest in open-field cultivations, which may lead to ineffective management strategies. This study was carried out to monitor fluctuations in adult populations of *T. absoluta* in organic and conventional cultivations of processing tomatoes using pheromone lures, and to collect inter-annual data on direct yield loss and fruit damage from larval feeding in two separate trials in Grosseto (Tuscany). The first trial included eight conventionally managed fields; the second trial was carried out in four organically managed fields. Results show relatively higher crop damage for tomatoes transplanted later in the season and harvested towards the end of August to early September, and limited fruit damage from this pest during the second year of the study for both conventional and organically managed fields. Finally, biological and chemical pest management strategies for the control of *T. absoluta* adopted by farmers within the region are reviewed and discussed.

Introduction

The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelichiidae), is a serious pest of tomato (*Solanum lycopersicum* L.) cultivations (EPPO, 2005). It originates from South America and has only recently been introduced to the Mediterranean region (Urbaneja *et al.*, 2007). However, since then it has spread very quickly along the Mediterranean basin and to other Central and Northern European countries (Potting, 2009; Desneux *et al.*, 2010). *Tuta absoluta* has been introduced to Tuscany (Italy) very recently, the first records being from the beginning of 2009 from the province of Grosseto (Bagnoli *et al.*, 2010). Tomato trade and, to a lesser degree, active flight or passive movement on wind currents are the main mechanisms of current spread of this pest (Desneux *et al.*, 2010). Adults of *T. absoluta* usually lay eggs on the underside of leaves and on stems. After hatching, young larvae penetrate leaves, aerial fruits or stems, on which they feed and develop, thus creating conspicuous mines which may be invaded later by secondary pathogens, leading to fruit rot (EPPO, 2005) and thereby directly reducing crop value.

Since the introduction of *T. absoluta* in the Mediterranean region, several studies have been conducted on the ecology of this pest as well as on its control, and several native natural enemies have been identified as potential biological control agents (Arnó *et al.*, 2009; Cabello *et al.*, 2009a,b; Nannini, 2009; Arnó & Gabarra, 2010; Desneux *et al.*, 2010; Loni *et al.*, 2011). Past research and experience with alien species invasions suggest that invaders are likely to attract natural enemies over time (Nash *et al.*, 1995; Vercher *et al.*, 2005). However, in the case of *T. absoluta*, limited data is available on the natural levels of biological control in open-field environments and the expected reduction in yield loss.

Pests such as *T. absoluta*, which have a short generation time and high biotic potential, are at increased risk of developing resistance to insecticide use. The use of a limited number of insecticides is proving to be an unsustainable management option in South America, where insecticide resistance has been recorded for several products. Resistance to abamectin, cartap, methamidophos and permethrin has been reported from Brazil (Siqueira *et al.*, 2000a,b, 2001). Resistance to abamectin, deltamethrin and methamidophos was also detected in Argentina (Lietti *et al.*, 2005), and resistance to organophosphates and pyrethroid insecticides has been reported in Chile (Salazar & Araya, 1997, 2001). A recent study on resistance to 10 different insecticides in Brazilian populations of *T. absoluta* found that resistance prevails for insecticides commonly employed in open fields, and that weather conditions and spatial dependence play an important role in favouring resistance to some insecticides (Silva *et al.*, 2011).

Even though the ecology of the pest is well known, limited data is available on management practices in open-field cultivations to control yield loss from this newly introduced invasive species. On the other hand, several (integrated) pest management strategies have been developed for the protection of glasshouse tomatoes. This study aims to provide a clearer picture of the status of this pest within the region, and to identify spatial and temporal trends relating to its distribution, associated fruit damage, and concurrent pest management strategies applied by farmers within the area. Field surveys were conducted in order to measure the intensity of *T. absoluta* attacks in open-field cultivations of conventional and organic processing tomatoes in Tuscany, Italy.

Methodology

Sampling sites and open-field tomato cultivations

Processing tomatoes are an important crop in Tuscany, and are the most important horticultural crop in terms of cultivated surface area within the province of Grosseto, where the field surveys in organically and conventionally managed fields were carried out (Fig. 1). Tomato cultivations represent a relatively important source of income for farmers in the area. Whilst land cover of cultivated horticultural crops has steadily decreased in Grosseto (Bonari *et al.*, 2009), the surface area under tomato cultivation, tomatoes for fresh consumption and processing tomatoes, has increased (Fig. 2). The total surface area under tomato cultivation in the province of Grosseto was more than 2000 ha for 2010, and may provide an important habitat and food resources for all life stages of *T. absoluta*. Yield data for Grosseto suggests a relatively important decrease in tomato yield for 2010, immediately after the introduction of *T. absoluta* within the region (Fig. 2).

Fig. 1 Monitoring sites for *T. absoluta* in Tuscany, Italy (different symbols indicate different monitoring surveys for conventional (triangles) and organic (open circles) fields in Grosseto, and adult monitoring using pheromone lures in Pisa (filled circles) (Source map: http://d-maps.com/m/toscane/toscane30.gif).

Monitoring of *T. absoluta* adults using pheromone lures

The dynamics of adult populations of *T. absoluta* were monitored by placing three pheromone lures (Isagro Italia, 0.5 mg) within a 2.5 ha experimental field transplanted with organic processing tomatoes at the Interdepartmental Centre for Agroenvironmental Research 'E. Avanzi' of the University of Pisa (lat. 43°40′ N, long. 10°19′ E). Pheromone lures were set when the crop initiated formation of the first green fruits, and sampling continued until harvest. The traps were monitored weekly and a count of the total number of *T. absoluta* adults was recorded on each occasion. A generalized linear model (GLM), using a quasi-Poisson distribution, was performed on this count data. The quasi-likelihood (or quasi-Poisson) model introduces a dispersion parameter to the Poisson model, which corrects standard errors to the level of overdispersion. Data was analysed using R version 2.11.1 (R Development Core Team, 2010).

Larval stage activity in conventionally managed fields

An assessment of crop damage was performed in eight conventionally managed processing tomato fields, four in the growing seasons of 2010 and four in 2011. All fields were situated within the province of Grosseto. Because transplant dates for the crop differed among fields, ranging from April to June, fruit damage analyses were timed to the phenology of the crop, and were carried out 7–14 days before harvest. Fruit damage was measured on a grid containing 15 (fields with surface area >1.5 ha) and nine (fields with surface area <1.5 ha) georeferenced 1 m^2 quadrats in 2010, and a grid of 12 sampling quadrats was used for all sampled fields during 2011. Typical fruit damage by *T. absoluta* consists of small galleries which may be contaminated with black frass. Any part of the tomato fruits can be affected, although there may be a preference for the area beneath the calyx (Arnó & Gabarra, 2010). During a time interval of 5 min, fruits in the quadrat were observed, and the number of fruits with galleries (yield loss) and the number of galleries per fruit (fruit damage) were recorded as an indication of larval stage activity. A GLM with a quasi-Poisson distribution was used to investigate the influence of temporal variance, in terms of year and harvest period, on the intensity of *T. absoluta* attack.

Larval stage activity in organically managed fields

In a separate study, leaf and fruit damage by *T. absoluta* larvae were monitored in a 60-point sampling grid per field. Two surveys of four organically managed fields were carried out between June and August 2011. During these surveys, *T. absoluta* larval gallery abundance on two upper-canopy

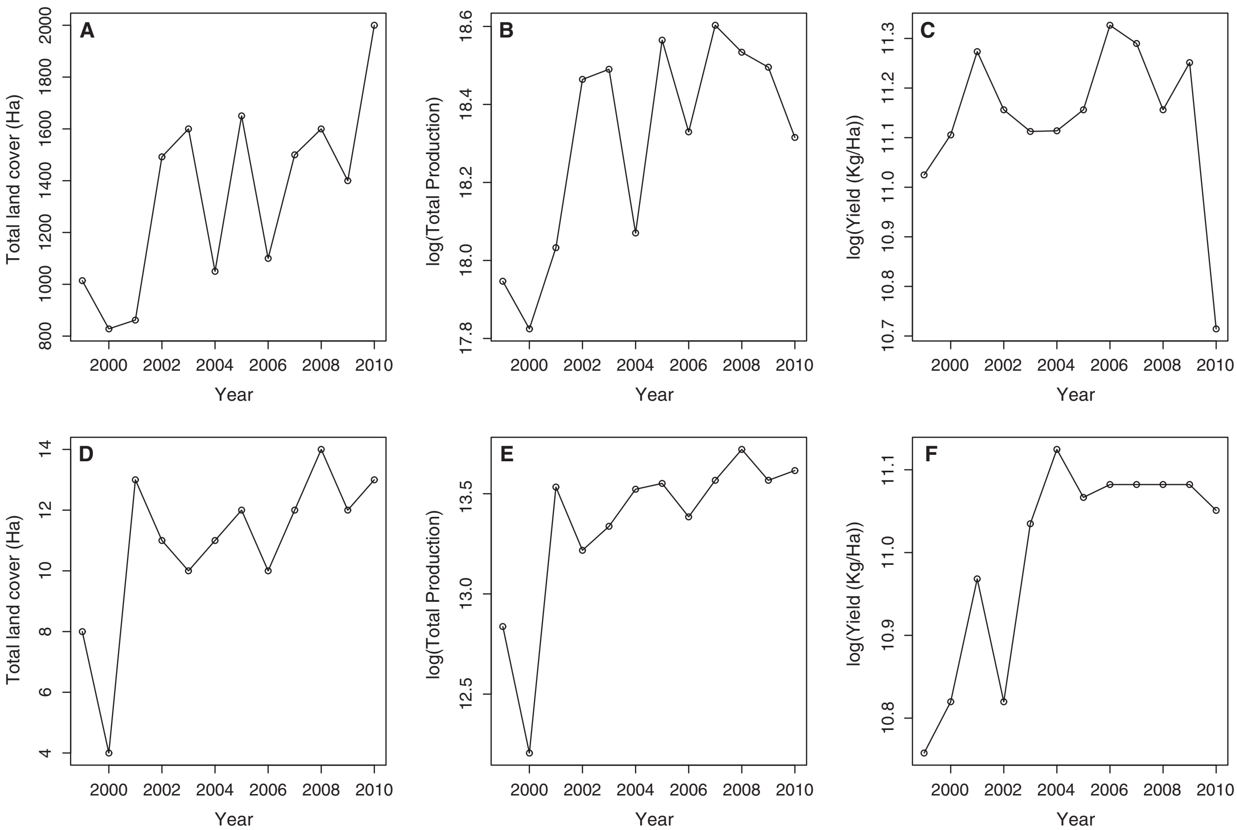

Fig. 2 Current trends in total land cover, production and yield per unit area for cultivations of processing tomatoes (A–C) and tomatoes for fresh consumption (D–F) in the province of Grosseto (elaborated from ISTAT data).

tomato leaves and five fruits were measured from each grid point. A Kruskal–Wallis test was subsequently used to give an indication of variability between the fields. Finally, a GLM using a quasi-Poisson distribution was used to determine the relationships between observed larval activity in foliage and number of galleries in fruit. The choice to use a different method to measure fruit damage in organic fields meant that a direct comparison could not be made between conventional and organic fields. However, this was chosen to examine the relationship between *T. absoluta* damage intensity in foliage and direct yield loss arising from within-fruit galleries.

Identification of farmers' pest management strategies

Current pest management practices were determined for eight conventionally managed fields from four farms, through semi-open interviews completed with pesticide records for 2010. Questions were also directed to provide an indication of farmers' perceptions and knowledge, decision-making indicators related to if and when pest management strategies are necessary, and the application of non-chemical pest management strategies. Pest management practices were also recorded for the four organic farms surveyed in 2011.

Results

Monitoring of *T. absoluta* adults using pheromone lures

Weekly data for adult *T. absoluta* captured through the use of pheromone lures shows an exponential increase in population size (Fig. 3), starting off from a count of fewer than 10 adults per trap per week from the beginning of June to mid-July, and increasing throughout the remaining weeks up to the first week of September, when counts reached an average of 105 adults per trap per week, just before crop harvest.

Larval stages activity in conventionally managed fields

Tuta absoluta was recorded in nearly all fields surveyed, except for fields with tomatoes harvested early in the growing season (June–July) during 2011. Larval activity, indicated by the number of galleries per 1 m^2 quadrat, varied considerably with harvest period and between the 2 years in the survey, and was always higher during 2010 (Table 1). During 2011, fruit damage caused by *T. absoluta* larval stages was particularly low, with an average of 3.4 galleries per m^2 and a mean yield loss of only 1.8 tomatoes per m^2, with no records of *T. absoluta* in fields

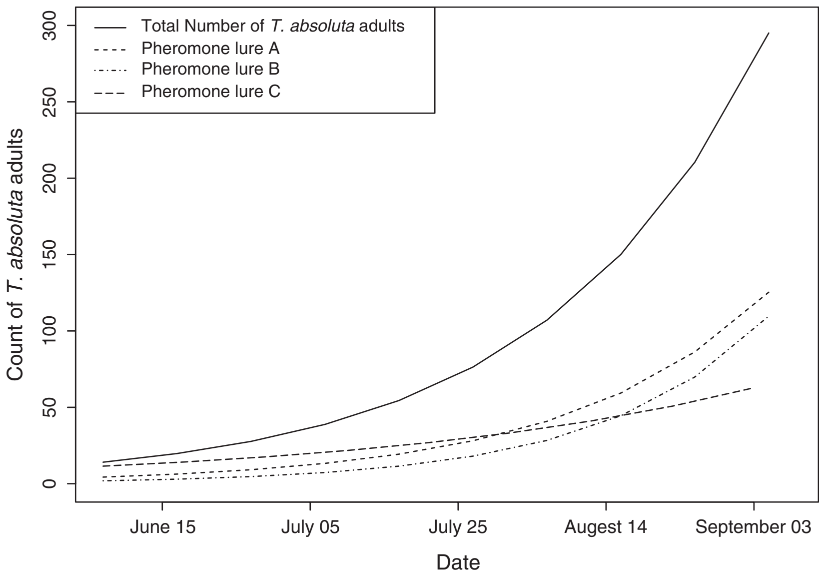

Fig. 3 Generalized linear models for population growth of *T. absoluta* adults in three pheromone lure traps in an organically managed field in Pisa, Italy ($P < 0.05$).

Table 1 Number of fields in which *T. absoluta* was recorded and corresponding average (±SD) of larval *T. absoluta* galleries per standardized quadrat observed for 5 min according to harvest period and year

	2010		2011	
Harvest	Number of fields (*T. absoluta*)	Average number of galleries per m^2 ± SD	Number of fields (*T. absoluta*)	Average number of galleries per m^2 ± SD
Early	2	0.73 ± 1.57 a	0	0 ± 0.00 a
Late	2	28.97 ± 45.52 b	2	6.83 ± 9.79 b

Values for each column followed by different letters are significantly different (Kruskal–Wallis test, $P < 0.05$).

harvested relatively early in the season and larval gallery abundance for tomatoes harvested in September significantly lower than that for 2010 (Table 1). These results are confirmed by the GLM, which indicates that both harvest period ($t = 3.65$, $P = 0.0004$; df = 1) and year ($t = -3.53$, $P = 0.0006$; df = 1) significantly influenced pest damage.

Larval stages activity in organically managed fields

Tuta absoluta larval damage in organic cultivations within the province of Grosseto was rather low throughout the whole growing season, with an average of 0.05 galleries per leaf and 0.007 galleries per fruit. The fruit damage level was not different in early- and late-transplanted fields. While some statistical variability (Table 2) may be observed between different organic tomato fields, results also showed that in 2011, abundance of *T. absoluta* larval galleries remained rather low throughout the season. Gallery density was always higher in leaves compared with fruit. However, a GLM relating average number of galleries per tomato leaf to those in fruits was not significant ($n = 480$, $t = 0.560$, $P = 0.576$).

Table 2 Larval activity of *T. absoluta* in organically managed fields in Grosseto (Italy)

Field (harvest)	Average number of galleries per leaf ± SD	Average number of galleries per fruit ± SD
A (early)	0.025 ± 0.143 b	0.007 ± 0.052 ab
B (late)	0.075 ± 0.289 ab	0.020 ± 0.088 a
C (early)	0.117 ± 0.282 a	0 ± 0.00 b
D (late)	0.025 ± 0.110 b	0 ± 0.00 b

Values for each column followed by different letters are significantly different using a Kruskal–Wallis test on galleries per leaf ($H' = 8.22$, df = 3, $P = 0.042$) and galleries per fruit ($H' = 6.07$, df = 3, $P = 0.107$) data.

Identification of farmers' pest management strategies

Pest management strategies applied by farmers of the organically managed fields were collected. Fields A and B belonged to the same farm, and in both fields pest management strategies were based mainly on application of *Bacillus thuringiensis* (Berliner) approximately every 14 days. Field A was planted early in the season, and pesticides (Table 3) were applied once a fortnight, starting about

Table 3 Pest management in organic cultivations of tomato in Grosseto, Italy

Field	Applied treatment	Type	Number of applications
A	Copper hydroxide	Fungicide	1
	Copper sulphate	Fungicide	3
	Sulphur	Fungicide	4
	Bacillus thuringiensis	Insecticide	3
B	Copper sulphate	Fungicide	4
	Sulphur	Fungicide	4
	Bacillus thuringiensis	Insecticide	4
C	Copper hydroxide	Fungicide	4
	Pyrethrine	Insecticide	1

30 days after tomato transplantation. Application of *B. thuringiensis* for field B, which was planted relatively late in the season (mid-June), was started soon after planting, and pesticide application was terminated in mid-August (3–4 weeks before harvest). Relatively limited inputs were applied to field C, where a pyrethrine-based insecticide was applied only once. No information was obtained for field D.

In the conventionally managed farms, interviews were conducted with four farmers who altogether managed a total of 291 ha dedicated to tomato cultivations during the 2010 growing season. Pest management strategies were based largely on chemical applications (Table 4). Insecticide treatments targeted at controlling *T. absoluta* and other lepidopteran pests (Noctuidae: Heliothinae) were mostly calendar-based, normally starting off 15–25 days after transplant date. Use of pheromone lures and other monitoring strategies appeared to be rather low, not only for the management of *T. absoluta* but also for other pests (e.g. Noctuidae).

Habitat management strategies, which aim to provide sites and resources for antagonist species, are widely recognized as important in pest management. Such management strategies aimed at the control of exotic pest species similar to *T. absoluta* have recently been reviewed (Jonsson *et al.*, 2010). This study reviewed farmer's knowledge and perceptions of habitat management for pest control in tomato cultivations. Farmers confirmed that weed and herbaceous species in uncultivated within-field areas, such as field edges, are normally controlled through chemical and mechanical measures. This could partially be a result of the apparently prevailing perception that these areas may harbour several pests for the crop. While most of the farmers mentioned that plant species other than tomato could act as host plants for *T. absoluta*, only one farmer rightly identified *Solanum nigrum* (L.) as an alternative host plant for *T. absoluta.* Nevertheless, the frequent nature of ecological disturbances (such as frequent pesticide application) which characterize cultivations of processing tomato within the study site, are likely to compromise biological control.

Discussion

The GLM for adult captures by the use of pheromone lure analysis showed that populations of *T. absoluta* have a relatively uncontrolled exponential growth throughout the warmer months, and reach relatively high counts towards the end of the growing season. This confirms the tendency for fruit harvested later in the season to be attacked by this pest. Moreover, *T. absoluta* damage varied significantly between the two years, with a lower level of galleries/fruit recorded in the second year of the study. This may indicate a higher level of pest control within the area of study, or less favourable climatic conditions for pest outbreak. The low level of pest attack and fruit damage was also observed in organically managed processing tomatoes in 2011. Data from the conventionally managed fields shows that the temporal variability of *T. absoluta* populations should be taken into consideration when developing pest management strategies. However, it was surprising that no correlation was detected between leaf gallery densities and fruit damage in organically managed fields. This may be due to the low, and therefore more random, pest attack in 2011, or may indicate more effective pest control by antagonists in crop areas where the *T. absoluta* attack on leaves is higher.

Pest management practices in Grosseto province remain largely based on chemical inputs and make relatively little use of biological control interventions from the wide range of antagonists which have been identified since the recent introduction of this pest within the region. Heavy pesticide use is likely to result in resistance development in *T. absoluta* and may also cause a multitude of undesired effects on non-target organisms (Table 5).

Desneux *et al.* (2010) pointed out that an effective integrated pest management (IPM) strategy should be based on rigorous sampling protocols that combine pheromone trapping to monitor adult abundance with direct yield loss observations. The authors suggest that once *T. absoluta* appears in pheromone traps, preventive measures such as *B. thuringiensis* should be initiated and could even be integrated with predator and/or parasitoid releases. Curative treatments with approved insecticides are suggested only in the case that *T. absoluta* outbreak levels are recorded (Desneux *et al.*, 2010). Results from organic fields from this study (Table 2) indicate that while fruit damage from *T. absoluta* was low throughout all study sites, field C registered significantly the highest level of larval gallery abundance compared with fields A and B, where pest management was based on calendar treatments of *B. thuringiensis*. Field C had received only one application of pyrethrine throughout the life cycle of the crop.

Current biological pest management strategies for *T. absoluta* have so far relied on the introduction of natural enemies to an attacked site. A complementary approach would be the adoption of farm management practices that enhance on-farm habitats (such as overwintering sites, oviposition sites and shelter) and resource availability (such as

Table 4 Pest management strategies and decision-making indicators reported by farmers in conventionally managed tomato cultivations in Grosseto, Italy

Farm	A	B	C	D
Land cover dedicated to processing tomato cultivation	150 ha	35 ha	102 ha	2 ha
Pheromone lures for Noctuidae	Y	N	Y	N
Pheromone lures for *T. absoluta*	N	N	N	N
Insecticide (against *T. absoluta* and Noctuidae) frequency	Visual yield loss observations/ noctuid traps (threshold 7–8 individuals/trap)	Calendar-based treatments	Calendar-based treatments	Calendar-based treatments
Insecticides targeted at *T. absoluta* and other lepidopteran pests (Active ingredients)	Deltamethrin; Lambda-cyhalothrin (30 days after transplant)	Deltamethrin (every 15 days, starting 20–25 days after transplant); lambda-cyhalothrin (three times)	Indoxacarb (once, at about 45 days after planting); lambda-cyhalothrin (three times, starting from approx. 40 days from planting)	Indoxacarb; Spinosad (every 7 days, repeat five times, starting with development of first fruits)
Other insecticides	Imidacloprid (twice, starting 30 days after planting, repeated 20 days later)	Imidacloprid (once, 20–25 days after planting)	Imidacloprid (once 35 days after tomato planting)	Thiamethoxam (soon after tomato planting)
Fungicides (active ingredients)	Mancozeb & metalaxyl-M (every 15–20 days, applied three times, starting 30 days after planting); copper hydroxide (three times, every 15–20 days)	Mancozeb & metalaxyl-M (every 12–15 days, from about 20–25 days after planting); copper hydroxide (twice)	Cimoxanil & fosetyl aluminium & mancozeb (twice, 25 days after planting, 3 weeks distance); sulphur (twice); metaloxil & copper hydroxide (twice, starting 35 days after planting, 7 days distance); copper sulphate (twice)	Mancozeb & metalaxyl-M; copper hydroxide (every 7 days; alternating)
Herbicides	Nicolsulfuron & rimsulfuron; metribuzin (twice, starting 10 days after treatment)	Nicolsulfuron & rimsulfuron; metribuzin (twice, starting 10 days after treatment)	Nicolsulfuron & rimsulfuron; metribuzin (weekly four times, starting 7 days after planting)	Glyphosate (once, pre-planting of crop)
Other host plants of *T. absoluta*	*Solanum nigrum*	No	Yes (but unable to name them)	Yes (mainly found in tomato crop)
Habitat management (perceptions)	Uncultivated areas and field edges provide habitat for pest species	Uncultivated areas and field edges provide habitat for pest species	Uncultivated areas and field edges provide habitat for pest species	Uncultivated areas and field edges provide habitat for pest species
Habitat management (techniques)	Mechanical	Mechanical and chemical	Mechanical and chemical	Mechanical and chemical

Table 5 Side effects of pesticides used in conventional (and organic*) cultivations in Grosseto (Italy) on selected taxa of natural enemies and their toxicity to humans, IOBC (field and semi-field) classification

		Side effects of pesticides used on:							
Active substance	Type	Predatory mites (*Typhlodromus pyri)*	Predatory mites (*Phytoseiulus persimilis*)	Spiders (*Pardosa* spp.)	Flower bugs (*Anthocoris nemoralis*)	Coccinelidae (*Coccinella septempunctata*)	Parasitoids (*Aphidius rhopalosiphi*)	Parasitoids (*Trichogramma cacoeciae*)	WHO toxicity class
Fosetyl-Al	F	N	N		M	N	N	M	U
Mancozeb	F	T	T		M	N	N	T	U
Glyphosate	H	M	M		N		N	M	U
Deltamethrin	I	T	T		T	T		T	II
Imidacloprid	I	N	N	T	T	T	T	T	II
Indoxacarb	I	N	N		M	M		M	III
Lambda-cyhalothrin	I	T	T	T	T	T		T	II
Pyrethrine*	I	N			M			M	II

Elaborated from data in Boller *et al.*, 2005.
Type: F, fungicide; I, insecticide; H, herbicide.Side effects: N, harmless or slightly harmful (reduction <50%); M, moderately harmful (reduction 51–75%); T, harmful (reduction >75%).World Health Organization (WHO) toxicity classes: U, unlikely to present acute hazard in normal use; III, slightly hazardous; II, moderately hazardous).

alternative hosts or prey, and plant-derived resources such as floral and extra-floral nectar, pollen and seeds) for natural enemies in order to enhance conservation biological control (Rusch *et al.*, 2010). These habitats can be established within the cropped field and in the surrounding field margins. Several groups of the identified natural enemies for this pest show life-history (e.g. Ichneumonoidea and Formicidae), temporal (e.g. Ichneumonoidea, Araneae) and permanent (Acari, Miridae, Anthocoridae, Geocoridae, Coccinelidae, Carabidae) omnivory (Wäckers & van Rijn, 2005), and would therefore benefit from such on-farm improvements. During this study, the authors have investigated farmers' perceptions of the ecology of *T. absoluta* and the importance of within-field habitats for the control of this pest. None of the farmers identified uncultivated areas as an important source of antagonist species, and most related these sites as a source of host plants for *T. absoluta* (and other pests). Habitat manipulation that aims at conserving antagonist species could potentially contribute to safer and more effective control of invasive pests (Jonsson *et al.*, 2010). Ongoing research by the authors is focusing on these aspects related to conservation biological control for *T. absoluta* and other pests in processing tomatoes.

Conclusion

Current management strategies aimed at the control of *T. absoluta* and other pests of tomato in open-field cultivations have so far relied on calendar-based application of a wide range of pesticides. Hardly any pest monitoring techniques are used in the study area to adjust pesticide applications. These frequent ecological disturbances are likely to compromise biological control services and make agroecosystems less resistant to invasions, such as that by *T. absoluta* currently being recorded, thereby rendering these systems dependent on external inputs. A shift from current pest management strategies is thus necessary, and is required according to current European legislation [Regulation (EC) No 1107/2009]. An IPM strategy that adopts a holistic approach at the agroecosystem level, rather than concurrent piecemeal pesticide applications, is likely to enhance the control of *T. absoluta and* other pests, such as the several Noctuidae species, which also cause considerable yield loss within these agroecosystems.

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Stratégies de gestion pour limiter les dégâts dus à *Tuta absoluta* (Lepidoptera: Gelechiidae) en cultures de tomates de plein champ destinées à la transformation en Toscane (Italie)

Depuis sa récente introduction dans la région méditerranéenne, *Tuta absoluta* (Meyrick) est devenu un ravageur important largement répandu dans l'ensemble de la région, notamment en Toscane où il a été signalé pour la première fois en 2009. Bien que plusieurs études aient été menées dans des environnements contrôlés sur l'écologie et la gestion de *T. absoluta*, peu d'informations sont actuellement disponibles sur l'importance de ce ravageur dans les cultures de plein champ, ce qui peut conduire à des

stratégies de lutte inefficaces. Cette étude a été réalisée pour surveiller les fluctuations dans les populations adultes de *T. absoluta* dans les cultures biologiques et conventionnelles de tomates de transformation en utilisant des phéromones et pour recueillir des données interannuelles sur les pertes de rendement directes et les dégâts aux fruits dus à l'alimentation des larves dans deux essais distincts à Grosseto (Toscane). Le premier essai comprenait huit champs gérés de façon conventionnelle et le second a été réalisé dans quatre champs en agriculture biologique. Les résultats montrent des dégâts aux cultures relativement plus élevés pour les tomates transplantées plus tard dans la saison et récoltées entre fin août à début septembre, et des dommages aux fruits limités au cours de la deuxième année de l'étude à la fois pour les champs conventionnels et biologiques. Enfin, les stratégies de lutte biologique ou chimique contre *T. absoluta* adoptées par les producteurs dans la région sont étudiées et discutées.

Стратегии управления для борьбы с *Tuta absoluta* (Lepidoptera: Gelechiidae), ущерб, наносимый в открытом грунте томатам, предназначенным для переработки, в Тоскане (Италия)

Начиная с ее недавней интродукции в зону Средиземноморья *Tuta absoluta* (Meyrick) стала широко распространенным и серьезным вредным организмом во всем регионе, включая Тоскану, где она была впервые зарегистрирована в 2009 г. Несмотря на то, что несколько исследований было проведено в управляемых условиях по экологии и управлению *T. absoluta*, в настоящее время имеется лишь ограниченная информация о значимости этого вредного организма в условиях открытого грунта, что не всегда может приводить к выбору эффективных стратегий управления. Исследование было проведено на основе двух отдельных опытов в Гроссето (Тоскана), чтобы проследить колебания взрослых популяций *T. absoluta* при экологически чистом и обычном возделывании томатов, предназначенных для переработки, используя при этом феромонные приманки, а также чтобы собрать сопоставимые по годам данные в отношении прямого снижения урожайности и повреждения плодов в результате питания личинок. Первый опыт включал восемь традиционно управляемых полей, в то время как второй проводился на четырех полях с экологически чистым методом управления. Результаты показывают сравнительно более высокий ущерб, наносимый урожайности томатов, пересаживаемых в конце сезона и собираемых в конце августа-начале сентября, и ограниченное повреждение плодов этим вредным организмом в течение второго года исследовалось как для обычных полей, так и для полей с экологически чистым управлением. И, наконец, в статье рассматриваются биологические и химические стратегии борьбы с *T. absoluta,* принятые фермерами в этом регионе.

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