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SCIENTIFIC OPINION

Scientific Opinion on the pest categorisation of *Helicoverpa armigera* (Hübner)[1]

EFSA Panel on Plant Health (PLH)[2,3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

The Panel on Plant Health undertook a pest categorisation of *Helicoverpa armigera* for the European Union territory. The taxonomy of *H. armigera* and related species worldwide is complex but, in Europe, only *H. armigera* is present. Although it has been recorded in all Member States, it persists throughout the year only in the southernmost parts of Europe where winters are not too cold. From these areas and from North Africa, long-distance northward migrations of up to 1 000 km can occur. In most of Europe, only transient populations are found outdoors. Nevertheless, damage to outdoor crops has been recorded as far north as the Netherlands. *H. armigera* also damages crops produced under protected conditions, with outbreaks related to the import of plants for planting. It is highly polyphagous, with over 180 host species recorded from more than 45 families, and it is particularly hard to detect and difficult to control because the larvae bore into reproductive structures with few visible external symptoms. Damage is especially severe in hot summers. Insecticide resistance is common and a wide range of insecticides may be applied. It is listed in Annex IIAII, and special requirements for *H. armigera* are formulated in Annexes IVAI and IVAII of Council Directive 2000/29/EC to regulate the movement of plants for planting of Solanaceae and three ornamental genera.

KEY WORDS

maize, migrant, polyphagous, quarantine pest, regulated non-quarantine pest, RNQP, tomato

[1] On request from the European Commission, Question No EFSA-Q-2014-00270, adopted on 09 September 2014.

[2] Panel members: Richard Baker, Claude Bragard, Thierry Candresse, Gianni Gilioli, Jean-Claude Grégoire, Imre Holb, Michael John Jeger, Olia Evtimova Karadjova, Christer Magnusson, David Makowski, Charles Manceau, Maria Navajas, Trond Rafoss, Vittorio Rossi, Jan Schans, Gritta Schrader, Gregor Urek, Irene Vloutoglou, Wopke van der Werf and Stephan Winter. Correspondence: alpha@efsa.europa.eu

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The current European Union plant health regime is established by Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (OJ L 169, 10.7.2000, p. 1).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants and plant products and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union, the list of harmful organisms whose introduction into or spread within the Union is prohibited and the control measures to be carried out at the outer border of the Union on arrival of plants and plant products.

The Commission is currently carrying out a revision of the regulatory status of organisms listed in the Annexes of Directive 2000/29/EC. This revision targets mainly organisms which are already locally present in the EU territory and that in many cases are regulated in the EU since a long time. Therefore it is considered to be appropriate to evaluate whether these organisms still deserve to remain regulated under Council Directive 2000/29/EC, or whether, if appropriate, they should be regulated in the context of the marketing of plant propagation material, or be deregulated. The revision of the regulatory status of these organisms is also in line with the outcome of the recent evaluation of the EU Plant Health Regime, which called for a modernisation of the system through more focus on prevention and better risk targeting (prioritisation).

In order to carry out this evaluation, a recent pest risk analysis is needed which takes into account the latest scientific and technical knowledge on these organisms, including data on their agronomic and environmental impact, as well as their present distribution in the EU territory. In this context, EFSA has already been asked to prepare risk assessments for some organisms listed in Annex IIAII. The current request concerns 23 additional organisms listed in Annex II, Part A, Section II as well as five organisms listed in Annex I, Part A, Section I, one listed in Annex I, Part A, Section II and nine organisms listed in Annex II, Part A, Section I of Council Directive 2000/29/EC. The organisms in question are the following:

Organisms listed in Annex II, Part A, Section II:

- *Ditylenchus destructor* Thome
- *Circulifer haematoceps*
- *Circulifer tenellus*
- *Helicoverpa armigera* (Hübner)
- *Radopholus similis* (Cobb) Thome (could be addressed together with the IIAI organism *Radopholus citrophilus* Huettel Dickson and Kaplan)
- *Paysandisia archon* (Burmeister)
- *Clavibacter michiganensis* spp. *insidiosus* (McCulloch) Davis *et al.*
- *Erwinia amylovora* (Burr.) Winsl. *et al.* (also listed in Annex IIB)
- *Pseudomonas syringae* pv. *persicae* (Prunier *et al.*) Young *et al.*
- *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye
- *Xanthomonas campestris* pv. *pruni* (Smith) Dye
- *Xylophilus ampelinus* (Panagopoulos) Willems *et al.*
- *Ceratocystis fimbriata* f. sp. *platani* Walter (also listed in Annex IIB)
- *Cryphonectria parasitica* (Murrill) Barr (also listed in Annex IIB)
- *Phoma tracheiphila* (Petri) Kanchaveli and Gikashvili
- *Verticillium albo-atrum* Reinke and Berthold
- *Verticillium dahliae* Klebahn
- Beet leaf curl virus
- Citrus tristeza virus (European isolates) (also listed in Annex IIB)
- Grapevine flavescence dorée MLO (also listed in Annex IIB)

- Potato stolbur mycoplasma
- *Spiroplasma citri* Saglio *et al.*
- Tomato yellow leaf curl virus

Organisms listed in Annex I, Part A, Section I:

- *Rhagoletis cingulata* (Loew)
- *Rhagoletis ribicola* Doane
- Strawberry vein banding virus
- Strawberry latent C virus
- Elm phloem necrosis mycoplasm

Organisms listed in Annex I, Part A, Section II:

- *Spodoptera littoralis* (Boisd.)

Organisms listed in Annex II, Part A, Section I:

- *Aculops fuchsiae* Keifer
- *Aonidiella citrina* Coquillet
- Prunus necrotic ringspot virus
- Cherry leafroll virus
- *Radopholus citrophilus* Huettel Dickson and Kaplan (could be addressed together with IIAII organism *Radopholus similis* (Cobb) Thome
- *Scirtothrips dorsalis* Hendel
- *Atropellis* spp.
- *Eotetranychus lewisi* McGregor
- *Diaporthe vaccinii* Shaer.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) No 178/2002, to provide a pest risk assessment of *Ditylenchus destructor* Thome, *Circulifer haematoceps, Circulifer tenellus, Helicoverpa armigera* (Hübner), *Radopholus similis* (Cobb) Thome, *Paysandisia archon* (Burmeister), *Clavibacter michiganensis* spp. *insidiosus* (McCulloch) Davis *et al, Erwinia amylovora* (Burr.) Winsl. *et al, Pseudomonas syringae pv. persicae* (Prunier *et al)* Young *et al. Xanthomonas campestris* pv. *phaseoli* (Smith) Dye, *Xanthomonas campestris* pv. *pruni* (Smith) Dye, *Xyîophilus ampelinus* (Panagopoulos) Willems *et al, Ceratocystis fimbriata* f. sp. *platani* Walter, *Cryphonectria parasitica* (Murrill) Barr, *Phoma tracheiphila* (Petri) Kanchaveli and Gikashvili, *Verticillium alboatrum* Reinke and Berthold, *Verticillium dahliae* Klebahn, Beet leaf curl virus, Citrus tristeza virus (European isolates), Grapevine flavescence dorée MLO, Potato stolbur mycoplasma, *Spiroplasma citri* Saglio *et al,,* Tomato yellow leaf curl virus, *Rhagoletis cingulata* (Loew), *Rhagoletis ribicola* Doane, Strawberry vein banding virus, Strawberry latent C virus, Elm phloem necrosis mycoplasma, *Spodoptera littoralis* (Boisd.), *Aculops fuchsiae* Keifer, *Aonidiella citrina* Coquillet, Prunus necrotic ringspot virus, Cherry leafroll virus, *Radopholus citrophilus* Huettel Dickson and Kaplan (to address with the IIAII *Radopholus similis* (Cobb) Thome), *Scirtothrips dorsalis* Hendel, *Atropellis* spp., *Eotetranychus lewisi* McGregor and *Diaporthe vaccinii* Shaer., for the EU territory.

In line with the experience gained with the previous two batches of pest risk assessments of organisms listed in Annex II, Part A, Section II, requested to EFSA, and in order to further streamline the preparation of risk assessments for regulated pests, the work should be split in two stages, each with a specific output. EFSA is requested to prepare and deliver first a pest categorisation for each of these 38 regulated pests (step 1). Upon receipt and analysis of this output, the Commission will inform EFSA for which organisms it is necessary to complete the pest risk assessment, to identify risk reduction options and to provide an assessment of the effectiveness of current EU phytosanitary requirements (step 2). *Clavibacter michiganensis* spp. *michiganensis* (Smith) Davis *et al.* and

Xanthomonas campestris pv. *vesicatoria* (Doidge) Dye, from the second batch of risk assessment requests for Annex IIAII organisms requested to EFSA (ARES(2012)880155), could be used as pilot cases for this approach, given that the working group for the preparation of their pest risk assessments has been constituted and it is currently dealing with the step 1 "pest categorisation". This proposed modification of previous request would allow a rapid delivery by EFSA by May 2014 of the first two outputs for step 1 "pest categorisation", that could be used as pilot case for this request and obtain a prompt feedback on its fitness for purpose from the risk manager's point of view.

As indicated in previous requests of risk assessments for regulated pests, in order to target its level of detail to the needs of the risk manager, and thereby to rationalise the resources used for their preparation and to speed up their delivery, for the preparation of the pest categorisations EFSA is requested, in order to define the potential for establishment, spread and impact in the risk assessment area, to concentrate in particular on the analysis of the present distribution of the organism in comparison with the distribution of the main hosts and on the analysis of the observed impacts of the organism in the risk assessment area.

ASSESSMENT

1. Introduction

1.1. Purpose

This document presents a pest categorisation prepared by the European Food Safety Authority (EFSA) Scientific Panel on Plant Health (hereinafter referred to as the Panel) for the species *Helicoverpa armigera* (Hübner) in response to a request from the European Commission.

1.2. Scope

The pest categorisation area for *H. armigera* is the territory of the European Union (hereinafter referred to as the EU) with 28 Member States (hereinafter referred to as MSs), restricted to the area of application of Council Directive 2000/29/EC, which excludes Ceuta and Melilla, the Canary Islands and the French overseas departments.

2. Methodology and data

2.1. Methodology

The Panel performed the pest categorisation for *H. armigera* following guiding principles and steps presented in the EFSA Guidance on the harmonised framework for pest risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures (ISPM) No 11 (FAO, 2013) and ISPM No 21 (FAO, 2004).

In accordance with the Guidance on a harmonised framework for pest risk assessment (PRA) in the EU (EFSA PLH Panel, 2010), this work was initiated as a result of the review or revision of phytosanitary policies and priorities. As explained in the background of the European Commission request, the objective of this mandate is to provide updated scientific advice to European risk managers to take into consideration when evaluating whether those organisms listed in the annexes of Directive 2000/29/EC deserve to remain regulated under Council Directive 2000/29/EC, or whether they should be regulated in the context of the marketing of plant propagation material, or should be deregulated. Therefore, to facilitate the decision-making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for a quarantine pest in accordance with ISPM 11 (FAO, 2013) but also for a regulated non-quarantine pest in accordance with ISPM 21 (FAO, 2004) and includes additional information required as per the specific terms of reference received by the EC. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 1 below presents the ISPM 11 (FAO, 2013) and ISPM 21 (FAO, 2004) pest categorisation criteria on which the Panel bases its conclusions. It should be noted that the Panel's conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation[4]); therefore, instead of determining whether the pest is likely to have an unacceptable impact, the Panel will present a summary of the observed pest impacts. Economic impacts are expressed in terms of yield and quality losses and not in monetary terms, in agreement with the Guidance on a harmonised framework for pest risk assessment (EFSA PLH Panel, 2010).

[4] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31/1, 1.2.2002, p. 1–24.

Table 1: International Standards for Phytosanitary Measures ISPM 11 (FAO, 2013) and ISPM 21 (FAO, 2004) pest categorisation criteria under evaluation

Pest categorisation criteria	ISPM 11 for being a potential quarantine pest	ISPM 21 for being a potential Regulated Non-Quarantine Pest (RNQP)
Identity of the pest	The identity of the pest should be clearly defined to ensure that the assessment is being performed on a distinct organism, and that biological and other information used in the assessment is relevant to the organism in question. If this is not possible because the causal agent of particular symptoms has not yet been fully identified, then it should have been shown to produce consistent symptoms and to be transmissible	The identity of the pest is clearly defined
Presence or absence in the PRA area	The pest should be **absent from all or a defined part of the PRA area**	The pest is **present** in the PRA area
Regulatory status	If the pest is present but not widely distributed in the PRA area, it should be under official control or expected to be under official control in the near future	The pest is under official control (or being considered for official control) in the PRA area with respect to the specified plants for planting
Potential for establishment and spread in the PRA area	The PRA area should have ecological/climatic conditions including those in protected conditions suitable for the establishment and spread of the pest and, where relevant, host species (or near relatives), alternate hosts and vectors should be present in the PRA area	–
Association of the pest with the plants for planting and the effect on their intended use	–	Plants for planting are a pathway for introduction and spread of this pest
Potential for consequences (including environmental consequences) in the PRA area	There should be clear indications that the pest is likely to have an unacceptable economic impact (including environmental impact) in the PRA area	–
Indication of impact(s) of the pest on the intended use of the plants for planting	–	The pest may cause severe economic impact on the intended use of the plants for planting
Conclusion	If it has been determined that the pest has the potential to be a quarantine pest, the PRA process should continue. If a pest does not fulfil all of the criteria for a quarantine pest, the PRA process for that pest may stop. In the absence of sufficient information, the uncertainties should be identified and the PRA process should continue	If a pest does not fulfil all the criteria for a regulated non-quarantine pest, the PRA process may stop

In addition, in order to reply to the specific questions listed in the terms of reference, three issues are specifically discussed only for pests already present in the EU: the analysis of the present EU distribution of the organism in comparison with the EU distribution of the main hosts; the analysis of the observed impacts of the organism in the EU; and the pest control and cultural measures currently implemented in the EU.

The Panel will not indicate in its conclusions of the pest categorisation whether the pest risk assessment process should be continued, as it is clearly stated in the terms of reference that, at the end of the pest categorisation, the European Commission will indicate to EFSA if further risk assessment work is required following its analysis of the Panel's scientific opinion.

2.2. Data

2.2.1. Literature search

A literature search on *H. armigera* was conducted at the beginning of the mandate. The search was conducted for the synonyms of the scientific name of the pest together with the most frequently used common names on the ISI Web of Knowledge database, CAB Abstracts and web based search engines such as Google scholar. Further references and information were obtained from experts, from citations within the references and from grey literature. The datasheet on *H. armigera* provided by the PERSEUS project was also used as a source of references (PERSEUS, in preparation).

2.2.2. Data collection

To complement the information concerning the current situation of the pest provided by the literature and online databases on pest distribution, damage and management, the PLH Panel sent a short questionnaire on the current situation at country level, based on the information available in the European and Mediterranean Plant Protection Organization (EPPO) Plant Quarantine Retrieval (PQR) system, to the National Plant Protection Organisation (NPPO) contacts of the 28 EU Member States, and of Iceland and Norway. Iceland and Norway are part of the European Free Trade Association (EFTA) and are contributing to EFSA data collection activities, as part of the agreements EFSA has with these two countries. A summary of the pest status based on EPPO PQR and NPPO replies is presented in Table 2.

In its analyses the Panel also considered the Pest Risk Analysis prepared by the Dutch Plant Protection Service (NL) and Central Science Laboratory (UK) for *H. armigera* (Lammers and MacLeod, 2007).

3. Pest categorisation

3.1. Identity and biology of *Helicoverpa armigera*

3.1.1. Taxonomy

The organism under assessment currently has the following valid scientific name:

Name: *Helicoverpa armigera* (Hübner, 1809).

Prior to a review by Hardwick (1965), the two species *H. armigera* and *H. zea* were not recognised as separate species and, therefore, earlier literature has to be carefully interpreted. Although Hardwick (1965) found that *H. armigera* is a group composed of two species, one of these, *H. helenae*, is confined to the small Atlantic island of St. Helena. One specimen was reared from tomato fruit, but there is no additional information on the host range (Hardwick, 1965). Hardwick also states that there are three subspecies of *H. armigera*. *H. armigera commoni* is known only from Canton Island in the central Pacific, but no information on its host range could be found in the literature. *H. armigera conferta* occurs in Australia, Eastern Indonesia, New Guinea and several islands in the Pacific. Matthews (1999) lists the host plants of *H. armigera conferta* in Australia, showing that it is highly polyphagous, attacking 131 species or genera from 34 families. Even though *H. armigera armigera* is the principal subspecies and the most important pest worldwide, the subspecies name is rarely used and the literature, e.g. the CABI (2014) datasheet, just refers to *H. armigera*. Determination keys have been developed to identify adults (e.g. Matthews, 1999; EPPO, 2003), but larvae are much more difficult to distinguish. Gilligan and Passoa (2014) have recently provided a practical interpretation of the taxonomy as an aid to identifying larval interceptions and this can also be used to help interpret the literature (Passoa, 2014). In summary, in the Old World, especially Europe and North Africa, only *H. armigera armigera* is found. However, confusion is possible in China owing to *H. assulta*, in Australia and New Zealand owing to *H. punctigera* and in central Africa owing to closely related species of *H. armigera*. Hybridisation can also occur (Wang and Dong, 2001). In the New World, *H. armigera* is present in Brazil, where larvae can only be distinguished reliably from those of *H. zea* by molecular methods (Tay et al., 2013). *H. armigera* has recently been reported from Paraguay and Argentina (EPPO, 2014).

Synonyms: Amongst its synonyms mentioned by CABI (2014) and Sullivan and Molet (2014), *Heliothis armigera* Hübner, was used in the early versions of the EU Plant Health Directive (Council Directive 2000/29/EC[5]).

Taxonomic position: Insecta, Lepidoptera, Noctuidae.

Most applied common names: Corn earworm, cotton bollworm, gram pod borer, scarce bordered straw, tobacco budworm (English), noctuelle des tomates, ver de la capsule (French), Altweltlicher Baumwollkapselwurm (German), elotide del pomodoro, nottua gialla del granturco (Italian), gusano bellotero del algodón, gusano de la cápsula, oruga de las cápsulas del algodón (Spanish).

3.1.2. *Helicoverpa armigera* biology

The literature on *H. armigera* biology is extensive, although, as noted above, the taxonomic complexity of the species implies that reports from some areas must be treated with caution. Since several detailed descriptions of *H. armigera* biology are available (Venette et al., 2003; Lammers and MacLeod, 2007; CABI, 2014; Sullivan and Molet, 2014), only those issues that relate to factors of particular relevance to the situation in the EU are summarised here.

In tropical areas, breeding is continuous, with up to 11 generations per year, but only two to five generations occur in the subtropics and temperate regions.

Diapause is induced by the decline in day length (from approximately 13 to 11 hours per day) and in temperatures (from approximately 24 to 15 °C). The variation in diapause response both within and between years seems to be related to differences in temperature and photoperiod, as observed in Japan, Australia and Israel (Mironidis et al., 2010).

Worldwide, *H. armigera* cannot survive winter north of 40° latitude and seasonal populations are sustained by immigration (Hardwick, 1965).

Eggs are laid singly on a wide variety of host plants, usually in the upper half of plants on or near floral structures. Plants that are in flower, hairy and tall are more attractive for oviposition (Sullivan and Molet, 2014). During the oviposition period, which lasts 5–24 days, a female can lay over 3 000 eggs (CABI and EPPO, 1990), but 700–2 200 is the average total fecundity rate observed from females emerging from larvae feeding on different hosts (Razmjou et al., 2014). Eggs hatch in about three days at 25 °C, but take up to 11 days at lower temperatures (Venette et al., 2003).

Larvae have five to seven instars, with the development time depending on temperature and the nutritional quality of the host. An optimum temperature for development of 33.9 °C has been recorded,

[5] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169/1, 10.7.2000, p. 1–112.

though larval survival was greatest at 24 °C (Twine, 1978). Venette et al. (2003) provides a table summarising the different development thresholds and degree-day requirements recorded in the literature and notes that a standard threshold of 11 °C has been determined, although strong winds and heavy rainfall can also affect larval survival. When food is scarce they can move from plant to plant (Venette et al., 2003; CABI, 2014).

Pupation occurs in the soil at a depth of 2.5 to 15.5 cm, but pupae may occasionally be found in leaf litter or on the plant (CABI, 2014).

Adults are nocturnal and, depending on food, pupal weight, temperature and activity, can live for up to 20 days (for males) and 18 days (for females) under laboratory conditions (Razmjou et al., 2014). Females emerge one to two weeks before males (Izquierdo and Millan, 1994). *H. armigera* males are attracted to females by pheromones, released two to five days after emergence. Many components have been identified, but a combination of two of them ((Z)-11-hexadecenal and (Z)-9-hexadecenal) is sufficient to trap a significant number of males (Liu et al., 2013).

3.1.3. Intraspecific diversity

The taxonomic complexity is discussed in section 3.1.1.

3.1.4. Detection and identification of *Helicoverpa armigera*

Gilligan and Passoa (2014) provide detailed guidance on the identification of larvae. Matthews (1999) gives a detailed description of the adults. Further details are given in section 3.1.1.

Funnel and sleeve pheromone traps are efficient methods of detecting adult males (e.g. Rai et al., 2000). Light trapping is also effective in providing a detailed picture of annual immigration in northern Europe (Ma et al., 2010; Puskas and Nowinszky, 2011).

Mitochondrial DNA markers have been used to estimate genetic diversity (Tan et al., 2001; Vijaykumar et al., 2008) and Orui et al. (2000) surveyed the occurrence of *H. armigera* in Japan using polymerase chain reaction–restriction fragment length polymorphism (PCR-RFLP) analysis.

Developing stages are difficult to detect because the eggs are very small (0.4–0.6 mm) and, although the larvae may be visible on the surface of the plant, they often bore into the reproductive structures with little external signs apart from the entrance hole and frass. Pupae may be hidden in the soil, e.a. with plants for planting. Although surveys can be targeted to the parts of plants preferred for oviposition and larval feeding, since eggs and young larvae are very small and the plants often need to be cut open to find larvae, Sullivan and Molet (2014) do not recommend visual inspections as an approved method for the Cooperative Agricultural Pest Survey in the USA.

3.2. Current distribution of *Helicoverpa armigera*

3.2.1. Global distribution of *Helicoverpa armigera*

As shown in Figure 1, the pest is present and widespread in Asia, Africa, Europe and Oceania. However, it is important to note that (i) as summarised in section 3.1, in China, Australia, New Zealand, central Africa and Brazil, populations of *H. armigera* may be confused with related species (Gilligan and Passoa, 2014) and (ii) this map includes countries, such as Finland, where the species is transient. The distribution in the EU is given in section 3.2.2.

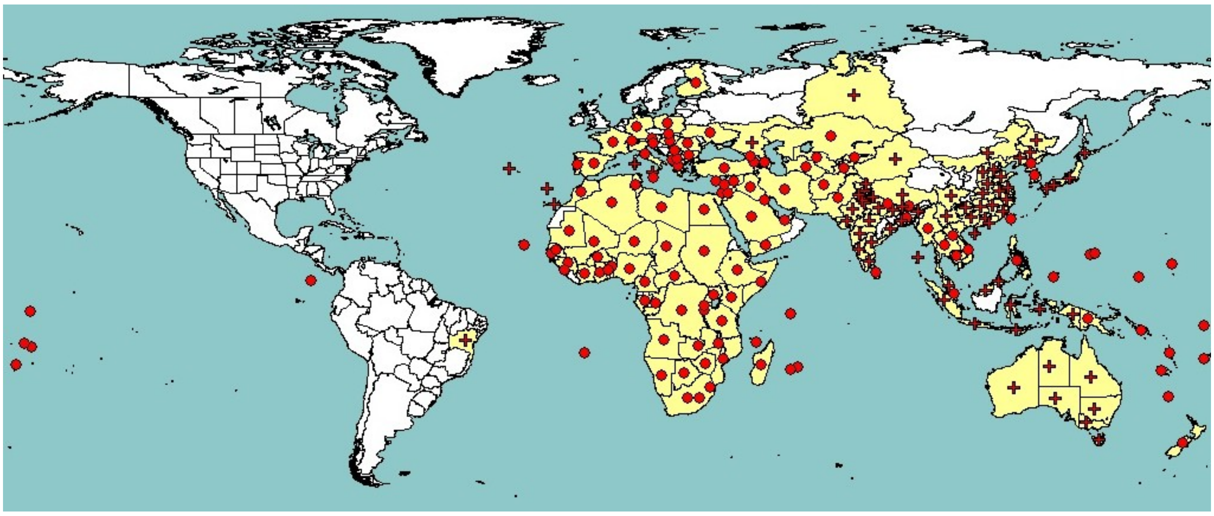

Figure 1: Global distribution of *Helicoverpa armigera* (extracted from EPPO PQR (2014, version 5.3.1), accessed on 25 June 2014). Red circles represent pest presence as national records and red crosses show pest presence as sub-national records

3.2.2. Distribution in the EU of *Helicoverpa armigera*

Table 2: The current distribution of *Helicoverpa armigera* in the EU, Iceland and Norway, based on the answers from the NPPOs, or, in absence of reply, on information from the EPPO PQR and the literature.

Country	NPPO answers on current situation	Other sources
Austria	Present, few occurrences	
Belgium	Transient, non-actionable. Since 2006, some observations outdoors have been reported through citizen science	
Bulgaria	Present, widespread	
Croatia	Present, only in some areas	
Cyprus	Present, widespread	
Czech Republic	Present, seasonally	
Denmark	Absent, intercepted only	
Estonia	Absent: pest eradicated	
Finland	Absent, confirmed by survey	
France	Present, restricted distribution	Established on a restricted area of distribution (EPPO, 2006; Lammers and MacLeod, 2007)
Germany	Present, few occurrences	
Greece	–	Present, widespread (EPPO PQR, 2014)
Hungary	Present, restricted distribution	'The pest occupied 94% of the area of Hungary within eight years' (Keszthelyi et al., 2013)
Ireland	Absent, no pest records	
Italy	Present, widespread in some years, above all in south Italy. Depending on the climatic conditions, damages also in northern Italy both outdoors and indoors	
Latvia		Absent, pest no longer present (EPPO PQR, 2014)
Lithuania	–	

Luxembourg	–	
Malta	Present, restricted distribution	
Netherlands	Absent, pest eradicated (incidental findings), confirmed by survey	
Poland	Present, few occurrences (does not overwinter in open air, so the populations are adventive; also some adults migrate from southern Europe)	
Portugal	Present, widespread	
Romania	–	Present, widespread , Roşca (2009)
Slovakia	Present: seasonally	
Slovenia	Present: seasonally	
Spain	Present	
Sweden	Not known to be established; known as a migrating species of which adults are observed in south-eastern Sweden in only certain years	
United Kingdom	Absent, pest eradicated in protected cultivation; transient outdoors	
Iceland	–	
Norway	–	Absent, pest no longer present (EPPO PQR, 2014)

NPPO, National Plant Protection Organization; EPPO PQR, European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval System.

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

H. armigera:

This species is a regulated harmful organism in the EU and is listed in Council Directive 2000/29/EC in Annex II as follows (see Table 3):

Table 3: *Helicoverpa armigera* in Annex II of Council Directive 2000/29/EC

Annex II, Part A—Harmful organisms whose introduction into, and spread within, all Member States shall be banned if they are present on certain plants or plant products	
Section II—Harmful organisms known to occur in the Community and relevant for the entire Community	
(a) Insects, mites and nematodes, at all stages of their development	
Species	**Subject of contamination**
6.2. *Helicoverpa armigera* (Hübner)	Plants of *Dendranthema* (DC) Des Moul, *Dianthus* L., *Pelargonium* l'Hérit. ex Ait. and of the family Solanaceae, intended for planting, other than seeds

Annex II regulated hosts for *Helicoverpa armigera* in Council Directive 2000/29/EC

H. armigera is a polyphagous pest with over 180 host plant species, and the pest has many more potential hosts than those for which it is regulated in Annex IIAII (see section 3.4.1). In addition, it is important to mention that other specific commodities could also be pathways of introduction of the pest in the risk assessment area. This is the case with soil and growing media, as pupation occurs in the soil.

Below, specific requirements of Annex III, IV and V of the Council Directive 2000/29/EC are presented for only the host plants and commodities regulated for *H. armigera* in Annex IIAII (see Table 4).

Table 4: *Helicoverpa armigera* host plants in Annex III, IV and V of Council Directive 2000/29/EC

Annex III, Part A—Plants, plant products and other objects the introduction of which shall be prohibited in all Member States

Description	Country of origin
10. Tubers of *Solanum tuberosum* L., seed potatoes	Third countries other than Switzerland
11. Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting, other than those tubers of *Solanum tuberosum* L. as specified under Annex III A (10)	Third countries
13. Plants of Solanaceae intended for planting, other than seeds and those items covered by Annex III A (10), (11) or (12)	Third countries, other than European and Mediterranean countries

Annex IV, Part A—Special requirements which must be laid down by all Member States for the introduction and movement of plants, plant products and other objects into and within all Member States

Section I—Plants, plant products and other objects originating outside the Community

Plants, plant products and other objects	Special requirements
27.1. Plants of *Dendranthema* (DC) Des Moul., *Dianthus* L. and *Pelargonium* l'Hérit. ex Ait., intended for planting, other than seeds	Official statement that: (a) no signs of *Helicoverpa armigera* (Hübner), or *Spodoptera littoralis* (Boisd.) have been observed at the place of production since the beginning of the last complete cycle of vegetation or (b) the plants have undergone appropriate treatment to protect them from the said organisms.

Section II—Plants, plant products and other objects originating in the Community

Plants, plant products and other objects	Special requirements
20. Plants of *Dendranthema* (DC) Des Moul., *Dianthus* L. and *Pelargonium* l'Hérit, ex Ait. intended for planting, other than seeds	Official statement that: (a) no signs of *Helicoverpa armigera* (Hübner) or *Spodoptera littoralis* (Boisd.) have been observed at the place of production since the beginning of the last complete cycle of vegetation; or

Annex V—Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community—in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community

Part A—Plants, plant products and other objects originating in the Community
Section I—Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport
1. Plants and plant products
1.3. Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting
2. Plants, plant products and other objects produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer, and for which it is ensured by the responsible official bodies of the Member States, that the production thereof is clearly separate from that of other products
2.1. Plants intended for planting other than seeds of the genera [...], *Dendranthema* (DC) Des Moul., *Dianthus* L. [...], and other plants of herbaceous species, other than plants of the family Gramineae, intended for planting, and other than bulbs, corms, rhizomes, seeds and tubers
2.2. Plants of Solanaceae, other than those referred to in point 1.3 intended for planting, other than seeds
Part B—Plants, plant products and other objects originating in territories, other than those territories referred to in Part A
Section I—Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community
2. Parts of plants, other than fruits and seeds of: — [...], *Dendranthema* (DC) Des. Moul., *Dianthus* L., [...], *Pelargonium* l'Hérit. ex Ait, [...],
3. Fruits of: — [...] and *Solanum melongena* L.

3.3.2. Marketing directives

Host plants of *H. armigera* that are regulated in Annex IIAII of council Directive 2000/29/EC are explicitly mentioned in the following Marketing Directives:

- Council Directive 2008/72/EC[6]: […] *Solanum melongena* […];
- Council Directive 98/56/EC[7]: *Dendranthema*, *Dianthus*, *Pelargonium*;
- Council Directive 2002/56/EC[8]: *Solanum tuberosum*.

3.4. Elements to assess the potential for establishment and spread in the EU

3.4.1. Host range

Helicoverpa armigera is extremely polyphagous and has been recorded on over 180 hosts (wild and cultivated) in over 45 plant families (Venette et al., 2003). CABI (2014) and Sullivan and Molet

[6] Council Directive 2008/72/EC of 15 July 2008 on the marketing of vegetable propagating and planting material, other than seed. OJ L 205/28, 1.8.2008, p. 28–39.
[7] Council Directive 98/56/EC of 20 July 1998 on the marketing of propagating material of ornamental plants. OJ L 226/16, 13.8.98, p. 16–23.
[8] Council Directive 2002/56/EC of 13 June 2002 on the marketing of seed potatoes. OJ L 193/60, 20.7.2002, p. 60–73.

(2014) both provide lists of hosts with references. The principal host crops grown in Europe are the following:

(i) regulated hosts for the insect in AIIAII in 2000/29/EC are plants of *Dendranthema*, *Dianthus* L. and *Pelargonium*, and plants of the family Solanaceae;

(ii) hosts in the EPPO PQR database (EPPO PQR, 2014) include *Cicer arietinum*, *Citrus* sp., *Glycine max*, *Gossypium* sp., *Helianthus annuus*, *Medicago sativa*, *Nicotiana tabacum*, *Phaseolus* spp., *Prunus* sp., *Solanum lycopersicum*, *Solanum melongena*, *Solanum tuberosum*, *Sorghum bicolour*, *Zea mays* and *Capsicum annuum*.

3.4.2. EU distribution of main host plants

Hosts are ubiquitous both outdoors and in protected cultivation.

3.4.3. Analysis of the potential distribution of *Helicoverpa armigera* in the EU

Hosts are available throughout the EU in the field, in protected cultivation and as wild species, but the pest can only overwinter in the southernmost parts of the EU, where the winters are relatively warm (see section 3.1.1). The maximum northernmost overwintering limit of 40 ° latitude indicated by Hardwick (1965) in Europe includes central Portugal, central Spain, central Sardinia, southern Italy and northern Greece. *H. armigera* may aestivate in very hot, dry climates, but this is unlikely to be required in Europe where many of its host plants are irrigated.

In southern Europe and other Mediterranean countries, two to four generations per year have been observed (Carter, 1984). In southern Bulgaria, there are two generations per year with a partial third generation and, in southern France, three generations are possible (CABI, 2014). In Romania, three larval generations have been observed, but successful completion of the third generation was not recorded (Pălăgeşiu and Crista, 2008). In Spain, two or three generations have been observed, depending on the zone and the crop. In northern Greece, *H. armigera* completes three or four generations per year (Mironidis et al., 2010). The same authors also found that part of the population is killed in winter because the larvae pupate but do not go through diapause or are killed by cold weather while they are still larvae. In the autumn, populations are also constrained by the lack of suitable food plants; thus, in northern Greece, cotton is the only plant available in late autumn. They also concluded that the established local diapausing population is supplemented each year by new migration events (Mironidis et al., 2010).

In conclusion, continuous breeding occurs in the EU in only southernmost areas with relatively mild winters where the pest overwinters as diapausing pupae.

3.4.4. Spread capacity

Long-distance seasonal movements from low to higher latitudes, usually with warm winds preceding cold fronts, are most common in summer, and adults may migrate up to 1 000 km and reach Britain and other parts of Europe from sources in southern Europe and North Africa (Pedgley, 1985). However, Sullivan and Molet (2014), when summarising the literature on migratory flights, stated that the maximum migration distance is 250 km. In the UK, although adults have been found from March to November, the peak arrival time is September to October (Heath and Maitland Emmet, 1983). In Northern Ireland, they are recorded from July to October, which is when they are attracted to light and *Hedera helix* blossom (Thompson and Nelson, 2003). Migrating *H. armigera* have been recorded as far north as Sweden, Finland and Estonia, but there are very few records of the successful completion of one generation in northern Europe. Pedgley (1986) considered that, because *H. armigera* adults are caught in Cyprus during winter months, when the local populations are likely to be in diapause, there is evidence that this species also undergoes winter migration in the Middle East with the aid of south-eastern winds. Zhou et al. (2000) found that populations in Turkey and Israel (and a small sample from Egypt and Ethiopia) were very similar genetically, implying a high level of gene flow caused by migration. Migration is facultative and occurs in response to local crop and climatic conditions (Fitt and Cotter, 2004) and the distances and directions travelled depend on various factors including the weather (Fitt, 1989). Non-migratory flights up to 10 km have been recorded (Sullivan and Molet, 2014).

Eggs and larvae can readily be transported with plants for planting, cut flowers and vegetables and many interceptions have been made on all three commodity types (Lammers and MacLeod, 2007; EUROPHYT database consulted in July, 2014).

Although it is suspected that climate change may play a role in allowing both established and transient populations to spread northwards, there is no clear evidence that, in recent years, the pest has extended its range in Europe (Lammers and MacLeod, 2007). In northern Europe, outbreaks have occurred in protected cultivations from imports of plants from southern Europe and third countries (see section 3.5.2).

3.5. Elements to assess the potential for consequences in the EU

3.5.1. Potential effects of *Helicoverpa armigera*

H. armigera is a major field and horticultural crop pest in many parts of the world (Fitt, 1989) and, in Australia, it is considered to be one of the most important agricultural pests (Sullivan and Molet, 2014). The larvae of this pest feed on leaves, buds and flowers, developing pods, fruits and seeds, with a preference for the reproductive parts of the plant. The damage results from the holes bored into the reproductive structures, which may lead to secondary infection by plant pathogens, and from the feeding within the plant. On maize, eggs are laid on the silks and the larvae invade the cobs and consume the developing grain; on tomato, young fruit are attacked and fall, with larger larvae boring into older fruit; and, on cotton, flower buds, leaves, shoots and bolls are attacked (Sullivan and Molet, 2014). Since *H. armigera* females lay their eggs individually, spacing them evenly on the plant and moving to other hosts when the population density becomes very high (Guoqing et al., 2001), a small number of larvae can damage many crop plants. Its pest potential is further exacerbated by its very wide host range, its high fecundity, its ability to migrate long distances, its capacity for facultative diapause, the difficulty of detection and its resistance to many insecticides.

3.5.2. Observed impact of *Helicoverpa armigera* in the EU

Pest damage in the EU has been reported in three situations: (i) protected cultivation, initiated by trade, (ii) outdoor crops, caused by immigration, and (iii) outdoor crops, where the established diapausing population is supplemented by migrants. Only a few outbreaks in protected cultivation have been reported. Damage to outdoor crops varies from year to year and from location to location, but it is more severe in very hot summers. Over-wintering survival also varies from year to year, blurring the distinction between situations (ii) and (iii). Examples are provided below for each of the three situations in the EU.

Damage to protected cultivations has been reported from the Czech Republic, Germany, the Netherlands and the UK. In 2012, one larva was found on a *Pelargonium* potted plant in a Dutch glasshouse and several plants showed damage symptoms. The Dutch NPPO stated that, "in recent years, similar findings have been recorded in the Netherlands linked to the import of cuttings from third countries, and all have been successfully eradicated" (EPPO, 2012). In the UK, it is reported that *H. armigera* larvae are often found in rooted *Pelargonium* cuttings or on growing chrysanthemum plants (Lammers and MacLeod, 2007). The damage is generally minor and restricted to a few plants. Prior to detection, extensive damage has been recorded in chrysanthemums, but insecticide applications, the removal of larvae and the destruction of damaged plants are effective in eradicating outbreaks. In the German federal state of Baden-Württemberg, *H. armigera* was found on cultivations under protected conditions (EPPO, 2004a). Carnation and tomato glasshouse crops in southern Moravia (Czech Republic) were infested. Although damage to carnations was not significant, up to 5 % of the tomato crops were affected (Marek and Navrátilová, 1995). In Italy, indoor crops may also be damaged (Sannino et al., 2006).

Transient outbreaks outdoors caused by immigration have been reported in Germany, France, Hungary, the Netherlands, Austria and Romania. In 2006, one larva was found in a *Phaseolus vulgaris* crop in Zuid-Holland (the Netherlands) and the crop was destroyed (EPPO, 2006). In 2003, chemical treatments and movement restrictions were applied to 90 ha of *P. vulgaris* in Gänserndorf (Niederösterrich), the north-easternmost state in Austria, following detection of the pest, even though no visible damage was observed (EPPO, 2004b). Also in Austria, at Steiermark (Feldbach District), chemical treatments were applied to a population feeding on tomatoes in a private garden in 2004 (EPPO, 2004c). In the very hot summer of 2003, extensive outbreaks were reported in Germany, France, Italy and Hungary. In Germany, severe damage to many crops occurred, including vegetable crops, maize, oil seed rape, tobacco, rose and chrysanthemum in Baden-Württemberg, Bodensee, Upper Rhine and Karlsruhe/Mannheim (EPPO, 2004a). Also in 2003, over 800 ha of land were abandoned in the southwest of France. The second generation caused some damage to maize and beans but the third generation was particularly damaging, with up to 150 individuals per m^2 attacking not only maize and beans, but also young carrots, tobacco and other crops. It was found throughout the country, even north of 45 °. In the departments of Loire Atlantique and Beauce, bean fields were infested. A partial fourth generation was also observed (Buès et al., 2004). Also in 2003, a severe infestation of sunflowers was reported in Hungary. In total, 64.4 % of the sunflower heads were infested with over five larvae per head in Kecskemét and Bácsalmás (Horvath et al., 2004). In Romania, losses to maize have been reported throughout the country, particularly on the Danube plain in the south of the country. In maize, the larvae attack both leaves and the cob, and the larvae, together with the associated frass, are reported to increase the amount of mycotoxins (Roşca, 2010).

In southern areas of Greece, Spain and Italy (and possibly France), outdoor crops are damaged by the established diapausing population supplemented by migrants. In Italy, *H. armigera* is an important horticultural pest on many crops, but particularly tomato. In 1996, high infestation levels were observed on tomatoes in Sicily, causing economic losses (Pinto et al., 1997). In 2003, owing to the extremely hot temperatures, particularly serious losses to many field and glasshouse crops occurred throughout Italy. For example, in the Basilicata Region, 30 % of the pepper fruits produced in the Metapontino area were damaged, and, in Grosseto (Tuscany), the heavy infestations on tomatoes required weekly treatments with pyrethroids until November (Sannino et al., 2004). Attacks on herbaceous crops were also observed in northern Italy, e.g. on soybean in the Friuli-Venezia Giulia region in 2007 (ERSA, 2014).

H. armigera is predominantly a pest of outdoor tomato crops in Portugal and Spain (Lammers and MacLeod, 2007), particularly those intended for processing (Arnó et al., 1999). It is estimated that 60 % of the tomato fruit may be affected (Montmany, 1993). In western Andalusia, it is considered to be the main pest of cotton (Sánchez et al., 2000). It may be also be found on maize and sorghum, strawberries, chickpeas, alfalfa, green beans, artichokes, onions, peppers, potatoes, cucumbers, lettuce, carnations, tobacco, citrus fruits and other ornamental (e.g. *Lonicera japonica*, *Rosa* spp., *Hibiscus rosa-sinensis*) and horticultural crops (Izquierdo, 1994; Sánchez et al., 2000). Mejías et al. (1998) observed that up to 4 % of chickpea sheaths were infested over two consecutive years on 13 parcels.

In the Larissa Plain of northern Greece, *H. armigera* is the major insect pest of cotton (Mironidis et al., 2010, 2012). It is also a serious pest of tomato and maize, but not in all areas or every year. In 2011 in central Greece, the damage to cotton was very high, possibly owing to the use of non-selective insecticides and a non-effective monitoring system. In tomatoes for processing, *H. armigera* is also a major threat and is considered to be the most important pest. It is most likely that it develops on maize and lucerne early in the season, with tomato being the main host for the second generation. The population may then move to cotton because it is the only crop left in most of the Larissa Plain and it is considered that the established population is supplemented by extensive immigration (Mironidis et al., 2010; D. Perdikis, personal communication, July 2014, Faculty of Crop Science, University of Athens, Athens, Greece).

3.6. Currently applied control methods in the EU

This pest is generally difficult to control because the larvae are protected within the host, it has developed resistance to many active ingredients and it is highly polyphagous. Its polyphagy allows it to find a wide range of food sources throughout the year, so that specific control protocols have to be applied to various crops.

Chemical, biological and cultural methods are applied to control *H. armigera* in the EU, as summarised below.

Many active ingredients are used against *H. armigera* in the EU, as listed in national and regional protocols (e.g. Registro de Productos Fitosanitarios, Ministerio de Agricultura, Alimentación y Medio Ambiente, España (MAGRAMA, 2014), Regional Agriculture Departments for Italy, Ministry of Rural Development and Food of Hellenic Republic for Greece). These include benzoylureas (e.g. lufenuron), oxadiazines (e.g. indoxacarb), pyrethroids (e.g. bifenthrin, cypermethrin, deltamethrin, etofenprox, lambda-cyhalothrin), pyrazoles, spinosyns, carbamates (e.g. methomyl), organophosphates (e.g. chlorpyrifos), semicarbazones (e.g. metaflumizone), moulting hormone agonists (e.g. methoxyfenozide), and other compounds derived from bacteria (e.g. abamectin), fungi (e.g. emamectin) and plants (e.g. azadirachtin). Furthermore, *Bacillus thuringiensis* and nucleopolyhedrovirus are also used against this pest.

For biological control, both parasitoids and predators are used. These include *Orius* spp. (predator), *Nabis* spp. (predator), *Chrysoperla carnea* (larval predator), *Trichogramma* sp. (egg parasitoid; Izquierdo et al., 1994; Sánchez et al., 2000), *Macrolophus caliginosus* (egg and larval predators; Izquierdo et al., 1994), *Dicyphus tamanini* (eggs and larval predators; Izquierdo et al., 1994), *Cotesia kazak* (endoparasitoid of larvae; Torres Vila et al., 2000a), *Hyposoter didymator* (endoparasitoid of larvae) and *Telenomus* spp. (egg parasitoids; Izquierdo et al., 1994). Laboratory trials of *Bacillus thuringiensis* (Berliner) Cry 1 Ac toxin on the larvae of *H. armigera* are described by Ramos Gutiérrez et al. (2004) and information on its synergic effect with other control methods are provided by Zenas and Crickmore (2012). In addition, pheromone traps are used not only to ensure the accurate timing of insecticides, but also to control the pest by mating disruption.

The cultural methods that are applied include reductions in the application of nitrogen fertilisers, the control of weeds to remove potential pest reservoirs, the selection of resistant crop varieties, and harrowing and ploughing of the soil in order to destroy the pupae or expose them to environmental extremes (Gengotti, 2005).

As mentioned above, one of the principal problems related to the control of *H. armigera* is its capacity to develop resistance, particularly to synthetic pyrethroid insecticides, but also to other insecticides in many of the areas of the world where these have been used. In the EU, insecticide-resistant populations are present in Spain (Torres Vila et al., 2002a,b) and France (Bués et al., 2005). The migration of *H. armigera* has been implicated in the spread of resistance from Spain to southern France (Bués et al., 2005).

Torres Vila et al. (2002b) tested several pyrethroids for resistance in Spain. A substantial inter-strain variation in resistance was evident. Zero, low or moderate insecticide resistance was found in most insecticide–strain combinations. However, high resistance to cypermethrin and deltamethrin and very high resistance to lambda-cyhalothrin and deltamethrin were recorded in four cases, some of which were associated with field control failures. Overall, pyrethroid resistance in *H. armigera* in Spain was not as high or as widespread as situations in other areas of the world (e.g. Central Africa; Achaleke and Brévault, 2010).

In 1995–1998, Torres Vila et al. (2000b) tested several pesticides in Extremadura and Murcia and found resistance to endosulphan, methamidophos, trichlorfon, monocrotophos, carbaryl, fenitrothion, azinphos-methyl, lindane and chlorpyrifos. The authors concluded that the resistance shown by *H. armigera* to such an array of insecticides was related to field control failures.

Mironidis et al. (2012) found that, in Greece, resistance levels were relatively moderate until 2009, with less than a 10-fold resistance ratio to organophosphates and carbamates and up to a 16-fold resistance to the pyrethroid alpha-cypermethrin. However, in 2010, resistance increased 46-fold for chlorpyrifos and 81-fold for alpha-cypermethrin and resurgence in the pest populations was observed.

Buès and Boudinhon (2003) concluded that it is important to choose insecticides carefully and use them alternately. They emphasised the risk of gene dispersion conferring resistance to insecticides as a result of the migratory behaviour of this species.

3.7. Uncertainty

Uncertainty is mainly related to the lack of information from some MSs concerning the current situation related to establishment, impact, control and resistance.

CONCLUSIONS

The Panel summarises in Table 5 below its conclusions on the key elements addressed in this scientific opinion in consideration of the pest categorisation criteria defined in ISPM 11 and ISPM 21 and of the additional questions formulated in the terms of reference.

Table 5: The Panel's conclusions on the pest categorisation criteria defined in the International Standards for Phytosanitary Measures (ISPM) No 11 and No 21 and on the additional questions formulated in the terms of reference

Criterion of pest categorisation	Panel's conclusions on ISPM 11 criteria	Panel's conclusions on ISPM 21 criteria	Uncertainties
Identity of the pest	*Is the identity of the pest clearly defined? Do clearly discriminative detection methods exist for the pest?* Although there is taxonomic complexity in some parts of the world, in Europe and other countries bordering the Mediterranean, *H. armigera* can clearly be distinguished from other species. Globally, the adults can be separated morphologically from related taxa, but molecular methods are required in Brazil and larvae are generally difficult to identify.		The taxonomic complexity worldwide means that care must be taken in interpreting the literature from some areas.
Absence/presence of the pest in the risk assessment area	*Is the pest absent from all or a defined part of the PRA area?* It is established outdoors only in the southernmost areas of the EU. Elsewhere, it is transient, with individuals arriving by immigration and with trade.	*Is the pest present in the PRA area?* It is established outdoors in the southernmost areas of the EU.	Uncertainty exists about where *H. armigera* can establish throughout the year.
Regulatory status	*In consideration that the pest under scrutiny is already regulated mention in which annexes of 2000/29/EC and the marketing directives the pest and associated hosts are listed without further analysis (the RM will have to consider the relevance of the regulation against official control). Indicate whether the hosts and/or commodities for which the pest is regulated in Annex IIAI or II are comprehensive of the host range.* *H. armigera* is listed in Annex IIAII of Council Directive 2000/29/EC to regulate the movement of three ornamental genera (*Dendranthema*, *Dianthus* and *Pelargonium*) and Solanaceae plants for planting, excluding seeds. Special requirements for the same three ornamental genera with respect to *H. armigera* are formulated in Annexes IVAI and IVAII. Host plants intended for planting must be subject to a plant health inspection before entry into or before movement within the EU, according to Annexes VAI and VBI. Hosts of *H. armigera* are included in a large number of measures in both the EU Plant Health and the Marketing Directives. However, *H. armigera* has more potential host plants than the limited number for which it is regulated in AIIAII.		
Potential establishment and spread	*Does the PRA area have ecological conditions (including climate and those in protected conditions) suitable for the establishment and spread of the pest?* *And, where relevant, are host species (or near relatives), alternate hosts and vectors present in the PRA area?* Ecological conditions are suitable only for establishment in the southernmost areas of the EU, although hosts are available throughout the EU.	*Are plants for planting a pathway for introduction and spread of the pest?* Plants for planting are the most important pathway for the spread of *H. armigera* to protected cultivations. Outdoors, the migration of adult moths is the most important pathway in southern Europe.	Information is missing or not up to date from some MSs.

Criterion of pest categorisation	Panel's conclusions on ISPM 11 criteria	Panel's conclusions on ISPM 21 criteria	Uncertainties
Potential for consequences in the risk assessment area	*What are the potential for consequences in the PRA area?* *Provide a summary of impact in terms of yield and quality losses and environmental consequences.*	*If applicable is there indication of impact(s) of the pest as a result of the intended use of the plants for planting?*	Information is missing or not up to date from some MSs.
	In southern parts of Europe, the pest can be highly damaging to many crops, particularly tomato, maize and cotton. The severity and the extent of the damage varies from year to year, with outbreaks occurring particularly in hot summers. Transient outbreaks can also occur in some years as far north as the Netherlands. Damage to many crops under protected conditions has also been reported. Insecticide resistance is widespread and a large number of compounds may be used for control.	The movement of *H. armigera* with plants for planting is of particular concern to protected cultivations because adults following the other main pathway, migration, are only likely to cause outbreaks in outdoor crops.	
Conclusion on pest categorisation	Under protected cultivation (i.e. greenhouses and crops grown under cover), in northern areas of the EU, this pest it is not widely distributed, causes significant damage and is under official control. In southernmost areas of the EU, it is established outdoors, transient populations may develop from migrating adults as far north as the Netherlands and it is under official control only for plants for planting of a few of its potential hosts.	For protected cultivation, plants for planting are the main source of infestation that results in significant impact. Outdoors, the principal pathway is the movement of migrating adults.	Information is missing or not up to date from some MSs.
Conclusion on specific ToR questions	*If the pest is already present in the EU, provide a brief summary of:* – *the analysis of the present distribution of the organism in comparison with the distribution of the main hosts, and the distribution of hardiness/climate zones, indicating in particular if in the PRA area, the pest is absent from areas where host plants are present and where the ecological conditions (including climate and those in protected conditions) are suitable for its establishment, and* – *the analysis of the observed impacts of the organism in the risk assessment area.*		
	H. armigera is highly polyphagous and its hosts are found outdoors and indoors throughout the EU. However, because it has only a limited capacity to survive cold weather, it is established only in the southernmost parts of the EU. Adults from these areas and from further south (in North Africa) can fly up to 1 000 km northwards, reaching all EU MSs in some years. Transient outdoor populations may occur as far north as the Netherlands, but are particularly numerous in southern Europe and in hot summers. Although damaging pest populations are found in protected cultivations, there are no records of establishment *H. armigera* is an important pest of many crops in southern Europe, particularly tomato, maize and cotton. Population densities and damage vary considerably, primarily depending on summer temperatures. Outbreaks can also occur in crops under protected conditions throughout the EU. It is especially damaging because it feeds on the reproductive structures and bores inside the plant, making it difficult to detect and control. A very large number of insecticides are deployed to control this pest and it is resistant to many compounds.		

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References

Achaleke J and Brévault T, 2010. Inheritance and stability of pyrethroid resistance in the cotton bollworm *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Central Africa. Pest Management Science, 66, 137–141.

Arnó J, Gabarra R, Roig J and Fosch T, 1999. Integrated pest management for processing tomatoes in the Ebro Delta (Spain). ISHS Acta Horticulturae, 487, 207–212.

Buès R, Bouvier JC, Kouassi A-S and Toubon J-F, 2004. La noctuelle *Helicoverpa armigera* (Hübner). Cycle évolutif, dégâts en France en 2003 et résistances aux insecticides. Phytoma, 568, 29–33.

Buès R Bouvier JC and Boudinhon L, 2005. Insecticide resistance and mechanisms of resistance to selected strains of *Helicoverpa armigera* (Lepidoptera: Noctuidae) in the south of France. Crop Protection, 24, 814–820.

CABI (CAB International), 2014. Crop protection compendium. Datasheet on *Helicoverpa armigera*. Date of report: 14 May 2014.

CABI (CAB International) and EPPO (European and Mediterranean Plant Protection Organization), 1990. Data sheets on quarantine pests – *Helicoverpa armigera*. 6 pp.

Carter DJ, 1984. Pest Lepidoptera of Europe with special reference to the British Isles. Dr W. Junk Publishers, Dordrecht, the Netherlands.

EFSA Panel on Plant Health (PLH), 2010. PLH Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options by EFSA. EFSA Journal 2010;8(2):1495, 66 pp. doi:10.2093/j.efsa.2010.1495

EPPO (European and Mediterranean Plant Protection Organization), 2003. Diagnostic protocols for regulated pests. *Helicoverpa armigera* – PM 7/19(1). Bulletin OEPP/EPPO Bulletin, 33, 289–295.

EPPO (European and Mediterranean Plant Protection Organization), 2004a. 2004/013 – Occurrence of *Helicoverpa armigera* in Germany. EPPO Reporting Service, 1, 8.

EPPO (European and Mediterranean Plant Protection Organization), 2004b. 2004/012 – First finding of *Helicoverpa armigera* in Austria. EPPO Reporting Service, 1, 8.

EPPO (European and Mediterranean Plant Protection Organization), 2004c. 2004/135 – *Helicoverpa armigera* found on tomatoes in Austria. EPPO Reporting Service, 9, 7.

EPPO (European and Mediterranean Plant Protection Organization), 2006. 2006/162 – Incursion of *Helicoverpa armigera* in the Netherlands. EPPO Reporting Service, 8, 5.

EPPO (European and Mediterranean Plant Protection Organization), 2012. 2012/072 – Incursion of *Helicoverpa armigera* in the Netherlands. EPPO Reporting Service, 4, 3–4.

EPPO (European and Mediterranean Plant Protection Organization), 2014. 2014/105 – First report of *Helicoverpa armigera* in Paraguay and Argentina. EPPO Reporting Service, 6, 5.

EPPO PQR, 2014, European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval System, version 5.3.1, accessed on 25 June 2014.

ERSA (Agenzia Regionale per lo Sviluppo Rurale), 2014. Nottue defogliatrici su soia. Available online: http://www.ersa.fvg.it/fitosanitaria/colture-erbacee/nottue-defogliatrici-soia/pyrrhia-umbra-su-soia-1

FAO (Food and Agriculture Organization of the United Nations), 2004. ISPM (International standards for phytosanitary measures) 21 – Pest risk analysis of regulated non-quarantine pests. FAO, Rome, Italy, 30 pp. Available from https://www.ippc.int/sites/default/files/documents//1323945746_ISPM_21_2004_En_2011-11-29_Refor.pdf

FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM (International standards for phytosanitary measures) 11 –Pest risk analysis for quarantine pests. FAO, Rome, Italy, 36 pp. Available from https://www.ippc.int/sites/default/files/documents/20140512/ispm_11_2013_en_2014-04-30_201405121523--494.65%20KB.pdf

Fitt GP, 1989. The ecology of *Heliothis* spp. in relation to agroecosystems. Annual Review of Entomology, 34, 17–52.

Fitt GP and Cotter SC, 2004. The *Helicoverpa* problem in Australia. In: *Heliothis*/*Helicoverpa* management: the emerging trends and need for future research. Ed. Sharma HC. CRC Press, Boca Raton, FL, 45–62.

Gengotti S, 2005. Una difesa a basso impatto ambientale. Il Divulgatore, 4, 54–77.

Gilligan TM and Passoa SC, 2014. LepIntercept – An identification resource for intercepted Lepidoptera larvae. *Helicoverpa* Factsheet. Identification Technology Program (ITP), USDA/APHIS/PPQ/S&T, Fort Collins, CO. Available online: http://idtools.org/id/leps/lepintercept/helicoverpa.html

Guoqing L, Zhaojun H, Lili M, Xiaoran Z, Changkun C and Yinchang W, 2001. Natural oviposition-deterring chemicals in female cotton bollworm, *Helicoverpa armigera* (Hübner). Journal of Insect Physiology, 47, 951–956.

Hardwick DF, 1965. The corn earworm complex. Memoirs of the Entomological Society of Canada, 40, 1–247.

Heath J and Maitland Emmet A, 1983. The moths and butterflies of Great Britain and Ireland. Volume 10. Harley Books, Great Horkesley, UK.

Horvath Z, Boros J and Skoric FD, 2004. Damage of sunflower caused by the cotton bollworm (*Helicoverpa armigera*, Hübner) in the region of Kecskemet and Bacsalmas in 2003. Helia, 27, 173–179 (abstract).

Izquierdo JI, 1994. Utilización de feromonas en la predicción fenológica de *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae). PhD Thesis, Escola Tecnica Superior d'Enginyeria Agrària, Universitat de Lleida, Lleida, Spain. 77 pp.

Izquierdo JI and Millan I, 1994. *Helicoverpa armigera* (Hübner) (Lepidoptera. Noctuidae): emergencia primaveral de adultos y capturas en trampas de feromonas. ARXIUS de l'Escuela Superior d'Agricultura, 15, 55–72.

Izquierdo JI, Solans P and Vitalle J, 1994. Parasitoides y depredadores de *Helicoverpa armigera* (Hübner) en cultivos de tomate para consumo en fresco. Boletín de Sanidad Vegetal: Plagas, 20, 521–530.

Lammers W and MacLeod AM, 2007. Report of a Pest Risk Analysis, *Helicoverpa armigera* (Hübner, 1808). Plant Protection Service, the Netherlands, and Central Science Laboratory, United Kingdom, Joint Pest Risk Analysis for *Helicoverpa armígera.* 18 pp.

Liu Y, Liu C, Lin K and Wang G, 2013. Functional specificity of sex pheromone receptors in the cotton bollworm *Helicoverpa armigera*. PLoS ONE, 8, e62094.

Ma J-h, Lu Z-z, Jin X-l, Pan Y-l and Gao G-z, 2010. Comparison of lights and capture efficiency of popular branch bundles for capturing moths of cotton bollworm (*Helicoverpa armigera*). Xinjiang Nongye Kexue, 47, 2023–2026.

MAGRAMA (Ministerio de Agricultura, Alimentación y Medio Ambiente, España), 2014. Registro de Productos Fitosanitarios. Available online: http://www.magrama.gob.es/es/agricultura/temas/sanidad-vegetal/productos-fitosanitarios/fitos.asp

Marek J and Navrátilová M, 1995. A new glasshouse pest, *Helicoverpa armigera* (Noctuidae, Lepidoptera). Ochrana Rostlin, 31, 143–147.

Matthews M, 1999. Heliothine moths of Australia. Monographs on Australian Lepidoptera Volume 7. CSIRO Publishing, Collingwood, Australia, pp. 106–115.

Mejías A, Del Moral J and López-Morillo M, 1998. Captura de adultos de *Helicoverpa armigera* (Hübner) en garbanzales de Extremadura y valoración de las vainas afectadas por el parásito. Boletín de Sanidad Vegetal: Plagas, 24, 829–840.

Mironidis GK, Stamopoulos DC and Savopoulou-Soultani M, 2010. Overwintering survival and spring emergence of *Helicoverpa armigera* (Lepidoptera: Noctuidae) in northern Greece. Environmental Entomology, 39, 1068–1084.

Mironidis GK, Despina Kapantaidaki M, Maria Bentila M, Morou E, Savopoulou-Soultani M and Vontas J, 2012. Resurgence of the cotton bollworm *Helicoverpa armigera* in northern Greece associated with insecticide resistance. Insect Science, 20, 505–512.

Montmany Faura M, 1993. Nivel de daños de *Heliothis Armigera*, en tomate exterior, para el consumo en fresco: Ensayos sobre la eficacia y persistencia en laboratorio de productos insecticidas.Valoraciones económicas de la protección insecticida, sobre un cultivo exterior de tomateras. Treball fi de carrera-Universitat Politècnica de Catalunya. Escola Superior d'Agricultura de Barcelona. Especialitat Hortofructicultura i Jardineria, 243 pp.

Orui Y, Matsuzawa H, Koike Y and Yoshimatsu SI, 2000. Discrimination of *Helicoverpa armigera* (Hübner) and *H. assulta* (Guenee) (Lepidoptera: Noctuidae) by PCR-RFLP analysis, and application to surveying occurrence of *H. armigera* in tobacco fields of Japan. Japanese Journal of Applied Entomology and Zoology, 44, 73–79.

Pălăgeşiu I and Crista N, 2008. Research concerning the biology of the pest *Helicoverpa armigera* Hbn. in maize crops in the western plain conditions. Scientific Papers Faculty of Agriculture, USAMVB, Timişoara, Editura Agroprint, 40, 83–88.

Passoa SC, 2014. Key to the identification of *Helicoverpa armigera* suspects intercepted at U.S. ports of entry, 3 pp. In: LepIntercept, an identification resource for intercepted Lepidoptera larvae. Eds Gilligan TM and Passoa SC. Identification Technology Program (ITP), USDA/APHIS/PPQ/S&T, Fort Collins, CO. Available online: www.lepintercept.org

Pedgley DE, 1985. Windborne migration of *Heliothis armigera* (Hübner) (Lepidoptera: Noctuidae) to the British Isles. Entomologist's Gazette, 36, 15–20.

Pedgley DE, 1986. Windborne migration in the Middle East by the moth *Heliothis armigera* (Hübner) (Lepidoptera: Noctuidae). Ecological Entomology, 11, 467–470.

PERSEUS, in preparation. Plant health pest surveys for the EU territory: an analysis of data quality and methodologies and the resulting uncertainties for pest risk assessment. EFSA Article 36 project by FERA, INRA, JKI and UPAD. Datasheet on *Helicoverpa armigera.*

Pinto ML, Agro A, Salerno G and Peri E, 1997. Serious attacks of the tomato moth *Helicoverpa armigera* (Hübner). Informatore Agrario, 53, 67–69.

Puskas J and Nowinszky L, 2011. Light trapping of the scarce bordered straw (*Helicoverpa armigera* Hbn.) in connection with the ozone content of air. Novenyvdelem, 47, 37–40.

Rai HS, Gupta MP and Verma ML, 2000. Comparative effectiveness of traps for trapping male moths of *Helicoverpa armigera*. Annals of Plant Protection Sciences, 8, 235–236.

Ramos Gutiérrez J, Ortiz JF and Vargas Osuna E, 2004. Susceptibilidad de larvas de *Helicoverpa armigera* (Hübner) y *Earias insulana* (Boisduval) (Lepidoptera: Noctuidae) a la delta-endotoxina CrylAc de *Bacillus thuringiensis* (Berliner). Boletín de Sanidad Vegetal: Plagas, 30, 239–245.

Razmjou J, Naseri B and Hemati SA, 2014. Comparative performance of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on various host plants. Journal of Pest Science, 87, 29–37.

Roşca I, 2009. Preliminary study regarding importance of species *Helicoverpa armigera* Hb. For maize culture in Romania. Scientific Papers, USAMV Bucharest, Series A, Vol. LII, 424–426.

Roşca I, 2010. Research regarding interaction of mon810 biotech corn on the *Helicoverpa armigera* in Romania. Scientific Papers, UASVM Bucharest, Series A, Vol. LIII, 2010, ISSN 1222–5339, 403–411.

Sánchez A, Alvarado M, Durán JM, Ortiz E, De La Rosa A and Serrano A, 2000. Curvas de vuelo de *Helicoverpa armigera* (Hübner, 1808) (Lepidoptera: Noctuidae) en el cultivo del algodonero de Andalucía occidental. Boletín de Sanidad Vegetal: Plagas, 26, 239–247.

Sannino L, Espinosa B, Caponero A and Manucci F, 2004. Infestazioni anomale di lepidotteri su colture erbacee nel 2003. Informatore Fitopatologico, 54, 35–38.

Sannino L, Espinosa B and Cozzolino E, 2006. Fitofagi e predatori riscontrati su tredici colture erbacee in Italia meridionale. Progetto Co.Al.Ta. Available online: http://www1.inea.it/ist/coaltabozza/fitofagi.pdf

Sullivan M and Molet T, 2014. CPHST Pest Datasheet for *Helicoverpa armigera*. USDA-APHIS-PPQ-CPHST. Original: 2007; revised: April 2014, 17 pp.

Tan S, Chen X, Zhang A and Li D, 2001. Isolation and characterization of DNA microsatellite from cotton bollworm (*Helicoverpa armigera*, Hübner). Molecular Ecology Notes, 1, 243–244.

Tay WT, Soria MF, Walsh T, Thomazoni D, Silvie P, Behere GT, Anderson C and Downes S, 2013. A brave New World for an Old World pest: *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Brazil. PLoS ONE, 8, e80134.

Thompson RS and Nelson B, 2003. *Helicoverpa armigera*. In: The butterflies and moths of northern Ireland. Available online: http://www.habitas.org.uk/moths/species.asp?item=6506

Torres Vila LM, Rodríguez Molina MC, del Estal P and Lacasa Plasencia A, 2000a. El complejo parasitario larvario de *Helicoverpa armígera* Hübner sobre tomate en las Vegas del Guadiana (Extremadura). Boletín de Sanidad Vegetal: Plagas, 26, 323–333.

Torres Vila LM, Rodríguez Molina MC, Palo E, Bielza Lino P and Lacasa Plasencia A, 2000b. La resistencia a insecticidas de *Helicoverpa armigera* Hübner en España: datos disponibles. Boletín de Sanidad Vegetal: Plagas, 26, 493–501.

Torres Vila LM, Rodriguez Molina MC, Lacasa Plasencia A and Bielza Lino P, 2002a. Insecticide resistance of *Helicoverpa armigera* to endosulfan, carbamates and organophosphates: the Spanish case. Crop Protection, 21, 1003–1013.

Torres Vila LM, Rodriguez Molina MC, Lacasa Plasencia A, Bielza Lino P and Rodriguez del Rincon A, 2002b. Pyrethroid resistance of *Helicoverpa armigera* in Spain: current status and agroecological perspective. Agriculture Ecosystems and Environment, 93, 55–66.

Twine P, 1978. Effect of temperature on development of larvae and pupae of the corn earworm, *Heliothis armigera* (Hübner) (Lepidoptera: Nocutidae). Queensland Journal of Agricultural and Animal Sciences, 35, 23–28.

Vijaykumar K, Fakrudin B, Krishnareddy KB, Kuruvinashetti MS and Patil BV, 2008. Genetic differentiation among cotton bollworm, *Helicoverpa armigera* (Hübner) populations of south

Indian cotton ecosystems using mitochondrial DNA markers. Italian Journal of Zoology, 75, 437–443.

Venette RC, Davis EE, Zaspelm J, Heisler H and Larson M, 2003. Mini risk assessment – Old World bollworm, *Helicoverpa armigera* Hübner [Lepidoptera: Noctuidae]. CAPS (Cooperative Agricultural Pest Survey), Department of Entomology, University of Minnesota, St Paul, USA. Available online: http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/downloads/pra/harmigerapra.pdf

Wang C and Dong J, 2001. Interspecific hybridization of *Helicoverpa armigera* and *H. assulta* (Lepidoptera: Noctuidae). Chinese Science Bulletin, 46, 490–492.

Zenas G and Crickmore N, 2012. *Bacillus thuringiensis* applications in agriculture. Chapter 2 In: *Bacillus thuringiensis* biotechnology. Ed. Sansinenea E. 19–40.

Zhou X, Faktor O, Applebaum SW and Coll M, 2000. Population structure of the pestiferous moth *Helicoverpa armigera* in the Eastern Mediterranean using RAPD analysis. Heredity, 85, 251–256.

ABBREVIATIONS

EFSA	European Food Safety Authority
EPPO	European and Mediterranean Plant Protection Organization
EPPO-PQR	European and Mediterranean Plant Protection Organization Plant Quarantine Retrieval System
EU	European Union
ISPM	International Standard for Phytosanitary Measures
MS(s)	Member State(s)
NPPO	National Plant Protection Organisation
PLH Panel	Plant Health Panel
PRA	Pest Risk Analysis
RNQP	regulated non-quarantine pest