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Data Sheets on Quarantine Pests

Helicoverpa zea

IDENTITY

Name: *Helicoverpa zea* (Boddie)
Synonyms: *Heliothis zea* (Boddie)
Bombyx obsoleta Fab.
Phalaena zea (Boddie)
Heliothis umbrosus Grote
Taxonomic position: Insecta: Lepidoptera: Noctuidae
Common names: American bollworm, corn earworm, tomato fruitworm, New World bollworm (English)
Chenille des épis du maïs (French)
Amerikanischer Baumwollkapselwurm (German)
Notes on taxonomy and nomenclature: The taxonomic situation is complicated and presents several problems. Hardwick (1965) reviewed the New World corn earworm species complex and the Old World African bollworm (Noctuidae), most of which had previously been referred to as a single species (*Heliothis armigera* or *H. obsoleta*), and pointed out that there was a complex of species and subspecies involved. Specifically he proposed that the New World *H. zea* (first used in 1955) was distinct from the Old World *H. armigera* on the basis of male and female genitalia. And he described the new genus *Helicoverpa* to include these important pest species, Some 80 or more species were formerly placed in *Heliothis* (*sensu lato*) and Hardwick referred 17 species (including 11 new species) to *Helicoverpa* on the basis of differences in both male and female genitalia. Within this new genus the *zea* group contains eight species, and the *armigera* group two species with three subspecies. See also Hardwick (1970).

Because the old name of *Heliothis* for the pest species (four major pest species and three minor) is so well established in the literature, and since dissection of genitalia is required for identification, there has been resistance to the name change (e.g. Heath & Emmet, 1983), but Hardwick's work is generally accepted and so the name change must also be accepted (see Matthews, 1991).
Bayer computer code: HELIZE
EPPO A1 list: No. 195
EU Annex designation: I/A1 - as *Heliothis zea*

HOSTS

H. zea is regarded as being polyphagous in feeding habits but it seems to show a definite preference in North America for young maize cobs and tassels, and particularly for the cultivars grown as sweet corn and popcorn, and also for sorghum. Feeding preference is shown for flowers and fruits of the host plant. Most hosts are recorded from the Poaceae, Malvaceae, Fabaceae and Solanaceae; in total more than 100 plant species are recorded as hosts.

The crops most frequently recorded as host plants are maize, sorghum, cotton, *Phaseolus*, peas, chickpeas, tomatoes, aubergines, *Capsicum*, *Vicia* and, to a lesser extent, *Trifolium*, okras, cabbages, lettuces, strawberries, tobacco, sunflowers, Cucurbitaceae and many of the other legumes. Damage to fruit and other trees has also been recorded. Buds and flowers of a wide range of ornamentals are attacked. Most infestations are of field and garden crops, but invasion of greenhouses is recorded and protected crops are clearly at risk.

The expression of host preference depends upon a complex of factors including spatial and temporal availability of the hosts at the preferred stage of development. Maize and grain sorghum are preferentially attacked in most locations, although legumes are widely infested. Cotton is a crop particularly susceptible to damage by *H. zea* but is clearly not a preferred (primary) host, because in many places it is only heavily attacked after alternative hosts have senesced or been harvested. *Trifolium* and other legumes are often important host plants in the spring before the annual crops are established. Crop harvesting (cutting of *Trifolium*, etc.) may often result in mass migration of larvae from the field, and then many less desirable hosts may be attacked (trees, etc.).

Many host crops for *H. zea* are available in the EPPO region, and especially in the southern part. Many wild host species could act as sources of infestation of commercial crops. Further north in the region, glasshouse crops could be attacked.

For further information see Barber (1937), Neunzig (1963), Davidson & Peairs (1966), Matthews (1991).

GEOGRAPHICAL DISTRIBUTION

EPPO region: Absent.
North America: Canada (British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Quebec and Saskatchewan), Mexico, USA (throughout, including Hawaii).
Central America and Caribbean: Antigua and Barbuda, Bahamas, Barbados, Bermuda, Costa Rica, Cuba, Dominica, Dominican Republic, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Montserrat, Nicaragua, Panama, Puerto Rico, El Salvador, St. Kitts and Nevis, St. Lucia, St. Vincent and Grenadines, Trinidad and Tobago, United States Virgin Islands.
South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Falkland Islands, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela.
EU: Absent.

The more extreme northerly and southerly records are due to annual migrations. Hardwick (1965) regards this species as a seasonal migrant occurring regularly as far north and south as the 52nd parallels of latitude, from Saskatoon in the north to the Falkland Islands in the south.

Distribution map: See IIE (1993, No. 239).

BIOLOGY

Eggs are laid mostly on the silks of maize plants in small numbers (one to three), stuck to the plant tissues. Choice of oviposition site by the female seems to be governed by a combination of physical and chemical cues. Female fecundity can be dependent upon the quality and quantity of larval food, and also on the quality of adult nutrition. Up to 3000 eggs have been laid by a single female in captivity, but 1000 to 1500 per female is more usual in the wild. Hatching occurs after 2-4 days and the eggs change colour from green through red to grey. The tiny grey larvae first eat the egg shell and after a short rest they wander actively for a while before starting to feed on the plant. They usually feed on the silks initially and then on the young tender kernels after entering the tip of the husk. By the third instar the larvae become cannibalistic and usually only one larva survives per cob. Feeding damage is typically confined to the tip of the cob. Larval development usually takes 14-25 (mean 16) days, but under cooler conditions 60 days are required. In the final instar (usually sixth) feeding ceases and the fully fed caterpillar leaves the cob and descends to the ground. It then burrows into the soil for some 10-12 cm and forms an earthen cell, where it rests in a prepupal state for a day or two, before finally pupating. Two basic types of pupal diapause are recognized, one in relation to cold and the other in response to arid conditions. In the tropics pupation takes 13 (10-14) days; the male takes 1 day longer than the female. Diapausing pupae are viable as far north as 40-45°N in the USA.

Adults are nocturnal in habit and emerge in the evenings. Maize fields in the USA regularly produce 40 000 to 50 000 adult moths per hectare. Flying adults respond to light radiations at night and are attracted to light traps (Hardwick, 1968), especially the ultra-violet type, in company with many other local Noctuidae. Sex aggregation pheromones have been identified and synthesized for most of the *Heliothis/Helicoverpa* pest species, and pheromone traps can be used for population monitoring. Adult longevity is recorded as being about 17 days in captivity; they drink water and feed on nectar from both floral and extra-floral nectaries. The moths fly strongly and are regular seasonal migrants, flying hundreds of kilometres from the USA into Canada. They migrate by flying high with prevailing wind currents.

The life cycle can be completed in 28-30 days at 25°C and in the tropics there may be up to 10-11 generations per year. All stages of the insect are to be found throughout the year if food is available, but development is slowed or stopped by either drought or cold. In the northern USA there are only two generations per year, in Canada only one generation.

For more information, see Hardwick (1965), Beirne (1971), Balachowsky (1972), Allemann (1979), King & Saunders (1984), Fitt (1989).

DETECTION AND IDENTIFICATION

Symptoms

Young maize plants have serial holes in the leaves following whorl-feeding on the apical leaf. On larger plants the silks are grazed and eggs can be found stuck to the silks. As the ears develop, the soft milky grains in the top few centimetres of the cobs are eaten; usually only one large larva per cob can be seen.

Sorghum heads are grazed. Legume pods are holed and the seeds eaten. Bore holes can be seen in tomato fruits, cotton bolls, cabbage and lettuce hearts, and flower heads.

Morphology

Eggs

Subspherical, radially ribbed, 0.52 mm high and 0.59 mm diameter, stuck singly to the plant substrate, green when laid, turning red and finally grey before hatching.

Larva

On hatching, the tiny grey caterpillars have a blackish head; they grow through six instars usually, but five and seven instars are not uncommon, and the final body size is about 40 mm long. In the third instar two colour phases can develop: brown (the predominant phase) and green (less frequent). Longitudinal lines of white, cream or yellow are present, and the spiracular band is the most distinct. As the larvae develop, the pattern becomes better defined, but in the final instar (sixth) the coloration changes abruptly into a bright pattern, often pinkish, and with extra striations.

Pupa

A typical noctuid pupa, shiny reddish-brown in colour, about 16 mm long, and with two distinct terminal cremaster spines, and normally not identifiable to species.

Adult

A stout-bodied brown moth of wing-span 35-40 mm; forewing pale brown to greenish with darker transverse markings, underwings pale with a broad dark marginal band. The adults are very similar in appearance, and both are indistinguishable morphologically from *H. armigera*, but differ in several details in their genitalia (Hardwick, 1965); microdissection and slide-mounting are required for specific determination, and some aspects are comparative so that a series of closely related species have to be available for comparison.

Detection and inspection methods

Feeding damage is usually visible and the larvae can be seen on the surface of plants but often they are hidden within plant organs (flowers, fruits, etc). Bore holes may be visible, but otherwise it is necessary to cut open the plant organs to detect the pest. Because of morphological similarity, it is impossible to distinguish the larvae of *H. zea* from those of *H. armigera*, already present in the EPPO region. Positive identification can also be done by rearing the larvae and examining the genitalia of the adult.

MEANS OF MOVEMENT AND DISPERSAL

H. zea is a facultative seasonal nocturnal migrant, and adults migrate in response to poor local conditions for reproduction, when weather conditions are suitable. Three types of movement are practised by *Helicoverpa* moths: short-range, long-range, and migration. Short-range dispersal is usually within the crop and low over the foliage, and largely independent of wind currents. Long-range flights are higher (up to 10 m), farther (1-10 km), and usually downwind, from crop to crop. Migratory flights occur at higher altitudes (up to 1-2 km) and may last for several hours. The moths can be carried downwind hundreds of kilometres - 400 km is not uncommon for such a flight. There is now evidence that many of them originate in Mexico as young adults and migrate northwards into the USA in the early spring. Probably three generations are required to effect the annual displacement from Mexico up to southern Ontario. Transatlantic dispersal is clearly a possibility for this moth, although it has not yet been demonstrated.

Air-freight transportation of agricultural produce from the New World to Europe is an ever increasing commercial enterprise, especially with vegetables and ornamentals. Almost every year, caterpillars of *H. zea* are intercepted on this produce in the UK (Seymour, 1978).

PEST SIGNIFICANCE

Economic impact

In North America it is reported that *H. zea* is the second most important economic pest species (preceded by codling moth) (Hardwick, 1965), and Fitt (1989) quotes the estimated annual cost of damage by *H. zea* and *H. virescens* together on all crops in the USA as more than US$ 1000 million, despite the expenditure of US$ 250 million on insecticide application.

Reasons for the success and importance of this agricultural pest include its high fecundity (large number of eggs laid), polyphagous larval feeding habits, high mobility of both larvae locally and adults with their facultative seasonal migration, and a facultative pupal diapause.

Damage is usually serious and costly because of the larval feeding preference for the reproductive structures and growing points rich in nitrogen (e.g. maize cobs and tassels, sorghum heads, cotton bolls and buds, etc.), and they have a direct influence on yield. Many of the crops attacked are of high value (cotton, maize, tomatoes). If this pest should become established in protected cultivation economic damage could be widespread.

Infestations of maize grown for silage or for grain are not of direct economic importance - losses are typically about 5% and no control measures are taken, but they serve as a focus, or reservoir of infestation. In many areas the first generation is not regarded as a pest (often on *Trifolium*) and it does not become an economic pest on cultivated crops until the second, third or even fourth generation.

Control

Control of *H. zea* has been advocated in the USA since the middle of the 19th century, and measures used fall into two broad categories, those aimed at an overall pest population reduction, and others aimed at the protection of a particular crop. In most situations it is now recommended that integrated pest management (IPM) be used (Bottrell, 1979). Various cultural practices can be used to kill the different instars, including deep ploughing, discing and other methods of mechanical destruction, manipulation of sowing dates and use of trap crops. Use of resistant cultivars and topping of the crop to hasten ripening, etc., can minimize infestation levels and consequent damage. In many areas, natural control of this pest may be quite effective for most of the time. Insect parasitoids attack the eggs (especially *Trichogramma* spp.) and larvae, and some predators can be important in reducing pest populations. The prospects for long-term biological control of *Heliothis/Helicoverpa* spp. are discussed by King & Coleman (1989), and clearly this should be an important component of any regional IPM programme.

Chemical control of the larvae has been the most widely used and generally successful method of pest destruction on most crops, but it is not easy because the secretive larvae are difficult to reach with insecticides once they are hidden. The early history of chemical control of corn earworms is given by Hardwick (1965), while COPR (1983; p. 87) includes a list of 29 insecticides effective for the control of *Heliothis/Helicoverpa* spp. at the recommended rates given. Pesticide resistance has been known for some years and is quite widespread (see Fitt, 1989; p. 42) especially on cotton crops.

Phytosanitary risk

H. zea was recently added to the EPPO A1 list of quarantine pests, and is also considered as a quarantine pest by APPPC. Originally, *H. zea* was considered as practically synonymous with *H. armigera*, an A2 quarantine pest (EPPO/CABI, 1996). The addition to the EPPO list harmonizes it with EU Directive Annex I/A1.

PHYTOSANITARY MEASURES

For the related *H. armigera*, EPPO (OEPP/EPPO, 1990) makes recommendations on phytosanitary measures which would also be suitable for *H. zea*. According to these, imported propagation material should derive from an area where *H. armigera* does not occur or from a place of production where *H. armigera* has not been detected during the previous 3 months. Consignments can be treated against this pest by refrigeration for 2-4 days at 1.7°C followed by fumigation with methyl bromide at 13.5 g/m^3 for 4 h (OEPP/EPPO, 1984).

BIBLIOGRAPHY

A comprehensive bibliography would occupy many pages, so only a selection of sources is listed here. Bibliographies are included in the monograph by Hardwick (1965) (2000 titles on *H. zea*), and the reviews by Fitt (1989) (194 titles), and King & Coleman (1989) (159 references). Most of the basic research on *H. zea* was done in the early 1900s and published under early synonyms. Many references to *H. zea* are made in publications relating to the cultivation/protection of specific crops, e.g. Chiang (1978), COPR (1983), Pitre (1985).

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