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Field survey guidance for *Spodoptera frugiperda*

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Introduction

This field survey guidance provides easy-to-follow guidelines for technical personnel of national plant protection organizations (NPPOs) to survey for *Spodoptera frugiperda*, a key plant pest commonly known as Fall armyworm.

Active and regular monitoring and surveillance are critical for countries to establish the presence or absence of plant pests, especially those with severe impacts on food security, the environment, trade, and agricultural productivity. This early warning information is crucial for rapid response, making sound phytosanitary decisions, effectively managing risks, and controlling and protecting borders against pest entry.

This document guidance provides a protocol to aid in the monitoring, detection, sample collection and identification of *Spodoptera frugiperda*, ensuring effective phytosanitary decision-making to manage the pest risk and protect trade in plants and plant products. This document also provides visuals and guidance on recommended *Spodoptera frugiperda* pest traps.

This field survey guidance complements the digital tools available to NPPO plant health inspectors, through the Africa Phytosanitary Programme (APP) mobile application and Geographic Information System (GIS) platforms.

APP is an IPPC initiative designed to transform pest management across Africa by enhancing the capabilities of phytosanitary personnel within NPPOs, to leverage advanced science and modern digital technology for effective and timely pest surveillance, detection, identification, control, and prevention. APP aims to strengthen the resilience of Africa's phytosanitary systems against plant pests of regulatory, economic, and environmental significance. Some of the countries involved in APP listed *Spodoptera frugiperda* as a priority pest in their countries, requiring effective surveillance.

The IPPC implements APP in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the African Union Department of Agriculture, Rural Development, Blue Economy and Sustainable Development, through the African Union Inter-African Phytosanitary Council (AU-IAPSC).

Acknowledgements

This document presents guidance to national plant protection organizations (NPPOs) to support active surveillance, detection, identification, control and prevention of *Spodoptera frugiperda*. This document was created with technical and financialsupport from the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) in 2023, in the framework of the Africa Phytosanitary Programme (APP), and reviewed by technical officers at the IPPC Secretariat. APP is an initiative of the International Plant Protection Convention (IPPC), implemented in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the African Union Commission on Agriculture, through its technical unit, the African Union Inter-African Phytosanitary Council (AU-IAPSC). The IPPC Secretariat and the IPPC community are grateful to all the institutions that contributed to the production of this document.

Abbreviations

APHIS	Animal and Plant Health Inspection Service
APP	Africa Phytosanitary Programme
AU-IAPSC	African Union Inter-African Phytosanitary Council
GIS	Geographic Information System
IPPC	International Plant Protection Convention
USDA	United States Department of Agriculture
WSDA	Washington State Department of Agriculture

Figure 1: Adult male fall armyworm moth *© Lyle Buss, University of Florida, Bugwood.org; licence: CC BY 3.0 US*

Field survey guidance for *Spodoptera frugiperda*

Scientific name

Spodoptera frugiperda (Smith)

Common name

Fall armyworm, corn leafworm, southern grass worm, grass worm

Type of pest

Moth, foliage feeder

Taxonomic position

Class: Insecta
Order: Lepidoptera
Family: Noctuidae

Known Hosts

Preferred hosts

The fall armyworm has a wide host range but prefers grasses (family: Poaceae). Preferred crop hosts include maize (*Zea mays*), rice (*Oryza sativa*), sorghum (*Sorghum bicolor*) and sugar cane (*Saccharum officinarum*).

Other hosts

Other hosts are numerous, including alfalfa (*Medicago sativa*), cotton (*Gossypium spp.*), barley (*Hordeum vulgare*), Bermuda grass (*Cynodon dactylon*), ryegrass (*Lolium spp.*) and wheat (*Triticum spp.*).

Survey protocol

Surveys should focus on detecting adult moths using pheromone traps.
Host plants can be surveyed for the presence of eggs and larvae or evidence of feeding.

Target life stage

- adult moth, using pheromone traps; and
- eggs and larvae, visual survey.

Time of year to survey

The survey can be continuous whenever the host crop is in the field.

Visual survey

Visual surveys for eggs and larvae on host plants (see Figure 2) as well as the evidence of their feeding on host plants (see Figure 3). Egg masses of up to 200 eggs are generally laid on the underside of leaves of the host plant (see Figure 2(a)) and covered with grey scales from the female's body (see Figure 2(b)). Eggs may also be deposited on poles and other structures when populations are high.

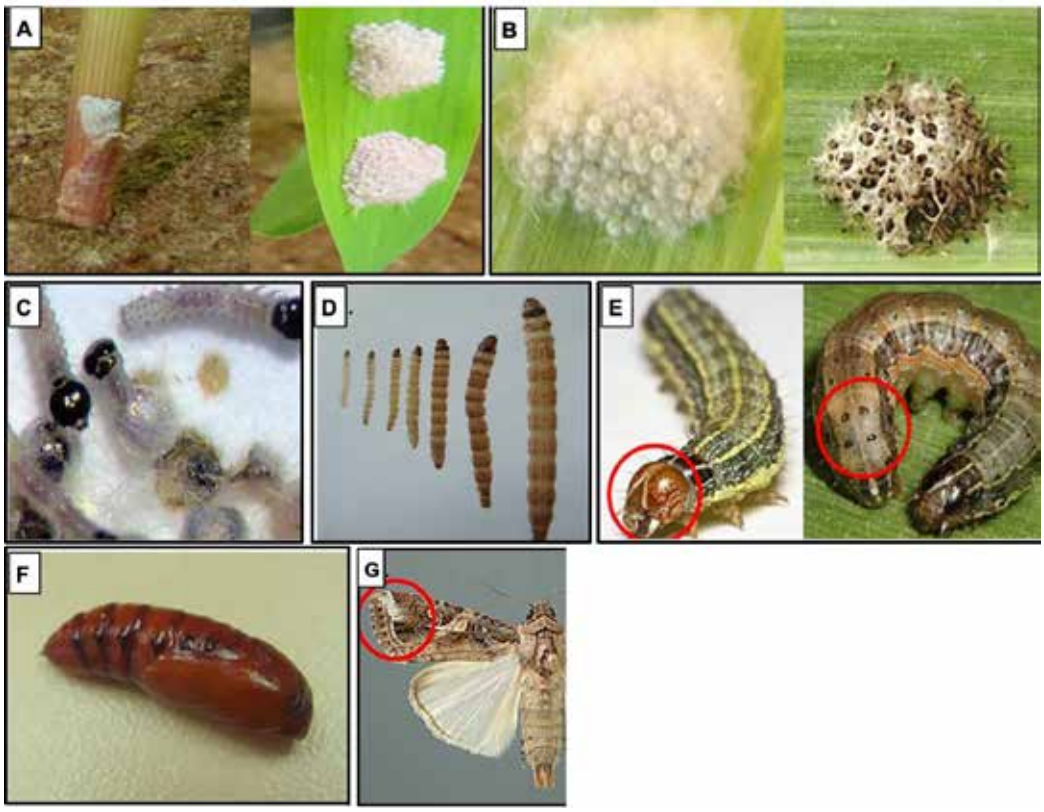

Figure 2. Life stages of the fall armyworm: (a) egg mass placed on stem (left) or leaf (right) at an early stage of the maize plant; (b) egg mass (left) and larvae hatching three days after oviposition (right); (c) black-headed larvae emerging out of the egg mass; (d) larval growth stages (1 mm to 45 mm); (e) distinguishing marks on medium- to large-sized larvae; (f) reddish-brown pupae; and (g) male moth with a conspicuous white spot on tip of the forewing *© Ivan Cruz/Embrapa*

Larvae can be found on seedlings or mature plants. Larvae create holes in leaves or ragged edges. In maize, fall armyworm feeding damage creates a distinct pattern with rows of holes in the leaf due to infestation and feeding in the whorl stage (see Figure 3). This pest also bores into the side of maize ears, damaging kernels, and can destroy tassels. Frass from larval feeding is also a sign of presence.

Figure 3. Damage from Spodoptera frugiperda on maize *© USDA/Brianna Flonc*

Trapping

Survey site selection

Surveys should target primarily maize but can include rice and sorghum.

Recommended traps

- Bucket trap (see Figure 4)
- Delta sticky trap (see Figure 5)

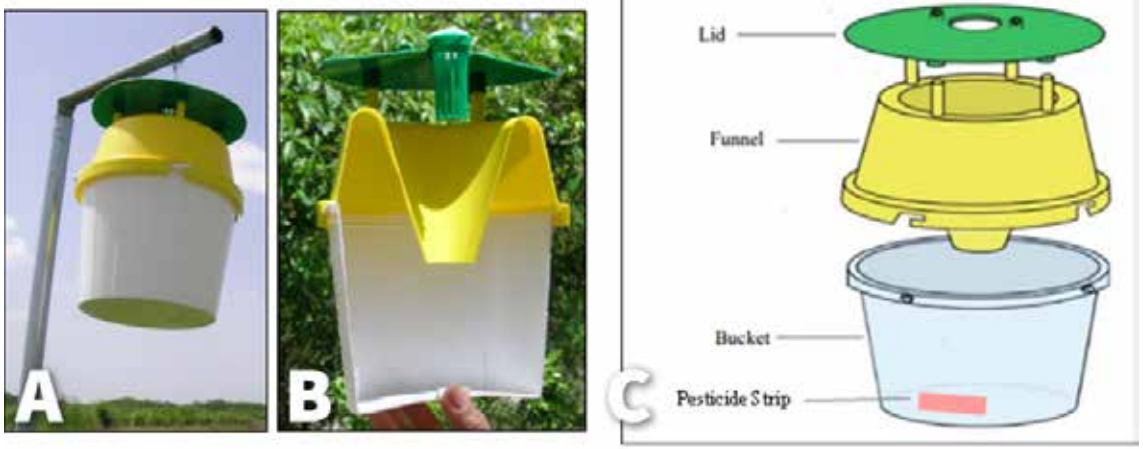

Figure 4. Bucket traps for the fall armyworm: (a) a bucket trap hanging by a field; (b) a trap cut in half showing the trap design; (c) a diagram of bucket trap components
© 4(a) and 4(b): Julieta Brambila, USDA-APHIS-PPQ; 4(c): FAO

Figure 5. Delta sticky traps hanging from trees *© Terry S. Price, Georgia Forestry Commission, Bugwood.org, licence: CC BY 3.0 US.*

Recommended lures

- standard fall armyworm lure (four-component lure);
- three-component fall armyworm lure; and
- two-component fall armyworm lure.

All three of these lures are effective, but there may be local differences that should be explored.

Trap placement and spacing

- Pheromone traps should be placed at the edge of the field, suspended on poles or hangers at a height of 1.5 m.
- Pheromone traps can also be suspended 20 cm to 70 cm above the top of plants.
- Traps should always be spaced at least 50 m apart.
- For detection, use one trap per square kilometre.

Trap servicing

- Traps should be checked every one to two weeks.
- Lures should be replaced once every four weeks.
- Pesticide strips should be replaced every 60 days.
- If using sticky traps, remove any leaves or debris, or replace trap if no longer sticky.
- If possible, photograph any specimens found inside.

Sample collection

Moths captured in bucket traps can be placed in a labelled vial or other container and stored in a cool, dry place until they are submitted for identification. Make sure the moths are dry before transferring them to a container to prevent moulding.

Moths cannot be removed from sticky traps without damaging the specimens. When suspect moths are captured, either the entire sticky trap/insert or an excised portion of the sticky trap containing the suspect moth can be submitted to an expert for identification.

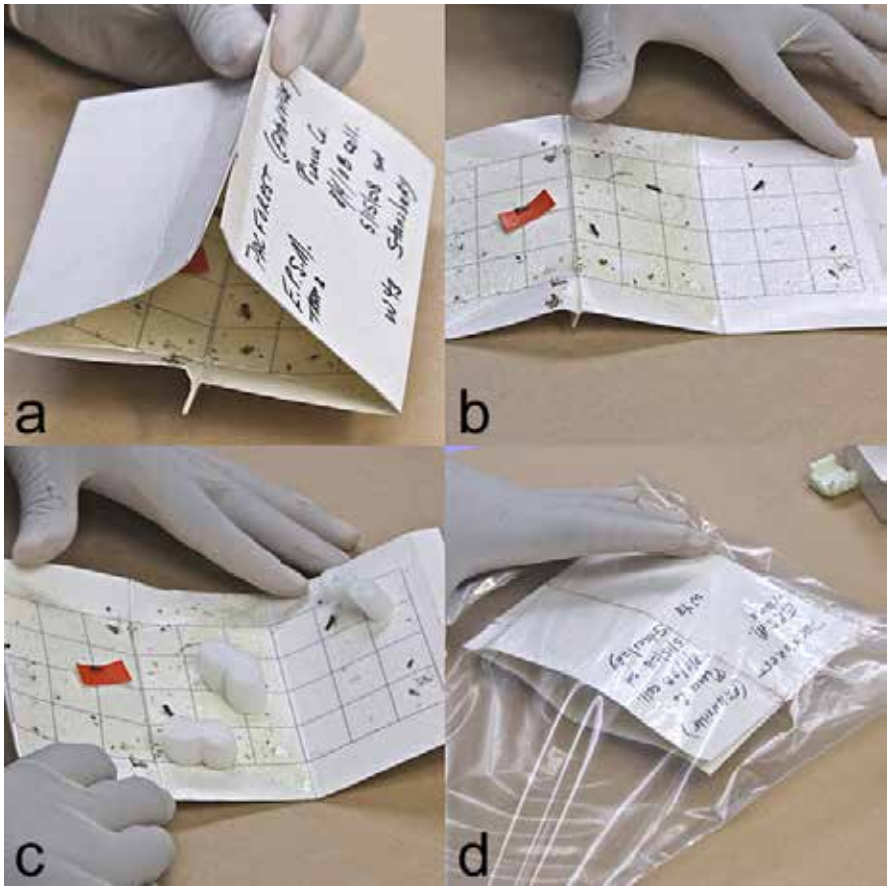

Figure 6. Recommended packing method for the shipment of sticky traps: (a) and (b) open and unfold the trap; (c) place two to three packing peanuts (or similar) in areas of the trap with no moths; (d) fold the trap, secure with a rubber band and place in a plastic bag if the samples are dry; otherwise store or ship in a paper bag so specimens can dry and do not rot *© E. LaGasa/WSDA.*

Pest identification and diagnostics

Pest description

Fall armyworm (*Spodoptera frugiperda*) is a foliage-feeding pest in its larval stage (see Figure 2(c–e)). It is a tropical and subtropical pest that does not enter diapause and cannot survive winter in temperate areas. However, the adult moth is highly migratory and can travel hundreds of kilometres during favourable weather. The life cycle can be completed in 30 to 90 days depending on temperature. Upon hatching, neonate larvae can disperse quickly by "ballooning" onto nearby plants using silken threads. There are usually six larval instars and pupation takes place in the soil.

Both morphological and molecular identification methods are available to identify fall armyworm. Morphologically, mature larvae have a white inverted "Y"-shaped marking on their face (see Figure 2(e)). Unlike other members of the genus *Spodoptera*, the fall armyworm has a distinct diagnostic character that will mark it out from other caterpillars found on agricultural crops. The second and third segments behind the head have raised plates (pinacula) with a keyhole-shaped depression on each side (see Figure 7). Specimens exhibiting this character are unlikely to be confused with other taxa. Note that this character may be hard to see in younger larvae. Adult males have somewhat distinctive white markings at the tips of their forewings (see Figure 8(a)), but the wings of female moths do not have distinctive markings. Morphological confirmation of both males and females requires a dissection of the genitalia. Suspect moths should be submitted to an expert for identification.

Figure 7. Lateral view of the anterior segment of a fall armyworm caterpillar. Red arrows point to a plate with keyhole-like depression *© USDA/Jim Young.*

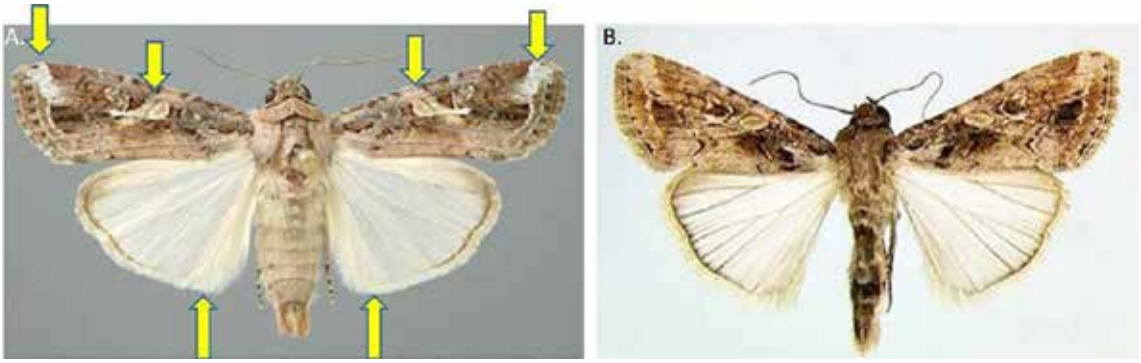

Figure 8. Male fall armyworm (S. frugiperda) versus male S. exempta: (a) male fall armyworm, with arrows showing somewhat distinctive characteristics, including a conspicuous white patch at the tip and in the middle of the forewings and white veins at the bottom edge of the hindwings, which can help distinguish the species; (b) male of S. exempta (Walker) lacking these characteristics

Easily mistaken species

Other species of *Spodoptera* may look superficially similar (see Figure 8(b)) and some relatives will appear in pheromone-baited traps. Non-target species of noctuid moths caught in fall armyworm traps in Africa include *Leucania curvula* (Walker), *L. loreyi* (Duponchel) and *S. triturata* (Walker). The closely related species *Spodoptera exempta*, *S. exigua* and *S. littoralis* also occur in Africa and may be difficult to distinguish from the fall armyworm.

Identification and diagnostic resources

EPPO (European and Mediterranean Plant Protection Organization). 2015. EPPO Standard on Diagnostics. PM 7/124 (1) Diagnostics for *Spodoptera littoralis, S. litura, S. frugiperda,* and *S. eridania. EPPO Bulletin,* 45(3): 410–444. doi.org/10.1111/epp.12258

Gilligan, T.M. & Passoa, S.C. 2014. NOCTUIDAE – *Spodoptera.* In: *LepIntercept – An identification resource for intercepted Lepidoptera larvae.* Fort Collins, USA, Identification Technology Program, United States Department of Agriculture. [Cited 12 July 2023]. https://idtools.org/id/lepintercept/spodoptera.html

Pogue, M. 2002. A World Revision of the Genus *Spodoptera* Guenée (Lepidoptera: Noctuidae). *American Entomological Society,* 43. https://archive.org/details/memoirsofameric432002amer/

IPPC

The International Plant Protection Convention (IPPC) is an international plant-health agreement that aims to protect global plant resources and facilitate safe trade. The IPPC vision is that all countries have the capacity to implement harmonized measures to prevent pest introductions and spread, and minimize the impacts of pests on food security, trade, economic growth, and the environment.

Organization

- There are over 180 IPPC contracting parties.
- Each contracting party has a national plant protection organization (NPPO) and an official IPPC contact point.
- Ten regional plant protection organizations have been established to coordinate NPPOs in various regions of the world.
- The IPPC Secretariat liaises with relevant international organizations to help build regional and national capacities.
- The secretariat is provided by the Food and Agriculture Organization of the United Nations (FAO).

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