***(To TWG Members: this is a living document. It is shared as an early stage to comment on the general structure and content. An updated vrsion will be presented during the 4th TWG )***

Guidelines for the prevention of *Spodoptera frugiperda*

1. *Spodoptera frugiperda*, known as Fall Armyworm or FAW, can cause unprecedented impacts to crops, particularly maize, rice and sorghum, if not managed properly. The introduction and spread of this pest should be prevented where still possible.
2. These guidelines for the prevention of *Spodoptera frugiperda* are directed at National Plant Protection Organization (NPPOs) of countries where the pest is absent or of limited distribution. NPPOs are the competent authorities to take preventive Phytosanitary measures.

This standard presents the basis of a national regulatory control

system for the monitoring, eradication and containment of

E. crassipes and describes:

d

Elements of the monitoring programme that should be

conducted to detect a new infestation or to delimit an infested

area

d

Measures aiming at eradicating recently detected populations

(including an incursion)

d

Containment measures: to prevent further spread in a country

or to neighbouring countries, in areas where the pest is present

and eradication is no longer considered feasible.

1. These guidelines present the basis for a country to take preventive measures and to prepare a prevention plan and describes:

* Preventive legislative and inspection measures;
* Elements of a surveillance plan to detect a new infestation or to delimit an infested area;
* Set procedures to guaranty a rapid response, effective and coordinated once an official outbreak of FAW in found in a new territory
* Identify individuals who should be involved in this prevention plan
* Define Phytosanitary measures to be taken once an outbreak is officially found.

1. These guidelines complement the series of publication on FAW available at <http://www.fao.org/fall-armyworm/background/en/>. CABI also maintains a very rich information portal on this pest containing the materials from multiple organizations <https://www.cabi.org/isc/fallarmyworm>.

Background information on the pest

1. Status of the pest

* FAW originates from tropical and sub-tropical regions of the Americas. FAW has recently spread across all of sub-Saharan Africa, the Near East and Asia.
* As of October 2020, FAW is absent or of limited distribution only in Southern Europe, some countries in Near East and North Africa and of the Pacific where it is listed as a quarantine pest.
* FAO maintains a map of the worldwide spread of FAW since 2016 (see <http://www.fao.org/fall-armyworm/monitoring-tools/faw-map/en/>), and the European and Mediterranean Plant Protection Organization (EPPO) maintains a referenced list of distribution and of status of the pest (see <https://gd.eppo.int/taxon/LAPHFR> ).

**General information on the biology of the pest**

1. Details on the biology and economic importance of the pest are available at [www.xxx](http://www.xxx) and general information only is provided here.

* **Taxonomic position**: Animalia: Arthropoda: Hexapoda: Insecta: Lepidoptera: Noctuidae
* **Hosts:** FAW is considered a highly polyphagous noctuid moth species, with larvae recorded feeding on more than 350 plant hosts from more than 75 families, although it has a preference for monocots, mainly Poaceae, Asteraceae and Fabaceae. A detailed host list is provided by EPPO at <https://gd.eppo.int/taxon/LAPHFR/datasheet>
* There are two FAW genotypes on the basis of the host plant preference: either ‘rice-preferred’ (Sfr) or ‘corn-preferred’ (Sfc). There are no distinguishable morphologically characters to differentiate between Sfc and Sfr, and identification is currently achieved via molecular characterization.
* **Developmental temperature range:** >13.8 ˚C – 32˚C (Barfield et al. 1978; Ali et al. 1990; Hogg et al. 1982)
* **egg-laying capacity per female:** females are highly fecund, capable of laying 1-8 egg masses per generation, with each egg mass containing few (e.g., 9) to >700 eggs. Up to 2,142 eggs have been reported to be laid by a single female during her life time (Luginbill 1928).
* **number of generations per year:** FAW is a tropical species and is capable of undertaking 6-8 generations under optimal temperature. Its development cycle can be completed in about 28 days under optimal temperature, which could extend to 80-90 days under colder temperature (Sparks 1979; Vickery 1929; Luginbill 1928).
* **long distance natural spread:** Adult FAW moth is a strong flyer and with the assistance of prevailing wind, has been reported to travel at least 160 km (Sparks 1979). Seasonal migration of adult moths are known to travel 1,600 km in 30 hours (Rose et al. 1975) from Mississippi to southern Canada.
* **pathways of introduction:** larvae and pupae of FAWcan be accidentally transported as contaminants of traded commodities, especially in parts of plants vegetables or fruits; and sometimes on herbaceous ornamentals (Seymour *et al*., 1985; Cock *et al*., 2017). In addition, the pest (adults or eggs) has been considered in the study by Early et al. (2018) as having the potential to be introduced as a stowaway on international flights such as via visiting tourists.
* **Resistance development:** The FAW readily develops resistance to conventional insecticides used for its control, in particular:
  + Widespread resistances were reported to organophosphates (OPs) and pyrethroids in both native populations from the Americas and Caribbean.
  + Resistance to the *Bacillus thuringiensis* (Bt) toxin Cry1F is also reported from native populations and is especially widespread in Latin America and Puerto Rico.
  + Resistance to the Vegetative Insecticidal Protein VIP3A has been reported in North American populations, and presence of the VIP3A resistance alleles has been detected in field populations of FAW from Brazil.
  + Insecticide resistances have also been reported in recent invasive populations from Africa and China (OP), and to Pyrethroid from China and Indonesia.

1. Detailed factsheets for Spodoptera frugiperda are provided by several organizations, including EPPO (2018) and CABI (2020). In addition, poster and videos on the life cycle of the pest are respectively provided by FAO & CABI (2019) and CABI (2019).

**Standard Operating Procedures for drafting and implementing a FAW prevention plan**

1. While FAW is still absent from the country:
2. Undertake a Pest Risk Analysis and register the pest as a quarantine pest in the national phytosanitary legislation
3. Secure financial resources on the general annual budget for drafting and implementing a FAW prevention plan
4. Nominate a staff responsible for drafting, maintaining and implementing the FAW prevention plan
5. Draft a FAW prevention plan with all relevant NPPO staff at national and regional level and in consultation with public and private stakeholders, including but not limited to producers organizations, seeds organizations, crops, fruits and vegetable harvest and transformation centers, sellers of crops, fruits and vegetables. Such stakeholders would particularly be informed on the impacts and status of the pest and any information related to the prevention plan, they could also be actively engaged in surveillance and the implementation of phytosanitary measures. The IPPC Guide on [Managing Relationships with Stakeholders](https://www.ippc.int/en/publications/86040/) would usefully be consulted.
6. Nominate staff responsible for the different parts of the plan in order to set a clear organogram at the national and local levels
7. Officially publish the FAW prevention plan, on the national and local NPPOs websites.
8. Organize training courses for the NPPO staff to be able to implement the plan, in particular surveillance activities and phytosanitary measures. Initiate molecular species diagnostic program to enable rapid turnaround of molecular diagnosis findings. For initial detections, identify suitable emergency control strategies such as initiate procedure to pre-approve classes of insecticides known to be effective against FAW for use in target agricultural crops; initiate biological diversity inventory especially for endemic/naturalized parasitoids that could be reared to control FAW; discuss and explore the use of other biological control agents including sprayable Bt toxins, S. frugiperda multiple nuclear polyhedrosis virus (Sfmnpv), metarhizium, etc.
9. Implement the prevention plan: surveillance, inspection and other phytosanitary measures, especially for movements of agricultural products (capable of supporting live-stages of FAW) between islands.
10. Coordinate and exchange information on the best prevention measures with neighboring countries.
11. Once an outbreak is officially found in the country:
12. Comply with its national Reporting Obligations and share the information with the IPPC Secretariat and other relevant bodies (e.g. Europhyt for EU countries).
13. Establish a crisis unit to be led by the national or local NPPO office, composed of all NPPO staff involved and the previously listed stakeholders.
14. Appoint a spokesperson from the NPPO, this person would be the sole entitled to provide information to the media according to contents and modalities defined within the crisis unit through a communication plan.
15. Implement all activities of the plan as necessary, including the communication plan.
16. Revise and update the FAW prevention plan to adapt to the situation.
17. Details on the technicalities of the surveillance, inspection and management are provided below. Elements to be taken account of in drafting a communication are also summarized.

**Communication and information sharing with various stakeholders**

1. In Africa, experience prove than the role of advisory services in supporting farmers’ decision-making is particularly important when farmers have a new situation to cope with, such as the arrival of a new pest. The 2017 evidence note highlighted that many players in the private and public sectors are involved in providing advice to farmers, and that for a new pest, this presents a challenge in ensuring farmers receive sound and consistent advice. The result is that farmers and decision-makers at various levels sometimes receive conflicting, biased or even erroneous advice (Rwomushana *et al*., 2018).
2. An IPPC Guide to Pest Risk Communication should usefully be consulted (FAO, 2019).
3. TBD

**Preparedness**

*Pest Risk Analysis*

1. Pest Risk Analysis or PRA is defined as “the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it” (ISPM 5). PRA should be undertaken in accordance with [ISPM 2 Framework for Pest Risk Analysis](https://www.ippc.int/en/publications/592/) and [ISPM 11 Pest Risk Analysis for Quarantine Pests](https://www.ippc.int/en/publications/639/).
2. According to the [European Food Safety Authority (EFSA) Pest Risk Assessment](https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2018.5351) (Jeger et al 2018), FAW could enter new countries through international trade. Being a polyphagous pest, it arrived and could arrive on several host plant products, such as eggplant, asparagus and cut rose. This EFSA Pest Risk Assessment includes pathway models which indicate that peppers (*Capsicum* spp.) are the most likely, although they are not preferred hosts. Being that pepper is regulated and inspected upon entry into many countries (e.g. in the EU), further regulation is estimated to have a marginal effect.
3. Given the high rate of natural spread of FAW, its likelihood of entry by natural dispersal is high. Indeed, FAW may continue to spread within North Africa, and could relatively easily enter southern European countries (particularly the Andalusia region in Spain and Sicily in Italy) through migration. In the Pacific, natural spread of FAW to Solomon Islands is possible with the confirmation of the pest (May 2020) in the north-west region of Papua New Guinea (Madang Province) that borders the Bismack Sea (Tay *et al*., 2020). Onward natural spread of *S. frugiperda* to other Pacific countries (e.g., Vanuatu, New Calidonia, Fiji, Tonga) may be less likely due to the geographic distance between these island nations despite the insect’s strong flight ability. However, examples of the spread of the coconut rhinoceros beetle *Oryctes rhinoceros* in the pacific nations (likely due to movements of contaminated plant material) also suggest that establishments of FAW across these Pacific nations may be possible with antropogenic-assisted spread.

**Legislation**

EU

*Inspection of consignments see* [*https://onlinelibrary.wiley.com/doi/epdf/10.1111/epp.12328*](https://onlinelibrary.wiley.com/doi/epdf/10.1111/epp.12328)

*Sample collection*

1. Suspected egg masses, caterpillars and/or adult moths should be stored in sufficient volume of high concentration ethanol (>75%, 95-99% preferred) in plastic insect specimen tubes and stored in -20˚C, replacing the ethanol at least once after 24-48hrs post collection. Survey metadata including date, host crops, location name and GPS coordinates, and name of collector/s should be recorded.

**Surveillance plan**

*Identification of the pest*

1. During its life cycle, FAW can be found on all plant parts, a careful visual check is therefore necessary. Eggs covered with a whitish fluff can be observed on the leaves. As the larvae feed inside young plants, little holes and even deep lacerations can be observed on leaves. The larvae can also enter the cob, significantly reducing yields.



Maize: eggs (on the left), signs of larvae feeding on the leaves (at the center), larvae inside the cob (on the right).

1. Identification leaflets are available, as for instance the ones developed by the FAO & CABI (2019b&c), by the Australian Grans Research & Development Corporation (GRDC) <https://grdc.com.au/resources-and-publications/resources/fall-armyworm>, CottonInfo <https://www.cottoninfo.com.au/sites/default/files/documents/ID_guide_sc2.pdf>, ICAR Research (Firake et al. 2019), or Réseau d’avertissement phytosanitaire – Ministère de l’agriculture, des pêches et de l’alimentation du Québec (MAPAQ) (2018).
2. [FAMEWS mobile app](https://play.google.com/store/apps/details?id=org.fao.famews&hl=en_US)is an application for Android v6 or higher smartphones provided by FAO. The app should be used every time a field is scouted and pheromone traps are checked for FAW. The app has these parts:

* Data entry: to collect, record and transmit:
  + Scouting data, including basic farm data, scouting data (manual or using artificial intelligence) and immediate advice;
  + Trap data
* IPM education
* Digital library
* Chat to share experiences
* Expert resources

1. Data are entered by making selections from drop-down lists. Each item provides a useful explanation that, in some cases, includes photos – for example, of different pests and natural enemies to help the user enter accurate data. The app is extremely intuitive, easy and fast to use. It is currently available in 29 languages and can include further languages upon demand. FAMEWS can be downloaded for free from the [Google Play Store](https://play.google.com/store/apps/details?id=org.fao.famews&hl=en_US).
2. The FAMEWS mobile app can be used to conduct both detection and delimiting surveys.
3. **A detection survey** is defined as “survey conducted in an area to determine if pests are present” (ISPM 5). They should be conducted regularly to rapidly identify individuals or populations of FAW which were accidentally introduced or spread naturally.
4. These detection surveys can be conducted through trapping, visual inspections and taking samples.

* Pheromone and light traps can can be used for surveys in crop fields of host species, or in sites identified at high risk of introduction of FAW. High risk places include ports, airports, vegetable markets and vegetable sorting centers. At least one pheromone trap should be set every 10.000 hectare of maize. One trap should be set in each site at risk and at least one should be identified per district. The sticky part of the trap should be changed every two weeks, or when dirty. It should be sent to the laboratory in the presence of suspicious insects. The attractant should be changed with a frequency adapted to the climate where it is situated (2 to 4 weeks).
* Visual inspections are mainly undertaken in the maize, rice or Solanaceae production areas. These surveys could focus on several pests (such as *Pantoea stewartii*).
* The sampling can be carried out when adults are found in traps or larvae or eggs are observed in symptomatic plants or on fruits, possibly supported by the use of magnifying glasses. The samples will be sent to the laboratory for the subsequent identification by taxonomic and biomolecular diagnosis.
* Finally, information and training programs are to be planed for those involved in the production and handling of herbaceous and horticultural crops in order to collect reports on cases of suspected presence of the insect.

1. **A delimiting survey** is defined as “survey conducted to establish the boundaries of an area considered to be infested by or free from a pest” (ISPM 5).
2. In the event that the presence of *Spodoptera frugiperda* is detected during detection surveys or following the verification of a report, a delimiting survey program must be put in place to establish the boundaries of the infested area. Depending on the data available on the mobility of the insect (which varies depending on climatic conditions), a radius of 100 km can be considered adequate as a radius of the area to be investigated. In the territory falling within this area, the phytosanitary services must conduct surveys through visual inspections and the use of traps, favoring the areas cultivated with corn, but at the same time guaranteeing homogeneous coverage of the entire area.
3. The Fall Armyworm Early Warning System (FAMEWS) should be used. FAMEWS is freely available for any low-cost Android 5.0 or higher smartphone from the Google Play store. There are many surveillance protocols available, as for instance the FAO & CABI (2019) instructions.
4. **Citizen science programme can be usefully undertaken to have everybody watch out for FAW, as done in Australia. Simple indications are provided to importers, growers and home gardeners for what to look and where and on how to report findings (Australian Government, Fall armyworm and other exotic armyworms website, 2020).**

**Diagnostic**

* The diagnostic activities for the identification of the species are carried out by the laboratory of the Phytosanitary Service according to the international standards available.
* Molecular diagnostics based on the partial mitochondrial DNA cytochrome c oxidase subunit I (mtCOI) gene has been the most widely used approach for species confirmation which also allows the differentiation of ‘rice’ and ‘corn’ host preference (i.e., Sfr and Sfc).
* The EPPO diagnostic protocol for *Spodoptera frugipera* can be consulted.

**Preventive measures**

* One preventive method is to ensure good weed control of sweet corn fields, because at when the eggs are laid, females are attracted to grassy areas (infested with grasses) inside and at the edge of the fields.

**Phytosanitary Measures**

* In the event that the presence of *Spodoptera frugiperda* is confirmed following official analyses, the Phytosanitary Service immediately delimits the territory and applies the phytosanitary measures deemed necessary to eradicate or to contain the spread of the insect.
* Delimitation: the delimited area consists of an infested area and a buffer zone as described below:
  + - Infested area: consists of the plot or plots in which the presence of *Spodoptera frugiperda* has been confirmed.
    - Buffer zone: An area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimize the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate (ISPM 5). It has a radius of at least 100 kilometers around the infested area. Where a portion of the municipal area falls within this extension, the entire municipality will become part of the buffer zone.
* If the presence of the specified organism is confirmed outside the infested area, the boundaries of the delimited area are modified accordingly
* Phytosanitary measures to be undertaken include:
  + - destruction of host plants found to be infested (to be evaluated according to the extent of the infestation);
    - any other measure defined by the Phytosanitary Service that may contribute to the eradication or containment of *Spodoptera frugiperda*.
    - if it is necessary to intervene with phytosanitary products, in a first phase it will be possible to use formulations that generically report the "night" target on the label, but it will be necessary to immediately promote the execution of efficacy tests to arrive in a short time to authorizations definitive with *Spodoptera frugiperda* as a target on the label or exceptional authorizations for phytosanitary emergencies.
* **Caution:** FAW has a high rate of spread of more than 100 km in one night; it is very polyphagous and can be easily confused with other pests. These factors rendered its early identification difficult. Biological factors such as high reproductive rates and short generation time have made the eradication of FAW impossible. Eradication of FAW was attempted in Taiwan and Brunei, involving total destruction (cut and burn) of infested maize crop, however this has been unsuccessful to prevent resurgence of the FAW. In Australia, eradication of the FAW was deemed not feasible following rapid detections of FAW at multiple sites (EPPO 2020) with Governmental agencies swiftly transitioned to advising industries and State Government agencies to mitigate and manage the pest via chemical control as a short-term solution, and to invest and develop IPM strategies for long-term ecologically responsible solutions. It is important to note that to-date, none of the >70 nations with which the FAW has successfully established populations, has been able to eradicate this invasive pest.

**References**

1. Ali A, Luttrell RG, Schneider JC. 1990. Effects of Temperature and Larval Diet on Development of the Fall Armyworm (Lepidoptera: Noctuidae). Ann. Entomol. Soc. Am. 83(4): 725-733.
2. Australian Government (2920) Fall armyworm and other exotic armyworms website. <https://www.agriculture.gov.au/pests-diseases-weeds/plant/exotic-armyworm>
3. Barfield, C. S., E. R. Mitchell & S. L. Poe. 1978. A temperature-dependent model for fall armyworm development. Ann. Entomol. Soc. Am. 71: 70-74.
4. CABI (2019) Fall armyworm: life cycle and damage to maize. <https://www.youtube.com/watch?v=eZxVouWM-t4&feature=youtu.be>
5. CABI (2020) *Spodoptera frugiperda* (fall armyworm) <https://www.cabi.org/isc/datasheet/29810>
6. Early, R; González-Moreno, P; Murphy, ST, Day R. Forecasting the global extent of invasion of the cereal pest Spodoptera frugiperda, the fall armyworm. NeoBiota 40: 25–50 . doi: 10.3897/neobiota.40.28165
7. EFSA (2018) Pest risk assessment of *Spodoptera frugiperda* for the European Union. EFSA Journal [Volume16, Issue 8](file:///C:\Users\BRUNEL\Desktop\Volume16, Issue%208). <https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2018.5351>
8. EPPO (2020) *Spodoptera frugiperda*. EPPO datasheets on pests recommended for regulation. Available online. [https://gd.eppo.int](https://gd.eppo.int/)
9. <http://www.fao.org/3/ca3800fr/ca3800fr.pdf>
10. EPPO (2015) PM 7/124 *Spodoptera littoralis, Spodoptera litura, Spodoptera frugiperda, Spodoptera eridania*. *Bulletin OEPP/EPPO Bulletin* 45 (3), 410–444. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/epp.12258>
11. EPPO Reporting Service (2020/031) <https://gd.eppo.int/taxon/LAPHFR/distribution/AU>
12. FAO (2015) Managing Relationships with Stakeholders A guide to stakeholder relations for national plant protection organizations. 58 p.
13. <http://www.fao.org/3/ca6383en/CA6383EN.pdf>
14. FAO (2019) IPPC guide to pest risk communication. Published by FAO on behalf of the Secretariat of the International Plant Protection Convention (IPPC). 58 pp. Licence: CC BY-NC-SA 3.0 IGO. <http://www.fao.org/3/ca3997en/ca3997en.pdf>
15. FAO & CABI (2019a) Fall armyworm: life cycle and damage to maize. <https://www.cabi.org/isc/FullTextPDF/2019/20197800314.pdf>
16. FAO & CABI (2019b) Fall Armyworm Field Handbook: Identification and Management, First Edition. 38 p. <https://www.cabi.org/isc/FullTextPDF/2019/20197200644.pdf>
17. FAO & CABI (2019c) Fall armyworm photo guide – identification. <https://www.cabi.org/isc/FullTextPDF/2019/20197800315.pdf>
18. Firake DM, Behere GT, Babu Subhash, Prakash N. 2019. Fall Armyworm: Diagnosis and Management (An extension pocket book). ICAR Research Complex for NEH Region, Umiam-793 103, Meghalaya, India. 48p
19. Hogg, D. B., H. N. Pitre, & R. E. Anderson. 1982. Assessment of early-season phenology of the fall ar- myworm (Lepidoptera: Noctuidae) in Mississippi. Environ. Entomol. 11: 705-710.
20. Italian Emergency plan for *Spodoptera frugiperda*
21. Réseau d’avertissement phytosanitaire – Ministère de l’agriculture, des pêches et de l’alimentation du Québec (MAPAQ) (2018) Fiche technique – Maïs sucré: Légionnaire d’automne. 7 p. https://www.agrireseau.net/documents/Document\_97303.pdf <https://www.agrireseau.net/documents/Document_97303.pdf>
22. Rwomushana e*t al*. (2018) Fall armyworm: impacts and implications for Africa. 53 p. <https://www.invasive-species.org/wp-content/uploads/sites/2/2019/02/FAW-Evidence-Note-October-2018.pdf>
23. Tay WT, Kuniata L, James W, Walsh TK. 2020. Confirmation of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Papua New Guinea by molecular diagnostics. BioInvations Records. Submitted 10-Sept. 2020