

**Diagnostics**  
**Diagnostic****PM 9/22 (1) National regulatory control system for *Epitrix* species damaging potato tubers****Specific scope<sup>1</sup>**

This Standard describes a national regulatory control system for species of *Epitrix* that are known to cause damage to both the haulm and tubers of potato. It provides guidance on preventing their introduction, surveillance and their eradication if found infesting potato. The decision on the most appropriate eradication measures that should be taken in any given outbreak situation will depend on the particular circumstances of the outbreak. However, to illustrate the

range of potential measures that can be taken, several outbreak scenarios are outlined in this Standard.

In some outbreak situations it may prove difficult to eradicate the pest, so a strategy for containment is also included.

**Specific approval**

First approved in 2016–09.

**1. Introduction**

Nearly 180 species of flea beetles are known in the genus *Epitrix* Foudras (Coleoptera: Chrysomelidae: Alticinae). Most species (130) occur in the neotropics, 12 species are found in the nearctic and 17 species in the palaeartic (Germain *et al.*, 2013). Six species are reported to feed on foliage and/or tubers of potatoes: *Epitrix cucumeris* (potato flea beetle), *Epitrix similaris* (no common name), *Epitrix tuberis* (tuber flea beetle), *Epitrix subcrinita* (Western potato flea beetle) and *Epitrix hirtipennis* (tobacco flea beetle) (EPPO, 2011), as well as the recently described *Epitrix papa* (Orlova-Bienkowskaja, 2015). All these species except for *E. hirtipennis* and *E. similaris* are reported to damage potato tubers. The four *Epitrix* species that damage tubers are covered in this Standard and are referred to later in the text as *Epitrix* species or ‘the pest’. The origin of *E. papa* is not known, but the other three are native to North America and are harmful to potato (Riley *et al.*, 2003).

*Epitrix tuberis* Gentner is an A1 pest for EPPO. Details of its biology, host plants, distribution and economic importance can be found in the EPPO Global Database ([https://](https://gd.eppo.int/)

[gd.eppo.int/](https://gd.eppo.int/)). *Epitrix subcrinita* LeConte is also an A1 pest for EPPO but much less is known about this species.

The distribution of *Epitrix* species within the EPPO region is currently restricted to some areas of Portugal and Spain. *Epitrix cucumeris* Harris is an EPPO A2 pest but has only been reported from Portugal (on the mainland and in the Atlantic islands of the Azores). *Epitrix papa* (EPPO A2 pest) is a newly described species, previously misidentified as *E. similaris* (Orlova-Bienkowskaja, 2015; Mouttet *et al.*, 2016). It is widely distributed in the main potato-growing areas of mainland Portugal and more recently has been reported in the Spanish regions of Galicia, Asturias and Andalusia regions of Spain. More information on *Epitrix papa*<sup>2</sup>, *E. cucumeris*, *E. tuberis* and *E. subcrinita* is provided in the ‘EPPO Pest Risk Analysis for *Epitrix* species damaging potato tubers’ (EPPO, 2011).

*Epitrix* species can be identified by morphology of genitalia (EPPO Standard PM 7/109 [under revision]; Boavida & Germain, 2009) and by molecular methods (Germain *et al.*, 2013 and corrigendum by Mouttet *et al.*, 2016).

In potato, *Epitrix* species are spread primarily through the movement of potato tubers when associated with soil and plant debris. They can also infest other species of Solanaceae, including tomato (*Solanum lycopersicum*) and

<sup>1</sup>It is recognized that data is being assembled that will help when considering further the most appropriate technically based measures. As soon as this data is available the Standard will be revised.

<sup>2</sup>Because of the evolution of the taxonomy, all information available in the pest risk analysis on *E. similaris* in Portugal should now be attributed to *E. papa*.

eggplant (*Solanum melongena*), so another potential pathway is the movement of such host plants for planting with the soil and growing medium attached. The risks associated with this pathway are, however, much lower than with potato tubers and this pathway is not addressed in this Standard.

Natural spread of *Epitrix* species is expected to be limited because adults tend only to fly short distances when in search of a new food supply. Observations in Canada with *E. tuberis* (R. Vernon, Agriculture and Agri-Food Canada, CA, pers. comm. 2010) and in Portugal with *E. papa* (C. Boavida, Instituto Nacional de Recursos Biologicos, PT, pers. comm. 2015) confirm that these species will fly short distances to colonize potato crops nearby if, for example, the haulm of a potato crop is destroyed. This demonstrates that adults can probably fly several hundred metres but there is considerable uncertainty as to how far they could potentially fly in search of a suitable host.

Prevention of further spread of this pest within the region may be achieved mainly by phytosanitary measures that restrict/prevent the movement of infested tubers and associated soil and plant debris. The operation of certification schemes for seed potato will also help reduce spread with planting material. The restrictions for *Epitrix*, specified in the pest-specific phytosanitary requirements of EPPO Standard PM 8/1 *Commodity-specific phytosanitary measures for potato* (under revision), are intended to form part of the phytosanitary regulations of EPPO countries.

The adults feed on the leaves of potato (and many other hosts) causing the characteristic shot-hole pattern (1–1.5 mm in diameter) common to flea beetles (Eyre & Giltrap, 2013). The females lay eggs in soil at the base of the stem, and the larvae develop underground and feed on the root system. They can also feed on the tubers, causing damage in the form of superficial tracks (serpentine), shallow holes and black splinters (deeper holes with a trail of corky material inside the tuber) (Boavida *et al.*, 2013). The larvae pupate in the soil. The life-cycle of *Epitrix tuberis* takes around 6 weeks in North America and normally 2–3 generations occur during the period between the planting and harvesting of a potato crop. This means that a low initial population of adults can build up to very high levels (one female can lay 200 eggs) and their larvae can cause extensive damage within a single season. Field observations in Portugal suggest that a similar number of generations occur with *E. cucumeris* and *E. papa*. Tuber damage can render stocks unmarketable for certain fresh markets and the presence of holes in tubers can result in rejection of consignments by processors (Boavida *et al.*, 2013). First detection of the pest usually results from the observation of the characteristic damage on tubers during or after harvest.

Given the wide host range of *Epitrix* species, which includes many wild plants and common arable weeds such as *Solanum nigrum*, early detection and prompt effective action will be essential if eradication is to be achieved. This is also very important if a containment strategy is followed.

## 2. Outline of the system

It is recommended that EPPO countries establish a national regulatory control system for *Epitrix* species based on this Standard to include measures to prevent the introduction of these pests to the potato production system. The Standard also outlines a monitoring programme to detect new infestations and measures aiming to eradicate recently detected localized populations. It also includes measures that could be followed for a containment strategy in situations where eradication is not considered possible.

The national regulatory control system should provide sufficient assurances to allow export of potatoes within the EPPO region, in conformity with the specific phytosanitary requirements for the pest. It is also recommended that EPPO member countries at risk prepare and test a pest-specific contingency plan (based on EPPO Standard PM 9/10 *Generic elements for contingency plans*) to ensure that the necessary management and operational arrangements are in place to deal with an outbreak. Pest-specific plans should be developed in consultation with industry sectors to make sure they are feasible, and plans rehearsed to help ensure that prompt and effective official action can be taken in the event of an outbreak occurring.

If the pest is found, phytosanitary measures are needed to contain, suppress and eradicate it. This includes the delimitation of a regulated area (i.e. the ‘infested’ area and ‘buffer zone’), the restriction of the cultivation of potato and the control of volunteer potatoes and other solanaceous weeds for several years. Other host crops of *Epitrix* (e.g. tomatoes and other Solanaceae) in the infested area should be assessed for infestation and, if appropriate, restrictions placed on their cultivation. Hygiene measures are also required, since the pest may be spread with soil and plant debris which could potentially contaminate vehicles and storage boxes, for example.

Even though *Epitrix* may be present, countries which apply a national regulatory control system should be able to export potatoes on the same basis as countries which have demonstrated that *Epitrix* does not occur.

## 3. Control system

This control system for *Epitrix* species has a number of objectives:

- to raise awareness about the pest
- to prevent its introduction into potato production systems
- to determine if the pest is present in potato production systems in the country through surveillance and, if present, to determine its distribution
- to prevent its spread
- to eradicate incursions
- to eradicate the pest from potato production systems in areas where it is feasible
- to contain the pest in situations where eradication is not possible.

### 3.1 Raising awareness

Raising pest awareness amongst farmers, inspectors and people involved in all parts of the potato supply chain is very important to encourage early detection and reporting. Campaigns should highlight the very distinctive symptoms produced on tubers and target those people most likely to encounter infested tubers, such as those trading, importing, packing and processing potatoes. Promotional activities can involve, for example, the internet, posters and workshops involving growers, potato traders and processors.

### 3.2 Prevention of introduction

The holding and handling of *Epitrix* species should be prohibited, except under special permit or licence, as recommended in EPPO Standard PM 3/64 *Intentional import of organisms that are plant pests or potential plant pests*.

To prevent the introduction of *Epitrix* species, requirements in EPPO Standard PM 3/61 *Pest free areas and pest-free production systems for quarantine pests of potato* should be followed.

Potatoes can be imported both from areas where the pest is known not to occur and from countries where it occurs and is regulated, provided that the potatoes are produced in areas that lie outside any regulated area for the pest.

In addition, ware potato tubers can be imported from areas where the pest is known to occur provided they undergo treatment (brushing and/or washing) to remove the pest and associated soil (no more than 0.1% soil in weight) so that there is no risk of introducing the pest. Seed potatoes, however, may only be moved from the regulated area after the application of a treatment that has been scientifically demonstrated to eliminate the pest.<sup>3</sup>

*Epitrix* species are not reported to be found internally within harvested tubers. Larvae feed externally and leave the tubers when disturbed, normally during harvesting. However, it should be noted that dead immature larvae of *E. papa* have recently been found in the serpentine tunnels of washed tubers imported from Spain to the UK (N. Giltrap, Defra, GB, pers. comm. 2016). This indicates that, in the case of this species at least, live larvae could potentially be present in tubers after harvest and therefore represent a potential pathway of introduction. Adults and pupae are reported to be associated with the harvested tubers, in association with soil and plant debris.

The potato tubers (ware or seed) produced in pest-free areas should also be free from symptoms of *Epitrix* species.

Potential risks of solanaceous hosts other than potato acting as a pathway to the potato production system should also be considered by NPPOs.

<sup>3</sup>No such treatment existed when this Standard was drafted but it was considered that it may be developed in the future.

### 3.3 Surveillance

*Epitrix* species should be considered as notifiable pests. All persons suspecting or confirming the presence of *Epitrix* species should notify the NPPO.

First detection of the pest usually results from the observation of the characteristic damage on potato tubers during or after harvest, but some outbreaks have been detected by damage on leaves of susceptible crops (e.g. eggplant). *Epitrix* infestation can remain undetected because the adults are very small, non-descript black beetles that are hard to find. In a crop they jump off the foliage when disturbed. Until effective trapping systems are developed, detection of the presence of the pest is therefore most likely to result from the observation of symptoms rather than detection of the pest itself. Shot-holing on leaves can also be observed, but this symptom can be caused by other pests or other *Epitrix* species that do not cause tuber damage (e.g. *Epitrix pubescens* that is present in the EPPO region; Hight & Pearson, 2015). Sweep nets should be used to catch adult flea beetles, which then need to be collected to confirm the species responsible.

Whilst adult feeding will always produce damage on the foliage, larval infestation can sometimes result in limited or no symptoms on the tubers. Not all potato varieties are equally susceptible to develop symptoms on tuber skin.

Surveillance for the presence of *Epitrix* species in a country or area not known to have the pest is usually based on a detection survey. If the pest is detected, a delimiting survey should be carried out in order to delimit the infested area and establish a regulated area. It is also recommended that actions to raise public and industry awareness are undertaken by the NPPO.

Surveillance (see ISPM No. 6 *Guidelines for Surveillance*) may be general surveillance based on historical data and/or specific surveys of growing potato crops and/or tubers in store.

#### 3.3.1 General surveys

In certification schemes for seed potatoes, both the growing crop and tubers are inspected.

In general there is less official monitoring of ware potato crops and tubers, although many EPPO countries undertake monitoring of ware potatoes for other pests that could potentially lead to the detection of *Epitrix* species. A good example is the official annual survey of ware (and seed) potato crops for ring rot (*Clavibacter michiganensis* subsp. *sepedonicus*) and brown rot (*Ralstonia solanacearum*) that is undertaken by European Union countries. Tubers are inspected in store and a sample of a minimum of 200 tubers is selected from each lot for laboratory testing. Inspectors should look out for possible symptoms of *Epitrix* during this procedure. If these are seen, a separate sample of symptomatic tubers should be sent to the laboratory for more detailed examination.

### 3.3.2 Specific surveys

Specific surveys are considered justified in situations such as:

- when an outbreak of *Epirix* species is confirmed in a country that supplies seed or ware potatoes
- where a country considers that *Epirix* poses a significant threat to its potato industry and wants to protect itself by increasing the probability of detecting an outbreak at an early stage and thereby reducing the potential impacts of the pest
- when the status of *Epirix* species is not certain in the country or needs to be established (e.g. for export certification).

**3.3.2.1 Potato crop and tuber inspections.** Specific surveys should include crop and tuber inspections.

Potato crop inspections are best undertaken when the crop is actively growing and *Epirix* adult populations, if present, have built up such that foliar damage will be more evident. Ideally inspections should also take place before any insecticide treatment that may suppress adult populations and start in the edges of the field because the overwinter adults come from neighbouring areas. If foliar symptoms are seen during growing season inspections, tubers from symptomatic plants should be examined for damage to provide further evidence that *Epirix* species are present. Examination of tubers will also help in the assessment of the levels of crop damage and infestation.

Tuber inspections are best undertaken on tubers during harvesting, grading or in store because a large number of tubers can be inspected more easily than in the growing crop. Tuber symptoms are also likely to be more evident later in the growing season. Tubers discarded on grading or packing lines should be targeted for inspection.

If any suspicious symptoms are seen on the foliage or tubers, further investigations should be undertaken to check for the presence of *Epirix* species (e.g. sweep netting in the crop to catch adult beetles).

**3.3.2.2 Surveys for specific purposes.** In addition to the specific survey, the NPPO should target surveys in high-risk locations:

- farms that have grown imported seed potatoes from countries where the pest occurs, as well as farms and areas with a history of growing crops using imported seed potatoes – inspections should include targeted inspections of growing crops and tubers but may also be combined with inspections of crops and tubers for other purposes (e.g. for seed certification)
- fields near to packers, processors and traders that have imported potatoes from countries where the pest occurs – inspections should target any volunteer potatoes and solanaceous weeds growing where soil and waste potatoes have been discarded on such premises and on any potato crops (including those in private gardens) growing nearby.

### 3.3.3 Delimiting surveys

If an outbreak is confirmed a delimiting survey should be carried out to delimit an infested area and establish a regulated area (see 3.4.1).

Growing crop inspections should be included in the delimiting survey because the absence of symptoms on tubers may not be a reliable indication of the absence of infestation in the field from which the sample has been derived. ISPM No. 31 *Methodologies for sampling of consignments* may be used as a basis for establishing sampling rates for the inspection of tubers.

### 3.3.4 Detection and identification

Morphological identification of *Epirix* to species level is possible only for adults and requires microscopic examination of their genitalia. To confirm identification, laboratories should use EPPO Diagnostic protocol PM 7/109 which outlines tests for *E. cucumeris*, *E. papa* and *E. tuberis* (under revision<sup>4</sup>). DNA sequencing and comparison with verified sequence data can be used to confirm the identity of larvae.

## 3.4 Determination of the presence of the pest and prevention of further spread

As part of contingency planning the NPPO should consider whether to adopt a strategy of eradication or containment in advance of any outbreak (see sections 3.5 and 3.6). In many cases, however, the initial strategy is likely to be one of eradication whilst the particular circumstances of the outbreak are determined and further survey work is undertaken.

If an outbreak or an incursion is suspected in potato production the NPPO should initially prohibit movement of all suspect material. This is likely to involve, as a minimum, the prohibition of movement of all potatoes or other host plants from the place of production concerned. Suspect material should be subject to confirmatory testing according to EPPO Standard PM 7/109. If the initial suspicions are not confirmed then any prohibitions should be lifted. If infestation by *Epirix* species is confirmed the prohibitions should be continued and appropriate eradication measures taken.

### 3.4.1 Outbreaks in a growing crop

The NPPO should designate as 'infested' the potato crop and the field where it is growing or has been grown. Machinery should be designated as 'contaminated' if it is associated with soil from the infested field.

A regulated area should also be established immediately upon the first detection of an outbreak. It should include:

- an infested area including at least the infested field(s)
- a buffer zone not less than 1 km wide adjacent to the infested area.

<sup>4</sup>In the meantime Orlova-Bienkowskaja (2015) may be used.

The infested area and buffer zone should be adjusted in response to any further findings. In the case of a small initial infestation established by a delimiting survey the size of the buffer zone may be reduced.

Designation of a monitoring area should also be considered. The boundary of this area should be based on evidence about the history of the outbreak, local cropping patterns and wind direction.

Movement out of the regulated area of any potatoes or field-grown host plants for planting should be prohibited in order to prevent the potential spread of *Epirix* species from the regulated area.

#### 3.4.2 Detection of infestation in tubers after harvest

When the pest is first detected in tubers after harvest (e.g. in a grower's potato store or during grading/packaging) or when the tubers can be traced back to a known crop or farm (e.g. in a potato store or during processing/packaging away from the place of production), the NPPO should first ascertain the place and the field(s) of production where the infested lot was grown and, where appropriate, stored to ensure that the measures are applied to the correct field(s) and store(s). This investigation should normally include determining the variety of the infested potato lot and carrying out an inspection of the infested field(s) for the presence of adult beetles and for symptoms of damage on tubers and any potato foliage. Any weed hosts within the field or in the immediate vicinity should also be checked for symptoms.

The NPPO should designate as 'infested', as appropriate:

- the lot from which the sample was taken
- the waste from the infested lot (e.g. soil, processing waste)
- the field where the lot was grown, if this can be determined.

The NPPO should designate as 'contaminated' the equipment and other articles (e.g. machinery, packing material and potato store) which have been in contact with the lot.

A regulated area should also be established, if appropriate, immediately upon the first detection of the pest. It should include:

- an infested area including at least the infested crop and field
- a buffer zone not less than 1 km wide adjacent to the infested area.

Movement of the infested material out of the regulated area should be prohibited in order to prevent the potential spread of *Epirix* species from the regulated area.

#### 3.4.3 Other findings

**3.4.3.1 Finding or suspicion of the presence of the pest at a facility handling imported potatoes.** If the presence of the pest is confirmed on a consignment of imported tubers or symptoms of the pest are found on imported tubers with soil attached (i.e. they have not been brushed and/or washed to remove soil), the infested material and associated

soil should be disposed of safely (see Appendix 1). Similarly, all containers, machinery and other objects, such as places of storage of infested lot(s) (storage facilities), that may have become contaminated should also be disinfested (see Appendix 1). An alternative option to disposal could in some cases be re-export of the whole consignment, especially where the infested potatoes have remained in their original packaging. Trace forward and trace back investigations should be undertaken where appropriate.

If the presence of the pest is confirmed at a facility handling imported potatoes and the finding cannot be directly associated with a particular consignment (for example, an adult is found within the facility or a larva is confirmed in soil waste after processing), investigations should be carried out to identify the possible source. The NPPO should also consider the risk that other potato stocks may have become contaminated within the facility. All infested or contaminated material (tubers, waste soil, sacks, etc.) should be disposed of safely and any other objects that may have become contaminated should be thoroughly cleansed (see Appendix 1).

In the above scenarios there may be a risk that adult *Epirix* species could have escaped from the facility and found a suitable host leading to an outbreak. This risk will need to be assessed on a case by case basis taking into account factors such as temperature within the facility and outdoors, and host availability. This will influence the extent and duration of survey work that should be undertaken. As a minimum, surveys should be undertaken in the vicinity of the facility where the pest has been found or suspected, or in other areas which may have been put at risk through the disposal of contaminated waste. Inspections should target any volunteer potatoes or solanaceous weeds growing on the premises and any solanaceous crops growing nearby (including those in private gardens). If no sign of infestation is found then the finding is an interception. Follow-up surveys should be undertaken, especially at sites considered to represent a high risk.

**3.4.3.2 Other findings in the supply chain.** If the live pest is found in the retail supply chain the infested material as well as sacks and boxes used for its storage should be disposed of safely. Premises where the infested lot was stored should be thoroughly cleansed (see Appendix 1). If symptoms but no live pest(s) are seen, then more intensive inspection of the consignment and related consignments may be carried out, followed by laboratory tests if necessary, to clarify the status of the potato lot (i.e. infested or not infested).

Following findings of the pest or symptoms of the pest, trace-back and trace-forward should be carried out to identify the source and any possible areas of resulting risk, taking into account the time of year and other risk factors.

#### 3.4.4 Source of the outbreak and other findings

In the case of an outbreak, the NPPO should investigate its possible source. In many cases this will be hard to

determine (except possibly where infested seed potatoes are planted or in a crop growing near a packer or a processor using potatoes from countries where the pest is present).

In the case of an outbreak or another finding, if the 'infested' potatoes present a risk to another country, the NPPO of that country should be informed immediately of a suspect finding so that it can take appropriate measures.

If a confirmed outbreak or another finding is associated with material received from another country, evidence such as appropriate specimens or material and documentation should be kept for up to 1 year according to the requirements in ISPM No. 13 *Guidelines for the notification of non-compliance and emergency action*.

### 3.5 Eradication

#### 3.5.1 Measures to be taken in the 'infested' area

In all cases, a rapid and detailed inspection of the whole crop area for signs and symptoms of *Epirix* should first be undertaken in order to establish the extent and the level of infestation. The crop should not be harvested.

The most appropriate eradication measures that should be taken for any given outbreak will depend on the particular circumstances of the outbreak, such as the growth stage of the crop and the level of infestation. The decision will also be influenced by other factors such as the availability of effective insecticides to control *Epirix*. The main aim should be to select control measures that will be effective in eliminating the pest population within the infested area but which do not significantly increase the risk of *Epirix* adults dispersing and flying off to infest other host crops or solanaceous species growing in field margins and other uncropped areas.

To illustrate the range of potential measures that can be taken, outbreak scenarios are outlined in this Standard:

- (1) Outbreak of *Epirix* species in a growing crop at an early stage of growth (when tubers are not developed or present but very small) and effective insecticide treatments are available for *Epirix* control. Measures are detailed in Appendix 2.
- (2) Outbreak of *Epirix* species in a growing crop close to maturity with tubers of marketable size and effective insecticide treatments are available for *Epirix* control. Measures are detailed in Appendix 3.
- (3) Outbreak in a growing crop but where no effective insecticide treatments are available for *Epirix* control

The use of effective insecticides forms a key element of any eradication programme. It also reduces the rate of spread of the pest by natural means. The lack of this control option will therefore significantly reduce the likelihood of success of any eradication programme. Whilst many of the measures outlined in Appendices 2 and 3 above can be employed, the lack of insecticide treatments means that the destruction of the potato haulm to limit pest development and build-up of the pest population will be a much higher priority. Consideration should also be given to

taking more precautionary measures in the buffer zone (see below).

- (4) Detection of infestation in tubers after harvest. Measures are detailed in Appendix 4.

#### 3.5.2 Measures to be taken within the buffer zone

Measures should be applied to potato crops and other field-grown host crops (e.g. tomatoes and other Solanaceae) growing in the buffer zone.

Host crops and fields should be inspected, with those in the immediate vicinity of the outbreak field being treated as a top priority. If infestation is found they should be designated as infested and treated as above.

If no infestation is found then a programme of insecticide treatments should be applied to potato crops and other host crops up until harvest. During this period the crops should continue to be monitored. Potato tubers should be inspected for symptoms of infestation by *Epirix* species during and/or immediately after harvesting.

Uncropped parts of the buffer zone including field boundaries, hedgerows and private gardens should be inspected for the presence of potential hosts and for signs of adult feeding damage. Sweep netting should be undertaken. If *Epirix* species are confirmed, consideration should be given to designating any field directly adjacent to the infested field boundary as infested. The host plants should ideally be sprayed first with an insecticide before being destroyed by chemical or physical means.

All potatoes crops harvested within the buffer zone should be brushed and/or washed to remove soil and the pest prior to movement outside the buffer zone. They should also only be marketed as ware potatoes (with labelling allowing traceability) and not used as farm-saved seed potatoes unless they have been subject to a treatment that has been scientifically demonstrated to eliminate the pest<sup>5</sup>. Movement under official control to a centralized facility for treatment or processing with approved waste disposal facilities may be considered where this can be demonstrated to reduce overall risks of pest spread.

The following measures may be applied:

- (1) Pre harvest official inspections at appropriate times, and no *Epirix* species have been detected.
- (2) Notification to the responsible official body of the intention of the producer to move the potatoes.
- (3) Transport to the packing facility in closed vehicles or in closed and clean packaging to ensure that the pest cannot escape or spread.
- (4) Processing of tubers immediately upon arrival at the packing facility.

The measures outlined above involve the use of insecticides. In situations where this is not an option, alternative measures will need to be considered such as:

- establishing a larger buffer zone

<sup>5</sup>No such treatment existed when this Standard was drafted but it was considered that it may be developed in the future.

- rigorous and early removal of all solanaceous weeds and potato volunteers in the infested area and buffer zone
- if trap crops are planted then these will need to be very closely monitored and measures taken promptly to prevent the pest completing its life cycle.

### 3.5.3 Measures to be applied to infested and contaminated material

Material designated as 'infested' (see section 3.4) should be disposed of safely. Other objects (equipment, machinery, storage facilities) that may be contaminated with infested material should be thoroughly cleansed. Measures are detailed in Appendix 1.

Successful application of the disposal methods recommended for all material designated as 'infested' will require careful implementation to ensure containment of the pest during treatment. Adults can fly and disperse so this risk needs to be taken into account when deciding on appropriate disposal options. This is especially the case when an eradication strategy is being followed. The NPPO should establish the most appropriate waste disposal measures and should monitor their efficient and effective application at all times. In addition, if material is transported for processing a system of cleansing should be in place for at least the vehicles and any containers that have been used for transportation.

### 3.5.4 Restrictions on cropping and measures in subsequent seasons

To achieve eradication, restrictions should be applied to the infested fields and fields within the buffer zone as soon as possible and before the growing season following the outbreak, and should continue in subsequent seasons. These are detailed in Appendix 5.

When surveys find no evidence of the pest for 3 years, the area (or a part of the area) may be deregulated.

### 3.5.5 Availability of effective insecticides to control *Epitrix*

Effective control is dependent on the timely application of insecticides with good activity against *Epitrix* species. The NPPO should assess the portfolio of insecticides available to control *Epitrix* in advance of any outbreak because it is likely to influence the overall control strategy adopted. Furthermore, if there is a shortage of effective insecticides it may be possible to apply for emergency clearance so that more effective chemicals are available in a future outbreak situation. It is also important to have chemicals available with different modes of action in order to mitigate against any existing resistance and to help limit the development of resistance to ensure control remains effective in the longer term.

A wide range of insecticides from several insecticide groups (e.g. pyrethroid, synthetic pyrethroid, carbamate, neonicotinoid and organophosphates) have been shown to be effective when applied as foliar sprays (Cuthbertson,

2015). In addition, some insecticides (e.g. phorate) have given good control when used as soil applications.

The NPPO should also give consideration to the possible control options and strategy available in the case of organic potato crops. For example, more extensive early destruction of haulm in the buffer zone may provide an acceptable level of risk mitigation, and in the case of organic growers this may be preferred to avoid the loss of organic status. Alternatively the NPPO may decide that the use of insecticides is essential for the effective control of *Epitrix* species in outbreak situations irrespective of the organic status of the farms affected.

## 3.6 Containment strategy

Achieving eradication will not be possible in all circumstances. For example in situations where an outbreak area is large and the pest has already spread to the wider environment.

Many of the measures outlined above for eradication will also be appropriate for a containment strategy because they will suppress the pest and reduce the risk of spread.

The measures recommended will differ according to whether or not effective insecticide treatments are available to control *Epitrix* species, and whether the infested area is large. In particular, where effective treatments are not available or cannot be applied because of the size of the infested area, a larger buffer zone will be needed to reduce the risk of spread out of the regulated area. Measures for a containment strategy are detailed in Appendix 6.

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## Appendix 1 – Disposal and decontamination measures

### Infested and probably infested tubers, soil and plant debris

Adults, pupae and possibly larvae may be present with the harvested tubers, associated soil and plant debris. It is important that all of this material is disposed of safely to eliminate the pest. When deciding on the most appropriate method(s) of disposal, factors such as the likelihood of adults being present together with the level of handling and transportation required all need to be taken into account. For all methods, measures need to be taken to ensure that there is no risk of spread during transport and treatment or disposal. Suitable methods should be carried out under official supervision. They include the following for tubers and plant debris or soil, respectively:

Tubers and plant debris:

- incineration (only suitable for small quantities)
- deep freezing (–20°C for 24 h)
- deep burial on site or at approved facilities

- steaming and feeding to animals
- anaerobic digestion for production of biogas at an officially approved site is also a suitable method for disposal provided the entire volume of material is subjected to a minimum temperature of 55°C maintained over a period of 24 h without interruption with an hydraulic dwell time in the reactor of at least 1 day
- industrial processing under official supervision depending on a risk assessment taking account of the arrangements for storage, handling, processing and waste disposal.

Soil:

- deep burial on site or at approved facilities
- incineration (only suitable for small quantities)
- deep freezing (–20°C for 24 h)
- heat sterilization.

Additional guidance on the management of phytosanitary risk of soil may be found in EPPO Standard PM 3 (under development).

### Other objects

All objects designated as ‘contaminated’ such as equipment, machinery, storage facilities that may be contaminated with infested soil or potato material should be thoroughly cleansed (e.g. with a high-pressure water washer) to remove the pest and all soil.

## Appendix 2 – Eradication measures to be taken after an outbreak in a potato crop at an early stage of growth and effective insecticide treatments are available for *Epitrix* control (scenario 1)

- A rapid and detailed inspection of the whole crop area for signs and symptoms of *Epitrix* should be undertaken in order to establish the extent and the level of infestation. This is most easily done by assessing the levels of foliar damage and the number of adult beetles present. Sweep nets should be used to catch adult beetles. Assessments should also be made of the extent of tuber development (size and number) and the haulm’s likely susceptibility to herbicide treatment if this is a possible treatment option for crop destruction. Additionally, tubers should be checked for symptoms, although the absence of symptoms, especially early in development, is not necessarily a good indicator of low pest populations.
- The whole infested crop should then be treated immediately with a foliar insecticide spray with good activity against *Epitrix* adults (see section 3.5.5 on insecticides). Treatment will have little or no effect on life stages present in the soil. Further regular insecticide treatments should therefore be applied to kill adults that may emerge from the soil after insecticide application. Alternative treatments such as drenches and granular insecticide treatments may be authorized in some countries or be possible under emergency use for an outbreak situation. Such



treatments will have activity against the various *Epitrix* life stages in the soil.

- The potato haulm should then be destroyed: haulm killing will reduce *Epitrix* survival and multiplication by eliminating its food supply. This should be undertaken after at least one insecticide spray has been applied. It is crucial that adults are effectively controlled before haulm destruction to minimize the potential for adults to disperse, so more than one insecticide treatment may be required. Adult populations should be assessed using sweep nets to check the effectiveness of treatment. Methods that destroy the haulm rapidly will be most effective in the short term in reducing pest multiplication, but the application of glyphosate or diquat, whilst slower acting, will reduce potato volunteer emergence in the following season. The use of flame burners will kill the haulm and any beetles present but could potentially encourage adult dispersal. Destruction of the haulm by any of these methods will not kill the tubers which, if present, could continue to provide a food source for larvae. There is a risk that haulm destruction could result in greater dispersal of adults that survive insecticide treatment or that emerge subsequently from the soil. Consideration should therefore be given to leaving several rows of crop at the edge of the field, and possibly also within the field, to act as trap plants for adults. These trap areas should be sprayed at regular intervals with insecticide and the haulm destroyed at a later date.
- It is important to continue spraying the infested field with insecticides for several weeks after haulm destruction in order to kill any adults that may subsequently emerge from the soil.
- Steaming remains an option for soil disinfestation, but less expensive alternatives are being developed. Biological soil disinfestation methods developed at Wageningen University (NL) (Runia *et al.*, 2011), using organic amendments and reducing supply of oxygen by covering with airtight plastic sheets, are likely to be effective in killing all *Epitrix* life stages present in the treated soil. These methods also kill potato tubers.
- In the regulated area, uncropped areas, field boundaries and hedgerows should be inspected for the presence of solanaceous host weeds and for signs of adult feeding damage. Inspections should first focus in the immediate vicinity of the infested crop. If symptoms and/or adults are found, these weeds should ideally be sprayed first with an insecticide to kill adults and then destroyed with a herbicide or by mechanical means. If there are no symptoms and no adults are found, these weeds should preferably be destroyed with a herbicide or by mechanical means.
- The infested crop should not be harvested because of the risk of spread of *Epitrix* species with the harvested tubers and associated soil.
- Measures should be taken to reduce potential volunteer growth in the following year. Options include:

- application of glyphosate to the growing crop to prevent sprout development of the progeny tubers and hence plant growth
- cultivations that reduce tuber survival (e.g. exposing tubers to frost)
- herbicide treatment or cultivations to kill volunteer potato plants soon after emergence in the following season.
- Cultural methods that also favour control include keeping fields free from weeds which can host the pest and destroying plant residues to hamper overwinter survival.
- Strict hygiene measures will be required for all vehicles, machinery and equipment to prevent the potential spread of *Epitrix* species out of the field with soil.

### **Appendix 3 – Eradication measures to be taken after an outbreak in a potato crop close to maturity with tubers of marketable size when effective insecticide treatments are available for *Epitrix* control (scenario 2)**

- A rapid and detailed inspection of the crop should be undertaken in order to establish the extent and level of infestation (same as scenario 1, see Appendix 2 for details).
- The whole crop should then be treated immediately with foliar insecticide sprays with good activity against *Epitrix* adults (same as scenario 1, see Appendix 2 for details).
- The benefits associated with the early destruction of the haulm to reduce *Epitrix* levels are more marginal for a crop close to maturity than in the case of a less mature crop. This is because tubers are present for the larvae to feed on. Adult pest populations are also likely to be higher so haulm destruction could encourage dispersal of adults to less mature potato crops. The application of a programme of foliar insecticides in the crop will therefore be the preferred strategy in many such situations.
- To achieve elimination with a high level of confidence the crop should not be harvested because of the risk of spread of *Epitrix* species with the harvested tubers and associated soil. This means that measures should be taken to reduce potential volunteer growth in the following year. Options include:
  - application of glyphosate to the growing crop to prevent sprout development of the progeny tubers and hence plant growth
  - cultivations that reduce tuber survival (e.g. exposing tubers to frost)
  - herbicide treatment or cultivations to kill volunteer potato plants soon after emergence in the following season.

### **Appendix 4 – Measures to be taken in the case of detection of infestation in tubers after harvest (e.g. in a grower's potato store or during processing/packaging when the tubers can be traced back to a known farm or field)**

- It is vital that the NPPO ascertains the place and the field(s) of production where the infested lot was grown

and, where appropriate, stored to ensure that the measures are applied to the correct field(s) and store(s).

- There is a risk that *Epitrix* may not be limited to the known infested field(s) and other potato crops grown nearby could also be infested. Investigations should therefore be carried out in the infested area and the buffer zone. This should involve inspections of all fields in the buffer zone and where host plants were grown (or are still growing) in the same season as the infested crop. Any tubers in storage should also be inspected for symptoms and for the presence of the pest.
- The NPPO should also consider the risk that other potato stocks may have become contaminated after harvest. This could happen, for example, through the transfer of infested soil through the use of grading lines or storage boxes potentially contaminated by an infested stock. In addition, adult beetles have the potential to transfer to other stocks during grading or during the storage period. Where the assessment indicates that a risk of spread of the pest exists, the lots at risk should also be designated as 'probably infested' and restrictions should be applied to them. Assessing the probability of contamination having occurred will need to be made on a case by case basis and this will inform decision-making about the appropriate options for safe disposal.
- The 'infested' and 'probably infested' material and waste should be disposed of safely, and contaminated equipment (including the potato store) should be cleansed (see Appendix 1).
- If the infested field can be determined, measures should be taken to reduce potential volunteer growth in the following year, and restrictions on cropping and measures in subsequent seasons should be applied (see Appendix 5)

## Appendix 5 – Restrictions on cropping and measures in subsequent seasons

### In the infested area

For a minimum of 3 years:

- No potato or other host crop should be planted for at least 3 years and until no volunteer potato plants or solanaceous weeds have been found for two consecutive years. The only exception to this rule is in the case where several rows of potatoes are planted around the edge of the field to act as trap plants for *Epitrix* species. In this case, the plants should be inspected very closely for the presence of foliar damage and adults. Insecticide sprays should be applied at regular intervals and the potato plants destroyed before viable tubers have developed.
- No root crops should be planted in the infested field for 1 year because of the risks of movement of infested soil.
- Volunteer potatoes should be controlled in the next crop at an early stage of development to prevent pest survival. If volunteer numbers are low they can be removed by

hand or spot treated with herbicide. High volunteer numbers are best controlled by the application of effective herbicide treatments to the crop. This consideration should influence crop selection for the subsequent seasons.

- If signs of *Epitrix* foliar damage are evident on volunteers the whole field should be sprayed with an appropriate insecticide programme, volunteers destroyed as soon as possible and restrictions continued for a further 3 years.
- Solanaceous weeds should be controlled in all crops and in field margins and other uncropped areas.
- A possible option for 'infested' fields is to maintain them in permanent pasture with frequent close cutting or intensive grazing. This option has the advantage of providing effective control of potato volunteers and other solanaceous weeds.
- When a potato crop is next grown for the first time after infestation only ware potatoes should be produced. However, if trap plants have been used for 3 years as described above and no *Epitrix* has been found, either ware or seed potatoes may be grown for the first time after infestation.
- The first potato crop or other host crop grown on an infested field should be officially inspected during the growing season for adults and foliar shot holing. Potato tubers should also be inspected after harvest for symptoms.

### In the buffer zone

For a minimum of 2 years:

- No host crops should be planted outdoors.
- All fields where potatoes have been grown in the past should be inspected for the presence of volunteer potatoes. These should be checked for shot-holing on leaves. If signs of *Epitrix* foliar damage are evident on volunteers the field should be designated as infested.
- Volunteer potatoes should be controlled, and any which do emerge destroyed very promptly. If this is not done the whole field should be sprayed with an appropriate insecticide programme and the field then reinspected.
- Solanaceous weeds should be controlled in all crops and in field margins

Based on survey results, other evidence and risk assessment the measures and size of the buffer zone should be re-evaluated as appropriate.

## Appendix 6 – Containment

### Containment measures where effective insecticide treatments available for *Epitrix* control

The main differences from the requirements for eradication (see section 3.5 and relevant Appendices) are as follows.

In the infested area:

- In an infested field, no potato or other host crop should be planted for at least 1 year and until no volunteer potatoes have been found for at least 1 year (instead of 3 and 2 years, respectively, for eradication).
- Non-host root crops can be produced in infested fields but hygiene precautions and safe soil disposal practices should be taken to prevent the potential spread of *Epitrix* with the movement of soil.

In the buffer zone:

- A larger buffer zone should be established (at least 3 km around the infested area).
- Ware potatoes can be produced within the buffer zone provided a programme of insecticides is applied to the crop to control *Epitrix* species. The harvested tubers will be subject to brushing and/or washing within the regulated area, prior to marketing, to remove the pest and all soil. In addition, all waste soil, tubers and other plant waste should be disposed of safely to minimize the risk of pest survival and spread.

In the entire regulated area:

- Use of farm-saved seed potatoes produced within the regulated area is permitted only if they are brushed and/or washed prior to planting. Planting is only allowed on the same place of production.
- Seed potatoes can be produced within the regulated area but only for planting within the regulated area. The tubers should be brushed and/or washed prior to marketing.

- All field-grown host crops should be officially inspected at least twice for the presence and/or signs of infestation. If infestation is found the infested area and buffer zone should be adjusted as necessary.

#### **Containment measures where effective insecticide treatments are not available for *Epitrix* control**

The requirements are the same as those above except that the buffer zone should be larger: at least 5 km around the infested area.

#### **Alternative containment strategy in the case of a large infested area**

In cases where the infested area becomes very large, consideration could be given to allowing growing and processing of ware potatoes within the infested area, while maintaining measures in a larger buffer zone of at least 10 km, taking measures to prevent spread into the buffer zone from the infested zone (e.g. chemical control at appropriate times), and continuing to control movements so that seed potatoes are not moved out of the regulated area and that ware potatoes are moved from the demarcated area only if previously brushed and washed. In such cases further details concerning the relevant measures would need to be elaborated.