



Department
for Environment
Food & Rural Affairs

Pest specific plant health response plan: Outbreaks of '*Candidatus Liberibacter solanacearum*' and its psyllid vector *Bactericera cockerelli* on glasshouse-grown crops



Figure 1. Adult *B. cockerelli* (2.5-2.75 mm long). Credit: Whitney Cranshaw, Bugwood.org.

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1. Introduction and scope

- 1.1. This pest specific response plan has been prepared by the Defra Risk and Policy team. It describes how the plant health service for England will respond if the solanaceous haplotypes of '*Candidatus Liberibacter solanacearum*' (Lso) and/or their psyllid vector *Bactericera cockerelli*, which together constitute the 'zebra chip' complex, are discovered on potato plants (*Solanum tuberosum*), tomato (*Solanum lycopersicum*), pepper (*Capsicum annum*), aubergine (*Solanum melongena*) or other solanaceous hosts¹ in glasshouses in England. There is also a response plan specifically for findings in potato fields in England.
- 1.2. The plant health authorities in Northern Ireland, Scotland and Wales have been consulted on this plan will use it as the basis for the action they will take in the event that Lso and/or *B. cockerelli* are detected in their territories.
- 1.3. This document is restricted to activities specific to haplotypes A and B of Lso and their vector *B. cockerelli* and will be used in conjunction with *Defra Contingency Plan for Plant and Bee Health in England* (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/593508/generic-contingency-plan-plant-bee-health-england.pdf), which gives details of the teams and organisations involved in pest response in England, and their responsibilities and governance. It also describes how these teams and organisations work together in the event of an outbreak of a plant health pest.
- 1.4. The aim of this response plan is to facilitate the containment and eradication of Lso and *B. cockerelli* in England.

2. Summary of threat

- 2.1. Lso is a rod-shaped unculturable gram-negative bacterium with approximate dimensions of around 4 by 0.2 µm, and in infected plants is confined to the phloem tissue (Leifiting *et al.*, 2008).
- 2.2. The plant disease known as 'zebra chip', caused by either of the two solanaceous haplotypes of Lso (A and B), was first reported on potato (*Solanum tuberosum*) in the early 1990s in the Americas (including Guatemala, Honduras, Mexico and the Southwestern USA), and has since been found further north and east in the USA. In 2008, the pathogen and its vector were also reported in New Zealand where they are causing economic losses in potato, pepper and tomato production, and have recently been found in *B. cockerelli* vectors in Alberta, Canada, though no evidence of disease in potatoes were found (Johnson *et al.*, 2017).
- 2.3. Haplotypes C, D and E have been found in Europe, Morocco and Israel associated with plants from the family Apiaceae, including carrots, celery, parsley and parsnips. Haplotype E has also been detected in potatoes with zebra chip symptoms in Spain (Cambra, 2014).

¹ Hosts of Lso refer to all plants which can be infected by any of the haplotypes of the bacterium whilst hosts of *B. cockerelli* refers to those plant species on which the psyllid completes its life cycle or which are the preferred food sources of the psyllid. A list of known hosts of *B. cockerelli* can be found in Biosecurity Australia (2009).

- 2.4. A further haplotype, named haplotype U, has also been identified in the psyllid *Trioza urticae* and *Urtica dioica* (stinging nettle) in Finland (Haapalainen *et al.*, 2018).
- 2.5. Haplotypes A and B are particularly damaging to the potato industry. They reduce yield and can kill plants, affect potatoes for the fresh market, and internal tuber discolouration can render harvested tubers unacceptable to the potato chip and crisp manufacturing industry, because chips and crisps made from infected tubers develop areas of brown discolouration after frying (figures 2 and 3). Besides causing disease in potato, the two solanaceous haplotypes of Lso (A and B) also cause disease in a number of other solanaceous crops and weeds, which can provide a reserve for the bacterium. A list of hosts for Lso can be found on the EPPO Global Database - <https://gd.eppo.int/taxon/LIBEPS/hosts>.
- 2.6. The psyllid vector, *B. cockerelli*, transmits haplotypes A and B both transovarially through the eggs, as well as from plant to plant during feeding. *Bactericera cockerelli* is a serious pest in the absence of Lso, causing the condition 'psyllid yellows' in potato and some other solanaceous plants (e.g. tomato, aubergine and pepper). Symptoms of psyllid yellows include yellowing, stunting, and leaf and tuber distortion.
- 2.7. *Bactericera cockerelli* is distributed in North and Central America, as well as Australia, New Zealand and Norfolk Island.
- 2.8. The psyllid, *Trioza apicalis*, transmits haplotype C, while the psyllid, *Bactericera trigonica*, transmits haplotypes D and E. *Trioza apicalis* is distributed in East Asia, in Russia and Mongolia, and much of Europe, including the UK. While, *Bactericera trigonica* is currently found sporadically over southern Europe and northern Africa. It has not been recorded as established in the UK.
- 2.9. *Bactericera cockerelli* has been intercepted twice in the UK, both in 2017. These interceptions were made on *Solanum melongena* (aubergine) from Mexico. *Bactericera trigonica* has not been intercepted in the UK.
- 2.10. There have been two confirmed interceptions of Lso in the UK, in 2017. One of these interceptions was on *Pastinaca* (parsnip) seed (haplotype E) and the other was on *Daucus carota* (carrot) seed. There was also a further interception of a *Candidatus liberibacter* spp. (likely to be Lso) on carrot seed in 2017.
- 2.11. Lso haplotype C has been confirmed in adult *Trioza anthrisci* caught in suction traps in Scotland and Sweden between 2015 and 2016 (Sjölund *et al.*, 2017). *Trioza anthrisci* is morphologically very close to *Trioza apicalis*.

3. Risk assessments

- 3.1. Lso and *B. cockerelli* have an unmitigated and mitigated UK Plant Health Risk Register score of 75. These scores are reviewed as and when new information becomes available (<https://secure.fera.defra.gov.uk/phiw/riskRegister/viewPestRisks.cfm?cslref=18132>). *Trioza apicalis* and *B. trigonica* are currently not on the Risk Register.
- 3.2. In 2012, EPPO published risk assessments (EPPO, 2012a, b) and data sheets (Munyaneza, 2013a, b) on solanaceous Lso and its vector, outlining their biology and distribution, and identifying and

evaluating economic risks and management options should the pathogen and/or vector establish in the EPPO region.

- 3.3. The Food and Environment Research Agency (Fera) carried out a Rapid Pest Risk Analysis for Lso and *B. cockerelli* (Fera, 2015).
- 3.4. The risk assessments concluded that if Lso along with *B. cockerelli* were introduced into the region, they would have a high chance of establishment wherever host plants were present, and that eradication or containment would be difficult, due to the likelihood that they would not be detected before becoming established and causing damage. If introduced together, the damage caused by Lso and *B. cockerelli* was assessed as being significant to host crops.



Figure 2. Zebra chip infected potato tuber.
Credit: Joseph E. Munyaneza, USDA ARS, Wapato, WA.



Figure 3. Zebra chip infected fried chips.
Credit: Joseph E. Munyaneza, USDA ARS, Wapato, WA.

4. Actions to prevent outbreaks

- 4.1. Lso is not currently regulated under EU plant health legislation. However, *B. cockerelli* is listed in EU directive Annex IAI, as of January 2018.
- 4.2. Lso (Solanaceae haplotypes) and *B. cockerelli* are A1 listed pests in the EPPO region and are therefore recommended for regulation by EPPO member countries. *Trioza apicalis* and *B. trigonica* are not EPPO listed.
- 4.3. In the event of Lso or any of its vectors being found in consignments entering England or at places of production, or in the wider environment, action should be taken under Articles 5 (c) of the Plant Health (England) Order 2015 (transposed from Article 16(2) of EU Council Directive 2000/29/EC) for third country imports.
- 4.4. The National Regulatory Control System PM 9/25 (1) *Bactericera cockerelli* and '*Candidatus liberibacter solanacearum*' provides guidance on excluding *B. cockerelli* and Lso from the EPPO region, and eradicating incursions of *B. cockerelli* and Lso (EPPO, 2017).

- 4.5. The Plant Health Service should be aware of the measures described in this plan and be trained in responding to an outbreak of Lso and/or its vectors (see 4.15 for links to additional information). It is important that capabilities in detection, diagnosis, and risk management are available.

Potato

- 4.6. The import of *Solanum tuberosum* tubers for propagation (seed potatoes) into the EU from third countries other than Switzerland is prohibited under Annex III, Council Directive 2000/29/EC. There is a derogation to bring in tubers for trial, scientific or varietal selection purposes (Commission Directive 2008/61/EC), but they must be placed under quarantine conditions and tested for pests before being used for propagation purposes. There is also derogation for Canadian seed potatoes. This allows Greece, Spain, Italy, Cyprus, Malta and Portugal to import, under specified conditions, seed potatoes originating from certain provinces of Canada:

<http://eurlex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014D0368&from=EN>
<http://eurlex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011D0778&from=EN>

- 4.7. Ware potatoes and their hybrids are prohibited from third countries, with the exception of Algeria, Egypt, Israel, Libya, Morocco, Syria, Switzerland, Tunisia and Turkey, and other European third countries which are recognised as being free from *Clavibacter michiganensis* ssp. *sepedonicus*, or in which provisions recognised as equivalent to those of the EU territory for mitigating *C. michiganensis* ssp. *sepedonicus* have been fulfilled (Annex III, Council Directive 2000/29/EC).
- 4.8. Movement of potato tubers within the EU from *Epitrix* demarcated to non-demarcated areas must be accompanied by a plant passport that is issued as per Commission Directive 92/105/EEC. The potato tubers must also meet the following conditions:
- That they have been grown in a registered place of production as per Commission Directive 92/90/EEC, or by a registered producer or moved from a warehouse or dispatching centre registered as per Commission Directive 93/50/EEC.
 - That they have been washed or brushed before export so that no more than 0.1% of soil remains if they have been imported from a demarcated area in Portugal or Spain.
 - That they are packaged in material that is clean.
- 4.9. From non-demarcated areas for *Epitrix*, the potatoes must be washed before export to the UK from mainland Spain in order to kill or remove any *Epitrix* which might be present.
- 4.10. Within the EU, potato tubers for planting must come from advanced breeding selections, have been produced within the EU, been maintained under appropriate conditions, and tested for harmful organisms using appropriate methods (Annex IV part A section 2, Council Directive 2000/29/EC).
- 4.11. Seed potatoes can only be marketed in the EU if they meet the requirements of Council Directive 2002/56/EU (includes information on certification schemes to ensure healthy plant material).
- 4.12. In response to other pests and diseases of potato, such as *Ralstonia solanacearum* (brown rot) and *Epitrix* potato flea beetles, seed and ware potatoes are surveyed.

Plants of Solanaceae

- 4.13. Plants of Solanaceae intended for planting, other than seeds, (except ware and seed potatoes, and other stolon- or tuber-forming plants for planting), are prohibited from third countries other than European and Mediterranean countries (Annex III, Council Directive 2000/29/EC).
- 4.14. Prohibited solanaceous plants can be imported and held under a plant health licence in quarantine conditions (usually for research purposes). Once work on the plants has been completed, destruction of the plants is normally required. However, given adequate testing, the plants can, in some cases, be released from the terms of the licence if they are shown to be free of pests and pathogens.

Communication

- 4.15. All stakeholders, particularly those involved in the production and processing of host plants, should be provided with the details of the disease, hosts, vectors and the available control methods. A factsheet and PRA report are available for both Lso and *B. cockerelli* on the EPPO Global Database – <https://gd.eppo.int/taxon/LIBEPS/documents> and <https://gd.eppo.int/taxon/PARZCO/documents>.

5. Response activities

Official action to be taken following the suspicion or confirmation of Lso and/or *B. cockerelli* on imported plants, including seeds

Holding consignments at point of entry, including packhouses

- 5.1. If Lso and/or any of the development stages of *B. cockerelli*, are suspected by the Plant Health and Seeds Inspectorate (PHSI) to be present in a consignment moving in trade, the PHSI must hold the consignment until a diagnosis is made. Ideally, the consignment should be placed in a sealed cold store and any opened containers should be resealed. Other consignments that are at risk of cross-contamination should also be held prior to a risk assessment on whether cross-contamination has or could have potentially occurred. Samples should be sent to Fera Science Ltd., National Agri-Food Innovation Campus, Sand Hutton, York, YO41 1LZ (01904 462000) in a sealed bag or container, within at least two other layers of containment, which are not liable to be crushed during transit.
- 5.2. When an infestation of Lso and/or *B. cockerelli* is confirmed, the PHSI should advise the client of the action that needs to be taken by way of an official plant health notice.
- 5.3. If *B. cockerelli* is present, the consignment should be destroyed by either incineration or deep burial, or re-exported in a sealed container (as in 5.77). For re-export, the consignment should be sent back to the place of production and the relevant NPPO notified. If it is not possible to organise destruction by deep burial or incineration, suitable alternatives should be discussed with the Defra Risk and Policy team (see 5.78).
- 5.4. Consignments that have tested positive for Lso, but where *B. cockerelli* is not found should also be destroyed by either incineration or deep burial, or re-exported in a sealed container due to the potential for *B. cockerelli* to be present. However, solanaceous fruit (without green parts), where *B.*

cockerelli has been shown to be definitely not present, may be allowed for processing at approved facilities or for retail following discussion with the Defra Risk and Policy team.

- 5.5. For interceptions inland where there is a risk of escape, any host plants (including any tubers or fruit, which should be held) should be surveyed on the site or in the immediate vicinity in the summer and again in the following year for signs of pest presence. If the site is in an area where hosts are grown, at least two fields/nurseries closest to the site and a field/nursery on the prevailing wind side should be surveyed. Waste disposal processes and areas should also be inspected.
- 5.6. A Europhyt notification should be made upon confirmation of an interception of live Lso and/or *B. cockerelli*.
- 5.7. In the event that all or part of the consignment has not been held and has been distributed to other premises prior to diagnosis, trace forward and trace back inspections should take place upon suspicion or confirmation of Lso and/or *B. cockerelli*. Details of recent past and future consignments from the same grower/supplier should also be obtained and a decision on action taken on a case by case basis.
- 5.8. A pest alert to raise awareness of Lso and *B. cockerelli* and their symptoms should be distributed to packers/processors and importers where Lso and *B. cockerelli* have been found, and to those associated with the infested premises. The pest alert is found on the plant health portal – <https://planthealthportal.defra.gov.uk/assets/factsheets/Bactericera-cockerelli-pest-alert-v3.pdf>.

Official action to be taken following the suspicion of Lso and/or *B. cockerelli* at a place of production

- 5.9. The occurrence of Lso in glasshouse-grown crops is likely to be confined to a main host such as tomato, pepper, aubergine, and potato minitubers.
- 5.10. A Contingency Core Group (CCG), chaired by the Chief Plant Health Officer (CPHO) or their deputy and including specialists from APHA, Defra and other organisations, should be set up to assess the risk and decide on a suitable response at strategic and operation levels. This may include gathering more information on the suspected outbreak, such as the completion of the outbreak assessment, notification of ministers and senior officials, and agreeing a communications strategy. The CCG will also decide who will be the control authority, and the control authority will then nominate an incident commander. An Incident Management Team (IMT) meeting, chaired by the Incident Commander, will subsequently convene to produce an Incident Action Plan (IAP). See the Defra *Generic Contingency Plan for Plant and Bee Health in England* for full details.
- 5.11. The CCG will set an alert status (using the factors to consider document, appendix IV of Defra *Generic Contingency Plan for Plant and Bee Health in England*), which will take into account the specific nature of the outbreak. Under most scenarios, an outbreak of Lso under protection is likely to be given a black alert status, which is used for a significant plant disease that has the potential for geographic spread. However, this can be downgraded to a white alert status (limited geographic spread) in the absence of *B. cockerelli*.

Restrictions on movement of material, equipment and machinery to and from the place of production

- 5.12. Lso and *B. cockerelli* are associated with plants for planting, fruit, vegetables and tubers, and living parts of plants (excluding plants for planting and fruit, vegetables and tubers, e.g. cut foliage), so these should be restricted from leaving the site, except for when they are being sent for destruction by deep burial or incineration (as in 5.77). There is some limited evidence that Lso can be transmitted by carrot seed (Bertolini *et al.*, 2014), therefore if haplotype A or B is suspected movement of seed (including true potato seed) should also be restricted as a precaution.
- 5.13. Movement of material, equipment and machinery, which may result in the movement of life stages of *B. cockerelli* between infested and non-infested areas, should also be restricted. However, if movement is necessary, the material, equipment and machinery should be thoroughly cleaned at the designated outbreak site to remove any life stage of *B. cockerelli*.
- 5.14. Movement of personnel into the affected glasshouse should be severely restricted, especially during the early investigation phase and/or if *B. cockerelli* is detected. Personnel should be briefed on the importance of good hygienic practice to reduce the risk of carrying psyllid eggs/nymphs to other areas of the production facility.

Precautionary measures

- 5.15. The glasshouse and other glasshouses at risk should be sealed to prevent the escape of *B. cockerelli*.
- 5.16. Although Lso has not been demonstrated to be transmitted mechanically, it can be mistaken for other diseases for which mechanical transmission is possible. Psyllid eggs and nymphs can also be transferred mechanically, and therefore hygiene best practice should be followed as below:
- Training staff to identify symptoms of Lso and basic characteristics of psyllids and to follow best practice procedures (see 4.15 for links to further information).
 - Using disposable garments (including overshoes), which will be destroyed after working on an infected/infested lot or only used in the infected area.
 - Using disposable gloves that can be destroyed following work on a particular crop, between different areas within a crop, or between plants, or only used in infected area.
 - Restricting the use of equipment and machinery to one location. If equipment or machinery must be moved between locations, then they should be thoroughly cleaned before being moved e.g. with high water pressure, steam cleaners etc.
 - Restricting access to the working area. The fewer people entering a particular lot, the less chance of psyllid vectors harbouring Lso will be introduced. Wherever possible, employees should work in the same areas or number of rows each day rather than swapping around work areas. Only trained staff should be able to access restricted areas, and there should be a sign in/sign out sheet to record movements.
 - Wherever possible, working in uninfested areas initially and finishing in areas that could be infested during work shifts.
- 5.17. Volunteer plants and weeds, particularly solanaceous perennials, may act as reservoirs for Lso, either as primary hosts (e.g. *Solanum dulcamara* and *S. elaeagnifolium*) or in *B. cockerelli* when it overwinters on these weed hosts. Other weed hosts of Lso may be present in Europe. Controlling

these plants within and around glasshouses reduces the chance of the crop becoming infected and reduces the risks of survival and persistence in the event of an outbreak. Volunteer plants and weeds can be controlled mechanically (e.g. hoeing), chemically (e.g. herbicides), and manually (e.g. roguing). For a list of host species of Lso and *B. cockerelli*, consult the EPPO Global Database (<https://gd.eppo.int/taxon/LIBEPS/hosts> and <https://gd.eppo.int/taxon/PARZCO/hosts>) and EPPO PRAs (<https://gd.eppo.int/taxon/LIBEPS/documents> and <https://gd.eppo.int/taxon/PARZCO/documents>).

Preliminary trace forward / trace backward

- 5.18. Information obtained regarding the origins of infested consignments should be used to locate other related and therefore potentially infested consignments. The relevant NPPO should be contacted and delivery notes sent. Information should also be obtained on the destination to which suspect consignments have been sent. This process is particularly important for propagation or seed potato stocks.
- 5.19. In addition to tracing investigations relating to consignments, trace forward/back investigations linked to equipment, machinery and personnel in the infested premise should also be made.

Confirming a new outbreak

How to survey to determine whether there is an outbreak

- 5.20. Information to be gathered by the PHSI on the suspicion of an infestation of Lso and/or *B. cockerelli*, in accordance with ISPM 6; guidelines for surveillance (http://www.acfs.go.th/sps/downloads/13717_ISPM_6_E.pdf):
- The origin of the host plants and associated pathways.
 - Details of other premises or destinations where the host plants/products have been sent, where Lso and/or *B. cockerelli* may be present.
 - The layout of the premises and surrounding area (in relation to potential buffer zones of at least 1 km), including a map of the fields/cropping/buildings, at risk growers, and details of neighbouring crops, especially any commercial or non-commercial hosts in fields, allotments, gardens or glasshouses.
 - Details of the host variety, growth stage and any other relevant information.
 - Description of the surrounding habitat, including all hosts e.g. *Convolvulus arvensis* (bindweed).
 - Area and level of infection/infestation, including life stages and a description of symptoms (photos should be taken).
 - The location of any known populations, including grid references.
 - The date and time the sample was taken, how it was identified and by whom.
 - Current treatments/controls in place e.g. chemical treatments.
 - Details of the movement of people, equipment, machinery etc. to and from the infested area.
 - Cultural, biosecurity and working practices.
 - The name, address, email and telephone number of the person who found the pest and/or its symptoms, and the business owner.
- 5.21. This information should be included on the plant pest investigation template (see Appendix III the Defra *Generic Contingency Plan for Plant and Bee Health in England*).

- 5.22. Further to information gathering, samples of other infected or infested plants should be taken to confirm the extent of the infection/infestation e.g. in associated glasshouses. This initial survey will be used to determine if it is an isolated finding or an established outbreak.
- 5.23. Finance for the surveys will depend on the individual circumstances of the outbreak, and will be subject to discussion, usually between Defra policy and the PHSI.

Sampling

Lso

- 5.24. Although symptoms may vary slightly between solanaceous host plants, above ground symptoms associated with Lso to look out for generally include chlorosis and the purpling of foliage, stunting of plants, erectness of new foliage, leaf distortion (e.g. cupping or curling), shortened and thickened internodes resulting in plant rosetting, enlarged nodes, leaf scorching, and deformed and poor quality fruit (see figures 4 and 5). These symptoms can be confused with other diseases caused by phytoplasmas, viruses etc.
- 5.25. In addition to crop plants, a survey of solanaceous weeds on and around the affected facility should be carried out to assess the extent of the outbreak. Although it is known that diseased plants may sometimes fail to exhibit symptoms of the disease, finding the disease in a weed implies the presence of a vector, as spread from crop plants to weeds would otherwise not be possible.
- 5.26. Lso is not normally distributed uniformly throughout the plant, and is often present in low titre, leading to difficulty in confirming its presence. To minimise this problem, representative sections of all plant parts should be sampled. For minitubers, sections of tubers should be sampled where applicable (if symptomatic) as Lso titre is often higher in tuberous tissue.
- 5.27. Symptomatic parts of the plant (e.g. leaves, fruit, stems and tubers) should be placed in a sealed bag or container and sent for diagnosis as in point 5.1.



Figure 4. Early zebra chip symptoms.
Credit: Joseph E. Munyaneza, USDA ARS, Wapato, WA.



Figure 5. Lso infected plant. Credit: Joseph E. Munyaneza, USDA ARS, Wapato, WA.

***Bactericera cockerelli* (Adapted from Plant Health Australia Threat Specific Contingency Plan – Plant Health Australia, 2011)**

- 5.28. *Bactericera cockerelli* can cause 'psyllid yellows', which is associated with the stunting and yellowing of plants, and the distortion of leaves (see figure 6). As for other sap sucking insects, *B. cockerelli* egests excess water and sugar in the form of honeydew, but before the honeydew is expelled, the psyllid also coats the honeydew in wax. These wax covered honeydew droplets are called psyllid sugars (see figure 7, 9).
- 5.29. While life stages of the psyllid are small, with adults around 2.5 mm in length (Figure 8, 9), they can be sampled throughout the affected premises by examining leaves from a number of plant species/varieties with a hand lens and collecting leaves with as many life stages as possible (or placing them in glass/plastic vials). Leaves from separate plant species and from different areas of the production facility should be packed separately and appropriately labelled (with information on the location within the facility and life stages seen). Random sampling of eggs, nymphs and adults on leaves of the crop can help to determine the composition of the psyllid populations.
- 5.30. A large number of samples should be collected with as many life stages of the population as are available. Of the three psyllid life stages (egg, nymph, adult), only the adults are identifiable to species level using morphological features, and males are easier to identify to species level than females. As species of *Bactericera* known to occur in the UK are not known to be associated with solanaceous plants, identification of males or females to this genus in a solanaceous crop will suggest the presence of *B. cockerelli*. In non-solanaceous crops, only one native species of *Bactericera* (*B. crithmi*) is associated with the Apiaceae, so findings of psyllids on Apiaceae crops may indicate *B. crithmi*, *B. nigricornis*, *B. tremblayi* or *B. trigonica*, which are hosts of European haplotypes of Lso on Apiaceae in some EU countries. *Bactericera crithmi* is not known to be a host of Lso.
- 5.31. Leaves and young shoots with feeding damage should be stored between sheets of newspaper to allow slow drying and sent to the laboratory with names and contact details of the sender and recipient.
- 5.32. Adults and nymphs can be stored short term in 70% ethanol but this makes the use of subsequent molecular diagnostic techniques more difficult. Alternatively, adults can be collected, killed by freezing and stored frozen, followed by dry mounting. Specimens to be used for diagnostic purposes should be kept cool during transport to the laboratory and then stored dry in a freezer at - 20 to - 80°C after arrival at the laboratory.
- 5.33. Yellow, neon green or neon orange sticky traps have been shown by Al-Jabar and Cranshaw (2007) to be effective for catching adults in glasshouses. The study by Al-Jabar and Cranshaw (2007) also indicated that traps should be placed near the tops of plants (e.g. 150 cm in tomato plants), should be partially shaded and should be facing north to give the best capture rates.
- 5.34. Yellow pan water traps can also be used to capture adults. The inside of the containers should be painted either yellow or orange and should contain a solution of 70% ethanol and water (1:10), with a few drops of liquid detergent to help break the surface tension when the psyllid lands on the water. The pan water traps should be checked regularly to ensure the water has not evaporated and should be changed every few days before the specimens deteriorate.

5.35. Sticky and water traps should be sent to Fera weekly for analysis. Suction traps may also be effective.



Figure 6. Psyllid yellows symptoms caused by *B. cockerelli*. © Kiwicare



Figure 7. Psyllid sugars excreted by *B. cockerelli*. © Plant & Food Research.



Figure 8. Adult *B. cockerelli*. Credit: Joseph E. Munyaneza, USDA ARS, Wapato, WA.



Figure 9. Adult *B. cockerelli* on leaf with yellow eggs and white wax-coated droplets of honeydew. Credit: Joseph E. Munyaneza, USDA ARS,

Diagnostic procedures

- 5.36. Diagnosis of Lso is based on PCR, and is detailed in the IPPC protocol (https://www.ippc.int/static/media/files/publication/en/2017/04/DP_21_2017_En_2017-03-31.pdf). There is currently no EPPO diagnostic protocol available for Lso.
- 5.37. Identification to haplotype requires the amplification and sequencing of three genomic regions. These sequences are then aligned to reference sequences for the five haplotypes.
- 5.38. Morphological identification of adult *B. cockerelli* is based on the protocol produced by Yen and Burckhardt (2012) and by comparing specimens with verified slide-mounted material obtained from New Zealand deposited in the Fera reference collections.
- 5.39. *Bactericera cockerelli* can also be identified using a taq-man real-time PCR assay by SASA. Further assays are being developed for *T. apicalis* and other potential vectors.

Criteria for determining an outbreak

5.40. If Lso and/or *B. cockerelli* is detected at a port or confined to a particular consignment with no risk of spread (e.g., tomato seed), then an outbreak should not be declared. If it is found to have spread or likely to have spread beyond its original consignment, for example if *B. cockerelli* is found across multiple lots in a glasshouse, then an outbreak should be declared.

Official action to be taken following the confirmation of an outbreak

5.41. The scale of the outbreak will determine the size and nature of the incident management team and action.

Communication

5.42. The IMT will assess the risks and communicate details to the IPPC, EU (via a Europhyt notification) and EPPO, in accordance with ISPM 17: pest reporting (<https://www.ippc.int/en/publications/606/>), as well as within Government to Ministers, senior officials, devolved authorities, and other government departments and agencies (e.g., the Environment Agency) on a regular basis as appropriate; and to stakeholders.

Surveillance and demarcated zones

5.43. After an outbreak has been detected, a demarcated area should be established that includes:

- An infested zone (i.e. the infested glasshouse).
- A buffer zone, which should extend out to at least 1 km from the infested zone, but may extend out further, particularly if *B. cockerelli* is found. This will be influenced by the local climatic and meteorological conditions. The buffer zone may include other premises in which staff/growers have visited or worked in, premises in which stock has been sent or received, and/or any other premises where there is a perceived risk.

5.44. Initial maps of outbreak sites should be produced by either the PHSI or the Risk and Policy team.

5.45. All host plants in the infested and buffer zones should be visually inspected and any suspect samples should be sent for diagnosis. Traps should be used as described in 5.33-5.35.

5.46. The demarcated area should be adjusted in response to further findings. If Lso and/or *B. cockerelli* is found within a glasshouse outside the infested zone, this should subsequently be designated as infested and the buffer zone changed accordingly.

Decontamination procedures

5.47. Within the infested zone, all non-disposable material, equipment and machinery, should be thoroughly cleaned to remove any life stages of the pest before movement to un-infested areas.

5.48. Any waste (plant or other potentially infested material) should be removed and destroyed (via deep burial, incineration or other appropriate methods) (as in 5.77-5.78).

Tracing forwards/backwards

5.49. Refer to section 5.18-5.19.

5.50. Once other sites that are potentially infested by Lso and/or *B. cockerelli* have been identified, these should be inspected as per 5.20-5.35.

5.51. A pest alert to raise awareness of Lso and/or *B. cockerelli* and its symptoms should be published and distributed to growers of host plants, to packers/processors and importers, and other areas at risk.

Pest management procedures

Infested zone (Lso with *B. cockerelli*)

5.52. The whole crop should be treated as soon as possible with a foliar insecticide if *B. cockerelli* is present. The PHSI will advise on an appropriate insecticide treatment regime in consultation with the Defra Risk and Policy team. These treatments should also be used on other susceptible hosts in the glasshouse.

5.53. If the crop is organic, pesticides will still have to be used if the situation demands it.

5.54. Growers will be placed under notice to apply the recommended pesticides and make the applications using their own or contractor's equipment. Records of applications will be kept, including details of the amount of product and water use.

5.55. Use of contact insecticides requires good coverage of the foliage as psyllids are found primarily on the undersides of leaves. Moreover, different chemicals are required for adults, nymphs and eggs, making selection of chemicals difficult, and necessitating knowledge of psyllid growth stages present in the crop in order to apply the appropriate chemicals at appropriate times in the growing season.

5.56. Sticky traps and pan water traps (or other appropriate traps) should be used to assess the efficacy of insecticide treatments.

5.57. Following insecticide use, all susceptible host crops including volunteers in the glasshouse should be destroyed by incineration or deep burial (as in 5.77). If possible, host crops in the vicinity of the glasshouse should also be treated and destroyed.

5.58. Once the infected/infested crop has been removed, all remaining material e.g., string, plastic flooring and growing media, should be destroyed or recycled, or if reused, thoroughly cleaned with water and detergent to remove any remaining plant material and finally disinfected with a suitable disinfectant. The permanent facility should also be cleaned and disinfected.

5.59. No host plants should be grown in the infested glasshouse for a period covering the lifespan of adult *B. cockerelli* (as well as other potential vectors) in the absence of host plants. This will depend on the climatic conditions within the glasshouse, particularly the temperature. Any volunteer plants should be removed.

5.60. Inspections, with the frequency determined by the IMT, should be carried out over the following growing season.

Infested zone (Lso in the absence of *B. cockerelli*)

5.61. Points 5.52 – 5.56 should be followed to knock down other potential vectors.

5.62. If other potential vectors are present, points 5.57-5.58 should be followed as a precaution.

5.63. If no other potential vectors are present, crops may be allowed to grow until the end of the season.

5.64. All infected plants should be destroyed, and if there are several infected plants in a lot, the whole lot should be destroyed. Host crops in the vicinity of the glasshouse should also be treated and destroyed.

5.65. Plants should be monitored weekly until the end of the growing season.

5.66. Harvesting of fruit may be allowed, but should only be sent for retail if agreed by the IMT.

5.67. All susceptible host crops in the glasshouse should be destroyed by incineration or deep burial (as in 5.77).

5.68. Once the infected/ infested crop has been removed, all remaining material e.g., string, plastic flooring and growing media, should be destroyed, recycled or, if reused, thoroughly cleaned with water and detergent to remove any remaining plant material and finally disinfected with a suitable disinfectant. The permanent facility should also be cleaned and disinfected.

5.69. No host plants should be grown in the infested glasshouse for a period covering the lifespan of adult potential vectors in the absence of host plants. This will depend on the climatic conditions within the glasshouse, particularly the temperature. Any volunteer plants should be removed.

5.70. Inspections, with the frequency determined by the IMT, should be carried out over the following growing season.

Measures to be taken in the case of detection of infection/infestation in fruit after harvest (e.g. during processing/packaging and grading)

5.71. The following should be designated as infested:

- The lot from which the sample was taken.
- The waste from the infested lot, such as processed waste.
- The equipment and other articles (e.g. machinery and packing material) which have been in contact with the lot).
- The glasshouse where the lot was grown.

5.72. As in 5.43, a buffer zone should be created that extends out to at least 1 km from the infested glasshouse.

5.73. Areas where potentially infested equipment, waste, and other articles, have been used should be surveyed, and any fruit harvested from these areas should be inspected.

5.74. Points 5.2 - 5.5 and 5.7 - 5.8 should be followed, but only destruction rather than re-export should be considered.

5.75. Refer to infested zone pest management procedures should *Lso* and/or *B. cockerelli* be found in a glasshouse.

Crops growing within the buffer zone (at least 1 km around the infested zone) in the year of the outbreak

5.76. If no infestation is found in host crops growing in the buffer zone following surveillance, then they should be treated with a programme of foliar insecticides under notice until harvest and monitored for any sign of *Lso* and/or *B. cockerelli*. Monitoring should include the use of sticky, water pan or other appropriate traps.

Disposal plan

Infested plant material

5.77. When deciding on the most appropriate method(s) of disposal, factors such as the likelihood of *B. cockerelli* adults being present, 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. Material that can be moved safely should be destroyed by incineration at a licensed facility (if in small quantities) or deep burial. Disposal and/or destruction should be under the approval of the PHSI, with any supervision decided on a case by case basis. If the material has to be moved off the premises, it should be contained within at least two layers if possible, and placed in a sealed vehicle for transport. Deep burial may be done at an approved landfill site, or on the site or nearby farm, but only in agreement with the local Environment Agency. Incineration must comply with appropriate waste management regulations, Environment Agency in England, Scottish Environment Protection Agency and Natural Resources Wales.

5.78. Aside from incineration and deep burial, other viable methods of destruction may include anaerobic digestion and recycling (e.g., of rockwool slabs for non-horticultural use). However, these and any other methods should be agreed by the IMT.

5.79. All objects designated as 'infested', such as equipment, machinery, storage facilities that may be contaminated with infested plant material should be thoroughly cleansed to remove the pest e.g. using high pressure water. This should be carried out at the outbreak site or a site nearby in agreement with a Plant Health and Seeds Inspector. Any waste material generated should be bagged and sent for deep burial or incineration (as in 5.77).

Review measures in the case of prolonged official action

5.80. Monitoring of the affected premises and demarcated areas should take place. In the following year, this should take place monthly throughout the growing season. Plants should be visually inspected and any plants showing suspect symptoms should be tested. Any volunteer plants should be removed and destroyed by incineration or deep burial. Monitoring should also include the use of sticky, water pan or other appropriate traps for *B. cockerelli*.

5.81. The EPPO protocol states that if continuing official action is required within the demarcated area over a prolonged period, a review of eradication and containment measures should be undertaken regularly to determine the success and cost-effectiveness of measures in the longer term. This review will involve consultation with stakeholders and should include:

- Evaluation of the effectiveness of current measures
- Evaluation of the economic impact and cost-effectiveness of continuing existing measures
- Consideration of further measures to strengthen containment and eradication actions
- Consideration of statutory obligations and impact on import and export procedures
- Consideration of alternative approaches, including pursuing measures to contain the pest rather than eradication or even the cessation of statutory action.

In circumstances where it is considered that the pest cannot be eradicated or contained and official action is no longer considered appropriate, stakeholders should be consulted and a timetable and mechanism for the removal of official measures, and for the dissemination of pest management information, should be agreed.

6. Criteria for declaring eradication / change of policy

6.1. Lso and/or *B. cockerelli* can be declared eradicated (by the Chief Plant Health Officer) if it has not been found for a year (or for a single cycle of the crop) after the infected/infested crop was removed.

7. Evaluation and review of the contingency plan

7.1. The Defra *Generic Contingency Plan for Plant and Bee Health in England* requires that the pest specific plan is reviewed following an outbreak. This pest specific contingency plan should also be reviewed annually to take into account of changes in legislation, control procedures, pesticides, sampling and diagnosis methods, and any other relevant amendments.

7.2. Lessons should be identified during and after any Lso/*B. cockerelli* outbreak or non-Lso/*B. cockerelli* outbreak, including what went well and what did not. These should be included in any review of the contingency plan leading to continuous improvement of the plan and response to outbreaks.

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