The Food & Environment Research Agency

Rapid Pest Risk Analysis for

Candidatus Liberibacter solanacearum

This document provides a rapid assessment of the risks posed by the pest to the UK in order to assist Risk Managers decide on a response to a new or revised pest threat. It does not constitute a detailed Pest Risk Analysis (PRA) but includes advice on whether it would be helpful to develop such a PRA and, if so, whether the PRA area should be the UK or the EU and whether to use the UK or the EPPO PRA scheme.

STAGE 1: INITIATION

1. What is the name of the pest?

Candidatus Liberibacter solanacearum (Lso). The prefix *Candidatus* is used in a unique trinomial name system, which indicates that the bacterium is unculturable. Lso is one of six *Candidatus* Liberibacter species (Liefting *et al.* 2009; Raddadi *et al.* 2011). Earlier reports refer to the pathogen as *Liberibacter solanacearum* or *Candidatus* Liberibacter psyllaurous. Five Lso sequence variants referred to as A, B, C, D and E haplotypes are recognised (Nelson *et al.* 2013; Teresani *et al*. 2014). Lso causes zebra chip disease in potato. In Spanish the disease is known as papa manchada. This PRA also assesses the risks of introducing the potato/tomato psyllid *Bactericera cockerelli*, which vectors Lso in potato and other solanaceous hosts.

2. What is the pest's status in the EC Plant Health Directive (Council Directive 2000/29/EC[1]) and in the lists of EPPO[2]?

Lso and *B. cockerelli* are listed as EPPO A1 organisms recommended for regulation but are not currently listed in the EC Plant Health Directive. The pathogen and *B. cockerelli* are both currently the subject of discussions at EU level to consider if regulatory measures are justified to reduce the risk of its entry to the EU.

3. What is the reason for the rapid assessment?

A requirement for a PRA was made as a priority action following its assessment in the UK Plant Health Risk Register. New concerns have been raised since the first reports of Lso in Europe in carrot. Additionally, the pathogen has also been causing increasing concern in North and Central America as well as in New Zealand, where significant production losses have occurred in potato and tomato production since the pathogen and its vector were introduced.

A PRA has recently been completed by EPPO, which provided a detailed analysis of the risks posed by Lso to the EPPO region (EPPO 2012a) and an accompanying summary report EPPO 2012b). This PRA considered Lso risks from the import of infected plant material as well as from the entry and establishment of *B. cockerelli*, which vectors Lso in solanaceous plants and is absent from the Europe. A separate PRA for *B. cockerelli* was also produced (EPPO, 2012c).

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0029:20100113:EN:PDF
[2] http://archives.eppo.int/EPPOStandards/PM1_GENERAL/pm1-02(21)_A1A2_2012.pdf

STAGE 2: RISK ASSESSMENT

4. What is the pest's present geographical distribution?
The EPPO PRA (EPPO 2012a) gives the distribution as:
North America: USA (Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, Oregon, Texas, Washington and Wyoming), Mexico,
Central America: (Guatemala, Honduras). The pathogen has been reported recently in Nicaragua (Bextine *et al* 2013a) and El Salvador (Bextine *et al*. 2013b).
Oceania: New Zealand.
Lso has recently been found in Europe affecting carrot in France, Finland, Norway, Sweden, mainland Spain and the Canary Islands and celery in Spain (see below).

In mainland Spain Lso was confirmed in carrot (*Daucus carota*) from Alicante, Albacete and Valencia provinces sampled between 2008 and 2010 (Alfaro-Fernández *et al.* 2012a). In the Canary Islands Lso was detected in carrot sampled in Tenerife between 2009 and 2010 (Alfaro-Fernández *et al*, 2012b). The pathogen has recently been confirmed in celery (*Apium graveolans*) from Villena, Alicante, Spain (Teresani *et al*. 2014). In Finland Lso was detected in carrot sampled from three commercial fields in the south of the country (*et al.* 2011a). In Norway Lso was detected in carrot sampled from five fields located in four provinces in the south of the country (Munyaneza, 2012a). In Sweden Lso was detected in carrot in Halland province, which is located in the south of the country (Munyaneza *et al.* 2012b). In France in 2012 Lso was detected in carrots crops being used to produce seed in central France (EPPO Reporting Service 2012/219) and destroyed under official control. There is some research in Europe to define the distribution of the bacterium within the areas of occurrence, for example the results of a recent survey from Norway are expected soon.

B. cockerelli occurs from Central America and the western USA up to southern Canadian states although some haplotypes may have only a transient presence in the northernmost part of its range (See Fig. 3). The species has been recently introduced to New Zealand.

5. Is the pest established or transient, or suspected to be established/transient in the UK?

There have been no reports of Lso in the UK although no official surveys have been carried out. However, as part of the EUPHRESCO-PHYLIB project carrot growers and agronomists in the UK have been asked to send carrot plants with symptoms of Lso infection in the foliage for testing. Although other pathogens have been detected Lso has not been detected so far.

6. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK?

Hosts known to be able to become infected with Lso (which may be asymptomatic) are referenced and listed in the EPPO PRA (EPPO 2012a) as: potato (*Solanum tuberosum*), tomato (*Solanum lycopersicum*), *Capsicum* spp. including bell pepper (*Capsicum annuum*), Cape gooseberry (*Physalis peruviana*), eggplant (*Solanum melongena*), tomatillo (*Physalis philadelphica*), tamarillo (*Solanum betaceum*), tobacco (*Nicotiana tabacum*) and several weeds in the family *Solanaceae*. There is some uncertainty as to whether Cape gooseberry could serve as a reservoir of Lso infection (EPPO 2012a). Recently, Lso has caused infections in carrot and celery (for references, see section four).

This PRA also considers the risks posed by plants which may introduce Lso vectors (see section 7). The most important hosts on which the Lso vector *B. cockerelli* can reproduce are species of *Solanaceae*, though some species of Convolvulaceae and Laminaceae may also serve as hosts. Preferred hosts have been listed and referenced in the EPPO PRA

(EPPO 2012a). Alternate hosts may be important for overwintering adults eg. *Solanum dulcamara* (see section 9.2). In addition to the solanaceous plants listed above, other plants may pose a risk of entry of *B. cockerelli* including *Convolvulus* sp., *Ipomoea* sp., *Mentha* sp. and *Micromeria* sp. (see references in EPPO 2012a). Refer to section 15 for proposals to increase import regulations from these hosts.

The most important crops at risk from Lso infection in the UK are potato, tomato, pepper and carrot.

7. If the pest needs a vector, is it present in the UK?

Although there is recent undocumented evidence that Lso is transmitted through carrot seed (based on a personal communication with M. Cambra (Jeffries, 2014), all the literature states that Lso requires psyllid insect vectors in order to be transmitted to new host plants.
In solanaceous crops including potato and tomato, only *B. cockerelli* has been demonstrated to vector Lso. This psyllid is listed as an EPPO A1 pest, reflecting the risks it poses in spreading Lso and its absence from the EPPO region. No psyllids that specialise on solanaceous plants to complete their life cycle are known in the UK. Although the majority of psyllids in Britain and Europe can only complete their development on a single or a couple of closely related host plant species, adult psyllids are capable of feeding (at least occasionally) on a wider range on hosts. Therefore, it is possible that other native British psyllid species may occasionally, and/or temporarily, feed on potato crops, but are incapable of breeding on this plant (see report by C. Malumphy, 2014 appendix 1).

In New Zealand, *B. cockerelli* has recently colonised both islands and has vectored Lso in potato and tomato causing serious economic damage (Liefting *et al.* 2008b, d). Two other psyllids from which Lso was detected have been identified in New Zealand: *Trioza* sp. (associated with *Pittosporum* and most likely the *Pittosporum* psyllid *Trioza vitreoradiata*) and an unidentified *Acizzia* species that was collected from *Acacia* (Scott *et al.* 2009).

The distribution of the old world potato psyllid *B. nigricormis* extends across Asia and Western Europe but has not been recorded in the UK. There is uncertainty over the population densities of this psyllid in Europe and the potential efficiency of this species in vectoring Lso in potato. High populations of *B. nigricormis* have been recorded infesting potato in Iran (Fathi, 2011).

The New World potato psyllid *Russelliana solanicola* has been reported as a pest of potato, tomato and pepper and can feed on species of Compositae including marigold (Chávez *et al.* 2003). This psyllid has been associated with severe damage to potato which may be caused by a virus named as SB26/29 (EPPO reporting service 2006/237; Salazar, (2006). More studies are needed to determine if *R. solanicola* could vector Lso in potato.

Lso has recently been detected in the carrot psyllid (*Trioza apicalis*) associated with infected carrot crops in Finland, Sweden and Norway (For references see section four). Lso infections of carrot in the Canary Islands were vectored by the psyllid *Bactericera trigonica* and in mainland Spain the vector has been identified to genus level as a species within the *Bactericera* (for references see section four). *B. nigricormis* can feed on both carrot and potato (Hodkinson, 1981) and therefore could potentially cross infect Lso from infected carrot to potato. Lso has been detected in a potato plant growing in a carrot field, which was heavily infested with *T. apicalis* (A. Nissinen pers. comm. 2014). However, it is not clear whether carrot Lso strains (haplotypes C. D and E) can produce systemic infections in potato, however, on a precautionary basis, it is assumed that they can. Very recently Jeffries (2014), has referred to Lso infection of *B. nigricornis* and *B. tremblayi* in Spain (as a personal communication with E. Hernández), which increases the potential transfer of Lso from carrot to potato in Europe (these vectors are absent in the UK-see appendix 1 section 2).

8. What are the pathways on which the pest is likely to move and how likely is the pest to enter the UK?

Four pathways have been assessed. Note that a further pathway (*B. cockerelli* on living parts of Solanaceae except fruit, seeds and plants for planting) was considered in the EPPO PRA (EPPO 2012a), along with nine pathways which were identified but not considered further.

8.1. Lso entry in plants for planting, fruit and vegetables in the absence of vector.

Very unlikely		Unlikely		Moderately likely	X	Likely	X	Very likely	X

Both ware and seed potato imports are prohibited from the Americas (except by derogation from New Brunswick & Prince Edward Island) and New Zealand, which effectively eliminates the risk of the pathogen entering from this source. Currently, there are no restrictions on import of solanaceous fruits, which may be infected with Lso. Europhyt trade data for 2012 indicate significant UK import of fresh or chilled fruits of genus *Capsicum* or pimento (*C. annuum*) from the USA, Mexico and Guatemala, which amounted to 437 000 kg (Table 1). Whilst no data is available on the extent of infection in these imported fruits the trade is scored to pose an unlikely or very unlikely risk of entry for the pathogen because of the absence of vectors, which could transfer the pathogen to UK plants.

If Lso infected carrots (in the absence of a vector) were to be imported to the UK, the risk of entry is minimised by the small opportunity of indigenous vectors to transmit the pathogen to UK plants. This is both because of the rare occurrence and limited distribution of *T. apicalis* in the UK and the fact that transmission could only occur from the green parts of plants on which the vector feeds. This restricts the risk of Lso to UK plants to carrots imported in bunches, which do have aerial plant parts attached to the root (see section 3 for more details of carrot vectors). Although no detailed statistics on the import to the UK of carrots in bunches it is anticipated that this will be small because of the relatively short shelf life of carrots in bunches, which reduces the profitability of international trade. Discarded carrots with aerial green parts are unlikely to provide a means of pathogen transfer to UK plants because psyllid vectors require fresh material to feed on. These limitations reduce the entry score to very unlikely. (See additional information on entry risks from carrot vectors in section 8.3).

There have been no published reports of Lso transmission through seed of any plant species (van Vuuren *et al*. 2011). However, it has been noted recently (through a personal communication with M. Cambra) that Lso can be seed transmitted in carrot (Jeffries, 2014). Whilst more details are required to evaluate this pathway more fully, the report has led very recently to carrot seed being proposed for regulation (Jeffries, 2014; see section 15). The UK entry risk for Lso in infected carrot seed is difficult to assess. However information from Howard Hinds (pers. comm. 2014), indicates that UK carrot seed is sourced from France, America, New Zealand Tasmania and Chile. As Lso in carrot has been reported from France in seed crops the risk of entry from infected seed may be very high. However, there is uncertainty since it is not known at present whether Lso is present in the regions used to produce carrot seed for varieties grown in the UK. The uncertainties surrounding the risk of Lso entry through infected carrot seed is reflected in the wide span of risk scores, where the highest score is based upon potential entry risks from infected carrot seed.

8.2 Lso entry through infected *B. cockerelli*.

Very unlikely		Unlikely		Moderately likely	X	Likely		Very likely	

Whilst current import regulations prevent import of plants for planting of solanaceous hosts from Lso affected areas there are restrictions on import of solanaceous fruit. Psyllid vectors feed on the aerial green parts of plants and would not be associated with plant produce devoid of green material. Some solanaceous fruits have green material, e.g the calyx, attached and these pose an entry risk for *B. cockerelli*, which could be transported as eggs and other life stages. Hence tomatoes, aubergine and pepper fruits represent a risk of entry of *B. cockerelli*, when these plants are imported from a region where this psyllid is present. Lso Infected adult *B. cockerelli* on arrival from the imported plant could fly to solanaceous hosts, especially potato and tomato, to initiate the first infections of UK plants. The potential entry risks from this pathway are scored as moderately likely (see section 15 for details of proposals to restrict this trade).

There is a risk of Lso entry from non-solanaceous hosts (in which infection by the pathogen has not been reported). Entry of the pathogen Lso from this pathway would therefore require *B. cockerelli* to initially feed on an infected (solanaceous) crop, become infected and then move to the non-solanaceous host on which eggs are laid to be imported as eggs or nymphs. Finally, in order to effect the entry of Lso, the infected mature vector would then need to find and infect a UK host. Whilst Lso can be transmitted vertically in *B. cockerelli* infected eggs (Munyaneza *et al*. 2007), the chain of events required for entry lowers the risk, which is scored as unlikely. There is some uncertainty because of the risks of unreported Lso infections in non-solanaceous hosts and also because it is not known if Lso infection of *B. cockerelli* can be maintained in non-solanaceous hosts.

There is a small risk of entry of infected vectors through illegal imports of solanaceous planting material or fruit in flight baggage. *B. cockerelli* may be associated with non solanaceous hosts (see following section 8.4).

8.3. Lso in other vectors not present in the UK

Very unlikely		Unlikely	X	Moderately likely	X	Likely		Very likely	

There is a risk of Lso infected carrot psyllid vectors (*Trioza apicalis* and *Bactericea* spp.) entering the UK through the import of carrots ‘in bunches’ that have foliage attached, on which psyllids could be imported. There is no restriction on the import of carrots from Europe and the UK does import bunched carrots from Spain and other countries. However, this entry pathway is considered unlikely because of the limited trade in carrot bunches from Lso affected regions (see section 8.1). There is some uncertainty in the entry score because of the absence of data on the quantity of carrots in bunches imported to the UK. There is also uncertainty on the distribution of Lso in carrot in Europe.

8.4. Uninfected *B. cockerelli* enters the UK from non-solanaceous hosts

Very unlikely		Unlikely	X	Moderately likely	X	Likely		Very likely	

Plants for planting of *Convolvulus* sp., *Ipomoea* sp., *Mentha* sp. and *Micromeria sp.* have been identified as hosts of *B. cockerelli* and could provide a means of entry for uninfected vector (see section 15 for proposals to regulate the import of these plants). There is uncertainty because the level of trade from regions with *B. cockerelli* is not currently known.

9. How likely is the pest to establish outdoors or under protection in the UK?

Three scenarios for establishment have been assessed:

9.1. Lso with no psyllid vectors present in addition to those already in the UK

Outdoors:	Very unlikely		Unlikely	X	Moderately likely		Likely		Very likely	
Under protection:	Very unlikely		Unlikely	X	Moderately likely		Likely		Very likely	

The extensive occurrence of Lso in some Scandinavian countries and New Zealand indicates that climatic conditions would be suitable for establishment in outdoor crops in the UK. However, without a vector Lso could not establish because the pathogen would not be able to be transmitted. Apart from occasional feeding by adult psyllids there is no known UK vector that is likely to be capable of transmitting Lso in potato or other solanaceous crops. Additionally, there have been no reports of vectors other than *B. cockerelli* that have been a significant factor in the transmission and establishment of Lso in solanaceous crops in other countries. The low risk of efficient Lso transmission in the absence of a vector new to the UK severely limits the potential for Lso establishment in solanaceous hosts and is scored as unlikely.

The likelihood of UK establishment of the pathogen in carrot, in the absence of introduction of a new invasive psyllid species, would largely be determined by the presence of the carrot psyllid *T. apicalis*, which vectors Lso in this host in some Scandinavian countries (Ossiannilsson, 1994). *T. apicalis* occurs in central and northern Europe including Scandinavian countries and high populations can occur in some parts of southern Finland (A. Nissinen pers. comm. 2014). In the UK the species has been recorded, but only rarely from Umbelliferae in southern England (Hodkinson and White, 1979). A recent limited survey (2012 and 2013) for *T. apicalis* in England (L. Collins pers. comm. 2014) and Scotland did not find the psyllid F Highet pers. comm. 2014). A full report of the survey will be available soon. The reasons for the small populations of *T. apicalis* in the UK compared to Scandinavian countries are not fully understood. However, in Norway *T. apicalis* is not found far from spruce, which is a favoured over-wintering host for the psyllid (R. Meadow pers. comm. 2014). Whilst other coniferous trees have been recorded as winter hosts, this host species may be an important determinant in maintaining local populations. There has been some investigation of alternative Umbelliferae as hosts for the carrot psyllid in Norway, which concluded that carrot is required to complete its life cycle (R. Meadow pers. comm. 2014). The restricted range and low population density of *T. apicalis* in the UK will restrict the potential for Lso transmission in carrot which reduces the risk of establishment of Lso in carrot to unlikely.

Carrots are field-grown from seed and would not be grown in glasshouses. Grown outdoors under protection, psyllid vectors may be able to survive but this will depend on the nature of the cover.

Recently, carrot seed has been implicated as a means of Lso transmission and it is important that only disease free seed is sown (see section 8.1 and proposals for regulation of carrot seed in section 15). The risks of establishment of Lso from infected carrot seed is uncertain, because of the lack of information on the extent of infected seed in Europe and details of the infection rate of mature plants grown from infected seed. The limited populations and distribution of carrot vectors in the UK would limit establishment as there is limited opportunity for transmission to non-infected carrot crops. The risk of establishment from Lso infected carrot seed is scored as unlikely.

Even in the presence of vectors, there may be limitations on the development and symptoms of Lso caused by temperature. However, Lso vectored by *B. cockerelli* has recently been found in Washington State (Crosslin et al. 2012) that has similar climatic conditions to the UK suggesting that Lso could establish in the UK if there is a suitable vector. Nevertheless, the range of *B. cockerelli* extends beyond the latitude at which disease in potato is observed in North America (Fig. 3), which indicates a northerly limit for Lso. The potential establishment of *B. cockerelli* is discussed in more detail in section 9.2.

9.2. Lso establishes from Lso infected *B. cockerelli*

Outdoors:	Very unlikely		Unlikely	X	Moderately likely	X	Likely		Very likely	
Under protection:	Very unlikely		Unlikely	X	Moderately likely	X	Likely		Very likely	

(Though in potato, non-infected vectors have been found in colder regions of the vectors range).

The most likely means of Lso establishment in UK solanaceous crops is via the entry and establishment of infected *B. cockerelli.* To determine the likelihood of *B. cockerelli* establishment in the UK, its presence in North America and New Zealand needs to be studied further.

In Central and North America this psyllid has a distribution range from Central America northwards to southern Canada. It was thought that this species cannot tolerate extreme temperatures within this range and migrates from southerly overwintering regions (southwards from Texas) in the spring (Abdullah, 2008) assisted by wind (Abernathy, 1991), However, a recent winter survey in north west USA found overwintering populations of *B. cockerelli* on riparian *Solanum dulcamara* (Murphy *et al* 2013). Additionally, genotyping analysis of *B. cockerelli* has distinguished three distinct haplotypes of the vector that appear to differ in overwintering, dispersal and Lso transmission capabilities (Swisher et al. 2013; Horton et al. 2014). The north-western haplotype has been implicated in the zebra chip outbreaks in Idaho, Oregon and Washington State from 2011 onwards and this haplotype can survive winter temperatures as low as 10°F (12.2°C) in *S. dulcamara* (Horton et al., 2014). The central and western haplotypes along the Rocky Mountains and California respectively may still disperse northwards in spring but it may also be that their over-wintering sites have yet to be found (Horton et al., 2014). At present, it appears that the north-western haplotype poses the most serious threat of establishment to the UK not only because it can survive very low temperatures but also because its overwintering host, *S. dulcamara,* is widespread in the UK. Milo Lewis et al., (2013, unpublished) found that a Texas population had a very low minimum temperature development threshold of 5.1°C and 362 degree days needed for development. In New Zealand 7.1°C and 358 degree days per generation have been applied to model the number of generations (Vereijssen et al. 2013). This indicates that the summers in the UK would be suitable for *B. cockerelli* development.

In New Zealand, *B. cockerelli* has been introduced and has colonised both North and South Island. In South Island it has been found at Invercargill (the southernmost town) so can clearly establish in potato fields throughout South Island but zebra chip disease has not been observed (see section 13). CLIMEX models have been attempted both in New Zealand (Vereijssen et al. 2012) and by EPPO (EPPO, 2012a) but need further work to take into account the presence of *B. cockerelli* at Invercargill and the new evidence of over-wintering from NW USA.

The uncertainty as to whether *B. cockerelli* could establish in the UK and the populations size it may attain could be investigated further using climatic models. The EPPO report (Jeffries, 2014) refers to 'local adaptation of psyllid populations to cold temperatures' and that 'Psyllids from cold climates can survive lower temperatures than those from warmer ones with adults still reproducing at low temperatures'.

Severe losses in New Zealand to glasshouse tomato and capsicum crops estimated at up to $1million were attributed to Lso infection vectored by *B. cockerelli* (Liefting, (2008c). It is likely that under protection *B. cockerelli* could establish sufficiently high populations to vector Lso in solanaceous crops including tomato, pepper and aubergine and cause significant disease.

Solanaceous species are grown in gardens by amateur growers and it is possible that populations of *B. cockerelli* could spread to the commercial production of tomatoes and potatoes.

9.3. Lso establishes with vectors other than *B. cockerelli*, which are new to the UK

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely
Outdoors:		X			
Under protection:			X		

B. trigonica vectors Lso in carrot and celery in the Canary Islands and mainland Spain respectively (see section 4 for details and references). There are no records of any *Bactericera* species in the UK. The distribution of *B. trigonica* is restricted to Mediterranean countries and the Middle East (Fig 2). Since UK conditions would most likely not support establishment of the known carrot vectors from Spain the risk of establishment Lso establishment from alien vectors is scored as unlikely.

10. How quickly could the pest spread in the UK?

	Very slowly	Slowly	Moderate pace	Quickly	Very quickly
Natural spread:			X	X	
In trade:					X

The rate of natural spread is determined by the spread of vector psyllids. Although *B. cockerelli* has been assumed to migrate long distances assisted by wind, northwards from southern US states to colonise more northern states (Abdullah, 2008; Abernathy, 1991), this has been called into question by the finding of overwintering populations of the north western haplotype (Horton et al., 2014). Trade in plants or produce, which harbour Lso infected vector psyllids would spread the disease very quickly.

11. What is the area endangered by the pest?

The main potato growing areas of the UK are at risk. In carrot, counties in southern England may be at greater risk. Glasshouse production sites where solanaceous plants are grown are assumed to provide good conditions for the survival of *B. cockerelli.*

12. What is the pest's economic, environmental or social impact within its existing distribution?

Very small	Small	Medium	Large	Very large
			X	X

Lso causes a highly damaging disease of potato which often kills the plant. Severe crop losses amounting to millions of dollars of damage have occurred in the United States, Mexico, Central America and New Zealand (Gudmestad and Secor, 2007). Large scale losses have also been reported in tomato production (Liefting et al 2008d). For more detailed accounts of economic losses in solanaceous crops and references see the EPPO PRA (2012a). Affected tubers when sliced and fried become discoloured producing an alternate light and dark shading from which the disease name 'zebra chip' is taken. In addition to direct yield and tuber quality losses, substantial economic costs arise indirectly. In New Zealand loss of export markets has been significant. The requirement for application of insecticides to control the vector of zebra chip disease is an additional cost. A survey of insecticide application to control *B. cockerelli* in Texas, Kentucky and Nebraska found an average cost per hectare of $700-740 from 2009-2011 (Guenthner *et al.* 2012).

In New Zealand severe losses to glasshouse tomato and capsicum crops estimated at up to $1miilion were attributed to Lso infection vectored by *B. cockerelli* (Liefting, (2008c). Significant economic impacts to solanaceous crops grown outdoors and in glasshouses caused by Lso vectored by *B. cockerelli* have been reported in the North Island of New Zealand (see section 12) but not in South Island although the vector is present even in Invercargill, the southernmost town. Generation number (based on degree days base 7.1°C and 358 degree days per generation) pre and post potato emergence from the ground) vary from location to location in NZ (Vereijssen *et al*. 2013) but have been used primarily to target insecticide delivery accurately, but although higher in North Island, they have not been directly implicated in the severity of damage.

Lso infected carrots produce roots which are deformed, small and woody and can only be used for animal feed (Nissinen *et al.* 2012). However, differentiation between damage caused by Lso infection and damage from direct psyllid feeding in the absence of Lso can be difficult (R. Meadow pers. comm. 2014). The seriousness and extent of damage in Scandinavia and Spain is also unclear. Consequently, until more survey work is done, it is difficult to estimate the full scale of damage to the carrot crop caused by Lso in its existing range in Europe.

13. What is the pest's potential to cause economic, environmental or social impacts in the UK?

Two scenarios are considered for evaluation of impacts from Lso.

1) Lso in the absence of the introduction of a new vector species.

Solanaceous crops.

Very small	Small	Medium	Large	Very large
X	X			

Carrot

Very small	Small	Medium	Large	Very large
	X	X		

The most serious threat of large economic losses from Lso is to the UK potato industry. Without *B. cockerelli*, which efficiently vectors LSO in solanaceous crops the disease would be poorly transmitted in potato or other solanaceous hosts and consequently would cause only minimal impacts. It is possible that indigenous adult psyllids, which do not use solanaceous hosts to complete their life cycle may occasionally, feed on alternative crops. However, as there are no reports of alternative psyllid vectors associated with diseased solanaceous crops it is difficult to evaluate the extent of this risk which is scored as very small or very small.

T. apicalis is the only one known potential vector of Lso in carrot present in the UK, but it is not common and its distribution is restricted to southern England. This limits the potential impacts from Lso in carrot to small or very small. There is considerable uncertainty in scoring impacts for carrot because rates of seed transmission may be variable (see section 8.1), which accounts for the rating span for Lso impacts on carrot.

2). Impacts when a vector species not present in the UK becomes established and transmits Lso (including *B. cockerelli*).

Potato

Very small	Small	Medium	Large	Very large
			X	X

In Carrot

Very small	Small	Medium	Large	Very large
X	X			

The extent of economic losses to this sector will depend on the presence and population levels of an efficient Lso vector, which for potato is *B. cockerelli*.

The economics of potential losses following introduction of Lso and *B. cockerelli* into the EU to potato have been studied in detail and an annual estimate of € 222M has been calculated for the region as a whole (Soliman *et al.* 2013). Potato processors have low tolerances for defective tubers as do supermarket retailers. For example, a large chip manufacturer sets a rejection tolerance at 5% for tubers affected by spraing. Tolerances may be lower still for Lso infected tubers and therefore even modest zebra chip incidence in a crop could produce significant losses. Loss of export markets for UK seed and ware potatoes as a consequence of the perceived or actual presence of zebra chip may also be significant as would costs of application of insecticide sprays.

The economic impact to the UK is scored as large to very large, reflecting uncertainties surrounding the potential population size that *B. cockerelli* may attain in the UK and the consequences to potato glasshouse production of solanaceous crops.

The impacts of Lso in carrot also depend on the vector. The population of *T. apicalis* in the UK is low with a limited distribution and even if *B. trigonica*) was introduced, this species is restricted to hotter climates, such as Spain and the Canary Islands (Fig. 2) and the impacts from introduction of this vector are considered very small or small reflecting the low probability of this species attaining significant population densities in the UK. There is more uncertainty in evaluating risks from the unidentified *Bactericera* species, which vectors Lso in carrot in mainland Spain. However, the fact that no species of this genus has established in the UK suggests that there is only a small risk that these potential vectors could attain population densities that may cause serious impacts in the UK.

14. What is the pest's potential as a vector of plant pathogens?

None, Lso is a bacterium.

STAGE 3: PEST RISK MANAGEMENT

15. What are the risk management options for the UK? *(Consider exclusion, eradication, containment, and non-statutory controls; under protection and/or outdoors).*

There are existing import prohibitions into the EU which should effectively prevent the entry of Lso and *B. cockerelli* in potatoes (Directive 2000/29/EC Annex IIIA 10, 11 and 12) and solanaceous plants for planting (Directive 2000/29/EC Annex IIIA 13) from the areas where Lso and in particular *B. cockerelli* are known to occur. A potential pathway for entry exists through importation of solanaceous fruits which have green aerial plant parts attached, e.g. tomatoes, aubergine and pepper. Regulation of this pathway is currently being considered at the EU level and the proposal for EU listing of *B. cockerelli* is likely to include the regulation of tomato, aubergine and pepper fruit.

As *B. cockerelli* is absent from the EU, listing in Annex IAI of the directive 2000/29/EC would be appropriate together with Annex IVAI requirements that require fruit of Solanaceae (including tomatoes, aubergines and peppers) to come from a pest free area, that has been verified using the appropriate international standards. This would follow EPPO's recommendations as supported by their PRAs on the pathogen and the vector.

Eradication or containment of introduced psyllid vectors in the environment is not feasible in practice unless a small outbreak is identified before adults have dispersed. Wild hosts are common and widespread, especially for the northwestern USA haplotype of *B. cockerelli* that overwinters at very low temperatures in *Solanum dulcamara*. Eradication of *B. cockerelli* from containment may be possible if flying adults have been prevented from escaping and green plant parts have not been moved. In practice however, it is likely that glasshouse populations would quickly escape into the environment and control in glasshouses is not considered reliable or feasible.

Additionally, there are some non-solanaceous plants that *B. cockerelli* is known to feed on, e.g. *Convolvulus* sp., *Ipomoea* sp., *Mentha* sp. and *Micromeria* spp, that although they are not currently known to serve as a reservoir of Lso infection, may pose a risk as they are widely grown or widespread in the environment and will enable vector populations to increase and spread. Therefore it would be appropriate to include them in the Annex IVAI requirements for plants for planting. These requirements could be the same as for fruit of solanaceous host, i.e. they have originated in an area free from *B. cockerelli.*

Very recently, since carrot seed has been implicated as a means of Lso transmission a proposal for its regulation has been made, which will require carrot seed to be sourced from an area free of the disease (see discussion document Jeffries, 2014).

There is a trade in imported carrot bunches with aerial plant parts attached which, pose a risk of introducing infected *Bactericera* psyllids from Europe. *T. apicalis* vectors Lso in some Scandinavian countries however, this psyllid is already present in the UK, albeit at low density and there is no evidence of its spread away from southern England (see section 9.1). The potential for establishment of *Bactericera spp.,* which vector Lso in carrot in Europe (see section 7 and 9.3) does not justify regulation of the carrot trade or of these vector species.

16. Summary and conclusion of rapid assessment.
(Highlight key uncertainties and topics that will require particular emphasis in a detailed PRA) General / overall summary and conclusion and then specific text on each part of assessment.

Candidatus Liberibacter solanacearum (Lso) is a highly damaging pathogen of solanaceous plants, which has caused very serious losses to the production of potatoes, tomatoes, peppers and aubergine. In potato the pathogen causes the disease zebra chip, which poses the most serious threat to the UK, though impacts on glasshouse production of tomatoes and peppers could also be important. Lso is currently only known to be transmitted to solanaceous plants by psyllid vectors although there is speculation that it can also be transmitted through seed. In the UK there are no significant vectors able to transmit Lso in potato or other solanaceous crop. The principle threat from the pathogen is to solanaceous hosts through the introduction of the highly efficient Lso vector *Bactericera cockerelli* from North or Central America or New Zealand.

Whilst existing regulations close most pathways for entry of *B. cockerelli* a potential pathway exists for the entry of this psyllid through the import of solanaceous fruits that have aerial green plant parts still attached and which could harbour eggs or immature nymphs. Options for regulation of this pathway are currently being considered at the EU level in order to close this pathway. In recent years it has been established that Lso infects carrot in some Scandinavian countries, France and Spain. In the UK, the vector psyllid (*Bactericera trigonica*) that vectors the disease in carrot in the Canary Islands is absent as are all members of this genus, which includes an unidentified species, which vectors the disease in carrot in mainland Spain. UK populations of the carrot psyllid *T. apicalis*, which vectors the pathogen in carrot in some Scandinavian countries, are very small and restricted to southern England. The absence or low population densities and restricted distribution of carrot vector populations able to transmit Lso in the UK and the small trade in imported carrot sold in bunches, minimises the threat of the disease in this crop in the UK. Very recently carrot seed has been implicated as a source of Lso and regulation of this entry pathway has been proposed.

Risk of entry

The import of solanaceous fruits with attached green plant parts, which can harbour the Lso potato vector *B. cockerelli* poses the most significant risk of pathogen entry, and this is judged to be moderately likely. Because of uncertainty over the extent of the trade in imported carrots in bunches the threat of Lso infected carrot vectors entering the UK is rated as unlikely to moderately likely, Very recently carrot seed has been implicated as a source of Lso and for this entry is rated as moderately likely to very likely.

Risk of establishment

There is uncertainty concerning the potential for establishment of *B. cockerelli* in the UK. In the UK, the vector which spreads Lso in carrot in some Scandinavian countries has only been recorded in small numbers in southern England, whilst the genus that vectors the pathogen in Spain has not been recorded. The absence or low populations of carrot vectors minimises the establishment risks of Lso in this crop. The restricted occurrence of psyllids able to transmit Lso in the UK would restrict establishment of the disease should it occur from infected carrot seed.

Economic impact

The introduction of *B. cockerelli* and spread of Lso in potato could have very large economic consequences and cause significant damage to the industry. Large losses to glasshouse production of solanaceous fruits has been reported in New Zealand, which could occur in the UK.

Endangered area

All the potato growing areas of the UK are at risk. In carrot, counties in southern England may be at greater risk because this region is known to support populations of the carrot psyllid *T. apicalis*. Glasshouse production sites where solanaceous plants are grown would provide good conditions for the survival of *B. cockerelli.*

Risk management

Since eradication of *B. cockerelli* once established would not be possible, measures to avoid its entry are most important. Regulations already exist that prohibit the import of solanaceous plants for planting from Lso affected countries. Regulation of the import of fruits from solanaceous hosts including tomato and pepper is currently being considered at the EU level, which will close this entry pathway. Trade in imported carrot bunches with aerial plant parts attached from the EU may pose a risk from Lso in this crop. Though no information is available on the scale of this import trade it is expected to be small because of the very short shelf life of this crop. However, the risks to the UK, where carrot vectors are either absent or are present at very low levels with a very restricted distribution, reduces risks to a low level, which does not justify regulation. Very recently carrot seed has been implicated as a source of Lso and regulation of this entry pathway has been proposed.

17. Is there a need for a detailed PRA? If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used. *(for PH Risk Management Work stream to decide) ✓ (put tick in box)*

Not for Lso. However, additional work on the climatic suitability of the UK for *B. cockerelli* would be appropriate given the importance of this vector.	X

		PRA area: UK or EU	UK	PRA scheme: UK or EPPO	EPPO Climatic suitability

18. IMAGES OF PEST

	
1) Early Lso symptoms in potato note leaf curl and discolouration. Photo Joe Munyaneza USDA/ARS	2) Raw and fried potato slices infected with Lso. Photo Joe Munyaneza USDA/ARS

19. Given the information assembled within the time scale required, is statutory action considered appropriate / justified?

Yes Statutory action	X	No Statutory action	

This PRA concludes that in the event of any findings of the vector *B. cockerelli* and Lso in potato or other Solanaceous crops or carrot in the UK, then statutory action would be justified under Article 16 (2) of directive 2000/29/EC.

Regulation against the import of solanaceous fruits that have attached green aerial plant parts and which could harbour *B. cockerelli* is presently being considered at the Annexes Working Group of the EU Standing Committee of Plant Health. Very recently, a proposal has been made to regulate the import of carrot seed requiring it to be sourced from an area known to be free of Lso (Jeffries, 2014).

REFERENCES

Abernathy RL (1991) Investigations into the nature of the potato psyllid toxin M. Sc Thesis, Colorado state University., Fort Collins, CO p54.

Abdullah NMM (2008) Life history of the potato psyllid *Bactericera cockerelli* (Homopter:Psyllidae) in controlled environment agriculture in Arizona. African Journal of Agricultural Research 3: 060-067.

Alfaro-Fernandez A, Cebrian MC, Villaescusa FJ, de Mendoza AH, Ferrandiz JC, Sanjuan S, Font MI (2012a) First Report of *'Candidatus* Liberibacter solanacearum' in Carrot in Mainland Spain. Plant Dis. 96: 582-582

Alfaro-Fernandez A, Siverio F, Cebrian MC, Villaescusa FJ, Font MI (2012b) *'Candidatus* Liberibacter solanacearum' Associated with *Bactericera trigonica*-Affected Carrots in the Canary Islands. Plant Dis. 96: 581-582

Bextine B, Arp A, Flores E, Aguilar E, Lastrea L, Gomez FS, Powell C, Rueda A (2013a) First Report of Zebra Chip and *'Candidatus* Liberibacter solanacearum' on Potatoes in Nicaragua. Plant Dis. 97: 1109-1109

Bextine B, Aguilar E, Rueda A, Caceres O, Sengoda VG, McCue KF, Munyaneza JE (2013b) First Report of "*Candidatus* Liberibacter solanacearum" on Tomato in El Salvador. Plant Dis. 97: 1245-1245

Chávez R; Salazar L; Upadhya M; Chujoy E; Cabello R; Garcia A; Linares J (2003) The occurrenceof genetic resistance and susceptibility to the new potato virus SB-29 among tetraploide potato populations (*Solanum tuberosum* L., 2n = 4x = 48 AAAA) in an arid agroecosystem. IDESIA (Chile) 21: 9-22. http://146.83.108.153/did/IDESIA%2021-1/21%20-%201%20-%20CAP1.pdf

Crosslin JM, Hamm PB, Eggers JE, Rondon SI, Sengoda VG, Munyaneza JE (2012) First Report of Zebra Chip Disease and "*Candidatus* Liberibacter solanacearum" on Potatoes in Oregon and Washington State. Plant Dis. 96: 452-453

EPPO (2012a) Pest risk analysis for *Candidatus* liberibacter solanacearum in *Solanaceae.* http://www.eppo.org

EPPO (2012b) Report of a pest risk analysis for *Candidatus* liberibacter solanacearum in *Solanaceae* and its vector *Bactericera cockerelli*. http://www.eppo.org

EPPO (2012c) Pest risk analysis for *Bactericera cockerelli.* http://www.eppo*.org*

Fathi SAA (2011) Population density and life-history parameters of the psyllid *Bactericera nigricornis* (Forster) on four commercial cultivars of potato. Crop Prot. 30: 844-848

Gudmestad NC and Secor GA (2007) A new disease in potato Nebraska Potato Eyes 19: 1 4pp

Guenthner J, Goolsby J, Greenway G (2012) Use and Cost of Insecticides to Control Potato Psyllids and Zebra Chip on Potatoes. South w. Entomol. 37: 263-270

Hodkinson, I. D. & White, I. M. (1979) Homoptera: Psylloidea. Handbooks for the Identification of British Insects, vol. II, part 5 (a). Royal Entomological Society of London, London

Hodkinson, I. D. 1981. Status and taxonomy of the Trioza (Bactericera) nigricornis Förster complex (Hemiptera: Triozidae). Bulletin of Entomological Research 71: 671–679.

Horton DR, Munyaneza JE, Swisher KD, Echegaray, E, Murphy, AF, Rondon SI, Sengoda VG, Neven LG (2014) What is the source of potato psyllids colonizing Washington, Oregon, and Idaho potato fields? Potato Progress 14(2): 1-6.

Jeffries J (2014) Report on Zebra chip disease (‘*Candidatus* Liberibacter solanacearum’ and *Bactericera cockerelli* produced for National regulatory control systems (EPPO) 14-19275 P POT, Point 5.3.

Lieftling LW, Ward LI, Shiller JB, Clover GRG (2008a) A New *'Candidatus* Liberibacter' Species in *Solanum betaceum* (Tamarillo) and *Physalis peruviana* (Cape Gooseberry) in New Zealand. Plant Dis. 92: 1588-1588

Liefting LW, Perez-Egusquiza ZC, Clover GRG, Anderson JAD (2008b) A new *'Candidatus* Liberibacter' species in *Solanum tuberosum* in New Zealand. Plant Dis. 92: 1474-1474

Liefting L (2008c) New *Candidatus* Liberibacter species infecting solanaceous crops. Biosecurity. 85:21

Liefting LW, Sutherland PW, Ward LI, Paice KL, Weir BS, Clover GRG (2009d) A New *'Candidatus* Liberibacter' Species Associated with Diseases of Solanaceous Crops. Plant Dis. 93: 208-214

Munyaneza JE, Crosslin JM, Upton JE (2007) Association of *Bactericera cockerelli* (Homoptera : Psyllidae) with "zebra chip," a new potato disease in southwestern United States and Mexico. J. Econ. Entomol. 100: 656-663

Munyaneza JE, Lemmetty A, Nissinen AI, Sengoda VG, Fisher TW (2011a) Molecular detection of aster yellows phytoplasma and "candidatus liberibacter solanacearum" in carrots affected by the psyllid *Trioza apicalis* (hemiptera: triozidae) in Finland. J. Plant Pathol. 93: 697-700

Munyaneza JE, Buchman JL, Sengoda VG, Fisher TW, Pearson CC (2011b) Susceptibility of selected potato varieties to zebra chip potato disease. Am. J. Potato Res. 88:435-440.

Munyaneza JE, Sengoda VG, Sundheim L, Meadow R (2012a) First Report of "*Candidatus* Liberibacter solanacearum" Associated with Psyllid-Affected Carrots in Norway. Plant Dis. 96: 454-454

Munyaneza JE, Sengoda VG, Stegmark R, Arvidsson AK, Anderbrant O, Yuvaraj JK, Ramert B, Nissinen A (2012b) First Report of "*Candidatus* Liberibacter solanacearum" Associated with Psyllid-Affected Carrots in Sweden. Plant Dis. 96: 453-453

Munyaneza JE, Sengoda VG, Aguilar E, Bextine B, McCue KF (2014) First Report of *'Candidatus* Liberibacter solanacearum' on Pepper in Honduras. Plant Dis. 98: 154-154

Murphy AF, Rondon SI, Jensen AS (2013) First Report of Potato Psyllids, *Bactericera cockerelli*, Overwintering in the Pacific Northwest. Am. J. Potato Res. 90: 294-296

Nelson WR, Sengoda VG, Alfaro-Fernandez AO, Font MI, Crosslin JM, Munyaneza JE (2013) A new haplotype of "*Candidatus* Liberibacter solanacearum" identified in the Mediterranean region. Eur. J. Plant Pathol. 135: 633-639

Nissinen AI, Lemmetty A, Pihlava JM, Jauhiainen L, Munyaneza JE, Vanhala P (2012) Effects of carrot psyllid (*Trioza* apicalis) feeding on carrot yield and content of sugars and phenolic compounds. Ann. Appl. Biol. 161: 68-80

Ossiannilsson F. (1992) The psylloidea (Homoptera) of Fennoscandia and Denmark. Fauna Entomologica Scandinavica (Ed. E.J. Brill) 26: 313-321

Raddadi N, Gonella E, Camerota C, Pizzinat A, Tedeschi R, Crotti E, Mandrioli M, Bianco P, Daffonchio D, Alma A (2011) *'Candidatus* Liberibacter europaeus' sp nov that is associated with and transmitted by the psyllid Cacopsylla pyri apparently behaves as an endophyte rather than a pathogen. Environ. Microbiol. 13: 414-426

Salazar L, (2006) Emerging and Re-emerging Potato Diseases in the Andes. Potato Research 49: 43-47

Scott I, Berry N, Walker G, Pitman A, Workman P, Wright P (2009) Psyllid/Liberibacter/Phytoplasma Science Research Programme Update. Horticulture New Zealand, Plant and Food Research. [powerpoint presentation on the Internet] Available at: http://potatonz.org/user_files/PDF/Psyllid_research_update_&_control_options_-_Plant_&_Food.pdf

Soliman T, Mourits MCM, Lansink AGJMO, van der Werf W (2013) Economic justification for quarantine status- the case study of "*Candidatus* Liberibacter solanacearum' in the European Union. Plant Pathology 62: 1106-1113.

Swisher KD, Sengoda VG, Dixon J, Echegaray E, Murphy AF, Rondon SI, Munyaneza JE, Crosslin JM (2013) Haplotypes of the Potato Psyllid, Bactericera cockerelli, on the Wild Host Plant, *Solanum dulcamara*, in the Pacific Northwestern United States. American Journal of Potato Research 90: 570-577

Teresani GR, Bertolini E, Alfaro-Fernandez A, Martínez C, Tanaka FA, Kitajima E, Rosello M, Sanjuan S, Ferrandiz JC, López MM, Cambra M, Font-San-Ambrosio MI. (2014) Association of *Candidatus* liberibacter solanacearum with a vegetative disorder of celery in Spain and development of a real-time PCR method for its detection. Phytopathology (Reprint ahead of publication available at http://www.ncbi.nlm.nih.gov/pubmed/24502203).

van Vuuren S P., Cook G, and Pietersen G. (2011) Lack of Evidence for Seed Transmission of *'Candidatus* Liberibacter africanus' Associated with Greening (Huanglongbing) in Citrus in South Africa, Plant Disease 95: 1026-1026.

Vereijssen J, Jorgensen N, Taylor N, Read S. & Berry N A. 2012. Tomato/potato psyllid phenology in a temperate climate. Proceedings of the 12th Annual Zebra Chip Annual Reporting Session, 2012 30 October – 2 November 2012, San Antonio, Texas, USAVereijssen J, Tran I T, Worner S, P. & Teulon D A J. 2013. The potential number of generations of *Bactericera cockerelli* in New Zealand. New Zealand Plant Protection, 66: 385.

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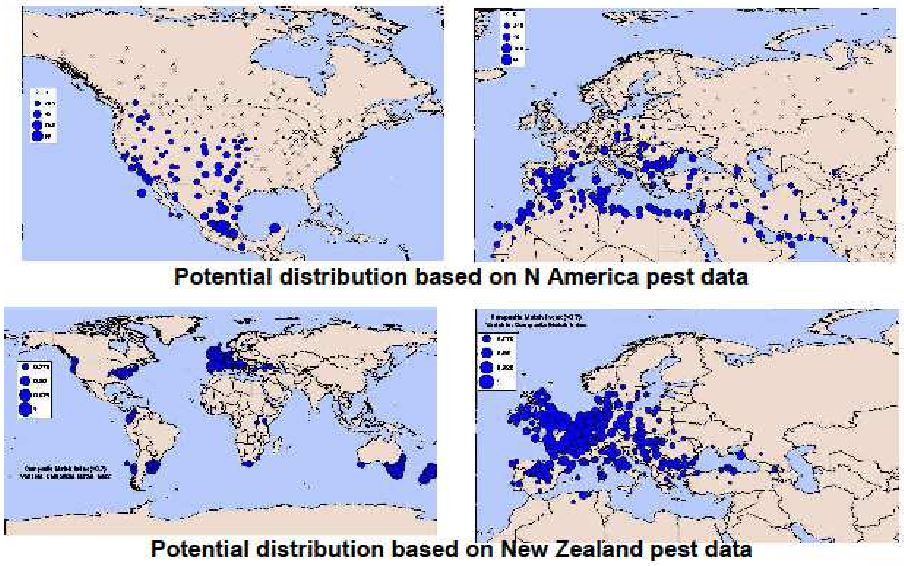

Fig. 1 Climex data predicting population range of *B. cockerelli* in Europe based on existing US climate/range (top) and New Zealand (bottom). (EPPO data).

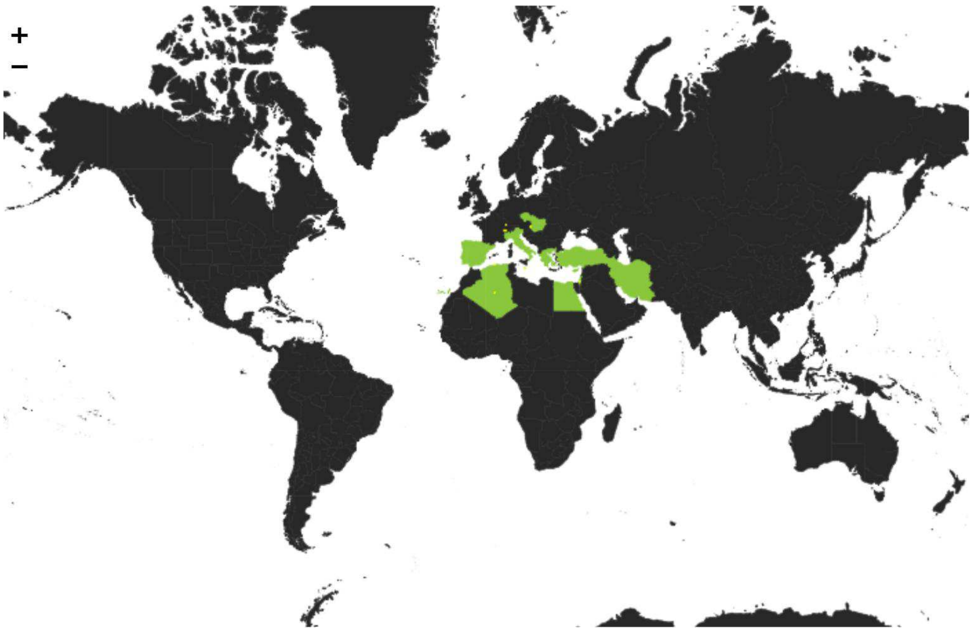

Fig. 2 Distrubution of *Bactericera trigonica*. Ouvrard, D. (2014) Psyl'list - The World Psylloidea Database. http://www.hemiptera-databases.com/psyllist - searched on 17 January 2014

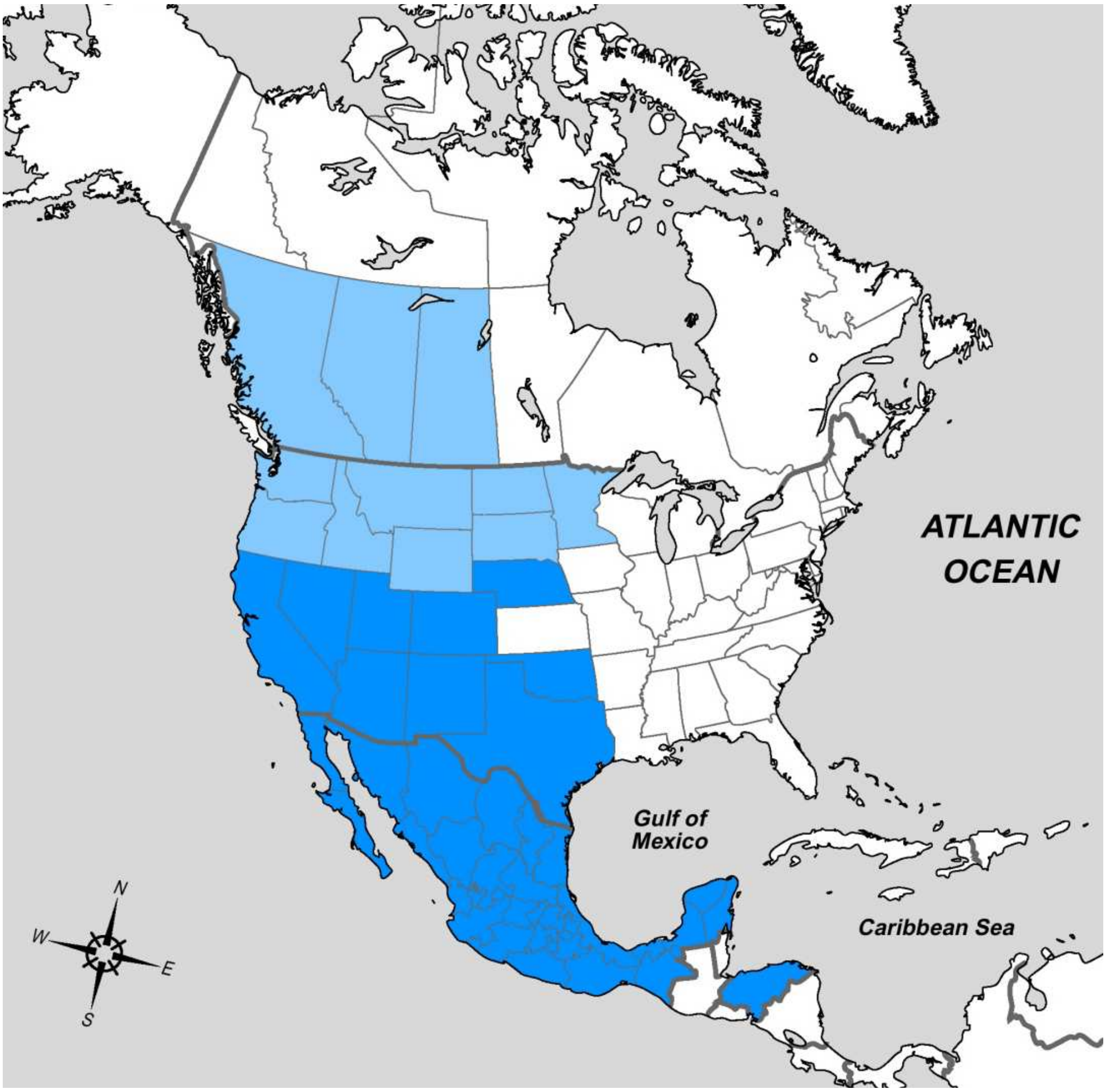

Fig. 3

Distribution map of Bactericera cockerelli in the Americas. •Lighter blue areas are colonized intermittently. Map: Scott Burton FDACS/ Div. Plant Industry

Table 1. UK imports of fresh or chilled fruits of Genus *Capsicum* or *Pimenta* excluding sweet peppers and industrial manufacture (CN 07096099).

	UK Imports 100's kg		
Year	***USA***	***Mexico***	***Guatemala***
2012	489	3694	190

2011	250	1383	0
2010	540	750	0
2009	1344	891	0
Total	2134	3024	0

Appendix 1

Potential vectors for *Candidatus* Liberibacter solanacearum in the UK and Europe (Chris Malumphy, 2014)

1. ***Bactericera cockerelli***

The principal vector of *Ca*. L. solanacearum in the USA and New Zealand is the potato psyllid *Bactericera cockerelli* (Hemiptera, Triozidae), which can be found on numerous species in 20+ plant families, and can complete its life cycle on some Solanaceae (including aubergine, peppers, potato and tomato), Convolvulaceae and Lamiaceae.

Bactericera cockerelli does not occur in Europe.

2. ***Trioza apicalis***

A different haplotype of *Ca*. L. solanacearum was reported on carrots in Finland, Norway and Sweden and Spain, and in celeriac in Spain, associated with the carrot psyllid *Trioza apicalis* (Hemiptera, Triozidae).

Trioza apicalis is present in Britain but is apparently uncommon and mainly confined to southern England, where it is most frequently found on umbellifers, which are ubiquitous in hedgerows. However, there are very few entomologists recording psyllids in the UK and this distribution is largely based on data from the 1970s and earlier (Hodkinson & White, 1979).

The psyllid *Bactericera nigricornis* (Foerster) is polyphagous, feeding on plants belonging to Apiaceae, Asteraceae, Brassicaceae, Chenopodiaceae, Liliaceae, Poaceae, Polygonaceae and Solanaceae. It feeds on several vegetable crops (including potato) and is also a pest of carrot (*Daucus carota*), Chinese cabbage (*Brassica chinensis*) and onion (*Allium cepa*) (Hodkinson 1981; Boertnes 1997; Hudák & Pénzes 2005). It occurs widely in Europe, Morocco, Kazakhstan, Russia and China, but has not been recorded from the UK. It is relatively common in Scandinavia and the Baltics and is likely to be able to naturalise throughout Britain. Malumphy *et al*.. (2009) recorded it from potato fields in Lithuania.

3. ***Acizzia* spp.**

In New Zealand, the bacterium has also been found in *Acizzia* sp. collected from *Acacia*.

Since the 1970s, four alien species of *Acizzia* (*A. acaciaebaileyanae*, *A. hollisi*, *A. jamatonica* and *A. uncatoides*) have established in Europe, feeding on mimosoid legumes, particularly *Acacia* and *Albizia* (Fabaceae). Two of these species, *A. uncatoides* and *A. acaciaebaileyanae*, are locally naturalized in parts of southern England.

4. ***Trioza vitreoradiata***

In New Zealand, the bacterium has also been found in a *Trioza* sp. on *Pittosporum*. The psyllid species was not determined although there appears to only be one species recorded on this host:

pittosporum psyllid, *Trioza vitreoradiata*. This psyllid is widely established in southern England and parts of western Scotland. It is only known to breed on *Pittosporum*.

Although the majority of psyllids in Britain and Europe can only complete their development on a single or a couple of closely related host plant species, adult psyllids are capable of feeding (at least occasionally) on a wider range on hosts. Therefore, it is possible that other species native British psyllids may occasionally, and/or temporarily, feed on potato crops, but are incapable of breeding on this plant.

In summary, the European psyllid species that presents the greatest risk of vectoring *Ca*. L. solanacearum between infected carrot and potato crops is *Bactericera cockerelli*. This psyllid is currently not known to occur in Britain although there appear to have been no surveys undertaken to detect this species.

References

Boertnes, G. 1997. Occurrence of the sucker *Bactericera nigricornis*: Damage situation to carrot and Chinese cabbage. *Gartneryrket* 86: 22–23.

Hodkinson, I. D. 1981. Status and taxonomy of the *Trioza* (*Bactericera*) *nigricornis* Förster complex (Hemiptera: Triozidae). *Bulletin of Entomological Research* 71: 671–679.

Hodkinson, I. D. and White, I. M. 1979. Homoptera: Psylloidea. *Handbook for the Identification of British Insects* 2: 1–98.

Hudák, K. and Pénzes, B. 2005. The new pest of bulbs is *Trioza* (*Bactericera*) *nigricornis* Förster. In: J. Horvath, A. Haltrich and J. Molnar (eds) *51st Plant Protection Days 2005*. *Abstracts of lectures and posters*, pp. 3. Budapest: Magyar Agrartudomanyi Egyesulet.

Malumphy, C., Ostrauskas, H. & Pye, D. 2009c. Contribution to the knowledge of jumping plant -lice (Hemiptera, Psylloidea) of Lithuania. *Acta Zoologica Lituanica*. **19**, 128-131.