The Food & Environment Research Agency

Rapid Pest Risk Analysis for *Acidovorax citrulli*

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?

Acidovorax citrulli (Schaad et al*,* 2008) is a non-sporulating bacterium, which is derived from saprophytic relatives within the genus through acquisition of plant virulence genes. The pathogen is also known as *Acidovorax avenae* subsp. *citrulli.* Disease names include bacterial fruit blotch of watermelon and fruit blotch. Two pathological types (Group 1 and Group II) have been differentiated. When tested experimentally, Group I strains were moderately aggressive to a wide range of cucurbits whilst Group II strains were most aggressive to watermelon and melon (Walcott et al., 2004). Group II strains were responsible for a significant global epidemic when commercial seed lots from watermelon became infected from 1989 (Walcott et al., 2004; Melo et al., 2014).

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]?

The pathogen is listed in the EPPO alert list (2009) but is not listed in the EC Plant Health Directive. EPPO is currently (June 2014) discussing its listing as a pest recommended for regulation.

3. What is the reason for the rapid assessment?

A PRA for *A. citrulli*, was produced as part of the 'Prima phacie' project (MacLeod et al 2010), which considered risks to Europe and was completed in December 2011 (see reference for links to the two PRAs, which were formatted using different assessment schemes). A PRA for *A. citrulli* focusing on the UK threat to cucumber was identified following consideration of the pest for the UK Risk Register. In addition to cucumber, this PRA also assesses risks to other cucurbits including *Cucurbita pepo* varieties (pumpkin, marrow, courgette and squash) that are often grown outdoors and under protection in the UK. Threats to watermelon or melon are not considered in detail because they are not a significant crop in the UK. An assessment is required to help inform the decision on whether statutory action against future interceptions is justified.

STAGE 2: RISK ASSESSMENT

4. What is the pest's present geographical distribution?

The distribution of *Acidovorax citrulli* is based on EPPO PQR (see also the EPPO data sheet available at: http://www.eppo.int/QUARANTINE/Alert_List/bacteria/Acidovorax_citrulli.htm).
North America: USA
Central America: Nicaragua, Costa Rica

[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

South America: Brazil, Costa Rica, Trinidad and Tobago
Europe: Greece, Hungary, Italy, Turkey,
Asia: China, Japan, Taiwan, Thailand, Israel
Oceania: Australia, Guam, Northern Mariana islands

5. Is the pest established or transient, or suspected to be established/ transient in the UK?
A. citrulli is not present in the UK and is not suspected to be established or transient.

6. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK?
(EPPO PQR data, see also PPO data sheet available at:
http://www.eppo.int/QUARANTINE/Alert_List/bacteria/Acidovorax_citrulli.htm)

Natural Hosts:
Citrullus lanatus (watermelon)
Cucumis melo (melon or cantaloupe melon)
Cucumis sativus (cucumber)
Cucurbita moschata (butternut squash; can also be referred to as 'pumpkin')
Cucurbita pepo (summer squash/courgette/zucchini, 'winter squash', pumpkin and marrow)
Piper betle (betel pepper)

Experimental:
Tomato, eggplant and pepper

The most vulnerable hosts are watermelon and melon, which are not significant crops to the UK. Cucumber is a commercially important UK protected crop, whilst marrow, courgette and pumpkin are widely grown outdoors in the UK, mostly by specialist producers and amateur growers.

7. If the pest needs a vector, is it present in the UK?
A. citrulli is not vectored.

8. What are the pathways on which the pest is likely to move and how likely is the pest to enter the UK? (*By pathway*):

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely
Pathway 1:		X			
Pathway 2:		X			
Pathway 3:	X				
Pathway 4:	X	X			

Pathway 1 Cucumber seed
Pathway 2 Cucumber plants for planting
Pathway 3 Infected melon fruit
Pathway 4 Seed from *C. pepo*.

A. citrulli infected seed is the most important primary transmission pathway in all cucurbit hosts (Hopkins and Thompson, 2002), though infected plants for planting (usually grown from infected seed) can occur and also present an entry risk. Only single reports of infection in cucurbits grown in the UK have been documented in the formal literature (from pumpkin and cucumber, see section 9), which suggests that either the seed from these hosts is not

infected or is not sufficiently infected to produce significant disease. Seed transmission in cucumber and pumpkin, (amongst other cucurbit species), has been determined experimentally in two trials (Hopkins and Thompson, 2002). This study found seed transmission frequencies of 0-2% over both trials for both these hosts, compared to transmission rates of up to 41% of seed from watermelon. The absence or very low seed infection rates in cucumber and pumpkin provides further evidence for the likelihood of low levels or absence of seed infection in these hosts. Entry risks are scored as unlikely or very unlikely to reflect the low or absent level of seed infection inferred from the low number of reports of disease from cucurbits that are grown in the UK.

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

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

In outdoor crops *A. citrulli* infection has been reported mainly from watermelon and melon, which are grown in climatic regions that are hotter than the UK. Only single reports have been documented in the formal literature from cucumber and pumpkin in Georgia (USA) and Australia respectively (Langston et al., 1999; Martin et al., 1999). The paucity of these reports suggests there are barriers to pathogen dissemination and establishment and the development of disease in these hosts. Even when climatic conditions are favourable for disease development in susceptible watermelon hosts, there is little evidence that *A. citrulli* persists outdoors at infected production facilities for more than one season. This is supported by experimental evidence which documents only relatively short survival of *A. citrulli* in soil. Measured over a 60 day period, *A. citrulli* populations declined from of more than 10^7 cells/ ml to 10 cells (Silva et al., 2006) and this rate of reduction suggests that survival in soil over more than a single growing season is unlikely. The absence of wild hosts in the UK precludes *A. citrulli* establishment in the UK environment. Whilst there have been no experimental studies to determine the minimum temperature conditions required for establishment of *A. citrulli,* disease has only been reported from regions that have a summer climate that is hotter than the UK suggests that outdoors, the UK is not be suitable for establishment of the pathogen. Experiments determining the effect of temperature on fruit blotch lesion development over a 2 hour period in melon found no symptoms developed at either at 15°C or 20°C, whilst lesions were rapidly produced at 25°C and 30°C (Silveira et al., 2004). This temperature profile for production of fruit soft rot is consistent with a low potential for the pathogen to cause disease under UK climatic conditions.

Under protection it is very likely that *A. citrulli* could establish in cucurbit hosts, principally cucumber in the UK (Martin et al., 1999).

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

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

Infected seed is the primary means by which *A. citrulli* is spread and disseminated (Hopkins and Thompson, 2002), though infected seedlings (produced from infected seed) can also efficiently spread the pathogen. Trade in infected seed and plants for planting would spread the pathogen very quickly. Since *A. citrulli* is not vectored, pathogen spread within the UK, apart from dissemination by infected plant material, would be very slow.

11. What is the area endangered by the pest?
All cucurbit protected crops.

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

A) In watermelon and melon

Economic

Very small	Small	Medium	Large	Very large
			X	

Environmental

Very small	Small	Medium	Large	Very large
X				

Social

Very small	Small	Medium	Large	Very large
	X	X		

Disease in watermelon, which is highly susceptible to *A. citrulli* infection, is very sporadic and favourable conditions (high temperature and humidity) are required for high-levels of damage to occur (Hopkins, 1993). *A. citrulli* has caused 90-100% losses in watermelon in the USA and up to 100% crop losses to melon producers in Brazil (Assis et al., 1999). Awareness of *A. citrulli* risks in these hosts together with seed testing for the pathogen has reduced impacts in recent years though outbreaks can sometimes recur (Hopkins and Thompson, 2002). In Europe *A. citrulli* has been reported to cause disease only in watermelon, where significant losses have occurred. In Hungary, (the most northerly latitude at which *A. citrulli* outbreaks have been reported) disease occurred when the mean maximum daytime temperature (in July 2007) exceeded 32° C (Palkovics et al., 2008).

B) In cucurbit hosts important to the UK (cucumber, pumpkin, marrow and courgette).

Economic

Very small	Small	Medium	Large	Very large
X	X			

Social

Very small	Small	Medium	Large	Very large
X				

Environmental

Very small	Small	Medium	Large	Very large
X				

In naturally infected cucumber, *A. citrulli* has been reported only on a single occasion when it infected a production facility in Australia and caused foliar lesions in more than 20% of plants (Martin et al, 1999). The report did not mention if significant economic or yield losses had occurred. Similarly, in *C. pepo* only a single report has documented disease from natural infection (Langston et al., 1999), when significant fruit damage occurred to pumpkin at a production site in Georgia (USA). Disease spread has been measured in several cucurbit species following experimental infection of plants grown in the glasshouse (Hopkins and Thompson, 2002), which found no inter-plant spread in either pumpkin or cucumber in either of the two years over which the trials were done. Inefficient *A. citrulli* spread in these hosts is consistent with the low reports of disease in this host. The higher levels of *A. citrulli* disease incidence recorded in the Australian report suggests however, that specific crop management conditions influence pathogen transmission. The use of mobile irrigation systems for example, can increase on-site disease spread.

No significant environmental impacts from *A. citrulli* have been reported.

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

Economic	Very small		Small	X	Medium		Large		Very large	
Environmental	Very small	X	Small		Medium		Large		Very large	
Social	Very small	X	Small		Medium		Large		Very large	

The main threat to the UK from *A. citrulli* is to intensive glasshouse production of cucumber where relatively small yield losses can result in significant economic losses. However, the absence of recorded damage to cucumber fruit (see section 12; Martin et al, 1999) limits potential economic impacts. The relatively short survival of the pathogen away from living host material (see section 9), reduces opportunities for carry-over of *A. citrulli* at production sites beyond a single season or growth cycle and further limits potential economic impacts. Additionally, should *A. citrulli* infection occur in cucumber in the UK, on-site disease management practices and the subsequent use of disease free seed or planting material would provide a means to mitigate crop damage. Together these factors justify a small economic impact score for cucumber. Potential losses to *C. pepo* (pumpkin, marrow and courgette) production are also scored as small because of the limited reports of disease in this host (see section 12; Langston et al., 1999), which suggests that there are significant barriers to disease expression and pathogen dissemination in this host. This is supported by experimental evidence demonstrating the absence of, or minimal, inter-plant spread and seed transmission in cucumber and pumpkin (Hopkins and Thompson, 2002). Additionally, it is very unlikely that *A. citrulli* could establish in cucurbit crops grown outdoors in UK climatic conditions. There are no UK naturally occurring hosts which, precludes environmental impacts and also limits risks of pathogen spread.

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

The bacterium cannot vector other pathogens.

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).*

The risk to crops other than melons is generally low. However, should *A. citrulli* be introduced to cucumber production, on-site management measures (e.g. removal of symptomatic plants and preventing contamination of irrigation systems) will limit pathogen spread and also reduce yield losses and it would be considered to be likely that the pathogen could be successfully eradicated. The UK's climate is not suitable for the infection of outdoor-grown cucurbits. There is little evidence for survival of the pathogen in the environment or in production premises and consequently the use of pathogen- free seed or planting material in conjunction with effective cleaning and removal of infective plant material, would prevent recurrence of the disease.

Currently, seed producers are required to comply with European Council Directive 2002/55/EC (EU, 2002), which stipulates that "diseases and harmful organisms which reduce usefulness of the seed shall be at the lowest possible level". Additional regulation of *A. citrulli* is likely to be considered at the EU level due to the risk posed to melon production in Southern Europe. Given there are few reports of disease caused by *A. citrulli* on cucurbits species grown in the UK, further regulation of seed production of pumpkin, marrow, courgette and squash would seem to be unnecessary. However EU regulation of melon seed could been seen as appropriate to protection melon production in Southern Europe but this would have little impact on the UK due to the assumed lack of commercial melon production.

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.
Risks from *A. citrulli* are primarily to watermelon and melon in which, under favourable conditions, fruit losses can be severe. However this host is not a significant crop in the UK. There is a threat to intensive cucumber production in the UK though there has been only a single report of disease on this host and symptoms were restricted to leaf blight. Similarly, there has been only a single report of damage to other cucurbit crops that are grown in the UK: pumpkin fruit (*C. pepo*) from Georgia (USA). The limited number of reports of disease affecting the cucurbit hosts grown in the UK suggests there are significant barriers to disease dissemination in these hosts. If a UK *A. citrulli* outbreak was to occur, on-site management including, for example, removal of symptomatic plants and the prevention of contamination in the irrigation system would limit impacts. The use of pathogen free seed and plants for planting would prevent recurrence of the disease. Additionally, *A. citrulli* is very unlikely to survive outdoors in the UK due to the climatic conditions. Regulation of *A. citrulli* is likely to be considered at the EU level due to the risk to melon production in Southern Europe.

Risk of entry
Entry risks of *A. citrulli* are from infected cucurbit seed (primarily cucumber, pumpkin or marrow and courgette) or infected plants for planting that may be produced from infected seed. These risks are scored as unlikely or very unlikely reflecting the minimal number reports of disease in these hosts, which suggests that *A. citrulli* seed infection in these hosts is absent or insufficient to produce significant disease.

Risk of establishment
A. citrulli could readily establish under protection in the UK and this risk is scored as very likely. Poor survival of the pathogen away from host plant tissue and absence of naturally occurring environmental hosts will limit establishment at production sites to a single season or growth cycle. Disease from *A. citrulli* in outdoor grown cucurbits has only been reported from countries with much hotter climatic conditions than the UK and the pathogen is very

unlikely to establishment outdoors. There are no wild growing cucurbit hosts that could serve as an *A. citrulli* infection reservoir.

Economic impact
Potential economic impacts from the pathogen are mainly to intensive cucumber production and are scored as small reflecting the absence of recorded fruit damage to this host and the potential for control of the pathogen through on-site management. The use of uninfected seed or plants for planting, in conjunction with removal of infected plant material would prevent recurrence of the *A. citrulli*, limiting impacts to a single growing season. Since the pathogen is very unlikely to establish outdoors, impacts to outdoor-grown cucurbits are not expected.

Endangered area
Protected cucumber crops.

Risk management
Once infected cucurbits are found, on-site disease management measures can be used to reduce pathogen spread and damage. Existing EU-regulations pertaining to seed production under European Council directive 2002/55/EC (EU, 2002) have been sufficient to preclude *A. citrulli* infections in UK grown cucurbits.

Additional regulation of *A. citrulli* is likely to be considered at the EU level due to the risk to melon production in southern Europe.
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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)*

No	X

Yes		PRA area: UK or EU		PRA scheme: UK or EPPO	

18. IMAGES OF PEST

Photo 1 Symptoms in watermelon.	Photo 2 Symptoms in melon.
	
Courtesy Jason Brock (Bugwood IPM Images)	Courtesy Jason Brock (Bugwood IPM images)

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

Yes Statutory action		No Statutory action	X

Additional regulation of *A. citrulli* is being considered at the EU level by the Annexes Working Group of the EC Plant Health Standing Committee.

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