NATIONAL EMERGENCY RESPONSE PLAN FOR CARIBBEAN COUNTRIES

Brown Rot of Potato, *Ralstonia solanacearum* (Smith,1986)
Yabuuchi et al., 1996 “race 3 biovar 2”

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The content of this document is an adaptation of the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ) **New Pest Response Guidelines *Ralstonia solanacearum*** (Smith, 1896) Yabuuchi et al., 1996 "race 3 biovar 2", Brown Rot of Potato (2019).
"*Please note: This document is based on the best information available at the time of development; however, at the time of the emergency, new scientific and technical information may be identified. In addition, each pest incursion has unique, site-specific characteristics that are not easily predictable. Therefore, this document should be considered only as a general guideline. As the pest situation evolves and new information is gathered, the response implemented, including survey protocols, may need to be modified from the original recommendations*".

Section I. Introduction

1

Safeguarding the borders of the Caribbean from pest incursions is critical for protecting agriculture production and natural resources, facilitating trade and improving the economic well-being of countries. Due to the geography of the Islands in the Region, the presence of high-risk pathways, the limited number of plant health professionals involved in safeguarding activities and the high ratio of border area to land mass, the Region is vulnerable to pest incursions. Over the years, there have been incidents of pathogen introductions, which have threatened exports and the economies of several countries.

Brown Rot of Potato, *Ralstonia solanacearum* race 3 biovar 2 (R3bv2) is an extremely destructive pathogen affecting a wide range of crops important to the Caribbean, such as potatoes, tomatoes, eggplant and peppers. Brown rot of potato occurs in the highland tropics and has been reported in more than 30 countries and almost all continents. Brown rot of potato has been estimated to affect 1.5 million hectares (3.75 million acres) in approximately 80 countries with global damage estimates exceeding $950 million United States Dollars per year (Floyd, 2007). Based on its potential impact on crops that are important for food security and poverty alleviation in the Region, it has been ranked as a priority pest for the Caribbean.

Having a comprehensive emergency response strategy to rapidly tackle this pathogen is critical for safeguarding the borders of the United States and the Caribbean. This publication aims at providing information that can be used to prevent the entry, establishment and spread of the brown rot of potato, *R. Solanacearum* R3bv2.

This Emergency Response Plan for the brown rot of potato, *R. Solanacearum* R3bv2, provides basic information on the biology, ecology, surveillance and management of the pest. It also provides an outline of the administrative responses to prevent the entry, spread and establishment of the pathogen. Specific sections include:

- Summary of relevant pest biology.
- Guide for the identification the pest in the field.
- Surveillance and monitoring of the pest.
- An outline of possible measures to eradicate and control the pest.
- Emergency response actions that should be considered in the event of an incursion.

It is expected that this publication will contribute to:

- Preventing the entry of the brown rot of potato into the Caribbean.
- Protecting the production of important Solanaceae crops cultivated.
- Sensitizing and training technicians, producers and other key stakeholders in the prevention of entry, spread and establishment of the pest, and the management of the emergency response should the pest be detected and established.
- Reducing the potential impact of the pest on plant health.

2 Section II. Pest Overview

Pest Summary

Ralstonia solanacearum R3bv2, a causal agent of brown rot of potato is thought to have originated in the Andean highlands of Colombia and Peru (Champoiseau et al., 2009; Cook and Sequeira, 1991). This pathogen affects mainly solanaceous crops and weeds and is considered a severe threat to plant health (Janse et al., 2004; USDA-APHIS-PPQ, 2018).

Key Information

- Can infect and cause disease at temperatures as low as 16 ºC (60.8 ºF), but symptoms are most likely observed at 24–35 ºC (75.2–95 ºF).
- Primarily spread through contaminated irrigation and surface runoff water, infested soil, tools and equipment.
- Major hosts are potato (*Solanum tuberosum* L.), tomato (*Solanum lycopersicum* L.) and geranium (*Pelargonium* spp.).
- Many native plant and weed species, such as bittersweet nightshade (*Solanum dulcamara* L.), can be infected but asymptomatic.
- Main symptoms are wilting, leaf chlorosis (yellowing), stunting, and vascular browning in stems.
- Symptoms of *R. solanacearum* R3bv2 can be mistaken for various other wilt pathogens on potato, tomato and geranium.
- Management in the field is very difficult due to strain variation, host range, pathogen persistence in asymptomatic hosts, infected soil and surface water, and lack of adequate chemical treatments.
- All potentially infected plants and planting material must be destroyed.
- Soil fumigation using chloropicrin has produced similar results to methyl bromide, but further studies are needed.
- Exclusion, use of certified seed, cultural practices and phytosanitation are the best control methods.

Pest Information

Scientific Name

- *Ralstonia solanacearum* (Smith, 1896) Yabuuchi et al., 1996 race 3 biovar 2.
- A revised classification system based on phylogenetic analysis of genome sequences places *Ralstonia solanacearum* R3bv2 strains in sequevars 1 and 2 of the phylotype II B subgroup (Allen et al., 2005; Prior and Fegan, 2005b).

Taxonomic Position

- Bacteria: Proteobacteria: Betaproteobacteria: Burkholderiales : Burkholderiaceae.

Synonyms

- *Burkholderia solanacearum* (Smith, 1896) Yabuuchi et al.
- *Pseudomonas solanacearum* (Smith, 1896) Smith.

Common Names

- Brown rot of potato
- Bacterial wilt of tomato
- Southern wilt of geranium

Biology and Ecology

Life Cycle

Ralstonia solanacearum R3bv2 is soil and waterborne and can survive for days to years in infected soil (at least 75 cm (28.53")) (Champoiseau et al., 2009; Graham et al., 1979), as well as surface irrigation water and weeds (Champoiseau and Momol, 2009). This bacterium thrives in the cool tropical highlands and in temperate zones. *Ralstonia solanacearum* R3bv2 is highly virulent at temperatures between 19 °C and 28 °C (66.2 °F and 82.4 °F) (Huerta et al., 2015). Virulence decreases with temperatures above 35 °C (95 °F) or below 16 °C (60.8 °F) (Champoiseau et al., 2009; Ciampi and Sequeira, 1980). Additionally, Milling et al. (2009) found that the bacterium can survive for more than four months in sterile water at 4 °C (39.2 °F). Other factors affecting disease development include soil type and structure, soil moisture, salt content and water pH (Champoiseau and Momol, 2009).

Infection can occur through wounds in roots (points of emergence of lateral root), injury caused by soil-borne organisms (e.g. the root-knot nematode) and stem injuries caused by agricultural practices (Champoiseau and Momol, 2009; Swanson et al., 2005). Once the plant is infected, the pathogen spreads systemically through the xylem vessels causing wilting and death (Champoiseau et al., 2009; Genin, 2010). Symptomless infection is common, especially at cooler temperatures.

Table 2.1 List of reported plant hosts of *R. solanacearum* R3bv2

Scientific name	Common name	References
Amaranthus viridis L.	green amaranth	Lin et al. (2015)
Capsicum annuum L.	sweet pepper	Martin and French (1995)
Capsicum spp.	pepper	Lin et al. (2015)
Oxalis latifolia Kunth	broadleaf wood-sorrel	Khoodoo et al. (2010)
Pelargonium × *hortorum* L. H. Bailey	zonal geranium	Williamson et al. (2002)
Pelargonium spp.	geranium	Ozakman and Schaad (2003)
Pelargonium zonale (L.) L'Hér.	horseshoe pelargonium	Janse et al. (2004)
Physalis angulata L.	cut-leaf ground-cherry	Swanepoel (1992)
Portulaca oleracea L	common purslane	Lin et al. (2015)
Solanum americanum Mill.	American nightshade	Khoodoo et al. (2010)
Solanum betaceum Cav. (=*Cyphomandra betacea* (Cav.) Sendtn.)	tree-tomato	Martin and Nydegger (1982)
Solanum cinereum R. Br.	Narrawa-bur	Graham and Lloyd (1978)
Solanum lycopersicum L.	tomato	Mahbou Somo Toukam et al. (2009)

Scientific name	Common name	References
Solanum melongena L.	aubergine eggplant	Caffier and Hervé (1996)
Solanum nigrum L.	black nightshade	Tomlinson and Guntber (1986)
Solanum pimpinellifolium L. (=*Lycopersicon pimpinellifolium* (L.) Mill.)	currant tomato	Khoodoo et al. (2010)
Solanum spp.	potato	Allen et al. (2005)
Solanum tuberosum L.	potato	Tahat and Sijam (2010)
Solanum tuberosum L. subsp. *andigenum* (Juz. & Bukasov)	Andean potato	Ciampi and Sequeira (1980)
Hawkes (=*Solanum phureja* Juz. & Bukasov)		Patil et al. (2012)

Table 2.2 List of reported asymptomatic hosts of *R. solanacearum* R3bv2

Scientific name	Common name	References
Ageratum conyzoides L.	goatweed	Tusiime et al. (1998)
Amaranthus spp.	pigweed	Tusiime et al. (1998)
Bidens pilosa L.	beggar-ticks	Tusiime et al. (1998)
Dopatrium sp.	dopatrium	Pradhanang and Momol (2001)
Drymaria cordata (L.) Willd. ex Schult.	tropical chickweed	Pradhanang et al. (2000)
Erigeron floribundus (Kunth) Sch. Bip.	Bilbao fleabane	Tusiime et al. (1998)
Galinsoga parviflora Cav.	dumb-nettle	Pradhanang and Elphinstone (1996) Tusiime et al. (1998)
Leucas martinicensis (Jacq.) W. T. Aiton	whitewort	Tusiime et al. (1998)
Monochoria vaginalis (Burm. f.) C. Presl ex Kunth	pickerel-weed	Pradhanang and Momol (2001)
Nicotiana glutinosa L.		Fernandez (1986)
Oxalis latifolia Kunth	broadleaf wood-sorrel	Tusiime et al. (1998)
Persicaria capitata (Buch.- Ham. ex D. Don) H. Gross (=*Polygonum capitatum* Buch.-Ham. ex D. Don)	Japanese knotweed	Pradhanang and Elphinstone (1996) Pradhanang et al. (2000)
Persicaria nepalensis (Meisn.) H. Gross (=*Polygonum nepalense* Meisn.)	Nepal knotweed	Tusiime et al. (1998)
Rumex abyssinicus Jacq.	mekmeko	Tusiime et al. (1998)
Solanum dulcamara L.	bittersweet nightshade	Wenneker et al. (1999)
Stellaria sennii Chiov.		Tusiime et al. (1998)
Spergula arvensis L.	corn spurrey	Tusiime et al. (1998)
Tagetes minuta L.	Aztec marigold	Tusiime et al. (1998)
Urtica dioica L.	stinging nettle	Wenneker et al. (1999)

Table 2.3 List of hosts of *R. solanacearum* R3bv2 that can be asymptomatically infected under artificial conditions

Scientific name	Common name	References
Brassica juncea (L.) Czern.	brown mustard	Pradhanang et al. (2000)
Brassica oleracea L.	cabbage	Álvarez et al. (2008)
Brassica spp.	wild mustard	Álvarez et al. (2008)
Calibrachoa sp.	calibrachoa	Janse et al. (2004)
Cerastium glomeratum Thuill.	mouse-ear chickweed	Pradhanang et al. (2000)
Cichorium endivia L.	endive	Álvarez et al. (2008)
Datura stramonium L.	jimsonweed	Fernandez (1986)
Nicandra physalodes (L.) Gaertn.	broadleaf-nightshade	Pradhanang et al. (2000)
Nicotiana glutinosa L.	knekt-tobak	Martin and French (1995)
Nicotiana rustica L.	Aztec tobacco	Martin and French (1995)
Petunia × *atkinsiana* (Sweet) D. Don ex W. H. Baxter (=*Petunia* × *hybrida* hort. Ex E. Vilm.)	common garden petunia	Janse et al. (2004)
Physalis pubescens L. (=*Physalis floridana* Rydb.)	downy ground-cherry	Fernandez (1986)
Salpiglossis sinuata *Ruiz & Pav.*	painted-tongue	Olsson (1976)
Solanum pseudocapsicum L. (=*Solanum capsicastrum* Link ex Schauer)	false capsicum	Fernandez (1986)
Solanum virginianum L. (=*Solanum xanthocarpum* Schrad.)	yellow-fruit nightshade	Pradhanang et al. (2000)
Stellaria media (L.) Vill.	chickweed	Pradhanang et al. (2000)
Tropaeolum majus L.	garden nasturtium	Pradhanang et al. (2000)

Dispersal

Natural Movement

Ralstonia solanacearum R3bv2 can spread naturally from infected roots to healthy roots of neighboring plants (Kelman and Sequeira, 1965 as cited by (Kelman, 1998)) and through insect and possibly nematode damage (Champoiseau et al., 2009). Note that this pathogen does not spread from plant to plant aerially or through casual contact or water splashing (Swanson et al., 2005).

Human-Assisted Spread

This pathogen is primarily water and soilborne and can be dispersed by contaminated irrigation and surface runoff water, infected soil and plant material, soil transfer on machinery and equipment, and unsanitized handling (Champoiseau and Momol, 2009; Janse, 1996). Greenhouse spread may occur through transplanting infected plants, pinching buds off plants without sanitizing (Jones et al., 2017), using contaminated tools between cuttings (Janse et al., 2004) and irrigating with sub-irrigation or ebb-and-flow systems (Swanson et al., 2005). Vegetative propagation also plays a key role in spreading *R. solanacearum* R3bv2 through asymptomatically infected seed tubers and cuttings of geranium and other ornamentals (Janse, 1996; Jones et al., 2017).

According to studies by Pasqua di Bisceglie et al. (2005), *R. solanacearum* can survive on poplar (*Populus* spp.) for 17 days, oak (*Quercus* spp.) for 4 days and on high-density polyethylene in cold storage at 4 °C (39.2 °F) and 80–90% relative humidity for 2 days. Survival of *R. solanacearum* on jute fabric dropped after 24 hours with the population reaching zero after 78 days.

Table 2.4 Pathways for movement of *R. solanacearum* R3bv2 into and within the entire [1]Greater Caribbean Region (GCR) (PERAL 2019; Review of the PERAL 2009 Greater Caribbean Region (GCR) Pathway Analysis June 21, 2019)

Pathway	Preliminary risk rating for the pest
Human Movement	Very High
Hitchhikers	Very High[20]
Wood packaging materials	Negligible[21]
Forestry-related pathways	Negligible[22]
Propagative Materials	Very High
Airline Passenger Baggage	Medium
International Mail	Medium
Natural Pest Spread	Medium[23]

[20] Based on soil, [21] Based on host range, [22] Based on host range

[23] Based on fact that is has wild hosts, can spread by water, and occurs in the GCR

Geographic Distribution

Table 2.5 Reported worldwide distribution of *R. solanacearum* R3bv2

Region	Country	References
Africa		
	Burundi	Autrique and Potts (1987)
	Cameroon	Mahbou Somo Toukam et al. (2009)
	Egypt	Farag et al. (1999)
	Ethiopia	Lemessa and Zeller (2007)
	Kenya	Janse et al. (2004)
	Malawi	Zayamba Kagona (2008)
	Mauritius	Khoodoo et al. (2007)
	Nigeria	Popoola et al. (2015)
	Reunion	Nicole et al. (1998)
	Rwanda	Uwamahoro et al. (2018)
	South Africa	Cellier et al. (2012)
	Tanzania	Mwankemwa (2015)
	Uganda	(Allen et al., 2005)

1 Greater Caribbean Region (GCR) defined as all countries bordering the Caribbean Sea, plus the Bahamas, Turks and Caicos, El Salvador, Suriname, Guyana, and the U.S. Gulf States (Florida, Alabama, Mississippi, Louisiana, and Texas)

Region	Country	References
Asia		
	Bangladesh	Chakraborty and Roy (2016)
	China	Wang et al. (2017)
	India	Sagar et al. (2013)
	Indonesia	Horita and Tsuchiya (2001)
	Iran	Izadiyan and Taghavi (2013)
	Japan	Horita and Tsuchiya (2001)
	Korea, Republic of	Jeong et al. (2007)
	Nepal	Pradhanang et al. (2000)
	Pakistan	Begum (2011)
	Philippines	Natural et al. (2005)
	Sri Lanka	EPPO (1998)
	Taiwan	Wu et al. (2011)
	Turkey	Ustun et al. (2008)
Europe		
	Belgium[1]	EPPO (2015b)
	Czech Republic[1]	EPPO (2012a)
	France[1]	EPPO (2014)
	Georgia	Lashkhi et al. (2018)
	Germany[1]	EPPO (2012b)
	Greece[2]	EPPO (2007)
	Hungary[2]	EPPO (2002), Nemeth et al. (2002)
	Netherlands	EPPO (2016)
	Poland[1]	EPPO (2015a)
	Portugal	Cruz et al. (2012)
	Russia	Matveeva et al. (2003)
	Slovakia[1]	EPPO (2004)
	Spain	Caruso et al. (2017)
	Sweden[1]	EPPO (2010)
	United Kingdom	
North America		
	Mexico	Hernández-Romano et al. (2012) Perea Soto et al. (2011)
Oceania		
	Australia	Graham and Lloyd (1979) Stansbury et al. (2001)
	New Caledonia	EPPO (2015c) IPPC (2015)
	Papua New Guinea	Tomlinson and Guntber (1986)
South America		
	Argentina	French (1988)
	Bolivia	Castillo and Plata (2016)
	Brazil	Almeida et al. (2003)

Region	Country	References
	Chile	Ciampi et al. (1997), van der Wolf et al. (2004)
	Colombia	Lebeau et al. (2011) Prior and Fegan (2005a)
	Costa Rica	Gabriel et al. (2006) Williamson et al. (2002)
	French Guiana	Deberdt et al. (2014)
	Guadeloupe	Prior and Steva (1990)
	Guatemala	Sanchez Perez et al. (2008)
	Peru	Gutarra et al. (2017)
	Uruguay	Siri et al. (2011)
	Venezuela	Garcia et al. (1999)

[1] *Under eradication,* [2] *Under official control*

Section III. Pest Identification and Damage

3

Species Description/Morphology

Ralstonia solanacearum R3bv2 is a gram-negative, rod-shaped, motile, strictly aerobic bacterium that is 0.5–0.7 × 1.5–2.0 cm (0.2–0.28 × 0.59–0.79") in size (Champoiseau et al., 2009; Smith, 1896; Yabuuchi et al., 1995).

Normal or virulent type colonies are irregularly shaped, white or cream-colored, opaque and highly fluidal, while the mutant or non-virulent type colonies appear consistently round, smaller, butyrous (buttery consistency) or dry (Champoiseau et al., 2009). *R. solanacearum* R3bv2 grows relatively slowly and is easily outcompeted by other microbes in culture; individual bacterial colonies that appear in less than 36 hours are not *R. solanacearum* (Allen, 2019).

ID/Diagnostic Molecular

- Real-time, multiplex PCR assay, specifically an assay for biovar 2A, can detect all strains of *R. solanacearum* (USDA-APHIS-PPQ- CPHST, 2015; Weller et al., 2000).
- An additional multiplex reaction was developed for infected potato tissue that integrates a third primer set with an internal control (USDA-APHIS-PPQ-CPHST, 2015).

Signs and Symptoms

Ralstonia solanacearum R3bv2 symptoms are identical to those from other *R. solanacearum* strains (Champoiseau, 2009). Additionally, under favorable conditions both geranium and potato plants may form asymptomatic infections (Swanson et al., 2005). Signs and symptoms of *R. solanacearum* R3bv2 include the following:

Potato and Tomato

- Early symptoms of wilting occur on the youngest leaves during the hottest time of the day. Wilting may be limited to the top portion of the plant on just one side of a leaflet or an individual branch. Plants may appear to recover following rain or when temperatures cool down at night (Champoiseau et al., 2009) (Fig. 3.1). Infected tomato plants often develop adventitious roots on the lower stem (Allen, 2019).
- The entire plant may decline rapidly under favorable conditions, starting with wilt, leaf chlorosis and ending with death. Leaves can wither, but dried leaves remain green (Champoiseau et al., 2009). In tomato, disease develops rapidly and plants may die within 4–7 days after the first appearance of wilt symptoms (Jones et al., 2017).
- Stunting is another common symptom, occurring at any stage of growth (Champoiseau et al., 2009).
- Infected stems may collapse, revealing vascular browning displayed as narrow, dark brown necrotic streaks with grey-white bacterial ooze (Champoiseau et al., 2009) (Fig. 3.2). When disease develops very rapidly, ooze may appear on the surface of intact stems (Allen, 2019).
- In symptomatic potato tubers the vascular ring turns a grey-brown color that may extend into the pith or cortex as the infection progresses. When infected potatoes are cut open, they ooze a

milky-white sticky exudate. Visible threads may form from the ooze when the two sides of a cut potato are pressed together and then pulled apart. This ooze may also cause dirt to adhere to the tuber (Champoiseau et al., 2009) (Fig. 3.3).

- A common diagnostic sign is bacterial streaming, which occurs when freshly cut stems from infected plants are placed in water. Fine, milky white strands of a viscous white slime containing bacteria often run from the cut end of the stem within 15 minutes (Jones et al., 2017) (Fig. 3.4).
- Bacterial streaming and oozing may not be visible in the early stages of disease development (Jones et al., 2017).

Geranium

- Early wilt symptoms in geranium are subtle and sometimes unnoticeable. Symptoms begin with chlorosis and wilt in the lower leaves and progress into upward curling of leaf margins (Champoiseau et al., 2009) (Figs. 3.5 and 3.6).
- Like potato and tomato, geraniums may appear to recover in the cooler night temperatures (Champoiseau et al., 2009).
- The disease develops rapidly as wilting moves upward from older to younger leaves (Champoiseau et al., 2009).
- Wilted leaves often have wedge-shaped areas of chlorosis that become necrotic (Champoiseau et al., 2009).
- In later stages of disease, stem collapse can occur. Stems (particularly at the root crown) and roots exhibit vascular discoloration, which can blacken and eventually become necrotic (Champoiseau et al., 2009).
- Bacterial streaming can also occur in geranium (Champoiseau and Momol, 2009).

Figure 3.1 Wilting on potato plant caused by infection with *R. solanacearum* R3bv2 (Image credit: Amilcar Sanchez Perez)

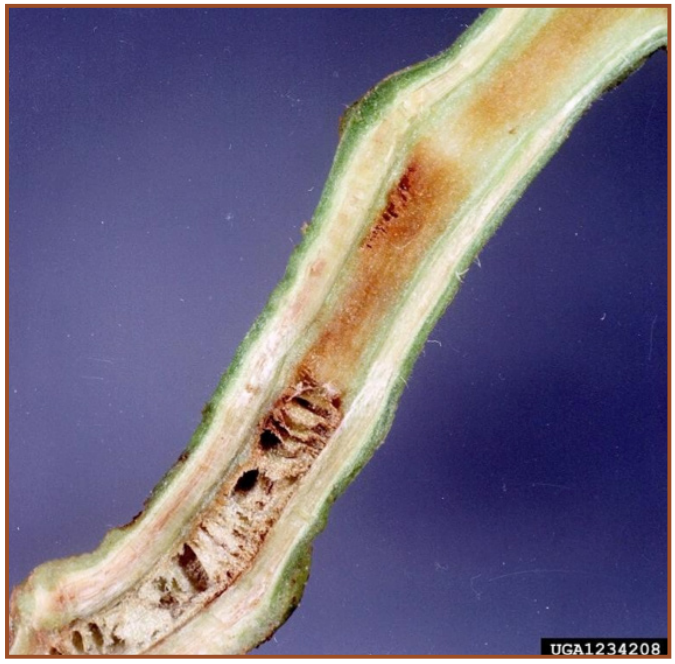

Figure 3.2 Cut section of a tomato stem displaying vascular browning caused by infection with *R. solanacearum* (Image credit: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Figure 3.3 Cut section of potato tubers displaying a brown discoloration to the vascular ring caused by infection with *R. solanacearum* R3bv2 (Image credit: Caitilyn Allen, University of Wisconsin-Madison)

Figure 3.4 Bacterial ooze on geranium caused by infection with *R. solanacearum* R3bv2 (Image credit: Margery Daughtrey, Cornell University, Bugwood.org).

Figure 3.5 Left: Chlorosis on geranium plants caused by infection with *R. solanacearum* R3bv2; Right: Healthy geranium (Image credit: Caitilyn Allen, University of Wisconsin- Madison)

Figure 3.6 Early wilting symptoms on geranium caused by infection with *R. solanacearum* R3bv2 (Image credit: Jean L. Williams-Woodward, University of Georgia, Bugwood.org)

Similar Species

Other diseases that produce symptoms that can be mistaken for *R. solanacearum* R3bv2 include the following:

- Other *R. solanacearum* strains that are endemic in the southern U.S. produce indistinguishable symptoms in the same hosts (Jones et al., 2017).
- *Xanthomonas hortorum* pv. *pelargonii* (Brown 1923) Vauterin et al. 1995, the causal agent of bacterial blight of geranium, produces wilting symptoms similar to *R. solanacearum* R3bv2 (Champosiseau et al., 2010).
- *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) W.C. Snyder & H.N. Hansen, the causal agent of *Fusarium* wilt on tomato, causes wilting and chlorosis on one side of the plant and dark brown streaks in the stem (Cook and Sequeira, 1991; Jones et al., 1991).
- *Verticillium albo-atrum* Reinke & Berthold and *V. dahliae* Kleb., the causal agent of *Verticillium* wilt on potato and tomato (Cook and Sequeira, 1991; Jones et al., 2017), causes leaf wilting during the day, which reverses at night (tomato), chlorosis on one side of the plant (potato) and vascular browning in infected stems (potato and tomato) (Jones et al., 1991; Stevenson et al., 2001).
- *Clavibacter michiganensis* subsp. *sepedonicus* (Spieckermann & Kotthof,) Davis et al., causal agent of potato ring rot, produces a vascular ring containing bacterial ooze and causes leaf wilting during the hottest period of the day that reverses at night (Stevenson et al., 2001). Abiotic stresses, such as drought, mechanical damage to the root or nutrient deficiency can also produce symptoms easily mistaken for *R. solanacearum* R3bv2. Therefore, diagnosis should not be based solely on symptoms (Jones et al., 2017).

4 Section IV. Surveillance and Monitoring

The purpose of this section is to establish a surveillance methodology that will allow for the early detection and delimitation of *Ralstonia solanacearum* R3bv2 should it become introduced. Practical applications of detection and delimiting surveys (as defined in ISPM 5[2] and in ISPM 6: 2018/2019) are provided. Suggestions for preparation, packaging and shipping of samples for identification are provided. This survey guide makes reference to geraniums, tomatoes, potatoes and other solanaceous hosts of *R. solanacearum* R3bv2.

Detection and Delimitation Surveys

I. Detection Surveys

Detection surveys are conducted to determine if a pest exists in an area. It is not valid to claim that a pest does not exist in an area if the survey results are negative. However, negative results are valuable for providing clues as to mode of dispersal, temporal occurrence, or industry practices, particularly when considered with results from similar areas or proximities.

Visual inspection is used to examine cultivated host plants (geraniums, potatoes, and other solanaceous hosts) and solanaceous weeds for wilting symptoms. Include plants in the field that were started in greenhouses or nurseries in association with imported geraniums. Other areas to survey include the following:

- **Areas where water accumulates.** Look for signs of wilting in areas where water accumulates or throughout the field. *R. solanacearum* R3bv2 is readily carried in irrigation water and can spread rapidly.
- **Water systems.** Inspect plants, including weeds, near drainage canals or irrigation systems.

Collect samples of symptomatic plants and submit samples for testing. Table 4.1 can be used to guide the testing of plant samples.

Table 4.1 Decision Table for Testing Plant Samples in a Detection Survey

If:	And:	Then:	And conduct further inspection of the following:
Samples test positive for the species *Ralstonia solanacearum* by ELISA or culture	Their origin is in areas where race 1 occurs[1]	Conduct monitoring and further tests at a qualified, authorized diagnostic laboratory to determine race and biovar.	Suspect geranium and potato shipments from infested greenhouses or fields and any other hosts in nurseries suspected of being infected by *R. solanacearum* race 3 biovar 2 should be contained and a Delimiting Survey conducted.
Samples test negative for the species *R. solanacearum* by ELISA or culture		Release plants from Regulatory Control	

[1]While race 1 of *Ralstonia solanacearum* occurs in many of the same hosts as race 3, it is indistinguishable from race 3 without further diagnostic testing.

2 International Standard for Phytosanitary Measures (ISPM) 5 - Glossary of phytosanitary terms

NOTE: Suspect shipments of geranium, or potato and other solanaceous crops (including vegetable transplants), are those held because of their association with a positive detection from another source country, rooting station, nursery, potato or other solanaceous crop field or potato storage facility. Be sure to follow sanitation procedures during nursery visits.

Surveys can be general or targeted to specific sites. Conduct a general survey at low-risk sites. Low-risk sites include fields with little or no history of solanaceous host production. Detection surveys in potatoes, tomatoes, and other solanaceous hosts, should be targeted at particular crop stages or geographic areas that may present some risk of infection and spread of the disease.

II. Delimitation Survey

Delimitation Area

The delimitation area may be influenced by factors known only at the time of introduction, including the initial detection area, occurrence of high-risk pathways, density and distribution of hosts near the initial detection area, wind direction and available surveillance resources at the time of introduction.

Information from trace-back and trace-forward investigations, the extent of natural and artificial spread of the disease, and available funding and logistics will impact the size of the delimitation area. The size of delimiting survey boundaries can range from a small production site to a broad geographical boundary.

(i) Surveying Potato fields

Conduct surveys in potato fields if:

- Close to local greenhouses with either imported geraniums that tested positive for the pathogen or received suspect varieties of geraniums associated with imported geraniums which tested positive for the pathogen.
- Potato fields are located downstream or adjacent to positive facilities that have ponds used for irrigating fields.
- Potato fields may have been irrigated with surface water or other water sources downstream from potato processing plants where the effluent from processing is **not** treated.

(ii) Surveying Potato Seed Tubers

The most likely way for *R. solanacearum* R3bv2 to spread in potato growing areas is through infected tubers used for seed.

Seed tubers are regularly sampled and screened as a part of potato seed certification programs. These programs assure that commercial potato seed tubers are inspected for a variety of potato diseases before receiving certification.

(iii) Surveying Tomato and Other Solanaceous Hosts

Similar to potato field surveys, visual observations of wilt in tomato, pepper, and eggplant crops can be used. Conduct surveys of tomato and other solanaceous hosts if:

- Seedling nurseries of solanaceous crops are in close proximity of fields. Tomato, eggplant, and pepper plants for commercial production are often grown as transplants in one area and moved to another area for field planting. These avenues of potential pathogen dissemination can be monitored for the presence of wilt. Send samples of symptomatic host plants to a diagnostic laboratory to detect *R. solanacearum* R3bv2.
- Hosts were grown in the same production greenhouses as imported geraniums, since they may represent a high-risk pathway for introducing infection into a field or home garden.
- Fields are located downstream or near nursery facilities that had imported geraniums which tested positive for *R. solanacearum* R3bv2 or had varieties of suspect geraniums that were associated with imported geraniums that tested positive for the pathogen.

(iv) Sampling Solanaceous Weed Hosts

R. solanacearum R3bv2 can survive in waterways and on weed hosts, including black nightshade (*Solanum nigrum* L.) and bitter nightshade (*S. dulcamara L.*). Weed hosts should be collected around holding ponds and run-off areas in or near fields with hosts that have tested positive.

General Survey Techniques

I. Survey Preparation, Sanitization and Clean-Up

The following will aid personnel in preparing to conduct a survey, procedures to follow during a survey, and instructions for proper cleaning and sanitizing of supplies and equipment after the survey has been completed.

1. Prior to beginning a survey, determine whether recent pesticide applications have occurred that would render it unsafe to inspect the plants and soil. Contact the property owner or manager and ask if there is a re-entry period in effect due to pesticide application. Look for posted signs indicating recent pesticide applications, particularly in commercial fields or nurseries.
2. Determine whether quarantines for other pests or crops are in effect for the survey area. Comply with all quarantine requirements.
3. When visiting the area to conduct surveys or take samples, take strict measures to prevent contamination by *R. solanacearum* R3bv2 or other pests between properties during inspections.
4. Designate a clean area where transport vehicles can park. Make sure this area is not located near infected fields.
5. **Important**: Use disposable protective clothing, gloves and footwear, and change them before entering each site.
6. Disinfect all potentially contaminated surfaces (i.e. benches, flats, walkways, footbaths, drainage areas under benches, footwear) and equipment near an infected greenhouse or area that may have come in contact with infected material (see Table 4-2 for approved disinfectant with active ingredients for *R. solanacearum*).
7. Clean any soil or media adhering to the surface.

8. Change the disinfectant in footbath reservoirs at least twice daily (USDA-APHIS, 2007).
9. When taking plant samples, disinfect tools with an approved surface disinfectant prior to and between uses (Table 4.2). Submerge the entire blade or portion of that tool that makes contact with soil or plant material.
10. **Important**: To disinfect large pieces of equipment, storage areas or bins, use a high-pressure delivery system, such as a steam pressure wash system, at 100 °C (212 °F).
11. Drain and clean all recirculating irrigation systems. Clean all parts of the system approved disinfectant solutions. To be effective against *R. solanacearum* R3bv2, systems must have ozonation with 0.4 ppm residual ozone for four minutes with ultraviolet (UV) light of at least 300 j/m^2 (1.36 ft-lb/in^2) at >50% transmission (USDA-APHIS, 2007).
12. When ponds, outdoor soil or holding areas have become contaminated during plant storage or runoff, contact the Ministry of Agriculture to obtain information about possible environmental consideration and treatment options.

Table 4.2. Approved skin disinfectant active ingredients for *R. solanacearum*. Follow product label instructions prior to using any product (USDA-APHIS, 2007)

Active Ingredient
Alcohols (>60% ethanol)
Chlorhexidine (0.5%-4.0%)
Chloroxylenol (0.3%-3.75%)
Iodine and iodophors (7.5%-10.0% povidone-iodine)
Quaternary ammonium
Triclosan (0.2%-2.0%)

Table 4.3 Approved surface disinfectant active ingredients for *R. solanacearum*. Follow product label instructions prior to using any product (USDA-APHIS, 2007)

Active Ingredient	Use Sites
Chlorine	• Greenhouse hard non-porous surfaces (i.e. floor, walls, benches, counter tops, buckets, coolers) • Shoes wash
Iodine	• Greenhouse hard non-porous surfaces (i.e. floor, walls, benches, counter tops, buckets, coolers) • Shoe wash
Quaternary ammonium (20% ammonium chloride)	• Outer clothing, field harvesting equipment, greenhouse packing areas • Greenhouse hard non-porous surfaces (i.e. floor, walls, benches, counter tops, buckets, coolers, tools, metal and plastic surfaces, knobs, handles, railings, glass) • Walkways

III. Sample Collection

Technicians visiting sites to place holds or obtain samples should collect the following information:

- Date of collection or observations
- Collector's name
- Growers name and address
- Type of property (nursery, farm, natural field, residence)
- GPS coordinates of the survey site
- Host plant species and specific crop plant varieties planted, if applicable
- Methods of irrigation
- History of farm machinery usage
- Observations of signs and symptoms
- Percentage of the field displaying disease symptoms
- General conditions or any other relevant information
- Collect entire plants (including roots) showing wilting symptoms and wash the soil from them
- At a minimum, enclose 1 gm (0.04 oz.) of symptomatic stem/crown tissue
- Double bag the samples and keep cool. Do not refrigerate**.** Samples may be held at room temperature if less than or equal to 15.56 ºC (60 ºF)

Sampling Potato Tubers

Sampling is not required for fields or facilities with a direct link to positive testing seed lots or fields. Tubers in this category are automatically considered positive and are subject to control (quarantine) actions without testing.

1. Sampling for subsequent testing is required for tubers:
   a. In adjacent fields.
   b. On a shared water source.
   c. Connected by a history of shared harvesting machinery.

2. Follow these guidelines for sample collection:
   a. Samples include potato tubers, stems from potato or other host plants, and seed pieces (Elphinstone et al., 2018).
   b. Repeat the sampling for each field, warehouse or storage unit at a given location.
   c. Collect a maximum of 200 samples from each location (Elphinstone et al., 2018).
   d. Collect samples throughout the entire building or storage area.
   e. If tubers are in bags, collect samples from each bag.
   f. Double bag the samples and keep cool. Do not refrigerate**.** Samples may be held at room temperature if less than or equal to 15.56 ºC (60 ºF).
   g. Prepare samples within 72 hrs. of collecting the sample.

Sampling Tomato and Other Solanaceous Hosts

1. Collect entire plants showing wilting symptoms, including roots, and wash them free of soil. Bare root plants are ideal. Since the pathogen is concentrated in the lower stem, leaf and partial stem samples are inadequate for testing.

a. Double the bag the samples and keep cool. Do not refrigerate. Samples may be held at room temperature if less than or equal to 15.56 ºC (60 ºF).
b. Submit entire plants, not sub-samples. Samples must include lower stems with the leaves and petioles removed. Samples that are dead or fermented upon arrival cannot be tested and will be rejected.

Sampling of Water Sources

1. Test irrigation and water sources near positive fields or processing plants to limit the bacterium's spread. At present, there is no test that can be used in the field. Therefore, all water samples must be sent to a diagnostics lab.

2. When taking samples:
   a. Sterilize bottles.
   b. Collect samples of approximately 0.47 L (0.50 qt.).
   c. Collect water samples at a depth of 30.48 cm (12").
   d. Keep samples cool and in a dark location and perform tests within 24 hours of collection.
   e. For best results, conduct sampling when water temperatures exceed 15ºC (59 ºF) and populations of bacterium are highest in water (Jones et al., 2017).

IV. Timing of Surveys

In general, surveys for this pathogen should take place during the day when temperatures are the hottest and symptoms of wilt, if present, are most obvious.

5 Section V. Eradication and Control Measures

This chapter presents information that can be used by PPQ decision-makers after the brown rot of potato *Ralstonia solanacearum* R3bv2 has been detected. Specifically, the information can be used to assess the suitability of potential actions to eradicate, contain or suppress *R. solanacearum* R3bv2. The efficacy and feasibility of each control option should depend on the pest situation at the time of detection. Factors including detection location (e.g., natural or urban environment, agricultural crops, greenhouses, orchards), area of spread, the climatic region, the time of year, the phenology of the host and current practices already in place contribute to determining whether a particular control option is appropriate.

I. ERADICATION OPTIONS

In countries where *R. solanacearum* R3bv2 is not known to be established, the first strategy is to prevent introduction and inadvertent spread of the pathogen. This can be achieved by quarantine and regulatory regulations and the establishment of exclusionary and sanitary practices.

Quarantine and Regulatory Procedures

- Remove all suspected or potentially infected plants (i.e. potato, tomato, geranium and weeds (to include aquatic)) (see Host Removal).
- Dispose of all host plant material on any property that tests positive or has positive-associated fields, including cull piles and other plant debris.
- Leave the field fallow for two years and irrigate to promote volunteer sprouting. During the two years, sample, test, cull and bury under the volunteer crop during the growing season every four weeks to eliminate host material. Spray weed hosts in the field and along the edges with efficacious labeled herbicides to eliminate them from the area.
- Following the two-year period, plant fields with non-host crops; irrigate to promote volunteer potato sprouting, and cull and bury any volunteer potatoes as sprouting occurs. Test fields semi-annually for four years after an initial positive find.
- No seed production can occur in the field for at least five years after detection of *R. solanacearum* R3bv2. Sample fields with susceptible hosts (potatoes or tomatoes) for two seasons prior to any new seed production on the property.
- Fields adjacent to positive testing or associated fields, or those on a shared water supply may **not** grow host crops **nor** seed potatoes for two years. Any volunteer potato or weed hosts must be tested and destroyed. Maintain strict sanitation of all vehicles entering and leaving infested fields.
- Quarantine storage facilities on properties with positive testing tubers until all potentially infested tubers are tested and found to be negative or destroyed. Clean and disinfect storage facilities with approved disinfectants in strict accordance with labeling.

Host Removal

- Place all potentially infected plants and planting material, as determined by the delimiting survey, in double plastic bags and seal for disposal or destruction. If large inventories must be destroyed,

then use of plastic bags may not be reasonable. Alternatives include a dumpster with double layers of plastic lining that can be folded over the top and sealed to prevent debris from escaping during transport or storage. Contact your regional PPQ office.

- Soil fumigation with an approved fumigant—such as methyl bromide or metam sodium—at the labeled rate will greatly reduce populations of the bacteria in infested fields. However, fields with plant residue including tubers, roots and stems may still harbor *R. solanacearum* R3bv2 for up to two years. Before fumigation, remove and destroy as much host plant material from the fields as possible.
- Fumigation of the soil may **not** totally eliminate the pathogen due to the presence of bacterial reservoirs in buried plant residue at the time of fumigation. Continue monitoring the soil for the presence of *R. solanacearum* R3bv2 for at least two years.

II. MANAGEMENT TECHNIQUES

In regions where the disease is endemic, cultural control methods appear to be effective in some conditions for reducing bacterial populations of *R. solanacearum* and subsequent disease incidence. There are, however, promising reports of suppression of the populations with chemical applications and biological control.

Cultural Control and Sanitary Measures

Cultural practices and phytosanitation are the best control measures for *R. solanacearum* R3bv2 in the field (Jones et al., 2017).

- Crop rotation every two or three years provides the best control in areas where *R. solanacearum* is already established and widespread (Jones et al., 2017). A two- season rotation with bean and cereal crops in potato fields in East Africa reduced *solanacearum* to < 50% compared to the controlled monocrop which was > 80% (Lemaga et al., 2005).
- Any contaminated irrigation water and wastewater from potato processing facilities must be disinfected. Adding 100 ppm of hydrogen peroxide to irrigation water can be sufficient to eliminate *R. solanacearum* (van Bueningen et al., 2005). A similar study conducted by Yao et al. (2010) using 1.3 ppm chlorine dioxide obtained >99% efficacy in inhibiting growth of *R. solanacearum*.
- Other management techniques that can be used to prevent introduction and spread of *R. solanacearum* R3bv2 include:
    - Plant healthy (certified) seed potatoes and propagative material in pathogen free soil (Janse, 2012; Jones et al., 2017).
    - Use cover crops to reduce weeds and possibly nematodes (Momol et al., 2005)
    - Use well-drained and leveled fields (Momol et al., 2005).
    - **Important:** Use strict sanitation practices with equipment, tools, transplanting, irrigation water, storage facilities, packing materials, etc. (Janse, 2012; Momol et al., 2005) (see Survey Preparation, Sanitization and Clean-Up).
    - Plow under crop residue immediately following harvest (Momol et al., 2005).
    - Store and grade potatoes in the original place of production to avoid spreading R. solanacearum R3bv2 (Janse, 2012).
    - Avoid use of ebb-and-flow and flooding irrigation systems in greenhouses (Jones et al., 2017).

Chemical Control

- Managing *R. solanacearum* R3bv2 in the field is very difficult due to strain variation, broad host range and lack of adequate chemical treatments (Jones et al., 2017). Listed below are three chemical control options shown to be effective against *R. solanacearum* R3bv2 experimentally, but they have not been tested on a larger scale.
- DL-3-aminobutyric acid (BABA) is an abiotic compound reported to induce resistance in tomato plants. When applied by soil drenching to tomato plants at 50 ml (10") per pot, it reduced the vascular browning index by 69.9% and leaf wilting index by 75.3% (Hassan and Abo-Elyousr, 2013).
- Stable bleaching powder (SBP) applied two weeks before planting at a rate of 25 kg/ha (22.3 lb./ac) suppressed *R. solanacearum* R3bv2 by 76.94% and 88.89% for tuber infection and 66.96% and 71.87% for plant infection in greenhouse and field studies, respectively (Dhital et al., 1997).
- During field trials on ginger, Mao et al. (2014) tested for alternatives to methyl bromide against infection with a phylotype I (Asian) *R. solanacearum* strain. Chloropicrin was injected at 50 g m^{-2} (1.47 oz yd^{-2}) and covered with either a 0.04 mm polyethylene film (PE) or a 0.04 mm (0.002") totally impermeable film (TIF), while methyl bromide was applied at a rate of 40 g m^{-2} (1.18 oz yd^{-2}) in situ under a PE sheet. Both treatments of chloropicrin produced similar efficacies to, or in some cases slightly lower than, methyl bromide in terms of controlling *R. solanacearum* R4bv4 infection.

Labeling

Countries will have to go through appropriate sources to test compounds for experimental purposes. All applicable label directions must be followed, including but not limited to requirements for personal protection equipment, maximum treatment rates, storage and disposal.

Biological Control

Initial studies on biological control of *R. solanacearum* gave promising results. The use of diverse bacterial strains antagonistic to *R. solanacearum* as biological control agents gave positive results in controlled environments such as the greenhouse or in strictly controlled field tests. Similarly, antagonists that are closely related to or derived from the wild type of *R. solanacearum* itself, were shown to confer protection against bacterial wilt disease on potato and tomato under greenhouse conditions (Champoiseau, 2008). Such antagonists may be able to colonize and survive asymptomatically on the host without reducing yield. The use of these strains as antagonist agents for control of *R. solanacearum* under true field conditions needs to be investigated.

Other Potential Management Measures

Soil solarization when used in combination with other control strategies is another method that was shown to reduce levels of *R. solanacearum* in soil. The efficacy of heat treatment may vary according to soil moisture content, heat temperature and duration of heat application. Application of plant resistance inducers, such as acibenzolar-S-methyl, might be used to enhance host resistance against *R. solanacearum* R3bv2, as it was recently shown to work for broad-host range strains of the pathogen. The use of suppressive soils was shown to slow infection of tomato seedlings by *R. solanacearum* and reduce bacterial wilt incidence in nurseries. These methods however need further investigation.

[3]Section VI. Management of the Emergency Response

6

It is the responsibility of all countries to prevent or retard the entry of any exotic[4] pest and to be prepared to deal with pest incursions, should they arise. Plant Quarantine Units must be prepared to act by having the necessary physical, financial and human resources ready to be mobilized in the event of an emergency situation.

This section outlines the administrative actions that should be considered to prevent or retard the entry of *Ralstonia solanacearum* R3bv2 and provides an emergency operations plan should *R. solanacearum* R3bv2 enter the country. The information presented should be implemented under a country's legislation on plant quarantine. The emergency response system provides: (i) a description of the management response, (ii) the administrative steps that should be taken to prevent the introduction of the pest as well as its containment, eradication and management and (iii) possible items for budgeting available resources.

DESCRIPTION OF THE ADMINISTRATION OF THE EMERGENCY ACTION PLAN

The emergency response to *R. solanacearum* R3bv2 is an organised approach to prevent its introduction into the country and to contain or eradicate this pest should it enter. A National Emergency Pest Committee (NEPC), which is responsible for the administration of the response should be established.

The NEPC should headed by the Minister of Agriculture or the Permanent Secretary with membership from national agencies - governmental or non-governmental as may be required (Fig 6.1). It is an inter-ministerial, inter-sectoral and inter-institutional group, with representatives from various Government Ministries, statutory boards and the private sector. The nature of the representation should ensure that it includes the required interest groups and obtains the necessary support to achieve its objectives. The composition of, and representation on the NEPC, is shown in Table 1. The proposed representation is not exhaustive, and the Minister/Permanent Secretary may invite other agencies as necessary.

The task of the NEPC is to promulgate policies and coordinate inputs and activities of the different Government Ministries and other agencies. The agencies represented on the NEPC should be selected based on their role in the prevention of entry of pathogen into the country and their possible role in the control, eradication and containment in the case of an introduced pest.

The NEPC coordinates the activities and ensures that the functions of each agency are adequately implemented. For example, the Director of Agriculture ensures that plant protection and quarantine measures are effectively carried out. The Collector of Customs or his nominee ensures that Customs personnel at the ports of entry are appropriately informed of the legislation and policy decisions of the Committee concerning the surveillance of arriving passengers and agricultural produce. The General Manager of the Air and Sea Ports Authority ensures the proper disposal of international garbage, and so on.

3 The following chapter is an excerpt from the Emergency Action Plan for Exotic Plant Pests and Diseases: A Model for Caribbean Countries. ISSN-0534-5391 A2/LC-97-02. Authored by Everton Ambrose. Castries, Saint Lucia. Revised February 2003. Modifications have been made to include the current Regional Plant Protection Organization for the Caribbean.

4 Any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products

Importantly, the NEPC must ensure that the National Plant Protection Organisation (NPPO) contacts the Regional Plant Protection Organisation (RPPO) for the Caribbean, that is, the Caribbean Agricultural Health and Food Safety Agency (CAHFSA) and inform them of the new pest incursion. Reporting to CAHFSA does not fulfill the international obligations of contracting parties to the IPPC; as such, countries through the NPPO must notify the IPPC of any new pest incursion. Once CAHFSA is alerted and the country has formally notified the IPPC, the Agency will notify the countries in the Region of the detection of the pest in this case, *R. solanacearum* R3bv2.

Given that *R. solanacearum* R3bv2 is a priority pest for the Region, the NEPC should meet regularly (possibly twice/year) to review and refine the implementation of procedures and to update the members on any developments as necessary. In the event *R. solanacearum* R3bv2 is detected in the country, the committee should meet as often as necessary.

Table 6.1 Inter-Institutional Composition of the National Emergency Pest Committee

Agency	Department or Division	Suggested Representative
Ministry of Agriculture	Administration	Minister/ Permanent Secretary
	Department of Agriculture and Divisions	Chief Agricultural Officer/ Director of Agriculture/ Plant Protection Officer
	Agricultural Information Unit	Officer in Charge
Ministry of Health	Environmental Health Unit	Chief Environmental Health Officer
Ministry of Public Utilities	Air and Sea Ports Authority	General Manager
Ministry of Communications and Works	Transportation Communications	Chief Engineer
Ministry of Finance and Planning	Customs	Comptroller of Customs
	Finance	Director
Ministry of National Security	Police Force	Commissioner
	Fire Department	Chief Fire Officer
Ministry of Legal Affairs	Attorney General Chambers	Counsel
Ministry of Local Government	Local Government Department	Local Government Officer
Statutory Boards	Production/ Marketing Division	General Manager of each
Private Sector	Farmers Organisations	Executive Secretary or Managing Director of each
	Chamber of Commerce	
	Other NGOs e.g. Supermarkets Associations, where present	

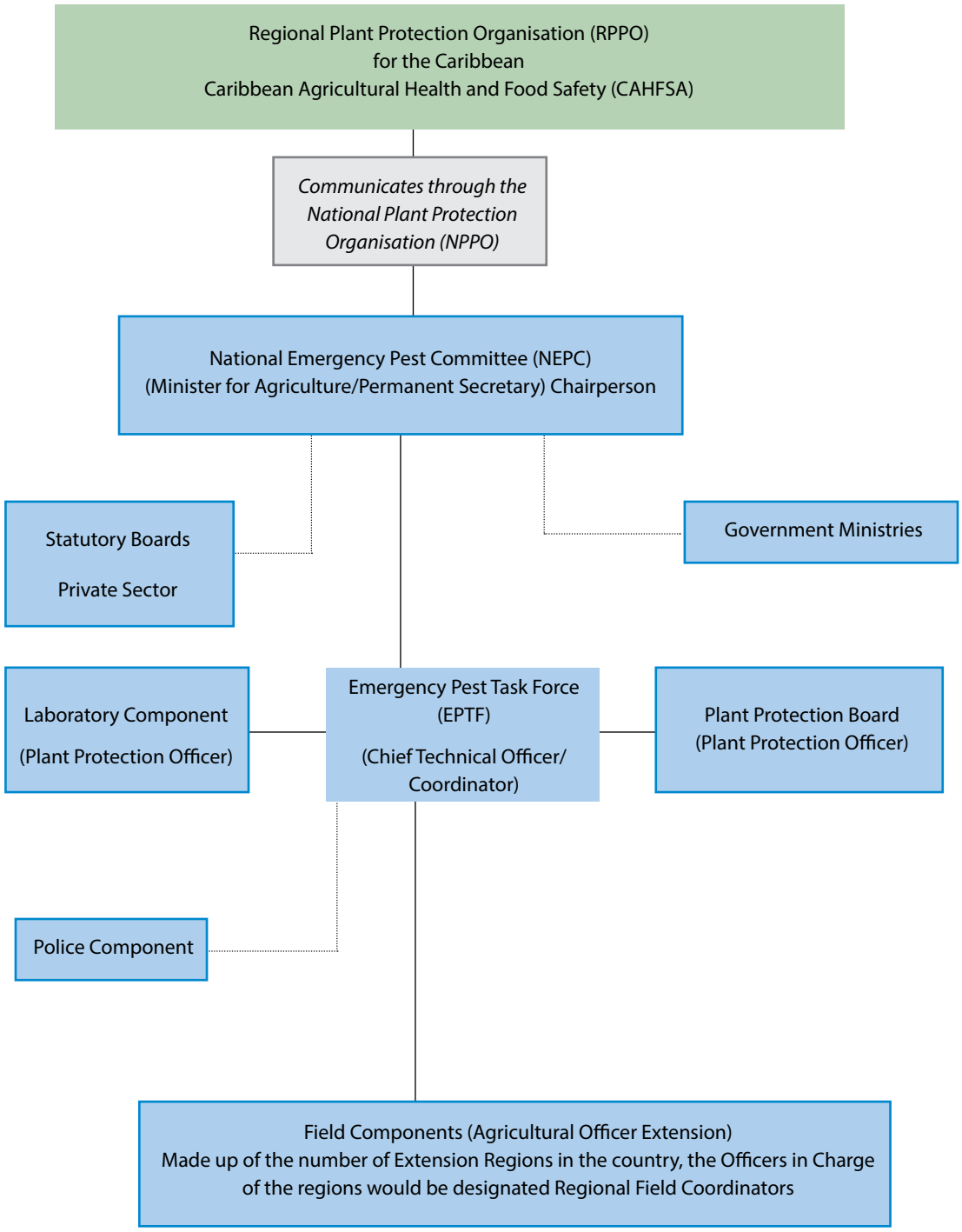

Figure 6.1 Organizational chart of the National Emergency Pest Committee

The NEPC establishes the **Emergency Pest Task Force (EPTF)** or Technical Committee with the Chief Technical Officer as the Task Force Coordinator. This is the technical operational committee and is responsible for all technical activities to be undertaken. It consists of the following components:

- Field Component
- Police Component
- Laboratory Component
- Plant Protection Board

The emergency response should include the conduct of regular field exercises (at least once/year) to enhance the reactive capacity. There is need for strong coordination and for each person to know his/her role in the Plan. The system should be in a state of readiness at all times.

EMERGENCY ACTIONS FOR *RALSTONIA SOLANACEARUM* R3BV2

The emergency response system for *R. solanacearum* R3bv2 should include: (i) steps to prevent the entry of the pathogen and (ii) the containment, eradication and management of the disease.

I. ROUTINE PREVENTION OF THE INTRODUCTION OF *R. SOLANACEARUM* R3BV2

Component activities for the prevention of the introduction of *R. solanacearum* R3bv2 include:

- Development and implementation of legislation relating to plant protection and quarantine.
- Surveillance - Port inspection and field monitoring.
- Proper handling and disposal of international garbage.
- Public information.
- Monitoring and review of preventative measures.

Component Activity I. Plant Protection and Quarantine Legislation

Countries should enforce strict quarantine procedures to prevent the entry and spread of *R. solanacearum* R3bv2. The Act and Regulations pertaining to the Country should be presented as an Annex to the National Emergency Response Plan. In the Act, provisions should be made for the establishment of a Plant Protection Board, a component of the EPTF which monitors plant protection and quarantine activities in the country on a regular basis. The Plant Protection Board should meet regularly.

Component Activity II. Surveillance - Port (Air, Sea and Frontier) and Field

Areas of the plant quarantine system relating to surveillance activities at the international ports of entry and the field should be on alert for possible pest incursions. For port and field surveillance to be effective, all plant quarantine and customs officers must be trained in the detection of the pest and disposal of suspicious materials. The following measures should be taken:

(a) Import Permit

- All planting material must be accompanied by an import permit. This is issued by a Plant Quarantine Officer with the approval of the Plant Protection Board. The decision taken should be based on a pest risk analysis.

(b) Arrival Notification

- The Comptroller of Customs or his/her representative should notify an Officer of the plant quarantine service of the arrival at the port of any plant or plant product which may be regulated by the Plant Protection Act of the country (*insert link to Plant Protection Act*).

- The Comptroller of Customs or his/her representative should not release or dispose of the above-mentioned item(s), unless so authorized by the plant quarantine service.

- An importer should notify a plant quarantine service officer in advance of the arrival of regulated material.

(c) Baggage Inspection

- Passenger baggage is a potential pathway of entry for *R. solanacearum* R3bv2. Hence there should be extreme vigilance. The passenger must hand to the Immigration Officer the signed Customs Declaration Form (*this should be included in the Annex*) which indicates whether he/she is carrying any regulated item(s). The Immigration Officer stamps the form and indicates to Customs whether the passenger is carrying a regulated item. The Customs Officer also enquires from the passenger whether he/she is carrying any regulated item(s). The Customs Officer may examine the baggage.

- If a regulated material is present, the Customs Officer requests the services of the Plant Quarantine Inspector.

- If the Plant Quarantine Inspector is not on site, the Customs Officer shall detain the material and may give the passenger a retention slip. The Customs Officer then informs the plant quarantine service and requests that an Officer inspects the material with minimal delay.

(d) Container Inspection

- Inspection of containers carrying plants or plant parts that are hosts of *R. solanacearum* R3bv2 is critical. It is the responsibility of the importer to ensure that the plant quarantine service is informed of the presence of regulated material in the container. The container is opened by the Customs Officer in the presence of the Plant Quarantine Officer. The Customs Officer shall not release any regulated material unless duly authorized by a Plant Quarantine Officer.

(e) Mail Inspection

- It is the responsibility of the importer to ensure that the plant quarantine service is informed of the presence of regulated material in the mail, international mail is a medium risk pathway for entry. The Customs Officer or the Postmaster should not release any regulated material unless it is authorized by a Plant Quarantine Officer.

(f) Ship and Aircraft Inspection

- The Plant Quarantine Officer should be a member of the boarding party, which also includes Customs Officer, Immigration Officer and a Public Health Inspector. Otherwise a Plant Quarantine Officer may board a ship or aircraft if he/she suspects that it is carrying a regulated material.

- If a Plant Quarantine Officer is not present at the ports, the Customs Officer should assist by giving the ship's captain to sign an appropriate declaration.

(g) Survey Activities

- Survey and monitoring activities for *R. solanacearum* R3bv2 must be undertaken to determine its status in the country. The survey activities may involve the other Sections of the Ministry of Agriculture, other governmental and non-governmental agencies and the public. Training in survey procedures should be conducted and the surveyors should ensure that all relevant areas are covered within a specific period to time. Refer to technical information provided in Section 4.

Component Activity III. Proper Handling and Disposal of International Garbage

All plant material or portion thereof, from an international carrier, to be disposed of must be placed in a metal container (in the carrier) that can be covered to ensure that any infested material is secured. If there is no incinerator, then the garbage is disposed of (after the carrier has left territorial waters) in a manner which would not cause the introduction of *Potato Brown Rot* into the country and according to international regulations. If facilities for disposal exist, this shall be done under the supervision of the plant quarantine service.

Component Activity IV. Public Information

There should be continuous campaigns to create and maintain the public awareness of pests of quarantine importance such as *R. solanacearum* R3bv2 and the need to be vigilant.

Activities include:

- Development and dissemination of Pest Alerts and Bulletins targeting Technical Personnel
- Regular press releases
- Radio and television spots, films, slides, videos
- Publication and dissemination of leaflets at public events
- Placement of posters and/or billboards at conspicuous locations at ports of entry
- Provision of information to travellers, travel agents, shipping agents concerning the prohibition of entry of agricultural produce without a permit
- Talks to the Customs, Police and other appropriate agencies.

Component V. Monitoring and Review of Preventive Measures

It is important that the activities that are being undertaken to prevent the entry and spread of *R. solanacearum* R3bv2 are monitored to ensure that actions are effective and are being efficiently implemented.

Monitoring of preventative measures are the responsibility of the Minister of Agriculture / Permanent Secretary (Chairman - NEPC), the Chief Agricultural Officer / Director of Agriculture and the Crop Protection Officer/Pest Management Officer.

Minister of Agriculture / Permanent Secretary (Chairman - NEPC):

- Monitors and reviews measures being undertaken in relation to the prevention of entry of exotic pests.

Chief Agricultural Officer / Director of Agriculture

- Conducts, through the EPTF, regular education sessions for all personnel actively involved in the implementation of preventative measures, such as Port Personnel, Customs Officers, Plant Protection / Quarantine Officers and other key stakeholders, including the public.
- Ensures that information is available on sources of material and equipment in an emergency.
- Conducts (at least once/year) field exercises simulating introduction of *R. solanacearum race 3 biovar 2* to assess the reactive capacity of the mobilization plan for control/eradication and containment of the pathogen.

Crop Protection Officer/Pest Management Officer

- Conducts regular training sessions for Plant Protection / Quarantine Officers, Extension Officers to educate and update them on symptoms of *R. solanacearum* R3bv2.
- Ensures that the relevant plant protection laboratory knows of reference centres for the confirmation of *R. solanacearum* R3bv2 and approved steps for preserving and submitting material.
- Ensures that the Plant Protection Board is active and involved in Plant Protection decisions.
- Knows where to source information on *R. solanacearum* R3bv2.

II. CONTAINMENT, ERADICATION OR MANAGEMENT OF EXOTIC PESTS

Part A - Emergency Action Plan (Sequence of Events)

The EPTF implements the containment and eradication operation of the Action Plan. The sequence of events is given below and in Figure 2.

Step 1	Suspicious case seen by Producer.
Step 2	Farmer reports to Extension Officer (EO) who investigates the case.
Step 2a	Diagnosis reveals endemic pest. Farmer advised of control measures by EO. **Sequence stops**.
Step 2b	EO unable to identify pest. Reports to Plant Protection Officer (PPO).
Step 3	PPO investigates.
Step 3a	Diagnosis reveals endemic pest. EO advised of control measure. **Sequence stops**.
Step 3b	Diagnosis creates suspicion of the presence of *R. solanacearum race 3 biovar 2*. Farmer and EO given precautionary instructions, specimens collected and pictures taken for preliminary laboratory diagnosis, by PPO.
Step 4	PPO notifies Supervisor / Chief Technical Officer (CTO) who notifies the Permanent Secretary / Minister.
Step 5	CTO activates Emergency Pest Task Force (EPTF) and additional samples and/ or pictures *of R. solanacearum* R3bv2 are collected and dispatched by the PPO to established Diagnostic Centres for more positive identification and confirmation.

Information on the pest (biology, hosts behaviour pattern, eradication or containment etc.) is reviewed and information also requested by the PPO from the Diagnostic Centres (DC) and Regional and International Organizations.

Step 6 The Minister / PS puts into operation the emergency mobilization plan and activates the National Emergency Pest Committee and notifies the relevant Ministries and Agencies of their role. Minister notifies Cabinet and issues declaration on internal plant quarantine regulation.

Step 7 The EPTF sets up the Headquarters and area centres, orders survey to determine possible spread and collects additional samples and takes pictures. Issues general information and instructs the Field and Quarantine Officers. *Survey protocols outlined in Section IV.*

Step 8 Report received from DC by the PPO and eradication plan is put into operation by the CTO. *See eradication measures outlined in Section V.*

Part B - Components and Description of Tasks

Component: National Emergency Pest Committee (NEPC)

Responsibility: Promulgation of policies and coordination of input of the different Government Ministries and other agencies to prevent the entry of, control and/or eradicate any exotic pest (*e.g. R. solanacearum* R3bv2).

Responsible Person: Chairman (Minister of Agriculture)

Functions

- Through NEPC, promulgates policies for the prevention of entry, control and eradication of *R. solanacearum* R3bv2.
- Coordinates the various inputs and makes available the resources of the different Ministries and agencies.
- Makes representation to Cabinet for additional financial assistance needed and in the issuance of special orders or proclamations.
- Ensures that all policies promulgated by the NEPC are implemented by the EPTF.
- Designates the Chief Technical Officer as EPTF Coordinator.

Component: Emergency Pest Task Force (EPTF)

Responsibility: Mobilisation and execution of the national emergency action plan and implementation of policies promulgated by the NEPC.

Responsible Person: Task Force Coordinator (TFCo) / Chief Technical Officer (CTO)

Functions

- Serves as the Executive Officer of the NEPC and ensures that all policies promulgated are expeditiously and effectively implemented.
- Ensures that the EPTF is in constant alert and readiness, and schedules regular field exercises to enhance its reactive capacity.
- Activates mobilization of the EPTF as soon as a report is made by the Plant Protection Officer.
- Makes immediate notification of the NEPC for mobilization of the EPTF.
- Coordinates the actions of the various components of the EPTF.
- Coordinates the activities of all the regions and assigns personnel as needed to the Regional Field Coordinator (RFCo).
- Orders the RFCo to proceed with disinfection of infected areas as soon as diagnosis has been confirmed.
- Through the RFCo, implements surveillance to monitor the efficacy of eradication and management measures.
- Through the RFCo, serves official quarantine notices.

Component: Regional Field Coordination (RFC)

Responsibility: Execution of all the field operations in the event of an outbreak of an exotic pest e.g. *R. solanacearum race 3 biovar 2* in that area. Ideally, the RFC shall consist of personnel within the region where the outbreak occurs. Authority for movement of support personnel from another region is vested upon the TFCo through the Officer-in-Charge of Extension.

Responsible Person: Regional Field Coordinator (RFCo)

Functions

- Establishes a field operating unit.
- Selects location of headquarters close to the infested areas, which should not be more than an hour drive to the most distant area of the outbreak area.
- Selects suitable headquarters building with ample space for storage of supplies and equipment, suitable communications and eating facilities. There should be ample parking space for field vehicles and should be located where there is easy flow of traffic.
- Makes available a map of the area under his/her jurisdiction and highlights infected areas to all RFC personnel.
- Establishes communication with the local authorities, public, police in order to ensure security of the infected areas.
- Refers all requests for information regarding the outbreak by the news media to the relevant Media/Information Officer and ensures that the Officer has the most up-to-date information.
- Establishes means of communication with personnel stationed in infected areas.
- Lists personnel complement of RFC and assigns them specific tasks to enable them to be put to work immediately upon arrival in the affected area.
- Gives specific assignments to support personnel arriving from the other regions.
- Requests the assignment of personnel to assist with administrative tasks.
- Meets with all personnel every evening for debriefing on the day's activities and problems, institutes

remedial measures to problems, and plans for activities for the following day.

- Instructs all personnel that information to be released to the media will be through the Media/ Information Officer only.
- Gives daily debriefing report to the TFCo.

Component: Laboratory Services

Responsibility: Handling preliminary diagnosis and submitting specimens to reference laboratory for confirmation of field diagnosis, and development of local capability for laboratory diagnosis.

Responsible Person: Laboratory Team Leader / PPO (This person may be the PPO or a Senior Laboratory Technician)

Functions

- Identifies reference laboratories and experts for the confirmation of *R. solanacearum* (in advance).
- Assesses competence of laboratory staff to diagnose the pathogen. If there is the need for training, communicate the need to the Task Force Coordinator and identify possible training opportunities.
- Collects specimens for laboratory diagnosis.
- Assembles and keeps in constant readiness additional emergency kits for further collection and shipment of specimens.
- Makes prior arrangement with airlines or courier service and the reference laboratory on how specimen could be shipped as quickly as possible.
- Supervises shipment of all samples being sent to reference laboratory.
- Once the EPTF is activated, makes arrangements to receive incoming specimens from the RFC and stores them until confirmation is made and local laboratory diagnostic capabilities are established.
- Once local laboratory capabilities are established to handle diagnosis, supervises the operation of said laboratory.

Component: QuarantineComponent

Responsibility: Establishment and staffing of quarantine and buffer zones.

Responsible Person: Quarantine Officer (This person is a plant protection staff member or a senior member of the extension service).

Functions

- Assists the TFCo in planning and establishing quarantine and buffer zones.
- Posts warning signs on all roads at the outer perimeters of the quarantine and buffer zones.
- Coordinates the establishment of 24-hour police patrol (if necessary) to cover roads in both buffer, and quarantine zones to control movement of plants and other products.
- Establishes a list of all farms or areas that have received plants or plant products or any products, which are capable of transmitting the pathogen.
- Arranges for the inspectors to visit these farms or areas and establish control measures.
- At his/her discretion, allows the movement, on a permit basis, of perishable crops for human consumption and other non-plant products from affected farms and farms not known to be affected within the quarantine area.

Component: Information Service

Responsibility: Dissemination of information to the media and the public

Responsible Person: Media/Information Officer. (This person is from the Agricultural Information Service. The TFCo will request the Minister of Agriculture to immediately assign and dispatch this person to the Regional Office).

Functions

- Compiles list(s) of local news outlets (e.g. radio, newspaper, television) to notify of the situation.
- Prepares pertinent information, publication, background, materials, and photographs for distribution to media personnel.

Component: Local Field Operations

Responsibility: Provision of support to operations

Responsible Person: Extension Officers

Functions

- Examines plants referred by farmers.
- Reports to the Plant Protection Officer without delay, the presence of suspicious pest case.
- Implements all instructions of the PPO to prevent spread of *R. solanacearum race 3 biovar 2*.
- After confirmation of *R. solanacearum race 3 biovar 2* and under the supervision of the RFCo, searches for cases and identifies all affected plants.
- Supervises and carries out destruction of all affected plants and plant parts.
- Implements on-the-spot disinfection of the area.

Component: Police Component

Responsibility: Provision of security

Responsible Person: Commissioner of Police

Functions

- Assists quarantine officials in securing the area.
- Prevents access as directed by the Quarantine Officer.

Component: Fire Department

Responsibility: Supervise, monitor and assist with cutting burning and disposal.

Responsible Person: Chief Fire Officer

Functions

- Makes fire equipment available for use in cleaning.
- Supervises clearing and burning of infected material.

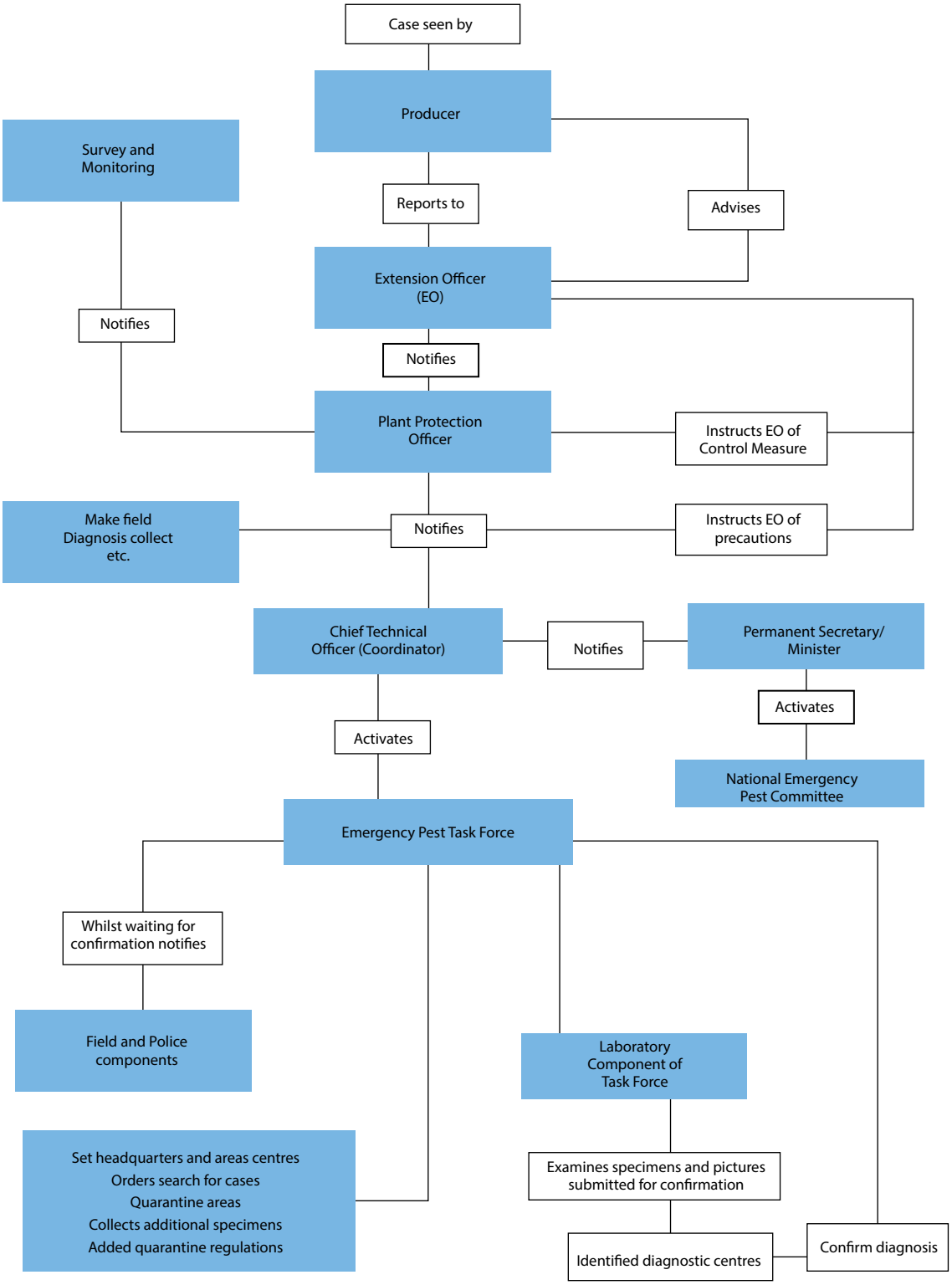

Figure 6.2 Flow-Chart – Mobilisation of the National Emergency Pest Committee

IMPORTANT NOTE

All country plans should have the following information presented as Annexes

Annex 1:	List of Names, Addresses and Telephone Numbers of Members of National Emergency Pest Committee
Annex 2	Map of (Country) by Agricultural Region and Ports of Entry
Annex 3	The Plant Protection and Quarantine Act
Annex 4	Customs Declaration Form
Annex 5	Cabinet Decisions
Annex 6	Sample of Declaration to be Signed by Captain
Annex 7	Pest List of (Country)

Financial Resources

When planning the national response for the prevention, entry and or establishment of *R. solanacearum* R3bv2, it is important to prepare a detailed budget outlining the material supplies required for each action. The Table below presents a possible list of items to be included in the budget and a template for setting-up a budget sheet to capture costs and the sources of funds.

Table 6.2: Budget items required for prevention, entry and or establishment of *R. solanacearum* R3bv2

Action	Budget Items	Action	Budget Items
Surveillance	- Cooler	Eradication and Management	- Field kit (magnifying glasses, bags, etc.)
	- Sample collection tools – bags, tags, forceps, magnifying glasses, etc.		- Motor Vehicle (gasoline, mileage for field officers)
	- Motor Vehicle (gasoline, mileage for field officers)		- Eradication and demonstration sites – farm tools and services, field labour
	- Equipment – GPS, Camera, field microscope		- Data collection tools (clip board, pens, paper)
	- Stationery and disposables		- Sample collection (bags, coolers, tags, markers)
			- Equipment – Camera, GPS, sprayers
Diagnostics	- Lab glassware (slides and cover slips, culture plates and flasks, media, petri dishes etc).	Public Awareness and Training	- Projector and screen
	Fees for diagnostic confirmation and Shipping costs for sending samples to reference laboratories.		- Development of information products such as Videos, posters, brochures and technical bulletins (- professional services for graphic artists for design and layout, printing services, videographer)
	- Cooler for sample storage		- Stationery
	- Disposables (Cotton, paper towels)		- Reproduction of reference material
	- Office supplies (stapler, staples, small clips, pens, highlighters, folders)		- Media services (newspaper articles, radio and TV broadcasts).
	- Computer supplies (paper, toner)		- Telephone hotline (establishing and maintaining)
	- cleaning and sanitizing of supplies		- Website and social media management
	- Equipment – computer, microscopes, PCR machine		

Example of Budget Sheet

Action	Materials	Unit Cost USD	Quantity	Total Costs USD	Source of Funds
TOTAL					

NB. Add as many rows required

References

Allen, C. 2019. Fwd: *Ralstonia solanacearum* R3bv2 NPRG draft. Personal communication to Jennifer.C.Cook@aphis.usda.gov on 19 February 2019, from callen@wisc.edu.

Allen, C., P. Prior, and A. C. Hayward. 2005. Bacterial wilt disease and the *Ralstonia solanacearum* species complex. APS Press, St. Paul, MN. 510 pp.

Almeida, I. M. G., S. A. L. Destéfano, J. Rodrigues Neto, and V. A. Malavolta Junior. 2003.

Ambrose, E. 2003. Emergency Action Plan for Exotic Plant Pests and Diseases: A Model for Caribbean Countries. ISSN-0534-5391 A2/LC-97-02. IICA Castries, Saint Lucia.

APHIS-USDA-PPQ. 2019. New pest response guidelines, *Brown Rot of Potato, Ralstonia solanacearum* (Smith, 1896) Yabuuchi et al., 1996 "race 3 biovar 2". 52 pp.

Southern bacterial wilt of geranium caused by *Ralstonia solanacearum* biovar 2/race 3 in Brazil. Revista de Agricultura (Piracicaba) 78(1):49-56.

Álvarez, B., J. Vasse, V. Le-Courtois, D. Trigalet-Démery, M. M. López, and A. Trigalet. 2008. Comparative behavior of *Ralstonia solanacearum* biovar 2 in diverse plant species. Phytopathology 98(1):59-68.

Autrique, A., and M. J. Potts. 1987. The influence of mixed cropping on the control of potato bacterial wilt (*Pseudomonas solanacearum*). Annals of Applied Biology 111(1):125-133.

Begum, N. 2011. Biological diversity of *Ralstonia solanacearum* strains causing bacterial wilt of solanaceous crops in Pakistan, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.

Caffier, D., and A. Hervé. 1996. La pourriture brune de la pomme de terre, un nouveau risque bactérien en Europe. La Pomme de Terre Française 492:20-23.

Caruso, P., E. G. Biosca, E. Bertolini, E. Marco-Noales, M. T. Gorris, C. Licciardello, and M. M. López. 2017. Genetic diversity reflects geographical origin of *Ralstonia solanacearum* strains isolated from plant and water sources in Spain. International Microbiology 20(4):155- 164.

Castillo, J. A., and G. Plata. 2016. The expansion of brown rot disease throughout Bolivia: Possible role of climate change. Canadian Journal of Microbiology 62(5):442-448.

Cellier, G., B. Remenant, F. Chiroleu, P. Lefeuvre, and P. Prior. 2012. Phylogeny and population structure of brown rot and Moko disease-causing strains of *Ralstonia solanacearum* phylotype II. Applied and Environmental Microbiology:2367–2375.

Chakraborty, R., and T. S. Roy. 2016. Threats faced by brown rot of potato in Bangladesh. Microbiology Research 7(1):8-12.

Champoiseau, P. G. (2008). *Ralstonia solanacearum* race 3 biovar 2. USDA-NRI Project: R. solanacearum race 3 biovar 2: detection, exclusion and analysis of a Select Agent Educational modules. http://plantpath.ifas.ufl.edu/rsol/Trainingmodules/RalstoniaR3b2_Sptms_Module.html

Champoiseau, P. 2009. *Ralstonia solanacearum* race 3 biovar 2 (Phylotype II, sequevar 1). From the field to the lab: Towards accurate identification of a select agent pathogen. Second National Meeting of the National Plant Diagnostic Network, 6-10 December 2009, Miami, Florida.

Champoiseau, P. G., J. B. Jones, and C. Allen. 2009. *Ralstonia solanacearum* race 3 biovar 2 causes tropical losses and temperate anxieties. Plant Health Progress DOI:10.1094/PHP-2009-0313-01-RV.

Champoiseau, P. G., and T. M. Momol. 2009. Bacterial wilt of tomato. University of Florida. 1-11 pp.

Champosiseau, P. J., J. B. Jones, T. M. Momol, P. Ji, C. Allen, D. J. Norman, D. W. Gabriel, T. P. Denny, K. K. Rane, and M. Royer. 2010. Recovery plan for *Ralstonia solanacearum* race 3 biovar 2 causing brown rot of potato, bacterial wilt of tomato, southern wilt of geranium.

United States Department of Agriculture, Animal and Plant Health Inspection Service, Agriculture Research Service, National Plant Disease Recovery System. 1-22 pp.

Ciampi, L., L. O. Burzio, and L. A. Burzio. 1997. Carriers for *Pseudomonas fluorescens*, antagonistic to *Pseudomonas* (*Ralstonia*) *solanacearum*, causal agent of bacterial wilt. Fitopatología 32(1):64-70.

Ciampi, L., and L. Sequeira. 1980. Influence of temperature on virulence of race 3 strains of *Pseudomonas solanacearum*. American Potato Journal 57(7):307-317.

Cook, D., and L. Sequeira. 1991. The use of subtractive hybridization to obtain a DNA probe specific for *Pseudomonas solanacearum* race 3. Molecular and General Genetics 227(3):401- 410.

Cruz, L., M. Eloy, F. Quirino, H. Oliveira, and R. Tenreiro. 2012. Molecular epidemiology of *Ralstonia solanacearum* strains from plants and environmental sources in Portugal. European Journal of Plant Pathology 133(3):687-706.

Deberdt, P., J. Guyot, R. Coranson-Beaudu, J. Launay, M. Noreskal, P. Rivière, F. Vigné, D. Laplace, L. Lebreton, and E. Wicker. 2014. Diversity of *Ralstonia solanacearum* in French Guiana expands knowledge of the "emerging ecotype". Phytopathology 104(6):586-596.

Dhital, S. P., N. Thaveechai, W. Kositratana, K. Piluek, and S. K. Shrestha. 1997. Effect of chemical and soil amendment for the control of bacterial wilt of potato in Nepal caused by *Ralstonia solanacearum*. Kasetsart Journal (Natural Sciences) 31(4):497-509.

Ebbels, D. L. 2003. Principles of plant health and quarantine. CABI. 302 pp.

Elphinstone, J. G., M. Bergsma-Vlami, J. van Vaerenbergh, G. Cellier, and F. Poliakoff. 2018. PM 7/21 (2) *Ralstonia solanacearum*, *R. pseudosolanacearum* and *R. syzygii* (*Ralstonia solanacearum* species complex). Bulletin OEPP/EPPO Bulletin 48(1):32–63.

EPPO. 1998. Second international bacterial wilt symposium (1998/24). EPPO Reporting Service 2. EPPO. 2002. Details on the situation of several quarantine pests in Hungary in 2001 (2002/159). EPPO Reporting Service 10.

EPPO. 2004. First report of *Ralstonia solanacearum* in Slovakia (2004/004). EPPO Reporting Service

EPPO. 2007. *Ralstonia solanacearum* reported in Greece (2007/176). EPPO Reporting Service 9.

EPPO. 2010. *Ralstonia solanacearum* detected in Sweden (2010/099). EPPO Reporting Service 5.

EPPO. 2012a. *Ralstonia solanacearum* detected in the Czech Republic (2012/218). EPPO Reporting Service 10.

EPPO. 2012b. *Ralstonia solanacearum* detected on *Pelargonium* in Germany (2012/139). EPPO Reporting Service 7.

EPPO. 2014. Outbreak of *Ralstonia solanacearum* in France (2014/070). EPPO Reporting Service 4.

EPPO. 2015a. First report of *Ralstonia solanacearum* on potatoes in Poland (2015/001). EPPO Reporting Service 1.

EPPO. 2015b. *Ralstonia solanacearum* detected in ware potatoes in Belgium (2015/131). EPPO Reporting Service 7.

EPPO. 2015c. *Ralstonia solanacearum* race 3 biovar 2 detected in New Caledonia (2015/146). EPPO Reporting Service 8.

EPPO. 2016. *Ralstonia solanacearum* found in *Solanum melongena* in the Netherlands (2016/136). EPPO Reporting Service 7.

Farag, N., D. E. Stead, and J. D. Janse. 1999. *Ralstonia* (*Pseudomonas*) *solanacearum* race 3, biovar 2, detected in surface (irrigation) water in Egypt. Journal of Phytopathology 147(7-8):485- 487.

Fernandez, M. C. 1986. Some hosts of *Pseudomonas solanacearum* in Chile [Abstract]. Agricultura Tecnica 46(1):101-105.

French, E. R. 1988. Strategies for integrated control of bacterial wilt of potatoes. Pages 133-141 *in* A. C. Hayward and G. L. Hartman, (eds.). Bacterial diseases of the potato: Report of the Planning Conference on Bacterial Diseases of the Potato, 1987. International Potato Center.

Floyd, J. 2007. New Pest Response Guidelines: Ralstonia solanacearum race 3 biovar 2. USDAAPHIS-PPQ, Emergency and Domestic Programs, Riverdale, MD. Online. http://www.aphis.usda.gov/import_export/plants/manuals/index.shtml [accessed August 10, 2009].

Gabriel, D. W., C. Allen, M. Schell, T. P. Denny, J. T. Greenberg, and Y. P. Duan. 2006. Identification of open reading frames unique to a select agent: *Ralstonia solanacearum* race 3 biovar 2. Molecular Plant-Microbe Interactions 19(1):69-79.

Garcia, R., A. Garcia, and L. Delgado. 1999. Distribution, incidence and variability of *Ralstonia solanacearum*, causal agent of bacterial wilt of potato in Merida state, Venezuela. Bioagro 11(1):12-23.

Genin, S. 2010. Molecular traits controlling host range and adaptation to plants in *Ralstonia solanacearum*. New Phytologist 187(4):920-928.

Graham, J., D. A. Jones, and A. B. Lloyd. 1979. Survival of *Pseudomonas solanacearum* race 3 in plant debris and in latently infected potato tubers. Phytopathology 69(10):1100-1103.

Graham, J., and A. B. Lloyd. 1978. *Solanum cinereum* R. Br., a wild host of *Pseudomonas solanacearum* biotype II. Journal of the Australian Institute of Agricultural Science 44(2):124-126.

Graham, J., and A. B. Lloyd. 1979. Survival of potato strain (race 3) of *Pseudomonas solanacearum* in the deeper soil layers. Australian Journal of Agricultural Research 30(3):489-496.

Gutarra, L., J. Herrera, E. Fernandez, J. Kreuze, and H. Lindqvist-Kreuze. 2017. Diversity, pathogenicity, and current occurrence of bacterial wilt bacterium *Ralstonia solanacearum* in Peru. Frontiers in Plant Science 8:1-12.

Hassan, M. A. E., and K. A. M. Abo-Elyousr. 2013. Activation of tomato plant defence esponses against bacterial wilt caused by *Ralstonia solanacearum* using DL-3-aminobutyric acid (BABA). European Journal of Plant Pathology 136(1):145-157.

Hernández-Romano, J., S. Ramírez-Rojas, and C. J. Ydrac-Morales. 2012. First report of *Ralstonia solanacearum* causing tomato bacterial wilt in Mexico. New Disease Reports 26:22.

Horita, M., and K. Tsuchiya. 2001. Genetic diversity of Japanese strains of *Ralstonia solanacearum*. Phytopathology 91(4):399-407.

Huerta, A. I., A. Milling, and C. Allen. 2015. Tropical strains of *Ralstonia solanacearum* outcompete race 3 biovar 2 strains at lowland tropical temperatures. Applied and Environmental Microbiology 81(10):3542-3551.

IPPC. 2015. *Ralstonia solanacearum* bv2, race 3 in New Caledonia. International Plant Protection Convention, Food and Agriculture Organization of the United Nations.

Izadiyan, M., and S. M. Taghavi. 2013. Host range variation and genetic diversity of Iranian isolates of *Ralstonia solanacearum* from potato and tomato with RAPD and (GTG) 5-PCR. Journal of Plant Pathology 95(1):87-97.

Janse, J. D. 1996. Potato brown rot in Western Europe–history, present occurrence and some remarks on possible origin, epidemiology and control strategies. Bulletin OEPP/EPPO Bulletin 26(3-4):679-695.

Janse, J. D. 2012. Review on brown rot (*Ralstonia solanacearum* race 3, biovar 2, phylotype IIB) epidemiology and control in the Netherlands since 1995: A success story of integrated pest management. Journal of Plant Pathology 94(2):257-272.

Janse, J. D., H. E. van den Beld, J. Elphinstone, S. Simpkins, N. N. A. Tjou-Tam-Sin, and J. van Vaerenbergh. 2004. Introduction to Europe of *Ralstonia solanacearum* biovar 2 race 3 in *Pelargonium zonale* cuttings. Journal of Plant Pathology 86(2):147-155.

Jeong, Y., J. Kim, Y. Kang, S. Lee, and I. Hwang. 2007. Genetic diversity and distribution of Korean isolates of *Ralstonia solanacearum*. Plant Disease 91(10):1277-1287.

Jones, J. B., E. R. Dickstein, P. G. Champoiseau, T. M. Momol, P. Ji, D. J. Norma, Q. Haung, C. Allen, S. A. Miller, T. Schubert, R. Bulluck, J. E. Fajardo, D. Norman, J. Hong, and D. Jones. 2017. Recovery plan for *Ralstonia solanacearum* race 3 biovar 2 causing brown rot of potato, bacterial wilt of tomato, and southern wilt of geranium. United States Department of Agriculture, Animal and Plant Health Inspection Service, Agriculture Research Service, National Plant Disease Recovery System. 1-48 pp.

Jones, J. B., J. P. Jones, R. E. Stall, and T. A. Zitter. 1991. Compendium of tomato diseases. American Phytopathological Society, St. Paul, MN. 73 pp.

Kelman, A. 1998. One hundred and one years of research on bacterial wilt. Pages 1-5 *in* P. Prior, C. Allen, and J. Elphinstone, (eds.). Bacterial wilt disease: Molecular and ecological aspects. Springer, Berlin.

Khoodoo, M. H. R., E. S. Ganoo, and A. S. Saumtally. 2010. Molecular characterization and epidemiology of *Ralstonia solanacearum* race 3 biovar 2 causing brown rot of potato in Mauritius. Journal of Phytopathology 158(7-8):503-512.

Khoodoo, M. H. R., E. S. Ganoo, and S. Saumtally. 2007. First report of *Ralstonia solanacearum* race 3 biovar 2A infecting potato and weeds in Mauritius. Plant Disease 91(9):1200.

Lashkhi, N., T. Kokashvili, T. Eliashvili, T. Koberidze, G. Tsertsvadze, M. Muradashvili, G. Meparishvili, Z. Sikharulidze, and M. Tediashvili. 2018. The isolation and biological characterization of bacteriophages lytic to Georgian strains of *Ralstonia solanacearum* race 3 biovar 2. International Journal of Advanced Research 6(2):850-860.

Lebeau, A., M. C. Daunay, A. Frary, A. Palloix, J. F. Wang, and J. Dintinger. 2011. Bacterial wilt resistance in tomato, pepper, and eggplant: Genetic resources respond to diverse strains in the *Ralstonia solanacearum* species complex. Phytopathology 101(1):154-165.

Lemaga, B., R. Kakuhenzire, B. Kassa, P. T. Ewell, and S. Priou. 2005. Integrated control of potato bacterial wilt in Eastern Africa: The experience of African Highlands initiative. Pages 145- 157 *in* C. Allen, P. Prior, and A. C. Hayward, (eds.). Bacterial wilt disease and the *Ralstonia solanacearum* species complex. APS Press, St. Paul, MN.

Lemessa, F., and W. Zeller. 2007. Isolation and characterisation of *Ralstonia solanacearum* strains from Solanaceae crops in Ethiopia. Journal of Basic Microbiology 47(1):40-49.

Lin, C.-H., J.-F. Wang, Y.-F. Wu, and A.-H. Cheng. 2015. Phylotype II race 3 biovar 2 strain of *Ralstonia solanacearum* in Taiwan: Survival potential and virulence on tomato, eggplant, and pepper. Acta Horticulturae 1069:293-300.

Mahbou Somo Toukam, G., G. Cellier, E. Wicker, C. Guilbaud, R. Kahane, and C. Allen. 2009. Broad diversity of *Ralstonia solanacearum* strains in Cameroon. Plant Disease 93(11):1123-1130.

Mao, L., Q. Wang, D. Yan, T. Ma, P. Liu, J. Shen, Y. Li, C. Ouyang, M. Guo, and A. Cao. 2014. Evaluation of chloropicrin as a soil fumigant against *Ralstonia solanacarum* in ginger (*Zingiber officinale* Rosc.) production in China. PloS one 9(3):e91767.

Martin, C., and E. R. French. 1995. Covered-field host range test for *Pseudomonas solanacearum* race 3/biovar 2. Bacterial Wilt Newsletter 12:9.

Martin, C., and U. Nydegger. 1982. Susceptibility of *Cyphomandra betacea* to *Pseudomonas solanacearum*. Plant Disease 66(11):1025-1027.

Matveeva, E. V., E. S. Pekhtereva, E. V. Nikolaeva, and N. W. Schaad. 2003. Pathogenicity, virulence, and phenotypic diversity of *Ralstonia solanacearum* strains in potato in Russian Federation. Phytopathology 96(6): S58.

Milling, A., F. Meng, T. P. Denny, and C. Allen. 2009. Interactions with hosts at cool temperatures, not cold tolerance, explain the unique epidemiology of *Ralstonia solanacearum* race 3 biovar 2. Phytopathology 99(10):1127-1134.

Momol, T., P. Ji, J. Jones, and S. Olson. 2005. Recommended management strategies for bacterial wilt on tomato caused by *Ralstonia solanacearum*. NFREC Extension Report No: 2005-8.

Mwankemwa, Z. 2015. Occurrence and distribution of potato bacterial wilt disease and variability of its causal agent in Southern Highlands of Tanzania. Master of Science, Sokoine University of Agriculture, Morogoro, Tanzania.

Natural, M. P., L. A. D. Lando, and E. M. Jover. 2005. Variability of the potato bacterial wilt pathogen, *Ralstonia solanacearum* (E. F. Smith) Yabuuchi et al., in the Philippines. Pages 493-499 *in* C. Allen, P. Prior, and A. C. Hayward, (eds.). Bacterial wilt disease and the *Ralstonia solanacearum* species complex. APS Press, St. Paul, MN.

NCSU-CIPM. 2019. Potatoes and Tomatoes Harvested Acres (2012) [map]. North Carolina State University, Center for Integrated Pest Management, Raleigh, NC.

NDSU. 2018. Potato seed calculation. Accessed on 19 February 2019, https://www.ag.ndsu.edu/potatoextension/tables-for-potato-seed-and-plant-population.

Nemeth, J., A. Kovacs, G. Galambos, F. Mero, and M. Molnar. 2002. Occurence of bacterial brown rot of potato *Ralstonia* (*Pseudomonas*) *solanacearum* in Hungary. Novenyvedelem Hungary 38(9):453-461.

Nicole, J. F., J.-J. Cheron, J.-C. Girard, and J. Luisetti. 1998. A tentative explanation of the distribution, on Reunion Island, of bacterial wilt caused by either biovar 2 or biovar 3 of *Ralstonia solanacearum*. Pages 343-350 *in* P. Prior, C. Allen, and J. Elphinstone, (eds.). Bacterial Wilt Disease. Springer, Berlin.

Olsson, K. 1976. Experience of brown rot caused by *Pseudomonas solanacearum* (Smith) Smith in Sweden. EPPO Bulletin 6(4):199-207.

Ozakman, M., and N. W. Schaad. 2003. A real-time BIO-PCR assay for detection of *Ralstonia solanacearum* race 3, biovar 2, in asymptomatic potato tubers. Canadian Journal of Plant Pathology 25(3):232-239.

Pasqua di Bisceglie, D., A. Saccardi, S. Giosue, F. Traversa, and U. Mazzucchi. 2005. Survival of *Ralstonia solanacearum* on wood, high density polyethylene, and on jute fabric in cold storage. Journal of Plant Pathology 87(2):145-147.

Patil, V. U., J. Gopal, and B. P. Singh. 2012. Improvement for bacterial wilt resistance in potato by conventional and biotechnological approaches. Agricultural Research 1(4):299-316.

Perea Soto, J. M., R. S. García Estrada, R. Allende Molar, J. A. Carrillo Fasio, J. León Félix, B. Valdez Torres, L. Soto, and F. S. Mell. 2011. Identification of races and biovars of isolated from tomato plants. Revista Mexicana de Fitopatología 29(2):98-108.

PERAL 2019. Review of the PERAL 2009 Greater Caribbean Region (GCR) Pathway Analysis June 21, 2019. Plant Epidemiology and Risk Analysis Laboratory (PERAL), Science and Technology, Plant Protection and Quarantine (PPQ), Animal and Plant Health Inspection Service (APHIS), United States Department of Agriculture (USDA)

Popoola, A. R., S. A. Ganiyu, O. A. Enikuomehin, J. G. Bodunde, O. B. Adedibu, H. A. Durosomo, and O. A. Karunwi. 2015. Isolation and characterization of *Ralstonia solanacearum* causing bacterial wilt of tomato in Nigeria. Nigerian Journal of Biotechnology 29(1):1–10.

Pradhanang, P., and M. Momol. 2001. Survival of Ralstonia solanacearum in soil under irrigated rice culture and aquatic weeds. Journal of Phytopathology 149(11-12):707-711.

Pradhanang, P. M., and J. G. Elphinstone. 1996. Identification of weed and crop hosts of *Pseudomonas solanacearum* race 3 in the hills of Nepal. Pages 39-49 *in* P. M. Pradhanang and J. G. Elphinstone, (eds.). Proceedings National Workshop Integrated Management of Bacterial Wilt of Potato: Lessons from the Hills of Nepal, Pokhara.

Pradhanang, P. M., J. G. Elphinstone, and R. T. V. Fox. 2000. Identification of crop and weed hosts of *Ralstonia solanacearum* biovar 2 in the hills of Nepal. Plant Pathology 49(4):403-413.

Prior, P., and M. Fegan. 2005a. Diversity and molecular detection of *Ralstonia solanacearum* race 2 strains by multiplex PCR. Pages 405-414 *in* C. Allen, P. Prior, and A. C. Hayward, (eds.).

Bacterial wilt disease and the *Ralstonia solanacearum* species complex. APS Press, St. Paul, MN.

Prior, P., and M. Fegan. 2005b. Recent developments in the phylogeny and classification of

Ralstonia solanacearum. Acta Horticulturae 695:127-136.

Prior, P., and H. Steva. 1990. Characteristics of strains of *Pseudomonas solanacearum* from the French West Indies. Plant Disease 74:13-17.

Sagar, V., A. K. Somani, R. K. Arora, S. Sharma, S. K. Chakrabarti, S. K. Tiwari, R. Chaturvedi, and B. P. Singh. 2013. Status of bacterial wilt of potato in the Malwa region of Madhya Pradesh in India. Journal of Plant Pathology 95(2):321-328.

Sanchez Perez, A., L. Mejia, M. Fegan, and C. Allen. 2008. Diversity and distribution of *Ralstonia solanacearum* strains in Guatemala and rare occurrence of tomato fruit infection. Plant Pathology 57:320-331.

Siri, M. I., A. Sanabria, and M. J. Pianzzola. 2011. Genetic diversity and aggressiveness of *Ralstonia solanacearum* strains causing bacterial wilt of potato in Uruguay. Plant Disease 95(10):1292-1301.

Smith, E. F. 1896. A bacterial disease of the tomato, eggplant and Irish potato (*Bacillus solanacearum* n. sp.). United States Department of Agriculture, Division of Vegetable Physiology and Pathology Bulletin 12:1-27.

Stansbury, C., S. McKirdy, A. Mackie, and G. Power. 2001. Bacterial wilt: *Ralstonia solanacearum*

- race 3. Exotic threat to Western Australia (No. 7/2001). *in* Factsheet. State of Western Australia, Department of Agriculture.

Stevenson, W. R., R. Loria, G. D. Franc, and D. P. Weingartner (eds.). 2001. Compendium of potato diseases (Second). APS Press, St. Paul, MN. 106 pp.

Swanepoel, A. E. 1992. Survival of South African strains of biovar 2 and biovar 3 of *Pseudomonas solanacearum* in the roots and stems of weeds. Potato Research 35(3):329-332.

Swanson, J. K., J. Yao, J. Tans-Kersten, and C. Allen. 2005. Behavior of *Ralstonia solanacearum*

race 3 biovar 2 during latent and active infection of geranium. Phytopathology 95(2):136-143.

Tahat, M. M., and K. Sijam. 2010. *Ralstonia solanacearum*: The bacterial wilt causal agent. Asian Journal of Plant Sciences 9(7):385-393.

Tomlinson, D. L., and M. T. Guntber. 1986. Bacterial wilt in Papua New Guinea. Pages 35-39 *in* G.

J. Persley and P. A. Batugal, (eds.). Bacterial wilt disease in Asia and the South Pacific: Proceedings of an international workshop held at PCARRD, Los Baños, Philippines, 8-10 October 1985. Australian Centre for International Agricultural Research.

Tusiime, G., E. Adipala, F. Opio, and A. S. Bhagsari. 1998. Weeds as latent hosts of *Ralstonia solanacearum* in Highland Uganda: Implications to development of an integrated control package for bacterial wilt. Pages 413-419 *in* P. Prior, C. Allen, and J. Elphinstone, (eds.). Bacterial wilt disease: Molecular and ecological aspects. Springer, Berlin.

USDA-APHIS-PPQ-CPHST. 2015. CPHST Pest Datasheet for *Ralstonia solanacearum* race 3 biovar 2. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science & Technology. 1- 14 pp.

USDA-APHIS-PPQ-CPHST. 2018. USDA-APHIS procedures for submitting domestically detected suspect *Ralstonia solanacearum* positives based on immunostrip testing. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science & Technology. 1-5 pp.

USDA-APHIS-PPQ. 2018. Select Agents and Toxins List. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine.

USDA-APHIS. 2007. Minimum sanitation protocols for offshore geranium cutting production. United States Department of Agriculture, Animal and Plant Health Inspection Service. 1-26 pp.

USDA-APHIS. 2017. Select agents and toxins list. Accessed on 11 March 2019, https://www.selectagents.gov/selectagentsandtoxinslist.html.

USDA-NASS. 2016. Floriculture Crops 2015 Summary. United States Department of Agriculture, National Agricultural Statistics Service. 1-59 pp.

USDA–APHIS–PPQ–S&T Fort Collins Lab. 2018a. Potatoes Harvested Acres for Sale (2012) [map]. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Science and Technology, Fort Collins, CO.

USDA–APHIS–PPQ–S&T Fort Collins Lab. 2018b. Tomatoes Harvested Acres for Sale (2012) [map]. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Science and Technology, Fort Collins, CO.

Ustun, N., M. Ozakman, and A. Karahan. 2008. Outbreak of *Ralstonia solanacearum* biovar 2 causing brown rot on potato in the Aegean region of Turkey. Plant Disease 92(6):973-973.

Uwamahoro, F., A. Berlin, C. Bucagu, H. Bylund, and J. Yuen. 2018. Potato bacterial wilt in Rwanda: Occurrence, risk factors, farmers' knowledge and attitudes. Food Security 10(5):1221-1235.

van Bueningen, A. R., M. Tax, J. G. B. Voogd, L. S. van Overbeek, and J. D. Janse. 2005. Brown rot of potato breakthrough in prevention and reintroduction as caused by irrigation and spraying. Gewasbescherming 36(6):248-252.

van der Wolf, J. M., J. R. C. M. van Beckhoven, E. G. de Haan, G. W. van den Bovenkamp, and G. O. M. Leone. 2004. Specific detection of *Ralstonia solanacearum* 16S rRNA sequences by AmpliDet RNA. European Journal of Plant Pathology 110(1):25-33.

Waggy, M. A. 2009. *Solanum dulcamara*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System (FEIS). https://www.fs.fed.us/database/feis/plants/shrub/soldul/all.html.

Wang, L., B. Wang, G. Zhao, X. Cai, S. Jabaji, P. Seguin, and H. Chen. 2017. Genetic and pathogenic diversity of *Ralstonia solanacearum* causing potato brown rot in China. American Journal of Potato Research 94(4):403-416.

Weller, S. A., J. G. Elphinstone, N. C. Smith, N. Boonham, and D. E. Stead. 2000. Detection of *Ralstonia solanacearum* strains with a quantitative, multiplex, real time, fluorogenic PCR (TaqMan) assay. Applied and Environmental Microbiology 66(7):2853-2858.

Wenneker, M., M. S. W. Verdel, R. M. W. Groeneveld, C. Kempenaar, A. R. van Beuningen, and J. D Janse. 1999. *Ralstonia* (*Pseudomonas*) *solanacearum* race 3 (biovar 2) in surface water and natural weed hosts: First report on stinging nettle (*Urtica dioica*). European Journal of Plant Pathology 105(3):307-315.

Williamson, L., K. Nakaho, B. Hudelson, and C. Allen. 2002. *Ralstonia solanacearum* race 3, biovar 2 strains isolated from geranium are pathogenic on potato. Plant Disease 86(9):987-991.

Wu, Y. F., C. H. Lin, J. F. Wang, and A. S. Cheng. 2011. Population density of *Ralstonia solanacearum* potato strain, phylotype II/race 3/biovar 2, and incidence of potato bacterial wilt in fields in Dounan, Yunlin County. Plant Pathology Bulletin 20(3/4):68-77.

Yabuuchi, E., Y. Kosako, I. Yano, H. Hotta, and Y. Nishiuchi. 1995. Transfer of two *Burkholderia* and an *Alcaligenes* species to *Ralstonia* gen. nov. Proposal of *Ralstonia pickettii* (Ralston, Palleroni and Doudoroff 1973) comb. nov., *Ralstonia solanacearum* (Smith 1896) comb. nov. and *Ralstonia eutropha* (Davis 1969) comb. nov. Microbiology and Immunology 39(11):897-904.

Yao, K.-S., Y.-H. Hsieh, Y.-J. Chang, C.-Y. Chang, T.-C. Cheng, and H.-L. Liao. 2010. Inactivation effect of chlorine dioxide on phytopathogenic bacteria in irrigation water. Environmental Engineering and Management Journal 20(3):157-160.

Zayamba Kagona, J. D. 2008. The incidence of bacterial wilt (*Ralstonia solanacearum*) in informal potato planting material used by farmers in Dedza and Ntcheu districts of Malawi. Masters of Science, Norwegian University of Life Sciences, Ås, Norway.

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