European Food Safety Authority

EFSA Journal 2014;12(6):3720

SCIENTIFIC OPINION

Scientific Opinion on the pest categorisation of *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye[1]

EFSA Panel on Plant Health (PLH)[2,3]

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ABSTRACT

The European Commission requested the EFSA Panel on Plant Health to perform the pest categorisation for *Xanthomonas campestris* pv. *vesicatoria*, which is the causal agent of bacterial spot of tomato and pepper. *X. campestris* pv. *vesicatoria* is not a single taxonomic entity, and four separate species have been described: *X. vesicatoria*, *X. euvesicatoria*, *X. perforans* and *X. gardneri*. These organisms can be accurately identified based on a range of discriminative methods. Detection methods are available for seeds. Among the four species described within *X. campestris* pv. *vesicatoria*, all except *X. gardneri* were reported to be present in the EU territory. The host plants (tomato and pepper) are cultivated throughout Europe and conditions are conducive to disease development in open fields in southern Europe and in greenhouses. The disease causes a range of symptoms on aerial parts of plants including fruits. Contaminated seeds and transplants are responsible for long-distance dissemination of the pathogen. Control is mainly based on prevention and exclusion. Extraction of seeds from fruit debris using fermentation and acid treatments and thermotherapy treatments were shown to be effective in reducing the bacterial load in seed lots. No methods and chemical control agents are available that effectively control xanthomonads in infected crops. Although no recent data are available on economic losses caused by these pathogens in the EU, the organisms are considered important bacterial pathogens of tomato and pepper. Infections resulting in up to 30 % losses have been reported. Xanthomonads causing bacterial spot of tomato and pepper meet all criteria defined in International Standard for Phytosanitary Measures (ISPM) 21 and they also meet all ISPM 11 criteria, although *X. vesicatoria*, *X. euvesicatoria* and *X. perforans* are present in the EU territory.

KEY WORDS

pest categorisation, *Xanthomonas campestris* pv. *vesicatoria*

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[1] On request from the European Commission, Question No EFSA–Q–2012–00808, adopted on 22 May 2014.

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[3] Acknowledgement: The Panel wishes to thank the members of the Working Group on Tomato Bacteria: Marie-Agnès Jacques, Michael John Jeger, Charles Manceau, Jan Schans, Emilio Stefani and Jan Martin van der Wolf for the preparatory work on this scientific opinion, and EFSA staff Svetla Kozelska and Tomasz Oszako for the support provided to this scientific opinion.

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), 2014. Scientific Opinion on the pest categorisation of *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye. EFSA Journal 2014;12(6):3720, 26 pp. doi:10.2903/j.efsa.2014.3720

Available online: www.efsa.europa.eu/efsajournal

SUMMARY

Following a request from the European Commission, the EFSA Panel on Plant Health (hereafter the Panel) was asked to deliver a scientific opinion on the pest categorisation of *Xanthomonas campestris* pv. *vesicatoria* for the European Union (EU) territory.

The Panel performed the pest categorisation for *X. campestris* pv. *vesicatoria* following the guiding principles and steps presented in the EFSA guidance on the harmonised framework for risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and ISPM No 21 (FAO, 2004).

After consideration of the evidence, the Panel reached the following conclusions:

Identity of the pest

Xanthomonas campestris pv. *vesicatoria* is not a single taxonomic entity, and strains causing bacterial spot of tomato and pepper known with that name nowadays fall into four separate species: *X. vesicatoria*, *X. euvesicatoria*, *X. perforans* and *X. gardneri*. These organisms under assessment are clear, distinguished taxonomic entities and they can be accurately identified based on a range of discriminative methods. All these species can cause a wide variety of symptoms on their host plants, which include angular lesions that later become brown and necrotic on the leaf, fruit, petiole and stem. Some symptoms may be confused with those caused by other organisms. No difference in aggressiveness has been reported between the four bacterial spot-causing species, whereas a variation in virulence has been observed. All bacterial species cause disease on tomato and pepper. Races were described within all *Xanthomonas* spp. causing bacterial spot on tomato and/or pepper according to the cultivar resistance pattern. The control methods for all four species are identical and the conclusions are the same for all four species.

Presence in the risk assessment area

Among the four species described within *X. campestris* pv. *vesicatoria*, only three were reported to be present in the EU territory. *X. vesicatoria* is reported from 12 EU countries; strains of *X. euvesicatoria* were reported in Spain, Hungary (Jones et al., 2004) and Italy (Buonaurio et al., 1994), although these data were obtained characterising isolates present in several collections. The presence of *X. perforans* was recently reported in Sicily, Italy (Aiello et al., 2013). *X. gardneri* has not been reported in the EU at present.

Regulatory status

The pathogen is listed in Council Directive 2000/29/EC, Annex II A II, as a harmful organism, known to occur in the Community, and as relevant for the entire Community, whose introduction into, and spread within, all Member States shall be banned if it is found to be present on certain plants or plant products. Measures regulating the import into and movement within the EU of potentially infected host plants include special requirements with respect to *X. campestris* pv. *vesicatoria* for specified plant material, prohibition of import for specified plants from specified third countries and official control of host plant material produced within the EU for use by professional producers of plants and fruits.

The Panel notes that there are no regulatory special requirements in place with respect to *X. campestris* pv. *vesicatoria* for the movement within the EU of seeds of *Capsicum*. This may increase the probability of spread of the pathogen on this commodity.

Potential for establishment and spread in the risk assessment area

Tomato and sweet pepper are major vegetable crops in Europe, which are widely grown in the Mediterranean countries of the EU, in Poland and in Romania. The main hosts of bacterial spot-causing xanthomonads are tomatoes and peppers.

The disease has mainly been observed in field crops but can occur in greenhouses as well. The environmental conditions in south Europe are particularly favourable for disease expression in the field, as the optimal growth temperature for xanthomonads is between 25 and 30 °C.

The pathogen is seed borne and seeds are considered the major means for long-distance dispersal. The pathogen can survive for years on seeds. A few infected plants can lead to outbreaks. Transplants can also be a primary infection source where xanthomonads can survive epiphytically and endophytically, and can serve as a means of long-distance dispersal. At production sites, tomato volunteer plants and crop debris, in which xanthomonads can survive, are recognised as playing a key role as a source of inoculum. Heavy rain, irrigation, wind and cultivation practices, including clipping and pruning, largely contribute to rapid spread of the pathogen in a crop.

Control is mainly based on prevention and exclusion. Detection methods are available for seeds. Extraction of seeds from fruit debris using fermentation and acid treatments reduces xanthomonad populations on tomato seeds. Thermotherapy treatment has been shown to be effective in eliminating xanthomonads in seed lots. No methods and chemical control agents are available that effectively control xanthomonads in infected crops.

Potential for economic and environmental consequences in the risk assessment area

Although no recent data are available on economic losses caused by the pathogen in the EU, the organism is considered an important bacterial pathogen of tomato and pepper. Infections resulting in losses of up to 30 % have been reported.

Xanthomonads causing bacterial spot meet the following ISPM 11 criteria:

Identity of the pest: X. campestris pv. *vesicatoria* is not a single taxonomic entity, and strains causing bacterial spot of tomato and pepper known with that name nowadays fall into four separate species: *X. vesicatoria*, *X. euvesicatoria*, *X. perforans* and *X. gardneri*. These organisms are clear, distinguished taxonomic entities and they can be accurately identified based on a range of discriminative methods. No difference in aggressiveness has been reported between bacterial spot-causing species, whereas a variation in virulence has been observed. All bacterial species cause disease on tomato and pepper.

Presence or absence in the risk assessment area: X. vesicatoria, *X. euvesicatoria* and *X. perforans* were reported to be present in the EU territory. However, *X. gardneri* has not been reported in the EU.

Regulatory status: the pest is under official control.

Potential for establishment and spread in the risk assessment area: the risk assessment area has ecological and climatic conditions, including in protected conditions, suitable for the establishment and spread of the pest and host species.

Potential for economic consequences (including environmental consequences) in the risk assessment area: the organism is considered an important bacterial pathogen of tomato and pepper. Infections resulting in losses of up to 30 % have been reported.

Xanthomonads causing bacterial spot meet all criteria defined in ISPM 21: they are seed-borne bacteria and can be present in plants for planting (seeds and transplants), which affects the intended use of those plants with an impact.

No major uncertainties were identified within the pest categorisation.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The current European Union plant health regime is established by Council Directive 2000/29/EC[4] on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (OJ L 169, 10.7.2000, p.l).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants and plant products and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union, the list of harmful organisms whose introduction into or spread within the Union is prohibited and the control measures to be carried out at the outer border of the Union on arrival of plants and plant products.

Arabic mosaic virus, Tomato black ring virus, Raspberry ringspot virus, Strawberry latent ringspot virus, Strawberry crinkle virus, Strawberry mild yellow edge virus, *Daktulosphaira vitifoliae* (Fitch), *Eutetranychus orientalis* Klein, *Parasaissetia nigra* (Nietner), *Clavibacter michiganensis* spp. *michiganensis* (Smith) Davis *et al.*, *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye, *Didymella ligulicola* (Baker, Dimock and Davis) v. Arx, and *Phytophthora fragariae* Hickmann var. *fragariae* are regulated harmful organisms in the EU. They are all listed in Annex II, Par A, Section II of Council Directive 2000/29/EC, which means that they are organisms known to occur in the EU and whose introduction into and spread within the EU is banned if they are found present on certain plants or plant products.

Given the fact that these organisms are already locally present in the EU territory and that they are regulated in the EU since a long time, it is considered to be appropriate to evaluate whether these organisms still deserve to remain regulated under Council Directive 2000/29/EC, or whether, if appropriate, they should be regulated in the context of the marketing of plant propagation material, or be deregulated. In order to carry out this evaluation a recent pest risk analysis is needed which takes into account the latest scientific and technical knowledge on these organisms, including data on their agronomic and environmental impact, as well as their present distribution in the EU territory.

The revision of the regulatory status of these organisms is also in line with the outcome of the recent evaluation of the EU Plant Health Regime, which called for a modernisation of the system through more focus on prevention and better risk targeting (prioritisation).

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) No 178/2002, to provide a pest risk assessment of Arabic mosaic virus, Tomato black ring virus, Raspberry ringspot virus, Strawberry latent ringspot virus, Strawberry crinkle virus, Strawberry mild yellow edge virus, *Daktulosphaira vitifoliae* (Fitch), *Eutetranychus orientalis* Klein, *Parasaissetia nigra* (Nietner), *Clavibacter michiganensis* spp. *michiganensis* (Smith) Davis *et al.*, *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye, *Didymella ligulicola* (Baker, Dimock and Davis) v. Arx, and *Phytophthora fragariae* Hickmann var. *fragariae*, for the EU territory.

For each organism EFSA is asked to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by the organism. EFSA is also requested to provide an opinion on the effectiveness of the present EU requirements against those organisms, which are laid down in Council Directive 2000/29/EC, in reducing the risk of introduction of these pests into, and their spread within, the EU territory.

Even though a full risk assessment is requested for each organism, in order to target its level of detail to the needs of the risk manager, and thereby to rationalise the resources used for its preparation and to

[4] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169/1, 10.7.2000, p. 1–112.

speed up its delivery, EFSA is requested to concentrate in particular on the analysis of the present spread of the organism in comparison with the endangered area, the analysis of the observed and potential impacts of the organism as well as the availability of effective and sustainable control methods.

The European Commission amended further the Terms of reference through a new request regarding 38 plant pests listed in the Annexes of the EC Directive 2000/29/EC (ARES (2014)970361) as follows:

"In line with the experience gained with the previous two batches of pest risk assessments of organisms listed in Annex II, Part A, Section II, requested to EFSA, and in order to further streamline the preparation of risk assessments for regulated pests, the work should be split in two stages, each with a specific output. EFSA is requested to prepare and deliver first a pest categorisation for each of these 38 regulated pests (step 1). Upon receipt and analysis of this output, the Commission will inform EFSA for which organisms it is necessary to complete the pest risk assessment, to identify risk reduction options and to provide an assessment of the effectiveness of current EU phytosanitary requirements (step 2). *Clavibacter michiganensis* spp. *michiganensis* (Smith) Davis *et al.* and *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye, from the second batch of risk assessment requests for Annex IIAII organisms requested to EFSA (ARES(2012)880155), could be used as pilot cases for this approach, given that the working group for the preparation of their pest risk assessments has been constituted and it is currently dealing with the step 1 "pest categorisation". This proposed modification of previous request would allow a rapid delivery by EFSA by May 2014 of the first two outputs for step 1 "pest categorisation", that could be used as pilot case for this request and obtain a prompt feedback on its fitness for purpose from the risk manager's point of view."

ASSESSMENT

1. Introduction

1.1. Scope and purpose

In this opinion, the EFSA Panel on Plant Health (hereafter the Panel) produced a pest categorisation for *Xanthomonas campestris* pv. *vesicatoria* as requested by the European Commission (ARES (2014)970361). In the conclusions of this opinion, the Panel summarises the main findings. The pest risk assessment area is the territory of the European Union (hereinafter referred to as the EU) with 28 Member States (hereinafter referred to as EU MSs), restricted to the area of application of Council Directive 2000/29/EC, which excludes Ceuta and Melilla, the Canary Islands and the French overseas departments.

2. Methodology and data

2.1. Methodology

The Panel performed the pest categorisation for *X. campestris* pv. *vesicatoria* following the guiding principles and steps presented in the EFSA guidance on the harmonised framework for risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and International Standard for Phytosanitary Measures No 21 (FAO, 2004).

In accordance with the Harmonised framework for pest risk assessment in the EU (EFSA PLH Panel, 2010), this work is initiated as result of the review or revision of phytosanitary policies and priorities. As explained in the background of the EC request, the objective of this mandate is to provide updated scientific advice to the European risk managers for their evaluation of whether these organisms listed in the Annexes of the Directive 2000/29/EC still deserve to remain regulated under Council Directive 2000/29/EC, or whether they should be regulated in the context of the marketing of plant propagation material, or be deregulated. Therefore, to facilitate the decision making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for quarantine pest according to ISPM 11 (FAO, 2013) but also for regulated non quarantine pest according to ISPM 21 (FAO, 2004) and includes additional information required as per the specific terms of reference received by the EC.

2.2. Data

2.2.1. Literature search

A literature search on *X. campestris* pv. *vesicatoria* was conducted at the beginning of the mandate. As the same species is sometimes mentioned under synonyms (section 3.1.1), the most frequent synonyms have been used for the literature search consulting the ISI Web of Knowledge database. Further references and information were obtained from experts and from citations within the references. Searches were also carried out on the Internet.

2.2.2. Data collection

To complement the information concerning the current situation of the pest provided by the literature and online databases on pest distribution, damage and management, the PLH Panel sent a short questionnaire on the current situation at the country level based on the information available in the European and Mediterranean Plant Protection Organization (EPPO) Plant Quarantine Data Retrieval system (PQR) (EPPO, online) to the National Plant Protection Organisation (NPPO) contacts in all the EU Member States (in January 2013, with answers received up to March 2013). In some cases, supplementary information was also sought for clarification. A summary table with the answers received is presented in Table 2.

In order to obtain information on the distribution of the main host plants, the EUROSTAT database was consulted.

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Taxonomy

Xanthomonas campestris pv. *vesicatoria* is the causal agent of bacterial spot of tomato and pepper. For a long time it was described as *X. vesicatoria* (Doidge) Dawson. After a number of earlier revisions, Dye (1978) proposed the name *X. campestris* pv. *vesicatoria*. Phenotypically and phylogenetically, this pathovar was shown to be composed of at least four different populations, all of which are pathogenic on tomato; those groups were named groups A, B, C and D (Dye, 1966; Stall et al., 1994; Vauterin et al., 1995; Jones et al., 2004).

A comparison was made on a large, but incomplete, collection of pathogenic xanthomonads and, on the basis of DNA homology, groups A and C were transferred into a new species–pathovar combination, *X. axonopodis* pv. *vesicatoria* - whereas group B, which showed clear distinctive features, was named *X. vesicatoria* (Vauterin et al., 1995; Jones et al., 2000). Later, three new species were proposed: *X. gardneri*, for group D strains, originally identified in the former Yugoslavia (Sutic, 1957) and including similar strains from Costa Rica (Jones et al., 2004); *X. euvesicatoria*, for a set of weakly amylolytic isolates, formerly included in group A and originally isolated in South Africa (Doidge, 1921); and *X. perforans*, for the starch-degrading isolates belonging to group C and first isolated and described by Gardner and Kendrick (1921). *X. axonopodis* pv. *vesicatoria* is no longer a valid name.

Table 1: Reclassification of *Xanthomonas campestris* pv. *vesicatoria* into four species

Reference	Classification			
Dye et al., 1980; Hayward and Waterston, 1964	*Xanthomonas campestris* pv. *vesicatoria*			
Hildebrand et al., 1990; Palleroni et al., 1993	*Xanthomonas campestris* pv. *vesicatoria*			*X. gardneri*
Stall et al., 1994; Bouzar et al., 1994	A		B	
Vauterin et al, 1995	*X. axonopodis* pv. *vesicatoria*		*X. vesicatoria*	
Jones et al., 1995; 2000; Bouzar et al., 1996	A	C	B	D
Jones et al, 2004	*X. euvesicatoria*	*X. perforans*	*X. vesicatoria*	*X. gardneri*

Therefore, *X. campestris* pv. *vesicatoria* is not a single taxonomic entity, but all pathogenic strains known with that name nowadays fall into four separate species with the following valid names (see also Table 1).

Names:
Xanthomonas euvesicatoria (Jones et al., 2004)
Xanthomonas gardneri (e.g. Sutic, 1957) (Jones et al., 2004)
Xanthomonas perforans (Jones et al., 2004)
Xanthomonas vesicatoria (e.g. Doidge, 1920) (Vauterin et al., 1995)

Synonyms:
Bacterium vesicatorium (Doidge, 1920); *Bacterium exitiosum* (Gardner and Kendrick, 1921); *Xanthomonas vesicatoria* (Doidge, 1920) Dawson 1939; *Pseudomonas gardneri* (Sutic, 1957) = *Xanthomonas gardneri*; *Xanthomonas campestris* pv. *vesicatoria* (Doidge, 1920) Dye 1978; *Xanthomonas axonopodis* pv. *vesicatoria* (Vauterin at al., 1995) (A type strains) = *Xanthomonas euvesicatoria*; *Xanthomonas axonopodis* pv. *vesicatoria* (Vauterin et al., 1995) (C type strains) = *Xanthomonas perforans*.

Taxonomic position:
Kingdom *Bacteria*; phylum *Proteobacteria*; class *Gamma Proteobacteria*; order *Xanthomonadales*; family *Xanthomonadaceae*.

Common names used in English-speaking countries are the following: "bacterial spot" (most common), but also "bacterial scab" or "black spot".

3.1.2. Disease cycle

3.1.2.1. Inoculum sources

For all four species, contaminated seeds and transplants are the main sources of primary inoculum. Additionally, volunteers and plant residues might be a minor source of primary inoculum (Jones et al., 1986). Secondary inocula are produced in the field: they are mainly bacterial cells, sometimes in exudates from lesions developing on affected, aerial parts. Sources of secondary inocula are contaminated tools (clips, pinching scissors, etc.) commonly used by labourers during the usual agronomic practices put in place during the production of table tomatoes.

3.1.2.2. Infection

Bacteria that cause bacterial spot diseases are seed borne (Schuster and Coyne, 1974; Kennedy, 1979). Bacteria, representing the primary inoculum, may be present and viable both on the tegument (Leite et al., 1995), if no sanitation or disinfection has been done during seed production, and under the tegument. Less frequently, primary infections may be caused by the presence of infected plant debris or volunteers from a previous crop. Secondary inocula released from lesions on leaves and stems are spread via splashing water and wind driven rain. Bacteria may penetrate the host through natural openings such as hydathodes, stomata and lenticels (Allipi, 1992). Additionally, wounds, caused by agronomic operations (grafting, topping, clipping, tying, staking and harvesting, during spraying with pesticides and on clothes during crop handlings), are important penetration sites for the pathogens, especially for table tomato. In open-field cultivation systems, bacteria-supporting plant particles are produced during cultural practices and are exported from the field by ascendant air flux (Lindemann and Upper, 1985; McInnes et al., 1988).

The period between infection and symptom expression varies, ranging from 8 to 21 days, and is determined by temperature, plant age and soil characteristics, including the nutrient status of the plants. Conditions decreasing incubation periods also favour disease severity. The optimal growth temperature for xanthomonads is between 25 and 30 °C (Holt, 1994).

3.1.2.3. Symptomatology

The main host plants of *X. vesicatoria*, *X. euvesicatoria* and *X. gardneri* are tomato and pepper, but *X. perforans* affects mainly tomato (Ritchie, 2000; Mbega et al., 2012). Some races infect both pepper and tomato (P/T strains), whereas other races are specific for tomato (T races) or pepper (P races) (Ritchie, 2000). Pathogen aggressiveness and the development of symptoms frequently depend on the host–pathogen combination, i.e. *X. euvesicatoria* appears to be far more aggressive on bell pepper than on tomato (Obradović et al., 2004; Ignjatov et al., 2010).

On tomato, symptoms may appear on all aerial parts: leaves, fruits, petioles and stems. Leaves show initially water-soaked, angular lesions, which later become brown and necrotic. Foliar lesions may coalesce into foliar blights. A chlorotic halo might be observed, but not always. Necrotic spots may appear on petioles and stems, later enlarging and splitting into canker-like lesions. On fruits, lesions are initially tiny, blister-like spots, and are frequently raised. Spots increase in size and cracks appear at the centres, which become darker and later necrotising. Recently, pith necrosis has been associated with the presence of *X. perforans* (Aiello et al., 2013). The symptoms observed resemble those caused by the pathogenic bacterium *Pseudomonas corrugata*: pith discoloration and necrosis, hollowing of the centre of the stem and swollen stems with the production of numerous adventitious roots.

On pepper, foliar spots are irregular in shape, initially water soaked and then necrotising. Frequently, chlorotic haloes surround the necrotic spots and large chlorosis may develop on those leaves which are particularly affected. When the infection is severe, leaves may fall, thus resulting in defoliation. On fruits, lesions are scab-like and raised, and are rapidly necrotising.

3.1.2.4. Survival

Survival between crops is ensured by contaminated seeds and by plant debris and residues (mainly stems) for tomatoes and pepper grown in the open. This is more common in warm areas than in colder climates, where plant residues and volunteers are killed and degraded during the winter. There are no data on possible pathogen survival in soil, including surface water. Volunteers (see section 3.3.1, host range) and weeds may harbour the pathogens as an epiphyte. The role of weeds and volunteers in the epidemiology is still unclear, but is considered minor (Jones et al., 1986; Bogatzevska and Boneva, 1992).

3.1.2.5. Dispersal and spread

Bacteria may escape from leaf and stem lesions as exudates: short-distance dispersal is ensured by splashing water (irrigation and rain). This is particularly threatening during transplant production, when several thousands of transplants are growing crowded together, and in the field, in the case of sprinkler irrigation. Short-distance spread of the pathogen is also possible through contaminated tools, such as pruning scissors, knives and clips. Long-distance spread of tomato and pepper *Xanthomonas* spp. is commonly related to the trade of infected seeds and transplants (Stall et al., 1993; see also Figure 1).

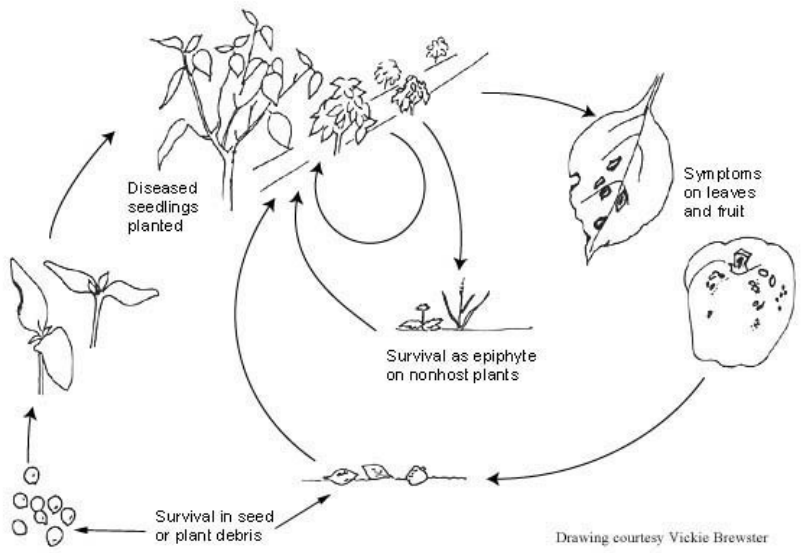

Figure 1: Disease cycle of the bacterial spot of tomato and pepper (Source: Ritchie, 2000)

3.1.3. Detection and identification of the pest

Detection and identification of the pest formerly known as *X. campestris* pv. *vesicatoria* should take into consideration that the pathogen listed in the Directive 2000/29/EU is now sub-divided into four different species. Nonetheless, the general procedure followed for their isolation and identification is based on the same strategy, for both tomato and pepper (EPPO, 2013). For symptomatic plant material, a few spots from leaves, petioles or fruits are collected and homogenised in a buffer. The resulting extract is then used for isolation on a general agar medium, such as YGCA or NA, or on a more specific medium, such as CKTM (Sijam et al., 1992), mMXV (Sijam et al., 1991) or mTMB (McGuire et al., 1982). Putative *Xanthomonas* spp. colonies grown on agar are then selected, purified and submitted to specific identification.

For symptomless material, mainly seeds and transplants, a representative sample is collected and analysed. For tomato and pepper seeds, a composite sample is represented by a minimum of 10 000 seeds, as recommended by the International Seed Federation (ISF) (ISF, 2011, 2013). For high-class hybrid seeds, the EPPO detection protocol for *Xanthomonas* spp. mentions a number of 2 000 seeds, although the probability of detecting the pathogen is lower (EPPO, 2013). For transplant analysis, there is no validated procedure.

Serological assays for the detection and identification of *Xanthomonas* spp. are indicated in the EPPO diagnostic protocol (EPPO, 2013). Nonetheless, no serological method has been validated so far and specificity of commercial polyclonal antibodies is not reported. Currently, two conventional duplex polymerase chain reaction (PCR) techniques are available to distinguish between the four species, in which four different couples of primers are used plus a 16S rRNA internal control (Koenraadt et al., 2009). A positive PCR assay on a pure culture should be preferentially followed by DNA barcoding identification for confirmation of the species identity and to distinguish races (Young et al., 2008; Parkinson et al., 2009; Hamza et al., 2010).

3.2. Current distribution

3.2.1. Global distribution

Xanthomonas campestris pv. *vesicatoria* is widely distributed, and is reported from all five continents. Nonetheless, in several countries, its presence is stated as either "no details" or as "few occurrences". The pest identity according to the new classification is, in most cases, "not stated/updated", since most of the reports date from before the new classification. According to the EPPO PQR database (EPPO, online), *X. vesicatoria* is widely distributed in all five continents (Ignatov et al., 2009; Kornev et al., 2009, Mbega et al., 2012). *X. euvesicatoria* is present in the USA (Ma et al., 2011), Tanzania (Mbega et al., 2012), some islands of the Indian Ocean (Hamza et al., 2010) and Serbia (Ignjatov et al., 2010; Gasić et al., 2011). *X. perforans* is reported to be present in the USA, Mexico, Brazil, Thailand (Jones et al., 2004), some islands of the Indian Ocean (Hamza et al., 2010) and Tanzania (Mbega et al., 2012). *X. gardneri* was isolated in the USA (Kim et al., 2010; Ma et al., 2011), Costa Rica (Bouzar et al., 1994), Canada, Brazil (Quezado-Duval et al., 2005), Russia (Kornev et al., 2009) and some islands of the Indian Ocean (Hamza et al., 2010).

3.2.2. Distribution in the risk assessment area

As indicated by the answers to a questionnaire sent by EFSA to Member States, the presence of *X. campestris* pv. *vesicatoria* is reported in 12 countries (Austria, Bulgaria, the Czech Republic, Germany, Greece, Hungary, Italy, Portugal, Romania, the Slovak republic, Slovenia and Spain) (Table 2). Data on the presence or absence of the organism are not available in Croatia, Latvia or Luxembourg.

Table 2: The current distribution of *Xanthomonas campestris* pv. *vesicatoria* in the risk assessment area, based on answers received from the 28 EU Member States, Iceland and Norway until March 2013

Member State	Current situation
Austria	**Present**, restricted distribution
Belgium	**Absent**, no pest record
Bulgaria	**Present**, restricted distribution
Croatia	– (no data at NPPO)
Cyprus	**Absent**, no records
The Czech Republic	**Present**, restricted distribution
Denmark	**Absent**, no pest records
Estonia	**Absent**, no pest records
Finland	**Absent,** no pest records

France	**Absent**
Germany	**Present**, few occurrences
Greece	**Present**, restricted distribution
Hungary	**Present**
Ireland	**Absent**, no pest records
Italy	**Present**, no details
Latvia[(a)]	–
Lithuania	**Absent**, no pest records
Luxembourg[(a)]	–
Malta	**Absent**, not known to occur
Poland	**Absent**, confirmed by surveys
Portugal	Unique detection in 1997
Romania	**Present**, restricted distribution
Slovak Republic	**Present**, widespread
Slovenia	**Present**, only in some areas
Spain[(a)]	**Present**, few occurrences
Sweden	**Absent**, no pest records
The Netherlands	**Absent**, confirmed by survey
The United Kingdom	**Absent**, pest no longer present
Iceland	**Absent**, no records
Norway	**Absent**, no pest record

(a): When no information was made available to EFSA, the pest status in the European and Mediterranean Plant Protection Organization Plant Quarantine Data Retrieval system (2014) was used.
–: No information available

Precise and detailed information concerning the current distribution in EU Member States of each of the four newly described *Xanthomonas* spp. is not available but, very recently, the presence of *X. perforans* was reported in Sicily (Aiello et al., 2013). Moreover, according to former comprehensive studies performed on a worldwide collection of isolates and based on serology, metabolic features and fatty acid methylester profiles (FAME), *X. euvesicatoria* (*X. campestris* pv. *vesicatoria* group A) have been detected on pepper in the past in Spain, Italy and Hungary (Bouzar et al., 1994; Buonaurio et al., 1994; Jones et al., 2004). *X. gardneri* has not been reported in the EU and no strain isolated in the EU has been described with features corresponding to those of *X. gardneri* in the literature and official collections of bacteria.

3.3. Host range and EU distribution of main host plants

3.3.1. Host range

Sweet pepper (*Capsicum annuum*) and tomato (*Solanum lycopersicum*) are the main host plants of strains belonging to the former *X. campestris* pv. *vesicatoria*.

Capsicum anomalum, *C. baccatum*, *C. chacoense*, *C. chinensis*, *C. frutescens*, *C. galapagoense* and one accession out of two of *C. pubescens* were found to be susceptible to *X. campestris* pv. *vesicatoria* race P6 after artificial inoculation (Sahin and Miller, 1998).

The new classification of the pathogen into four distinct species made by Jones et al. (2004) gave new insights into host preferences and pathogenicity. *X. vesicatoria* and *X. euvesicatoria* are both pathogenic on tomato and pepper, although their amylolytic and pectolytic activities are different. *X. gardneri* is a pathogen mainly affecting tomato and, to a lesser extent, *C. annuum*. *X. perforans* has been reported to affect tomato only, except for one recent report in Tanzania mentioning pathogenicity on both tomato and pepper for a set of 18 isolates (Mbega et al., 2012).

No other natural hosts have been reported so far. Nonetheless, survival of *X. campestris* pv. *vesicatoria*, was seen on the following weeds, if present during tomato cultivation in Florida (USA): *Solanum americanum*, *Physalis pubescens*, *Ambrosia artemisiifolia*, *Eclipta alba*, *Trifolium repens* and *Eupatorium capillifolium* (Jones et al., 1986). With the exception of *T. repens* (native in Europe) all listed weeds are native to the Americas. *A. artemisiifolia* is now also present in the EU.

Races and pathotypes have been described in the past for *X. campestris* pv. *vesicatoria* (11 races for pepper, four races for tomato) (Cook and Stall, 1982; Hartman and Yang, 1990; Kousik and Ritchie, 1996; Sahin, 2001) before the re-organisation into the cited four different species. Shifts in races have also been documented (Jones at al., 1998). The current species show the presence of races as well, for example *X. vesicatoria*, *X. gardneri* (Sahin, 2001; Quezado-Duval and Camargo, 2004) and *X. perforans* (Hutton at al., 2010; Wang et al., 2011).

3.3.2. EU distribution of main hosts

Tomato is one of the most important vegetable crops in Europe; apart from in a few countries, it is widely cultivated, both in protected environments and in the open (Hucorne, 2012). Pepper is also an important vegetable, although its area of production is less extensive. In Table 3, the production area for tomato and pepper (*Capsicum annuum*) in the EU Member States in 2012 is shown.

Table 3: Area of production in 1 000 ha of tomatoes and peppers in 2012, as extracted from the EUROSTAT database (crops products – annual data (apro_cpp_crop)) on 18 March 2014

Country	Tomatoes	Tomatoes for fresh consumption under glass or high accessible covers	Red peppers	Red peppers under glass or high accessible covers
Austria	0.2	0.2	0.2	0.1
Belgium	0.5	0.5	0.1	0.1
Bulgaria	3.4	0	3	0
Croatia	0.4	0.1	1	0.6
Cyprus	0.2	–	–	–
The Czech Republic	0.4	0	0	0
Denmark	0	0	0	0
Estonia	0	0	–	–
Finland	0.1	0.1	0	0
France	5.2	2	0.5	0
Germany	0.3	0.3	0.1	0.1
Greece	16	2.8	4.3	1
Hungary	1.8	0.4	2	–
Ireland	0	0	0	0
Italy	91.9	6.4	9	2.3
Latvia	0	0	0	0
Lithuania	0.6	0	0	0
Luxembourg	0	0	–	–
Malta	0.3	–	–	–
The Netherlands	1.7	1.7	1.3	1.3
Poland	13.1	2.2	2.5	1.1
Portugal	15.4	1	1.4	0.1
Romania	29.8	1.4	11.6	0.3
Slovakia	0.5	0	0.3	0
Slovenia	0	0	0	0
Spain	48.6	18.5	17.4	10.7
Sweden	0	0	0	0
The United Kingdom	0	0	0	0
EU-28	230.4	37,6	54.7	17.7

–: Data not available.

3.4. Regulatory status

3.4.1. Legislation directly addressing the pest

The pathogen is regulated as a harmful organism in the EU and is listed in Council Directive 2000/29/EC in the following section:

Annex II, Part A - Harmful organisms whose introduction into, and spread within, all Member States shall be banned if they are present on certain plants or plant products

Section II - Harmful organisms known to occur in the Community and relevant for the entire Community

(b) Bacteria

Species	Subject of contamination
2. *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye	Plants of *Lycopersicon lycopersicum* (L.) Karsten ex Farw. and *Capsicum* spp., intended for planting

3.4.2. Legislation addressing hosts of the pest

It is prohibited to import plants intended for planting, other than seeds, of host plant species of *X. campestris* pv. *vesicatoria* from third countries, other than European and Mediterranean countries (Council Directive 2000/29/EC, Annex III, part A (13)).

Annex III, Part A - Plants, plant products and other objects the introduction of which shall be prohibited in all Member States

Description	Country of origin
13. Plants of *Solanaceae* intended for planting, other than seeds and those items covered by Annex III A (10), (11) or (12)	Third countries, other than European and Mediterranean countries

Special requirements with respect to *X. campestris* pv. *vesicatoria* have been formulated in Council Directive 2000/29/EC for the import of seeds of tomato, originating in non-EU countries, into EU Member States (Annex IV, part A, section I) and for movement of seeds of tomato, originating in the EU, within the EU (Annex IV, part A, section II).

Annex IV, part A - Special requirements which must be laid down by all Member States for the introduction and movement of plants, plant products and other objects into and within all Member States

Section I - Plants, plant products and other objects originating outside the Community

Plants, plant products and other objects	Special requirements
48. Seeds of *Lycopersicon lycopersicum* (L.) Karsten ex Farw.	Official statement that the seeds have been obtained by means of an appropriate acid extraction method or an equivalent method approved in accordance with the procedure referred to in Article 18(2), AND (a) either the seeds originate in areas where *Clavibacter michiganensis* ssp. *michiganensis* (Smith) Davis et al., *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye and *Potato spindle tuber viroid* are not known to occur; OR (b) no symptoms of diseases caused by those harmful organisms have been observed on the plants at the place of

	production during their complete cycle of vegetation; OR (c) the seeds have been subjected to official testing for at least those harmful organisms, on a representative sample and using appropriate methods, and have been found, in these tests, free from those harmful organisms.

Section II — Plants, plant products and other objects originating in the Community

Plants, plant products and other objects	**Special requirements**
27. Seeds of *Lycopersicon lycopersicum* (L.) Karsten ex Farw.	Official statement that the seeds have been obtained by means of an appropriate acid-extraction method or an equivalent method approved in accordance with the procedure referred to in Article 18(2), AND (a) either the seeds originate in areas where *Clavibacter michiganensis* ssp. *michiganensis* (Smith) Davis et al., or *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye are not known to occur; OR (b) no symptoms of diseases caused by those harmful organisms have been observed on the plants at the place of production during their complete cycle of vegetation; OR (c) the seeds have been subjected to official testing for at least those harmful organisms, on a representative sample and using appropriate methods, and have been found, in these tests, free from those harmful organisms.

The Panel notes that, according Annex II, part A, section II, the introduction of *X. campestris* pv. *vesicatoria* into, and its spread within all Member States, shall be banned if it is found to be present on plants of *Lycopersicon lycopersicum* and *Capsicum* spp. intended for planting. For introduction via plants for planting of these species, other than seeds, into the EU from third countries other than European and Mediterranean countries, this ban is covered by Annex III, part A (13). For the introduction of *X. campestris* pv. *vesicatoria* into the EU via tomato seeds, this ban is covered by Annex IV, part A, section I (48). However, no special requirements have been formulated to prevent the introduction into the EU of *X. campestris* pv. *vesicatoria*, when present on seeds of *Capsicum* spp. Since *Capsicum* spp. are the main hosts of *X. campestris* pv. *vesicatoria*, the absence of such special requirements may increase the probability of entry into the EU of this pathogen.

Special requirements with respect to *X. campestris* pv. *vesicatoria* have been formulated for the movement of tomato seeds within the EU (Annex IV, part A, section II (27)), but not for seeds of *Capsicum* spp. Moreover, there are no special requirements with respect to *X. campestris* pv. *vesicatoria* in Annex IV, part A, section II, for the movement within the EU of plants for planting (other than seeds) of tomato and *Capsicum* spp. The absence of such special requirements may increase the probability of spread within the EU of this pathogen.

Plants for planting other than seeds of *Solanaceae*, and seeds of tomato, originating in the EU, are listed in Annex V, part A, section I (2), of Council Directive 2000/29/EC. This means that a plant passport is required for movement of these plants within the EU if their production and sale is authorised by persons professionally engaged in plant production, that is producers of solanaceous plants and fruits.

Plants for planting other than seeds of *Solanaceae*, and seeds of tomato, prepared and ready for sale to the final consumer (hobby gardeners), do not require a plant passport for movement within the EU, provided that it is ensured by the responsible official bodies of the Member States that their production is clearly separate from that of other products.

Annex V - Plants, plant products and other objects which must be subjected to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community, or in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community

Part A - Plants, plant products and other objects originating in the Community

> Section I—Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport
>
> 2. Plants, plant products and other objects, the production and sale of which is authorised by persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer, and for which it is ensured by the responsible official bodies of the Member States that the production thereof is clearly separate from that of other products
>
> > 2.2. Plants of *Solanaceae*, other than those referred to in point 1.3, intended for planting, other than seeds
> >
> > 2.4. Seeds of *Helianthus annuus* L., *Lycopersicon lycopersicum* (L.) Karsten ex Farw. and *Phaseolus* L.

The Panel notes that a plant passport is not required for seeds of *Capsicum* spp.

According to Annex V, part B, section I (1), a plant health inspection in the country of origin or the consignor country is required for plants intended for planting other than seeds, of *Capsicum* spp. and *Lycopersicon lycopersicum* (L.) Karsten ex Farw. (among other plant species), originating outside the Community.

Part B - Plants, plant products and other objects originating outside the Community

> Section I - Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community
>
> > 1. Plants, intended for planting, other than seeds, but including seeds of […], *Capsicum* spp. […], *Lycopersicon lycopersicum* (L.) Karsten ex Farw. […]

3.5. Potential for establishment and spread in the risk assessment area

3.5.1. Availability of suitable host plants (outdoors, in protected cultivation or both)

Suitable host plants for xanthomonads causing bacterial spot of tomato and pepper are present in all Member States in the EU. Tomato and pepper plants are cultivated in greenhouses, tunnels or other protected environments in all EU Member States (see Table 3). Both are susceptible crops, especially tomato for industrial processing, and are cultivated in open fields in southern EU Member States.

3.5.2. Suitability of environments

The severity of bacterial spot on tomato and pepper is under the influence of temperature, humidity and leaf wetness period (Timmer et al., 1987). Tomato bacterial spot is more severe at 25 °C (Marcuzzo et al., 2009). Suitable climatic conditions for bacterial spot are frequently met in open fields in several Member States where the disease has been regularly reported (Bulgaria, Greece,

Spain, Italy, Hungary, Romania). Favourable climatic conditions for bacterial spot were also reported in pepper crop grown in greenhouses in Germany (Griesbach et al., 1988).

3.5.3. Cultural practices

Cultivation practices may largely contribute to the spread of the disease within the plots (Pohronezny et al., 1990) by disseminating the bacteria, via wounding of the plants, and through the establishment of conditions favouring symptom expression. In the nursery, grafting on rootstock (for both tomato and pepper) and clipping of tomato plants to produce two stems have favoured the dissemination and spread of the pathogen, as these practices produce wounds on both rootstock and scion. Grafting pepper on tomato rootstocks is particularly important for a productive crop, in order to obtain plants with a certain degree of tolerance to soil fungi, especially *Rhizoctonia solani*. In greenhouses and open fields, the handling of transplants, clipping and pruning, to remove leaves or shoots that developed from axillary buds, de-leafing, suckering are practices that allow bacterial infection. Peppers are regularly harvested by cutting the fruit with a blade or a scissor at the base of the stem; therefore, large wounds are caused through which bacteria may easily penetrate and start new infections. In the cultivation of processing tomatoes, seedlings are sometimes clipped with rotary mowers to ensure a uniform stand. Xanthomonads released from infected plants or present as epiphytes can be spread by overhead irrigation or chemical sprays.

3.5.4. Control methods

Methods and procedures are available to control xanthomonads that affect both tomato and pepper. Control methods should be routinely applied to seeds and, after a disease outbreak, at the field level. Nevertheless, the best control strategy is achieved through seed certification and development of resistance varieties.

3.5.4.1. Seed treatment

Directive 2000/29/EC indicates that tomato seeds should be obtained by means of an appropriate acid extraction method or an approved equivalent method. The two methods of tomato seed extraction available are the fermentation process and acid extraction. The fermenting process is performed for 48 to 96 hours and the temperature stays under 21 °C. Clean seeds extracted by mechanical means without fermentation should be acid treated. Acid treatments include 5 % HCl, 10 % HCl, 5 % H_2SO_4, 10 % H_2SO_4 and sodium carbonate (5 %) (Shumbulo et al., 2012). Although the fermentation process and the acetic acid treatment result in some reduction in germination, this is usually negligible. Pepper seeds are only mechanically extracted and there is no indication in the above mentioned Directive regarding whether or not they should be treated. For both seeds, a hot water soak has long been recommended (50 °C for 25 minutes) to control seed-borne bacteria. Satisfactory control has been obtained for bacterial diseases of tomato and pepper (Grondeau and Samson, 1994). Dry heat therapy treatment (70 °C for 96 hours) was shown to be effective for eliminating *X. campestris* pv. *vesicatoria* in seed lots (Silva et al., 2002). Additionally, seed disinfection with selected chemicals is commonly used in seed processing by seed companies (i.e. film coating), but methods and chemicals vary and are either confidential or patented for competitive aspects.

3.5.4.2. At the field level

Control of the disease in the field is particularly cumbersome once infection occurs. Various chemicals were tested to control bacterial spot on tomato and pepper (Pham et al., 2004; Silva et al., 2006; Maneva et al., 2009; Nascimento et al., 2013). No chemicals were found to be efficient to control the disease in the field. Nonetheless, Italian integrated pest management (IPM) strategies suggest treatments with copper compounds and Acybenzolar-S-Methyl, both in covered crops and in the field, to reduce the secondary spread of the pathogen in tomato and pepper cultivations. In addition to these chemicals, Mancozeb enhanced the bactericidal activity of copper in France (Lecigne et al., 2000). Bacteriophages have been described as being very active against *X. euvesicatoria in vitro*, but their use in the field has not yet been attempted (Gasić et al., 2011). A four-year crop rotation is recommended

in IPM to control disease, including tomato bacterial spot in tomato crop production for industrial processing in Italy.

3.5.4.3. Selection for resistant varieties

Three sources of resistance were identified in different species of *Solanum lycopersicon* (Jones and Scott, 1986; Scott et al., 1995; Astua-Monge et al., 2000a, b). Furthermore, quantitative resistance was identified in some commercial tomato varieties (Stall et al., 2009). Pepper was extensively used for studying the host specificity of *X. vesicatoria* and *X. gardneri* in pepper varieties. However, no variety is resistant to all races of *Xanthomonas* (Kousik and Ritchie, 1998; Stall et al., 2009).

3.5.5. Spread capacity

3.5.5.1. Role of seed

Long-distance dissemination of xanthomonads causing bacterial spot disease is ensured by means of contaminated seeds in trade (Gardner and Kendrik, 1921, 1923; Bashan et al., 1982; Moffett and Croft, 1983; Jones at al, 1986; Sijam et al., 1991; Carmo et al., 2001). Black et al. (2001) reported that farmers saved tomato seeds that often were more contaminated than commercial tomato seeds. Pepper seeds were found to be more frequently contaminated than tomato seed lots (Black et al., 2001). Contaminated seeds lead to infection of seedlings; therefore, bacteria colonise the whole plants and can survive as residents on roots, epicotyls, cotyledons and leaves at least 30 days after sowing without necessarily causing symptoms (Silva et al., 2013).

Current seed extraction from tomato fruits involves fermentation or acid extraction, which supposedly reduce the bacterial load. Consequently, there is controversy regarding whether or not sanitised tomato seeds are still a source of primary inoculum and a pathway for pathogen dissemination (Jones et al., 1986). The pathogen is seed borne and seeds are considered the major means for long-distance dispersal. The pathogen can survive for years on seeds. A few infected plants can lead to outbreaks (Jones et al., 1991).

3.5.5.2. Role of planting material

Most tomato and pepper plants planted for producing fruit in the field, and in greenhouses as well, have been raised in nurseries. Transplants can also be a primary infection source where xanthomonads can survive epiphytically and endophytically, and can result in for long-distance dispersal. Transplants may have been contaminated without visible symptoms before planting, because the environmental conditions in nurseries could be unfavourable for disease expression (lack of free water on plant surface, no wind, no optimal temperature, tolerant varieties).

3.5.5.3. Role of crop debris and volunteer plants

The pathogen can survive in tomato debris or plant residues on the soil surface for enough time to establish infections on seedlings in the following season (Jones et al., 1986). Dead tomato plants were shown to play a role in the survival of *X. campestris* pv. *vesicatoria* in the USA (Peterson, 1963). Infected volunteer tomato plants were found to be a source of inoculum of *X. campestris* pv. *vesicatoria* (Gardner and Kendrick, 1923; Peterson, 1963). *X. campestris* pv. *vesicatoria* was detected on volunteer tomato plants grown in the spring from seeds produced the previous year.

3.5.5.4. Role of alternative hosts

Apart from tomato and pepper, no alternative host is known for *X. campestris* pv. *vesicatoria* (Ravikumar and Khan, 2000).

3.5.5.5. Other sources of inoculum

No other sources of inoculum are known.

3.6. Potential for consequences in the risk assessment area

3.6.1. Pest effects on host plants

Pohronezny and Volin (1983) noted significant yield losses, especially of larger fruits, from early infection by bacterial spot pathogens. Disease severity on tomato reached 30.22 % with a total productivity of 117.88 tonnes per ha in Brazil (Marcuzzo et al., 2009). A reduction from 30 % to 43 % of marketable tomato fruit was recorded in non-treated fields, caused by bacterial spot of tomato (Pernezny et al., 1996). Fruit yields are directly affected, but the presence of fruit spots usually results in a loss of marketability. Bacterial spot has become a very worrying disease in Serbia (Obradović et al., 2004), Macedonia (Mitrev and Kovačević, 2006) and Turkey (Aysan and Sahin, 2003). The leaf spots tend to coalesce causing leaf blight and premature abscission, especially in pepper. In Italy, the most important tomato-producing country of the EU, epidemics have been reported over the past decades (Laviola, 1965; Ragozzino, 1968; Buonaurio and Stravato, 1992) and, nowadays, the disease is considered a major threat for tomato and pepper production. In Spain, *X. campestris* pv. *vesicatoria* is considered a major bacterial pathogen and affects peppers more severely than tomatoes (Lopez et al., 1985; Melgarejo et al., 2010).

3.6.2. Environmental consequences

No impact was reported on any plants other than tomato and pepper caused by any strains of *X. vesicatoria*, *X. euvesicatoria*, *X. perforans* or *X. gardneri*.

3.7. Conclusions on the pest categorisation

Identity of the pest

Xanthomonas campestris pv. *vesicatoria* is not a single taxonomic entity, and strains causing bacterial spot of tomato and pepper known with that name nowadays fall into four separate species: *X. vesicatoria*, *X. euvesicatoria*, *X. perforans* and *X. gardneri*. These organisms under assessment are clear, distinguished taxonomic entities and they can be accurately identified based on a range of discriminative methods. All these species can cause a wide variety of symptoms on their host plants, which include angular lesions that later become brown and necrotic on the leaf, fruit, petiole and stem. Some symptoms may be confused with those caused by other organisms. No difference in aggressiveness has been reported between the four bacterial spot-causing species, whereas a variation in virulence has been observed. All bacterial species cause disease on tomato and pepper. Races were described within all *Xanthomonas* spp. causing bacterial spot on tomato and/or pepper according to the cultivar resistance pattern. The control methods for all four species are identical and the conclusions are the same for all four species.

Presence in the risk assessment area

Among the four species described within *X. campestris* pv. *vesicatoria*, only three were reported to be present in the EU territory. *X. vesicatoria* is reported from 12 EU countries; strains of *X. euvesicatoria* were reported in Spain, Hungary (Jones et al., 2004) and Italy (Buonaurio et al., 1994), although these data were obtained characterising isolates present in several collections. The presence of *X. perforans* was recently reported in Sicily, Italy (Aiello et al., 2013). *X. gardneri* has not been reported in the EU at present.

Regulatory status

The pathogen is listed in Council Directive 2000/29/EC, Annex II A II, as a harmful organism, known to occur in the Community, and as relevant for the entire Community, whose introduction into, and spread within, all Member States shall be banned if it is found to be present on certain plants or plant products. Measures regulating the import into and movement within the EU of potentially infected host plants include special requirements with respect to *X. campestris* pv. *vesicatoria* for specified

plant material, prohibition of import for specified plants from specified third countries and official control of host plant material produced within the EU for use by professional producers of plants and fruits.

The Panel notes that there are no regulatory special requirements in place with respect to *X. campestris* pv. *vesicatoria* for the movement within the EU of seeds of *Capsicum*. This may increase the probability of spread of the pathogen on this commodity.

Potential for establishment and spread in the risk assessment area

Tomato and sweet pepper are major vegetable crops in Europe, which are widely grown in the Mediterranean countries of the EU, in Poland and in Romania. The main hosts of bacterial spot-causing xanthomonads are tomatoes and peppers.

The disease has mainly been observed in field crops but can occur in greenhouses as well. The environmental conditions in south Europe are particularly favourable for disease expression in the field, as the optimal growth temperature for xanthomonads is between 25 and 30 °C.

The pathogen is seed borne and seeds are considered the major means for long-distance dispersal. The pathogen can survive for years on seeds. A few infected plants can lead to outbreaks. Transplants can also be a primary infection source where xanthomonads can survive epiphytically and endophytically, and can serve as a means of long-distance dispersal. At production sites, tomato volunteer plants and crop debris, in which xanthomonads can survive, are recognised as playing a key role as a source of inoculum. Heavy rain, irrigation, wind and cultivation practices, including clipping and pruning, largely contribute to rapid spread of the pathogen in a crop.

Control is mainly based on prevention and exclusion. Detection methods are available for seeds. Extraction of seeds from fruit debris using fermentation and acid treatments reduces xanthomonad populations on tomato seeds. Thermotherapy treatment has been shown to be effective in eliminating xanthomonads in seed lots. No methods and chemical control agents are available that effectively control xanthomonads in infected crops.

Potential for economic and environmental consequences in the risk assessment area

Although no recent data are available on economic losses caused by the pathogen in the EU, the organism is considered an important bacterial pathogen of tomato and pepper. Infections resulting in losses of up to 30 % have been reported.

Xanthomonads causing bacterial spot meet the following ISPM 11 criteria:

Identity of the pest: X. campestris pv. *vesicatoria* is not a single taxonomic entity, and strains causing bacterial spot of tomato and pepper known with that name nowadays fall into four separate species: *X. vesicatoria*, *X. euvesicatoria*, *X. perforans* and *X. gardneri*. These organisms are clear, distinguished taxonomic entities and they can be accurately identified based on a range of discriminative methods. No difference in aggressiveness has been reported between bacterial spot-causing species, whereas a variation in virulence has been observed. All bacterial species cause disease on tomato and pepper.

Presence or absence in the risk assessment area: X. vesicatoria, *X. euvesicatoria* and *X. perforans* were reported to be present in the EU territory. However, *X. gardneri* has not been reported in the EU.

Regulatory status: the pest is under official control.

Potential for establishment and spread in the risk assessment area: the risk assessment area has ecological and climatic conditions, including in protected conditions, suitable for the establishment and spread of the pest and host species.

Potential for economic consequences (including environmental consequences) in the risk assessment area: the organism is considered an important bacterial pathogen of tomato and pepper. Infections resulting in losses of up to 30 % have been reported.

Xanthomonads causing bacterial spot meet all criteria defined in ISPM 21: they are seed-borne bacteria and can be present in plants for planting (seeds and transplants), which affects the intended use of those plants with an impact.

No major uncertainties were identified within the pest categorisation.

DOCUMENTATION PROVIDED TO EFSA

1. Request to provide a scientific opinion on the risk to plant health of 13 regulated harmful organisms, for the EU territory. Ref. Ares(2012)880155—19/07/2012. Submitted by European Commission, DG SANCO (Directorate General for Health and Consumers).

2. Request to provide a scientific opinion on the risk to plant health of 38 regulated harmful organisms, for the EU territory. Ref. Ares(2014)970361—28/03/2014. Submitted by European Commission, DG SANCO (Directorate General for Health and Consumers).

REFERENCES

Aiello D, Scuderi G, Vitale A, Firrao G, Polizzi G and Cirvilleri G, 2013. A pith necrosis caused by *Xanthomonas perforans* on tomato plants. European Journal of Plant Pathology, 137, 29–41.

Allipi AM, 1992. Histopatologia de hojas de tomate inoculadas com *Xanthomonas campestris* pv. *vesicatoria*. Agronomie, 12, 115–122.

Astua-Monge G, Minsavage GV, Stall RE, Davis MJ, Bonas U and Jones JB, 2000a. Resistance of tomato and pepper to T3 strains of *Xanthomonas campestris* pv. *vesicatoria* is specified by a plant –indicible avirulence gene. Molecular Plant Microbe Interactions, 13, 911–921.

Astua-Monge G, Minsavage GV, Stall RE, Vallejos CE, Davis MJ and Jones JB, 2000b. Xv4-AvrXv4: a new gene-for-gene interaction identified between *Xanthomonas campestris* pv. *vesicatoria* race T3 and the wild tomato relative *Lycopersicon pennellii*. Molecular Plant Microbe Interactions, 13, 1346–1355.

Aysan Y and Sahin F, 2003. Occurrence of bacterial spot disease, caused by *Xanthomonas axonopodis* pv. *vesicatoria*, on pepper in the Eastern Mediterranean region of Turkey. Plant Pathology, 52, 781.

Bashan Y, Diab S and Okon Y, 1982. Survival of *Xanthomonas campestris* pv. *vesicatoria* in pepper seeds and roots, in symptomless and dry leaves, in on-host plants and in the soil. Plant and Soil, 68, 161–170.

Black R, Seal S, Abubakar Z, Nono-Womdin R and Swai I, 2001. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) of tomato and sweet pepper in Tanzania. Plant Pathology, 50, 810.

Bogatzevska N and Boneva P, 1992. Survival of *Xanthomonas vesicatoria* on weeds in Bulgaria. Report of the Tomato Genetic Cooperative, Cornell University, Ithaca, New York, 42, p. 12.

Bouzar H, Jones JB, Stall RE, Hodge NC, Minsavage GV, Benedict AA and Alvarez AM, 1994. Physiological, chemical, serological and pathogenic analyses of a worldwide collection of *Xanthomonas campestris* pv. *vesicatoria* strains. Phytopathology, 84, 663–671.

Bouzar H, Jones JB, Stall RE, Daouzli N, Lambe R and Felix-Gastelum RC, 1996. Diversity of *Xanthomonas campestris* pv. *vesicatoria* in tomato and pepper fields of Mexico. Canadian Journal of Plant Pathology, 18, 75–77.

Buonaurio R, Stravato VM and Scortichini M, 1994. Characterization of *Xanthomonas campestris* pv. *vesicatoria* from *Capsicum annuum* L. in Italy. Plant Disease, 78, 296–299.

Buonaurio R and Stravato VM, 1992. *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye su peperone in Italia central. Informatore Fitopatologico, 42, 49–52.Cook AA and Stall RE, 1982. Distribution of races of *Xanthomonas vesicatoria* pathogenic on pepper. Plant Disease, 66, 388–389.

Carmo MGF, Macagnan D and Carvalho AD, 2001. Progreso da mancha bacteriana do pimentão a partir de diferentes niveis iniciais de inoculo e do emprego ou não do controle com oxicloreto de cobre. Horticultura Brasileira, 19, 210–215.

Doidge EM, 1921. A tomato canker. Annals of Applied Biology, 7, 407–430.

Dye DW, 1966. Cultural and biochemical reaction of additional *Xanthomonas* species. New Zealand Journal of Science, 9, 913–919.

Dye DW, 1978. Genus IX. *Xanthomonas*. Dowson 1939. In: A proposed nomenclature and classification for plant pathogenic bacteria. Eds Young JM, Dye DW, Bradbury JF, Panagopoulos CG and Robbs CF. New Zealand Journal of Agricultural Research, 21, 153–177.

Dye DW, Bradbury JF, Goto M, Hayward AC, Lelliott RA and Schroth M, 1980. International standards for naming pathovars of phytopathogenic bacteria and a list of pathovar names and pathotypes. Review of Plant Pathology, 59, 153–168.

EFSA PLH Panel (EFSA Panel on Plant Health), 2010. Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options by EFSA. EFSA Journal 2010;8(2):1495, 66 pp. doi:10.2093/j.efsa.2010.1495

EPPO (European and Mediterranean Plant Protection Organization), 2013. EPPO Standards Diagnostic PM 7/110(1) *Xanthomonas* spp. (*Xanthomonas euvesicatoria*, *Xanthomonas gardneri*, *Xanthomonas perforans*, *Xanthomonas vesicatoria*) causing bacterial spot of tomato and sweet pepper. EPPO Bulletin, 43, 7–20.

EPPO (European and Mediterranean Plant Protection Organization), online. EPPO-PQR (Plant Quarantine Data Retrieval system). Available at: www.eppo.int/DATABASES/pqr/pqr.htm

FAO (Food and Agriculture Organization of the United Nations), 2004. ISPM 21: International standards for phytosanitary measures; pest risk analysis of regulated non-quarantine pests. FAO, Rome. Available at: https://www.ippc.int/sites/default/files/documents//1323945746_ISPM_21_2004_En_2011-11-29_Refor.pdf

FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM 11: International standards for phytosanitary measures; Pest risk analysis for quarantine pests,. FAO, Rome. Available at: https://www.ippc.int/sites/default/files/documents/20140512/ispm_11_2013_en_2014-04-30_201405121523--494.65%20KB.pdf

Gardner MW and Kendrick JB, 1921. Bacterial spot of tomato. Journal of Agricultural Research, 21, 123–156.

Gardner MW and Kendrick JB, 1923. Bacterial spot of tomato and pepper. Phytopathology, 13, 307–315.

Gasić K, Ivanovic MM, Ignjatov M, Calic A and Obradovic A, 2011. Isolation and characterization of *Xanthomonas euvesicatoria* bacteriophages. Journal of Plant Pathology, 93, 415–423.

Griesbach E, Lattauschke G, Schmidt A and Naumann K, 1988. On the occurrence of *Xanthomonas campestris* pv. *vesicatoria* on pepper under glass and plastic. Nachrichtenblatt fur den pflanzenschutz in der DDR, 42, 176–178.

Grondeau C and Samson, R, 1994. A review of thermotherapy to free plant materials from pathogens, especially seeds from bacteria. Critical Reviews in Plant Sciences, 13, 57–75.

Hamza AA, Robene-Soustrade I, Jouen E, Gagnevin L and Lefeuvre P, 2010. Genetic and pathological diversity among *Xanthomonas* strains responsible for bacterial spot on tomato and pepper in the Southwest Indian Ocean Region. Plant Disease, 94, 993–999.

Hartman GL and Yang CH, 1990. Occurrence of three races of *Xanthomonas campestris* pv. *vesicatoria* on pepper and tomato in Taiwan. Plant Disease, 74, 252.

Hayward AC and Waterson JM, 1964. *Xanthomonas vesicatoria*. CMI description of pathogenic fungi and bacteria No 20. CABI International, Wallingford, UK.

Hildebrand DC, Palleroni NJ and Schroth MN, 1990. Deoxyribonucleic acid relatedness of 24 xanthomonad strains representing 23 *Xanthomonas campestris* pathovars and *Xanthomonas fragariae*. Journal of Applied Bacteriology, 68, 263–269.

Holt JJ, 1994. Bergey's manual of determinative bacteriology. Lippincott William and Wilkins, Philadelphia, Pennsylvania, 787 pp.

Hucorne P, 2012. The actual distribution of crops in Europe. 36 pp. Available at: www.eppo.int/PPPRODUCTS/zonal_efficacy/zonal_map.pdf

Hutton SF, Scott JW, Yang W, Sim S-C, Francis DM and Jones JB, 2010. Identification of QTL associated with resistance to bacterial spot race T4 in tomato. Theoretical and Applied Genetics, 121, 1275–1287.

Ignatov AN, Kornev KP, Matveeva EV, Pekhtereva ES, Polytiko VA, Budenkov, NI and Schhad NW, 2009. Occurrence of bacterial spot and bacterial canker in the Russian Federation. Acta Horticulturae (ISHS), 808, 247–249.

Ignjatov M, Gasić K, Ivanović M, Šević M, Obradović A and Milošević M, 2010. Characterisation of *Xanthomonas euvesicatoria* strains pathogens of pepper in Serbia. Pesticidi i Fitomedicina, 25, 139–149.

ISF (International Seed Federation), 2011. Method for the detection of *Xanthomonas* spp. on tomato seed. Version 4, August 2011. 5pp. Available at: www.worldseed.org/cms/medias/file/TradeIssues/PhytosanitaryMatters/SeedHealthTesting/ISHI-Veg/Tomato_Xanthomonas_spp_010811.pdf

ISF (International Seed Federation), 2013. Method for the detection of *Xanthomonas* spp. on pepper seed. Version 5, November 2013. 7 pp. Available at: www.worldseed.org/cms/medias/file/TradeIssues/PhytosanitaryMatters/SeedHealthTesting/ISHI-Veg/Pepper_Xanthomonas_spp_Nov_2013.pdf

Jones JB and Scott JW, 1986. Hypersensitive response in tomato to *Xanthomonas campestris* pv. *vesicatoria*. Plant Disease, 70, 337–339.

Jones JB, Pohronezny KL, Stall RE, and Jones JB, 1986. Survival of *Xanthomonas campestris* pv. *vesicatoria* in Florida on tomato crop residues, weeds, seeds and volunteer tomato plants. Phytopathology, 76, 430–434.

Jones JB, Woltz SS, Jones JP and Portier KL, 1991. Population dynamics of *Xanthomonas campestris* pv. *vesicatoria* on tomato leaflets treated with copper bactericides. Phytopathology, 81, 714–719.Jones JB, Stall RE, Somodi GC, Bouzar H and Hodge NC, 1995. A third tomato race of *Xanthomonas campestris* pv. *vesicatoria*. Plant Disease, 79, 395–398.

Jones JB, Bouzar H, Somodi GC, Stall RE, Pernezny K, El-Morsy G and Scott JW, 1998. Evidence for the preemptive nature of tomato race 3 of *Xanthomonas campestris* pv. *vesicatoria* in Florida. Phytopathology, 88, 33–38.

Jones JB, Bouzar H, Stall RE, Almira EC, Roberts PD, Bowen PW, Sudberry J, Strickler PM and Chun J, 2000. Systematic analysis of xanthomonads (*Xanthomonas* spp.) associated with pepper

and tomato lesions. International Journal of Systematic and Evolutionary Microbiology, 50, 1211–1219.

Jones JB, Lacy GH, Bouzar H, Stall RE and Schaad NW, 2004. Reclassification of the xanthomonads associated with bacterial spot disease of tomato and pepper. Systematic Applied Microbiology, 27, 755–762.

Kennedy BW, 1979. In: Seed pathology problems in progress. Eds Yorinori JT, Sinclair JB, Mehta YR and Mohan SK. Parana, Brazil, 155–156.

Kim SH, Olson TN, Peffer ND, Nikolaeva EV, Park S and Kang S, 2010. First report of bacterial spot of tomato caused by *Xanthomonas gardneri* in Pennsylvania. Plant Disease, 94, 638.

Koenraadt H, van Betteray B, Germain R, Hiddink G, Jones JB, Oosterhof J, Rijlaarsdam A, Roorda P and Woudt B, 2009. Development of specific primers for the molecular detection of bacterial spot of pepper and tomato. Proceedings of the 2nd International Symposium on Tomato Diseases. Eds Saygili H, Sahin F and Aysan Y. Acta Horticulturae, 808, 99–102.

Kornev KP, Matveeva EV, Pekhtereva ES, Polytiko VA, Ignatov AN, Punina NV and Schaad NW, 2009. *Xanthomonas* species causing bacterial spot of tomato in the Russian Federation. Acta Horticulturae (ISHS), 808, 243–246.

Kousik CS and Ritchie DF, 1996. Race shift in the *Xanthomonas campestris* pv. *vesicatoria* within a season in field grown pepper. Phytopathology, 86, 952–958.

Kousik CS and Ritchie DF, 1998. Response of bell pepper cultivars to bacterial spot pathogen races that individually overcome major resistance genes. Plant Disease, 82, 181–186.

Laviola C, 1965. *Xanthomonas vesicatoria* (Doidge) Dye su peperone (*Capsicum annum* L.) in Italia. Phytopathologia Mediterranea, 4, 116–120.

Lecigne P, Bezert J, Mercy L, Prunet JP, Ginibre T, Garcin A, Verharghe A, Guillaume J and Manceau C, 2000. Mancozèbe, cuivre et bactérioses: resultats sur tomate, melon, noyer, vigne. Phytoma La Defence des Vegetaux, 531, 13–16.

Leite RP, Jones JB, Somodi GC, Minsavage GV and Stall RE, 1995. Detection of *Xanthomonas campestris* pv. *vesicatoria* associated with pepper and tomato seed by DNA amplification. Plant Disease, 79, 917–922.

Lindemann J and Upper CD, 1985. Aerial dispersal of epiphytic bacteria over bean plants. Applied and Environmantal Microbiology, 50, 1229–1232.

Lopez MM, Salcedo CI and Perez MA, 1985. Caracteristicas de aislados espanoles de *Corynebacterium michiganense* and *Xanthomonas vesicatoria*. Anales del Instituto National de Investigaciones Agrarias. Serie Agricola, 28, 235–243.

Ma X, Lewis Ivey ML and Miller SA, 2011. First report of *Xanthomonas gardneri* causing bacterial spot of tomato in Ohio and Michigan. Plant Disease, 95, 1584.

Maneva S, Bogatzevska N and Miteva E, 2009. Excess copper in soil as a factor affecting bacterial spot caused by *Xanthomonas vesicatoria* in tomato plants; bio-interaction between two stress factors and their influence on plants. Acta Physiologiae Plantarum, 31, 125–131.

Marcuzzo LL, Fernandes JMC and Becker WF, 2009. Influência da temperatura e da duração do molhamento foliar na severidade da mancha bacteriana do tomateiro. Summa Phytopathologica, 35, 229–230.

Mbega ER, Mabagala RB, Lund OS, Wulff EG and Mortensen CN, 2012. Five species of Xanthomonads associated with bacterial leaf spot symptoms in tomato from Tanzania. Plant Disease, 96, 760–761.

McGuire RG, Jones JB and Sasser M, 1982. Tween media for semiselective isolation of *Xanthomonas campestris* pv. *vesicatoria* from soil and plant material. Plant Disease, 70, 887–891.

McInnes TB, Gitaitis RD, McCarter SM, Jaworski CA and Phatak SC, 1988. Airborne dispersal of bacteria in tomato and pepper transplant fields. Plant Disease, 72, 575–579.

Melgarejo P, Garcia-Jimenez J, Jordà MC, Lopez MM, Andrés MF and Duran-Vila N, 2010. Patogenos des plantas descritos en Espana, 2nd Edition. Ministerio de Medio Ambiente y Medio Rural y Marino, Madrid, Spain, 309–310.

Mitrev S, and Kovačević B, 2006. Characterisation of *Xanthomonas axonopodis* pv. *vesicatoria* isolated from peppers in Macedonia. Journal of Plant Pathology, 88, 321–324.

Moffett MI and Croft BJ, 1983. *Xanthomonas*. In: Plant bacterial diseases. A diagnostic guide. Eds Fahy PC and Persley GJ. Academic Press, Waltham, Massachusetts, 189–228.

Nascimento AR, Fernandes PM, Borgews LC, Moita AW, and Quezado-Duval AM, 2013. Controle quimico da mancha-bacteriana do tomate para processamento industrial em campo. Horticultura Brasileira, 31, 15–24.

Obradović A, Mavridis A, Rudolph K, Janse JD, Arsenijevic M, Jones JB, Minsavage GV and Wang JF, 2004. Characterization and PCR-based typing of *Xanthomonas campestris* pv. *tomato* from peppers and tomatoes in Serbia. European Journal of Plant Pathology, 110, 285–292.

Palleroni NJ, Hildebrand DC, Schroth MN and Hendson M, 1993. Deoxyribonucleic acid of 21 strains of *Xanthomonas* species and pathovars. Journal of Applied Bacteriology, 75, 441–446.

Parkinson NM, Cowie C, Heeney J and Stead DE 2009. Phylogenetic structure of *Xanthomonas* as determined by comparison of *gyrB* sequences. International Journal of Systematic and Evolutionary Microbiology, 59, 264–274.

Pernezny K, Datnoff LE, Mueller T and Collins J, 1996. Losses in fresh-market tomato production in Florida due to target spot and bacterial spot and the benefits of protectant fungicides. Plant Disease, 80, 559–563.

Peterson GH, 1963. Survival of *Xanthomonas vesicatoria* in soil and diseased tomato plants. Phytopathology, 53, 765–767.

Pham HT, Riu KZ, Janf KM, Cho SK and Cho M, 2004. Bactericidal activity of glycinecin A, a bacteriocin derived from *Xanthomonas campestris* pv. *glycines*, on phytopathogenic *Xanthomonas campestris* pv. *vesicatoria* cells. Applied and Environmental Microbiology, 70, 4486–4490.

Pohronezny K and Volin RB, 1983. The effect of bacterial spot on yield and quality of fresh market tomatoes. HortScience, 18, 69–70.

Pohronezny K, Moss MA, Dankers W and Schenk J, 1990. Dispersal and management of *Xanthomonas campestris* pv. *vesicatoria* during thinning of direct-seeded tomato. Plant Disease, 74, 800–805.

Quezado-Duval AM and Camargo LEA, 2004. Raças de *Xanthomonas* spp. asociadas à mancha-bacteriana em tomate para processamento industrial no Brasil. Horticultura Brasileira, 22, 80–86.

Quezado-Duval AM, Lopes CA, Leite Jr RP, Lima MF and Camargo LEA, 2005. Diversity of *Xanthomonas* spp. associated with bacterial spot of processing tomatoes in Brazil. Proceedings of the 1st International Symposium on Tomato Diseases, Orlando, Florida, 21–24 June 2004. Acta Horticulturae, 695, 101–108.

Ravikumar MR and Khan ANA, 2000. Host range studies of *Xanthomonas campestris* pv. *vesicatioria* causing bacterial leaf spot of tomato. Karnatka Journal of Agricultural Studies, 13, 1009–1010.

Ritchie DF, 2000. Bacterial spot of pepper and tomato. The plant health instructor. American Phytopthological Society. 6 pp. Available at: www.apsnet.org/edcenter/intropp/lessons/prokaryotes/Pages/Bacterialspot.aspx

Ragozzino A, 1968. La scabbia batterica del peperone (*Capsicum annuum* L.) in Campania. Rivista di Ortoflorofrutticoltura Italiana, 52, 269–273.

Sahin F and Miller SA, 1998. Resistance in *Capsicum pubescens* to *Xanthomonas campestris* pv. *vesicatoria* pepper Race 6. Plant Disease, 82, 794–799.

Sahin F, 2001. Pepper races 7, 8 and 10 of *Xanthomonas axonopodis* pv. *vesicatoria* isolated from diseased pepper plants in Turkey. Plant Pathology, 50, 809.

Scott JW, Jones JB, Somodi GC and Stall RE, 1995. Screening tomato accessions for resistance to *Xanthomonas campestris* pv. *vesicatoria*, race T3. HortScience, 30, 579–581.

Schuster ML and Coyne DP, 1974. Survival mechanisms of phytopathogenic bacteria. Annual Review of Phytopathology, 12, 199–221.

Shumbulo A, Gidago G and Handiso S, 2012. Participatory evaluation of seed treatment techniques to improve seed quality and yield in tomato (*Lycopersicum esculentum*) at Wolaita zone, Southern Ethiopia. Food science and quality management, Vol 7. Available at: www.iiste.org/Journals/index.php/FSQM/article/view/2723/2747

Sijam K, Chang CJ and Gitaitis RD, 1991. An agar medium for the isolation and identification of *Xanthomonas campestris* pv. *vesicatoria* from seed. Phytopathology, 81, 831–834.

Sijam K, Chang SJ and Gitaitis RD, 1992. A medium differentiating tomato and pepper strains of *Xanthomonas campestris* pv. *vesicatoria*. Canadian Journal of Plant Pathology, 14, 182–184.

Silva AMS, Carmo MGF, Olivares FO and Pereira AJ, 2002. Termoterapia via calor seco no tratamento de sementes de tomate: eficiência na eradicação de *Xanthomonas campestris* pv. *vesicatoria* e efeitos sobre as sementes. Fitopatologia Brasileira, 27, 587–593.

Silva DAG, Rocha MC, Carvalho AO, Fernandes MCA and Carmo MGF, 2006. Efeito de produtos quimicos e biologicos sobre a mancha bacteriana, flora microbica no filoplano e produtividade de pimentão. Horticultura Brasileira, 24, 34–140.

Silva DAG, Carvalho AO, Pereira MB, Olivares FL and Carmo MGF, 2013. Transporte de *Xanthomonas vesicatoria* de sementes para plântulas e mudas de tomate. Horticultura Brasileira, 31, 50–58.

Stall RE, Gottwald TR, Koizumi M and Schaad NC, 1993. Ecology of plant pathogenic xanthomonads. In: *Xanthomonas*. Eds Swings JG and Civerolo EL. Chapman and Hall, London, UK, 265–299.

Stall RE, Beaulieu C, Egel G, Hodge NC, Leite RP, Minsavage GV, Bouzar H, Jones JB, Alvarez AM and Benedict AA, 1994. Two genetically diverse groups of strains are included in *Xanthomonas campestris* pv. *vesicatoria*. International Journal of Systematic Bacteriology, 44, 47–53.

Stall RE, Jones JB and Minsavage GV, 2009. Durability of resistance in tomato and pepper to Xanthomonads causing bacterial spot. Annual Review of Phytopathology, 47, 265–284.

Sutic G, 1957. Bakterioze crvenog patlidzana (Tomato bacteriosis). Posebna Izd. Inst. Zast. Bilja Beograd (Spec. Edit. Inst. Plant Prot. Beograd), 6, 1–65. English summary: Review of Applied Mycology, 36, 734–735.

Timmer LW, Marois JJ and Achor D, 1987. Growth and survival of xanthomonads under conditions nonconducive to disease development. Phytopathology, 77, 1341–1345.

Vauterin L, Hoste B, Kersters K and Swings J, 1995. Reclassification of *Xanthomonas*. International Journal of Systematic Bacteriology, 30, 472–489.

Wang H, Hutton SF, Robbins MD, Sim S-C, Scott JW, Yang W-C, Jones JB and Francis D, 2011. Molecular mapping of hypersensitive resistance from tomato 'Hawaii 7981' to *Xanthomonas perforans* race T3. Phytopathology, 101, 1217–1223.

Young JM, Park DC, Shearman HM and Fargier F, 2008. A multilocus sequence analysis of the genus *Xanthomonas*. Systematic and Applied Microbiology, 31, 366–377.