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Data Sheets on Quarantine Pests

Clavibacter michiganensis subsp. *michiganensis*

IDENTITY

Name: *Clavibacter michiganensis* subsp. *michiganensis* (Smith) Davis *et al.*
Synonyms: *Corynebacterium michiganense* pv. *michiganense* (Smith) Dye & Kemp
Corynebacterium michiganense (Smith) Jensen
Taxonomic position: Bacteria: Firmicutes
Common names: Bacterial canker, bird's eye (English)
Chancre bactérien (French)
Bakterienwelke (German)
Marchitez bacteriana (Spanish)
Cancro batterico (Italian)
Bayer computer code: CORBMI
EPPO A2 list: No. 50
EU Annex designation: II/A2

HOSTS

The main host of economic importance is tomatoes, but the pathogen has also been reported on other *Lycopersicon* spp. and on the wild plants *Solanum douglasii*, *S. nigrum* and *S. triflorum*. A number of solanaceous plants are susceptible on artificial inoculation (for details see Thyr *et al.*, 1975). Doubtful reports from other hosts include *Phaseolus* beans, peas and maize. Recently, Stamova & Sotirova (1987) have also reported wheat, barley, rye, oats, sunflowers, watermelons and cucumbers as hosts on artificial stem inoculation.

In the EPPO region, the main host is tomato, while some susceptible solanaceous weeds could be potential reservoirs of the pathogen.

GEOGRAPHICAL DISTRIBUTION

C. michiganensis subsp. *michiganensis* was first described in North America and presumably originated there.
EPPO region: Austria, Belarus, Belgium, Bulgaria, Czech Republic, Egypt, Finland (unconfirmed), France, Germany, Greece, Hungary, Ireland, Israel, Italy (including Sardinia and Sicily), Lebanon, Lithuania, Morocco, Netherlands, Norway (eradicated), Poland, Portugal (eradicated), Romania, Russia (European, Siberia), Slovenia, Spain, Switzerland, Tunisia, Turkey, UK (found in the past but not established), Ukraine, Yugoslavia.
Asia: Armenia, Azerbaijan, China (found in the past but not established), India (Madhya Pradesh), Iran, Israel, Japan, Lebanon, Turkey.
Africa: Egypt, Kenya, Madagascar, Morocco, South Africa, Tunisia, Togo, Uganda, Zambia, Zimbabwe.

North America: Widespread in Canada (British Columbia to Nova Scotia) and USA (California, Florida, Georgia, Hawaii, Iowa, Illinois, Indiana, Michigan, North Dakota, Ohio, Wyoming), Mexico.
Central America and Caribbean: Costa Rica, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Martinique (unconfirmed), Panama.
South America: Argentina, Brazil (São Paulo), Chile, Colombia, Ecuador, Peru, Uruguay.
Oceania: Australia (New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia), New Zealand, Tonga.
EU: Present.
Distribution map: See IMI (1996, No. 26).

BIOLOGY

Infected tomato seeds give rise to contaminated seedlings. Where studied, not more than 1% seed transmission occurred (Grogan & Kendrick, 1953). Spread of the disease in the field or under glass is favoured by water (rainsplash, irrigation) and cultural practices (trimming, chemical sprays). The bacterium enters plant tissue through stomata and other natural openings, as well as wounds and roots.

Young plants have been shown to be more susceptible (Van Vaerenbergh & Chauveau, 1985). Nevertheless, under natural conditions, tomato plants seem to be susceptible throughout their life (Rat *et al.*, 1991). After infection, there is a long latent period before any symptoms appear (for details on biology and symptoms see Strider, 1969).

The bacterium is located in the xylem vessels (Leyns & De Cleene, 1983) where it can cause lysigenous cavities. Infected vessels contain viscous granular deposits, tyloses and bacterial masses (Marte, 1980). The pathogen also produces a toxic glycopeptide which has biological activity (Miura *et al.*, 1986). The bacterium survives for a long time in plant debris, soil and on equipment and glasshouse structures. It probably does not survive long in soil *per se*. However, it remains viable for at least 8 months in seeds.

DETECTION AND IDENTIFICATION

Symptoms

Contaminated seeds usually give rise to apparently healthy seedlings, symptoms only appearing as plants approach maturity. Under glasshouse conditions, the first symptom is a reversible wilting of leaves during hot weather. Leaves may show white then brown necrotic interveinal areas. Wilting quickly becomes irreversible and the whole plant desiccates.

In the field, the first symptom is desiccation of the edge of the leaflets mainly on lower leaves. The plant slowly desiccates, usually without showing wilting. At an advanced stage, small whitish pustules appear on leaf veins and petioles. Brown stripes may appear on stems and petioles. They may split to expose yellowish to reddish-brown cavities, giving a canker symptom.

Fruits may fail to develop and fall, or ripen unevenly. They also often show external marbling and internal bleaching of vascular and surrounding tissue. Infrequently, fruits may show characteristic "bird's eye" spots. Initially slightly raised and white, these spots develop light-brown roughened centres surrounded by a flat whitish halo.

On cutting stems, petioles and peduncles, particularly at their junctions, a creamy-white, yellow or reddish-brown discoloration of vascular tissue and pith and cavities within the pith will be evident. These discolorations are only visible at advanced stages of the disease. At the beginning of its development, the pathogen causes no change in the vascular tissue.

Sometimes, a very light pinky discoloration of the vascular tissue can be observed. Bacterial canker is then easily confused with *Verticillium* or *Fusarium* wilts.

Morphology

Isolation of the causal organism can be attempted on nutrient glucose agar or yeast peptone glucose agar (Lelliott & Stead, 1987). *C. michiganensis* subsp. *michiganensis* develops slow-growing, smooth, shining, round, yellow colonies with entire margins. White, pink, red and orange mutants, however, do occur (Hayward & Waterston, 1964).

C. michiganensis subsp. *michiganensis* is an aerobic, non-motile, Gram-positive, non-sporing, curved rod (for details see Bradbury, 1986).

Detection and inspection methods

Many seed-testing methods have recently been investigated. The use of semi-selective media for isolation of the pathogen from seed extracts (Fatmi & Schaad, 1988; Shirakawa & Sasaki, 1988) is usually not sensitive enough because of the presence of many antagonists in the saprophytic flora. Serological methods are sensitive (Rat, 1984) but there are difficulties in obtaining sufficiently specific sera. Bioassays have been described (Van Vaerenbergh & Chauveau, 1987) which are specific and sensitive but expensive and time-consuming. New methods including fatty acid profiles (Gitaitis & Beaver, 1990), molecular hybridization (Thompson *et al*., 1989) and protein profiles (Bruyne *et al*., 1987) are now suggested.

MEANS OF MOVEMENT AND DISPERSAL

Seed is the main long-distance vector of the pathogen. The seed trade has facilitated the worldwide distribution of the disease. Locally, transfer of contaminated equipment may allow transmission of the disease from one glasshouse, field or farm to another.

PEST SIGNIFICANCE

Economic impact

Since the first report of the disease in the USA in 1910, *C. michiganensis* subsp. *michiganensis* has spread throughout the world and causes serious losses to both glasshouse and field tomato crops, either by killing the young plants or disfiguring the fruits. In North Carolina (USA), a 70% reduction in yield has been recorded in some years. Recent experiments carried out in France have shown a yield loss of 20-30% (Rat *et al.*, 1991).

Control

Use of healthy seeds is the first and most important condition for controlling the disease. Only seeds that have been acid extracted should be used (Thyr *et al.*, 1973). A substantial reduction of infection can be achieved by chemical treatment of the seed (Dhanvantari, 1989).

Once the disease has appeared in a crop, strict hygiene measures such as eradication of infected plants and isolation of infected rows can minimize yield loss. Prophylactic measures (destruction of crop residues, disinfection of structures and equipment) are essential to prevent breakdowns in protected crops.

Sources of resistance are available (Van Steekelenburg, 1985) but have not yet been incorporated to any significant degree into commercial cultivars.

Phytosanitary risk

EPPO has listed *C. michiganensis* subsp. *michiganensis* as an A2 quarantine pest (OEPP/EPPO, 1982), and CPPC and IAPSC also consider it of quarantine significance.

The bacterium causes one of the most serious diseases of glasshouse tomatoes, which can moreover readily be controlled by phytosanitary measures. It remains absent from several countries in different parts of the EPPO region.

PHYTOSANITARY MEASURES

EPPO recommends that seeds be extracted by the hydrochloric acid method, or that the seed crop should have been inspected during the growing season (OEPP/EPPO, 1990). However, seed-testing methods have now developed sufficiently (Van Vaerenbergh & Chauveau, 1987) for EPPO's recommendations to need revision. As an alternative to the above, seed lots should be tested by an appropriate method on a representative sample and found free from the bacterium (OEPP/EPPO, 1992).

BIBLIOGRAPHY

Bradbury, J.F. (1986) *Guide to plant pathogenic bacteria*. CAB International, Wallingford, UK.

Bruyne, E. de; Vantomme, R.; Ley, J. de (1987) Enzymatic features and SDS gel electrophoretic protein patterns of *Corynebacterium michiganense*. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* **52** (3b), 1095-1100.

Dhanvantari, B.N. (1989) Effect of seed extraction methods and seed treatments on control of tomato bacterial canker. *Canadian Journal of Plant Pathology* **11**, 400-408.

Fatmi, M.; Schaad, N.W. (1988) Semiselective agar medium for isolation of *Clavibacter michiganense* subsp. *michiganense* from tomato seed. *Phytopathology* **78**, 121-126.

Gitaitis, R.D.; Beaver, R.W. (1990) Characterization of fatty acid methyl ester content of *Clavibacter michiganensis* subsp. *michiganensis*. *Phytopathology* **80**, 318-321.

Grogan, R.G.; Kendrick, J.B. (1953) Seed transmission, mode of overwintering and spread of bacterial canker of tomato caused by *Corynebacterium michiganense*. *Phytopathology Abstracts* **43**, 473.

Hayward, A.C.; Waterston, J.M. (1964) *Corynebacterium michiganense*. *Descriptions of Pathogenic Fungi and Bacteria* No. 19. CAB International, Wallingford, UK.

IMI (1996) *Distribution Maps of Plant Diseases* No. 26 (edition 8). CAB INTERNATIONAL, Wallingford, UK.

Lelliott, R.A.; Stead, D.E. (1987) *Methods for the diagnosis of bacterial diseases of plants*. Blackwell Scientific Publications, Oxford, UK.

Leyns, F.; De Cleene, M. (1983) Histopathology of the bacteriosis caused by inoculation of *Corynebacterium michiganense* and *Xanthomonas campestris* pv. *vesicatoria* in tomato stems. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* **48** (3), 663-670.

Marte, M. (1980) Histological and histochemical observations on tomato stems naturally infected by *Corynebacterium michiganense*. *Phytopathologische Zeitschrift* **97**, 252-271.

Miura, L.; Romeiro, R. da S.; Gomes, J.C. (1986) Production, purification and biological activity of an exotoxin produced *in vitro* by *Corynebacterium michiganense* pv. *michiganense*. *Fitopatologia Brasileira* **11**, 789-794.

OEPP/EPPO (1982) Data sheets on quarantine organisms No. 50, *Corynebacterium michiganense*. *Bulletin OEPP/EPPO Bulletin* **12** (1).

OEPP/EPPO (1990) Specific quarantine requirements. *EPPO Technical Documents* No. 1008.

OEPP/EPPO (1992) Quarantine procedures No. 39, *Clavibacter michiganensis* subsp. *michiganensis* - test methods for tomato seeds. *Bulletin OEPP/EPPO Bulletin* **22**, 219-224.

Rat, B. (1984) *Corynebacterium michiganense*. Technique de détection dans les semences de tomate. In: *Report on the 1st International Workshop on Seed Bacteriology*, pp. 35-35. ISTA, Zürich, Switzerland.

Rat, B.; Poissonnier, J.; Goisque, M.J.; Burgaud, A. (1991) Le point sur le chancre bactérien. *Fruit et Légumes* **86**, 38-40.

Shirakawa, T.; Sasaki, T. (1988) A selective medium for isolation of *Corynebacterium michiganense* pv. *michiganense*, the pathogen of tomato bacterial canker disease. *Annals of the Phytopathological Society of Japan* **54**, 540-543.

Stamova, L.; Sotirova, V. (1987) Reaction of different crops to artificial inoculation with *Corynebacterium michiganense*. *Archiv für Phytopathologie und Pflanzenschutz* **23**, 211-216.

Strider, D.L. (1969) Bacterial canker of tomato caused by *Corynebacterium michiganense*: a literature review and bibliography. *Technical Bulletin North Carolina Agricultural Experiment Station*, No. 193.

Thompson, E.; Leary, J.V.; Chun, W.W.C. (1989) Specific detection of *Clavibacter michiganense* subsp. *michiganense* by homologous DNA probe. *Phytopathology* **79**, 311-314.

Thyr, B.D.; Webb, R.E.; Jaworski, C.A.; Ratcliffe, T.J. (1973) Tomato bacterial canker: control by seed treatment. *Plant Disease Reporter* **57**, 974-977.

Thyr, B.D.; Samuel, M.J.; Brown, P.G. (1975) New solanaceous host records for *Corynebacterium michiganense*. *Plant Disease Reporter* **59**, 595-598.

Van Steekelenburg, N.A.M. (1985) Resistance to *Corynebacterium michiganense* in tomato genotypes. *Euphytica* **34**, 245-250.

Van Vaerenbergh, J.P.C.; Chauveau, J.F. (1985) Host plant inoculation for detection of (latent) *Corynebacterium michiganense*. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* **50** (3a), 973-995.

Van Vaerenbergh, J.P.C.; Chauveau, J.F. (1987) Detection of *Corynebacterium michiganense* in tomato seed lots. *Bulletin OEPP/EPPO Bulletin* **17**, 131-138.