

Data Sheets on Quarantine Pests

Xanthomonas oryzae

The newly constituted species *X. oryzae* includes the two non-European rice pathogens pvs *oryzae* and *oryzicola*. These present a phytosanitary risk for the EPPO region which can be met by similar measures; they are accordingly treated together in this data sheet.

IDENTITY

Taxonomic position: Bacteria: Gracilicutes

Notes on taxonomy and nomenclature: Swings *et al.* (1990) has recently transferred the two pathovars covered by this data sheet from *Xanthomonas campestris* to *X. oryzae*.

- ***Xanthomonas oryzae* pv. *oryzae***

Name: *Xanthomonas oryzae* pv. *oryzae* (Ishiyama) Swings *et al.*

Synonyms: *Pseudomonas oryzae* Ishiyama
Xanthomonas campestris pv. *oryzae* (Ishiyama) Dye
Xanthomonas itoana (Tachinai) Dowson
Xanthomonas kresek Schure
Xanthomonas oryzae (Ishiyama) Dowson
Xanthomonas translucens f.sp. *oryzae* (Ishiyama) Pordesimo (this name has also, incorrectly, been used for pv. *oryzicola*).

Common names: Bacterial leaf blight, Kresek disease, BLB (English)
 Maladie bactérienne des feuilles du riz (French)
 Bakterielle Weissfleckenkrankheit, bakterieller Blattbrand (German)
 Enfermedad bacteriana de las hojas del arroz (Spanish)

Bayer computer code: XANTOR

EPPO A1 list: No. 2

EU Annex designation: II/A1 - as *Xanthomonas campestris* pv. *oryzae*

- ***Xanthomonas oryzae* pv. *oryzicola***

Name: *Xanthomonas oryzae* pv. *oryzicola* (Fang *et al.*) Swings *et al.*

Synonyms: *Xanthomonas campestris* pv. *oryzicola* (Fang *et al.*) Dye
Xanthomonas oryzicola Fang *et al.*
Xanthomonas translucens f.sp. *oryzicola* (Fang *et al.*) Bradbury

Common names: Bacterial leaf streak, BLS (English)
 Brûlure bactérienne, stries bactériennes, du riz (French)
 Quemaduras bacterianas, estrías bacterianas, del arroz (Spanish)

Bayer computer code: XANTTO

EPPO A1 list: No. 3

EU Annex designation: II/A1 - as *Xanthomonas campestris* pv. *oryzicola*

HOSTS

The principal host of both pathovars is rice. *Oryza sativa* subsp. *japonica* is usually more resistant than subsp. *indica* to pv. *oryzicola*. The two bacteria also attack a number of wild

or minor cultivated Poaceae (*Leersia* spp., *Leptochloa* spp., *Oryza* spp., *Paspalum scrobiculatum*, *Zizania*, *Zoysia* spp.), including poaceous weeds which may act as carriers (Li *et al.*, 1985). Many more are susceptible on artificial inoculation (Bradbury, 1970a; 1970b).

GEOGRAPHICAL DISTRIBUTION

- ***Xanthomonas oryzae* pv. *oryzae***

EPPO region: Russia (Far East, Southern Russia; found but not established); Ukraine, found on rice seeds by Koroleva *et al.*, 1985; but status of this record uncertain.

Asia: Bangladesh, Cambodia, China (widespread), India (widespread), Indonesia (widespread), Japan (Honshu, Kyushu), Korea Democratic People's Republic, Korea Republic, Lao, Malaysia (Peninsular, Sabah, Sarawak), Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Viet Nam.

Africa: Burkina Faso, Cameroon, Gabon, Madagascar (probably not, but suspect symptoms seen by Buddenhagen, 1985), Mali, Niger, Senegal, Togo. See John *et al.* (1984).

North America: Mexico, USA (Louisiana, Texas).

Central America and Caribbean: Costa Rica, El Salvador, Honduras, Nicaragua (unconfirmed), Panama.

South America: Bolivia, Colombia, Ecuador, Venezuela.

Oceania: Australia (Northern Territory, Queensland).

EU: Absent.

Distribution map: See CMI (1974, No. 304).

- ***Xanthomonas oryzae* pv. *oryzicola***

EPPO region: Absent.

Asia: Confined to tropical areas including Bangladesh, Cambodia, China (Fujian, Guangdong, Hainan), India (Bihar, Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh), Indonesia (widespread), Lao, Myanmar, Nepal, Pakistan, Philippines, Thailand, Malaysia (Peninsular, Sabah, Sarawak), Viet Nam.

Africa: Madagascar (Buddenhagen, 1985), Nigeria, Senegal.

Oceania: Australia (Northern Territory).

EU: Absent.

Distribution map: See CMI (1970, No. 463).

BIOLOGY

- ***Xanthomonas oryzae* pv. *oryzae***

The bacterium enters by way of hydathodes and wounds on the roots or leaves. Penetration may also occur via stomata, where there will be a resultant build-up of bacteria which subsequently exude onto the leaf surface and re-enter the plant through the hydathodes. Once inside the vascular system, the bacterium multiplies and moves in both directions. Spread takes place in wind and rain, but primarily in flood and irrigation water (Dath & Devadath, 1983). The spread pattern in a rice field has been analysed by Nayak & Reddy (1985).

Potential inoculum sources include infected planting material, volunteer rice plants (Durgapal, 1985), infected straw or chaff (Devadath & Dath, 1985), and weed hosts, although the exact role of these sources in nature is poorly understood. Seed transmission is generally thought to occur to a certain extent (Hsieh *et al.*, 1974), but Murty & Devadath (1984) had difficulty in demonstrating this experimentally - infected seeds did not give rise

to infected seedlings but did introduce the bacterium into the soil. Singh *et al.* (1983), however, observed seed transmission regularly in growth chambers when using heavily infested samples. Singh (1971) found that the bacterium cannot survive in unsterilized soil and only 15-38 days in field and pond water, but Murty & Devadath (1982) showed that this depends on the soil type. Raj & Pal (1988) failed to obtain overwintering in soil or seed, and found survival only in infected leaves. Reddy (1972) states that *X. oryzae* pv. *oryzae* survives for 7-8 months in seed, but for only 3-4 months in straw and stubble; Kauffman & Reddy (1975) reported that, although glumes were readily infected, viable bacteria could not be detected on seed stored for 2 months. It is thought that bacteriophages play a role in reducing bacteria in germinating seed. In general, it is clear that present results on survival and sources of inoculum are contradictory.

Many different races (or pathotypes) of the bacterium exist, distinguished by their behaviour on differential cultivars (Mew, 1987). New races appear readily and the bacterium is very variable in virulence.

- ***Xanthomonas oryzae* pv. *oryzicola***

The bacterium enters the leaf through stomata or wounds. Spread within a crop occurs by mechanical contact and in rain and irrigation water; under favourable warm wet conditions, rapid and severe disease development can occur. The role of seed transmission in perpetuation of the disease is recognized, but the part played by weeds is little understood. Rao (1987) suggested that seed transmission can occur from one summer season to the next, but not if summer seed is sown in the winter season, as the pathogen cannot establish in cool, dry winter weather. The bacterium can persist from season to season on infected leaves and leaf debris, but is unable to survive in non-sterile soil (Devadath & Dath, 1970). No distinct race or varietal specificity has been reported.

For more information on the biology of the two bacteria, see Bradbury (1970a; 1970b), Singh (1971), Ou (1972).

DETECTION AND IDENTIFICATION

Symptoms

- ***Xanthomonas oryzae* pv. *oryzae***

Bacterial leaf blight appears on leaves of young plants, after planting out, as pale-green to grey-green water-soaked streaks near the leaf tip and margins. These lesions coalesce and become yellowish-white with wavy edges. Eventually, the whole leaf may be affected, becomes whitish or greyish and then dies. Leaf sheaths and culms of the more susceptible cultivars may be attacked. Systemic infection, known as kresek (Reddy, 1984), results in desiccation of leaves and death, particularly of young transplanted plants. In older plants, the leaves become yellow and then die. In later stages, the disease may be difficult to distinguish from bacterial leaf streak. For more information, see Bradbury (1970a; 1970b), Feakin (1971), Ou (1972).

A simple test to differentiate leaf blight consists of immersing the cut end of the basal part of an infected leaf in a dilute solution of basic fuchsin for 1-2 days (Goto, 1965). The area of latent bacterial infection beyond the visible lesion remains unstained and appears as green spots with undulate margins clearly separated from the stained healthy part of the leaf. This reaction only occurs with *X. oryzae* pv. *oryzae* and not with other blight organisms. A limitation of this technique is that young flag leaves and short old leaves do not stain well.

- ***Xanthomonas oryzae* pv. *oryzicola***

Narrow, dark-greenish, water-soaked, interveinal streaks of various lengths appear, initially restricted to the leaf blades. The lesions enlarge, turn yellowish-orange to brown depending on cultivar and eventually coalesce. Tiny amber droplets of bacterial exudate are often present on the lesions. In its advanced stages, the disease is difficult to distinguish from that caused by *X. oryzae* pv. *oryzae* but lesion margins remain linear rather than wavy as in the latter case. Direct observation of the bacterium may be necessary for confirmation. Damage is often associated with lepidopterous leaf rollers, leaf-folders and hispa beetles, since bacteria readily enter the damaged tissue resulting from insect infestation.

Morphology

To isolate the bacteria, sections of leaf tissues are surface-sterilized and macerated in distilled water, and the resulting suspension is streaked on 1% dextrose nutrient agar or Wakimoto agar (Reddy & Ou, 1974) and incubated at 25-28°C. Colonies of *X. oryzae* pv. *oryzae* are slow-growing, mucoid and straw-coloured to yellow in colour, and those of *X. oryzae* pv. *oryzicola* are fairly slow-growing, usually pale-yellow, round, smooth, entire, domed and mucoid. Both bacteria are Gram-negative rods, capsulated and motile with a polar flagellum. Dimensions are, for *X. oryzae* pv. *oryzae*, 1.1-2.0 x 0.4-0.6 µm and for *X. oryzae* pv. *oryzicola*, 1.0-2.5 x 0.4-0.6 µm.

Modern taxonomic techniques have clearly confirmed that the two pathovars are quite distinct from each other, from *Xanthomonas campestris* pathovars, and from the rice “brown blotch” pathogen (numerical analysis of phenotypic features and protein gel electrophoregrams: Vera Cruz *et al.*, 1984; monoclonal antibodies: Benedict *et al.*, 1989; DNA:DNA hybridization: Kersters *et al.*, 1989; fatty acid profiling: Stead, 1989; DNA sequences: Leach *et al.*, 1990). Swings *et al.* (1990) have reclassified them as *X. oryzae* and provide up-to-date details of their distinctive characters.

Detection and inspection methods

For details on confirmatory tests see Dye & Lelliott (1974). Further biochemical tests for differentiating the two bacteria are given by Reddy & Ou (1974). Unlike the commonly occurring yellow saprophytes, *X. oryzae* pv. *oryzae* and *X. oryzae* pv. *oryzicola* are oxidative and inhibited by 0.1% triphenyl-tetrazolium chloride.

Various seed-testing methods are used for *X. oryzae* pv. *oryzae*: bacterial streaming tests (Jain *et al.*, 1985); ELISA with monoclonal antibodies (Zhu *et al.*, 1988). For a general review see Agarwal *et al.* (1989), and for up-to-date details on diagnostic characters see Swings *et al.* (1990).

MEANS OF MOVEMENT AND DISPERSAL

The bacteria can only move short distances in infected crops. The only means of long-distance dispersal is in infected rice seeds. The bacteria are usually found in the glumes, but may also penetrate the endosperm. Seed transmission is not considered to be a particularly important means of carry-over of *X. oryzae* pv. *oryzae* in infested countries. It is, however, frequent enough to present a quarantine risk. For *X. oryzae* pv. *oryzicola*, the planting of disease-free seed is considered of utmost importance in control.

PEST SIGNIFICANCE

Economic impact

- ***Xanthomonas oryzae* pv. *oryzae***

Bacterial leaf blight is the most serious disease of rice in South-East Asia, particularly since the widespread cultivation of dwarf high-yielding cultivars (Ray & Sengupta, 1970; Feakin, 1971). In 1954, in Japan, 90 000-150 000 ha were affected and annual losses put at 22 000-110 000 t. The disease was first reported in India in 1951, but it was not until 1963 that an epiphytotic occurred. In the Philippines, present losses are of the order of 22.5% in wet to 7.2% in dry seasons in susceptible crops and 9.5-1.8%, respectively, in resistant crops (Exconde, 1973). Nitrogen fertilization considerably increases susceptibility. Losses are generally less important in the less fertile soils and in summer-grown crops (December-April). Transplanted autumn (May-September) and winter (July-December) crops, however, suffer considerable losses. Diseased crops contain a high proportion of chaffy grains. The world situation has been reviewed by an International Workshop held at Manila, Philippines (Banta, 1989).

- ***Xanthomonas oryzae* pv. *oryzicola***

Bacterial leaf streak is only of importance in some areas during very wet seasons and where high rates of nitrogen are used. It does not usually reduce yields if low N rates are applied. Losses of 5-30% have been reported from India, while in the Philippines losses were not considered significant in either wet or dry seasons (Opina & Exconde, 1971). In general, bacterial leaf streak is a much less important disease than bacterial leaf blight.

Control

- ***Xanthomonas oryzae* pv. *oryzae***

Careful crop management (Padmanabhan, 1983), use of resistant cultivars and seed treatments (Singh & Monga, 1985) help reduce incidence of the disease. Dipping rice seedlings in antibiotic at transplanting has been proposed (Durgapal, 1983). Systemic bactericides are being developed (Takahi, 1985). Bacterization of seeds with fluorescent pseudomonads has been tried as a biological control method (Anuratha & Gnanamanickam, 1987). Since the increase in disease severity in the 1970s and 1980s, varietal resistance has become a very important consideration and there is a large volume of literature on breeding and screening for resistance to leaf blight. The existence of different races (see Biology) makes it important to obtain stable (Nayak & Chakrabarti, 1986) or adult-plant (Qi & Mew, 1985) resistance. See Buddenhagen (1983), Kaul & Sharma (1987) or Mew (1987) for reviews on bacterial blight resistance.

- ***Xanthomonas oryzae* pv. *oryzicola***

The bacterial leaf streak pathogen hardly requires any particular control measures except the use of healthy seed. Neither treatments nor resistance are mentioned to any significant extent in the literature.

Phytosanitary risk

Both *X. oryzae* pv. *oryzae* and *X. oryzae* pv. *oryzicola* are EPPO A1 quarantine pests (OEPP/EPPO, 1979; 1980). The former is also of quarantine significance for COSAVE, CPPC, IAPSC and NAPPO, while the latter is listed only by COSAVE and IAPSC. Bacterial leaf blight is an extremely severe disease, causing extensive problems in the Far East, but is absent from the European rice-growing areas. Its existing distribution suggests that it could survive in Mediterranean countries and it clearly presents a serious risk for the EPPO region. Bacterial leaf streak is a much less important disease, with a more tropical distribution and correspondingly lower probability of establishment in the EPPO region. Its quarantine status for the EPPO region is arguable, but in any case the measures taken against *X. oryzae* pv. *oryzae* will also exclude it.

PHYTOSANITARY MEASURES

EPPO suggests that countries may prohibit import of rice seeds from infested countries (OEPP/EPPO, 1990). Alternatively, such seeds should come from a seed-crop subject to growing-season inspection, and should themselves be tested before and after import for the two bacterial pathogens. EPPO quarantine procedures for testing rice seeds are in preparation.

BIBLIOGRAPHY

- Agarwal, P.C.; Mortensen, C.N.; Mathur, S.B. (1989) Seed-borne diseases and seed health testing of rice. *Phytopathological Papers* No. 30. CAB International, Wallingford, UK.
- Anuratha, C.S.; Gnanamanickam, S.S. (1987) *Pseudomonas fluorescens* suppresses development of bacterial blight symptoms. *International Rice Research Newsletter* **12**, 1, 17.
- Banta, S.J. (Editor) (1989) *Bacterial blight of rice*. IRRI, Manila, Philippines.
- Benedict, A.A.; Alvarez, A.M.; Berestecky, J.; Imanaka, W.; Mizumoto, C.Y.; Pollard, L.W.; Mew, T.W.; Gonzalez, C.F. (1989) Pathovar-specific monoclonal antibodies for *Xanthomonas campestris* pv. *oryzae* and for *Xanthomonas campestris* pv. *oryzicola*. *Phytopathology* **79**, 322-328.
- Bradbury, J.F. (1970a) *Xanthomonas oryzae*. *CMI Descriptions of Pathogenic Fungi and Bacteria* No. 239. CAB International, Wallingford, UK.
- Bradbury, J.F. (1970b) *Xanthomonas oryzicola*. *CMI Descriptions of Pathogenic Fungi and Bacteria* No. 240. CAB International, Wallingford, UK.
- Buddenhagen, I.W. (1983) Disease resistance in rice. In: *Durable resistance in crops* (Ed. by Lamberti, F.; Waller, J.M.; Graaff, N.A. van der), pp. 401-428. Plenum, New York, USA.
- Buddenhagen, I.W. (1985) Rice disease evaluation in Madagascar. *International Rice Commission Newsletter* **34**, 74-78.
- CMI (1970) *Distribution Maps of Plant Diseases* No. 463. CAB International, Wallingford, UK.
- CMI (1974) *Distribution Maps of Plant Diseases* No. 304 (edition 3). CAB International, Wallingford, UK.
- Dath, A.P.; Devadath, S. (1983) Role of inoculum in irrigation water and soil in the incidence of bacterial blight of rice. *Indian Phytopathology* **36**, 142-144.
- Devadath, S.; Dath, A.P. (1970) Epidemiology of *Xanthomonas translucens* f.sp. *oryzae*. *Oryza* **7**, 13-16.
- Devadath, S.; Dath, A.P. (1985) Infected chaff as a source of inoculum of *Xanthomonas campestris* pv. *oryzae* to the rice crop. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* **92**, 485-488.
- Durgapal, J.C. (1983) Management of bacterial blight of rice by nursery treatment - preliminary evaluation. *Indian Phytopathology* **36**, 146-149.
- Durgapal, J.C. (1985) Self-sown plants from bacterial blight-infected rice seeds - a possible source of primary infection in northwest India. *Current Science, India* **54**, 1283-1284.
- Dye, D.W.; Lelliott, R.A. (1974) In: *Bergey's manual of determinative bacteriology*, 8th edition (Ed. by Buchanan, R.E.; Gibbons, N.E.), pp. 243-249. Williams & Wilkins Co., Baltimore, USA.
- Exconde, O.R. (1973) Yield losses due to bacterial leaf blight of rice. *Philippines Agriculture* **57**, 128-140.
- Feakin, S.D. (1971) Pest control in rice. *PANS Manual* No. 3, pp. 69-74.
- Goto, M. (1965) A technique for detecting the infected area of bacterial leaf blight of rice caused by *X. oryzae* before symptom appearance. *Annals of the Phytopathological Society of Japan* **30**, 37-41.
- Hsieh, S.P.Y.; Buddenhagen, I.W.; Kauffman, H.E. (1974) An improved method for detecting the presence of *Xanthomonas oryzae* in rice seed. *Phytopathology* **64**, 273-274.
- Jain, R.K.; Dath, A.P.; Devadath, S. (1985) Detection and quantitative estimation of *Xanthomonas campestris* pv. *oryzae*-infected seeds in some rice cultivars. *Seed Science and Technology* **13**, 775-779.

- John, V.T.; Dobson, R.; Alluri, K.; Zan, K.; Efron, Y.; Wasano, K.; Thottapilly, G.; Gibbons, J.W.; Rossel, H.W. (1984) Rice: pathology, virology. In: *Annual Report, International Institute of Tropical Agriculture 1983, 1984*, pp. 19-22. IITA, Ibadan, Nigeria.
- Kauffman, H.E.; Reddy, A.P.K. (1975) Seed transmission studies of *Xanthomonas oryzae* in rice. *Phytopathology* **65**, 663-666.
- Kaul, M.L.H.; Sharma, K.K (1987) Bacterial blight of rice - a review. *Biologisches Zentralblatt* **106**, 141-167.
- Kerstens, K.; Pot, B.; Hoste, B.; Gillis, M.; Ley, J. de (1989) Protein electrophoresis and DNA:DNA hybridization of xanthomonads from grasses and cereals. *Bulletin OEPP/EPPO Bulletin* **19**, 51-55.
- Koroleva, I.B.; Gvozdyak, R.I.; Pasichnik, L.A. (1985) [*Xanthomonas campestris* pv. *oryzae*, causal agent of a bacterial disease of rice seed in Ukraine]. *Mikrobiologicheskii Zhurnal* **47**, 93-95.
- Leach, J.E.; White, F.F.; Rhoads, M.L.; Leung, H. (1990) A repetitive DNA sequence differentiates *Xanthomonas campestris* pv. *oryzae* from other pathovars of *X. campestris*. *Molecular Plant Microbe Interactions* **3**, 238-246.
- Li, Z.Z.; Zhao, H.; Ying, X.D. (1985) [The weed carriers of bacterial leaf blight of rice]. *Acta Phytopathologica Sinica* **15**, 246-248.
- Mew, T.W. (1987) Current status and future prospects of research on bacterial blight of rice. *Annual Review of Phytopathology* **25**, 359-382.
- Murty, V.S.T.; Devadath, S. (1982) Survival of *Xanthomonas campestris* pv. *oryzae* in different soils. *Indian Phytopathology* **35**, 32-38.
- Murty, V.S.T.; Devadath, S. (1984) Role of seed in survival and transmission of *Xanthomonas campestris* pv. *oryzae* causing bacterial blight of rice. *Phytopathologische Zeitschrift* **110**, 15-19.
- Nayak, P.; Chakrabarti, N.K. (1986) Stable resistance to bacterial blight disease in rice. *Annals of Applied Biology* **109**, 179-186.
- Nayak, P.; Reddy, P.R. (1985) Spread pattern of bacterial blight disease in rice crop. *Indian Phytopathology* **38**, 39-44.
- OEPP/EPPO (1979) Data sheets on quarantine organisms No. 3, *Xanthomonas campestris* pv. *oryzicola*. *Bulletin OEPP/EPPO Bulletin* **9** (2).
- OEPP/EPPO (1980) Data sheets on quarantine organisms No. 2, *Xanthomonas campestris* pv. *oryzae*. *Bulletin OEPP/EPPO Bulletin* **10** (1).
- OEPP/EPPO (1990) Specific quarantine requirements. *EPPO Technical Documents*, No. 1008.
- Opina, O.S.; Exconde, O.R. (1971) Assessment of yield loss due to bacterial leaf streak of rice. *Philippine Phytopathology* **7**, 35-39.
- Ou, S.H. (1972) *Rice diseases*. CAB International, Wallingford, UK.
- Padmanabhan, S.Y. (1983) Integrated control of bacterial blight of rice. *Oryza* **20**, 188-194.
- Qi, Z.; Mew, T.W. (1985) Adult-plant resistance of rice cultivars to bacterial blight. *Plant Disease* **69**, 896-898.
- Raj, K.; Pal, V. (1988) Overwintering of *Xanthomonas campestris* pv. *oryzae*. *International Rice Research Newsletter* **13**, 22-23.
- Rao, P.S. (1987) Across-season survival of *Xanthomonas campestris* pv. *oryzicola*, causal agent of bacterial leaf streak. *International Rice Research Newsletter* **12**, 2, 27.
- Ray, P.R.; Sengupta, T.K. (1970) A study on the extent of loss in yield in rice due to bacterial blight. *Indian Phytopathology* **23**, 713-714.
- Reddy, P.R. (1972) Studies on bacteriophages of *Xanthomonas oryzae* and *Xanthomonas translucens* f.sp. *oryzicola*, the incitants of blight and streak diseases of rice. *PhD thesis, Banaras Hindu University*. Varanasi, India.
- Reddy, P.R. (1984) Kresek phase of bacterial blight of rice. *Oryza* **21**, 179-187.

- Reddy, P.R.; Ou, S.H. (1974) Differentiation of *Xanthomonas translucens* f.sp. *oryzicola* (Fang *et al.*) Bradbury, the leaf-streak pathogen, from *Xanthomonas oryzae* (Uyeda and Ishiyama) Dowson, the blight pathogen of rice, by enzymatic tests. *International Journal of Systematic Bacteriology* **24**, 450-452.
- Singh, D.; Vinther, F.; Mathur, S.B. (1983) Seed transmission of bacterial leaf blight in rice. *Seed Pathology News* No. 15, p. 11.
- Singh, R.A.; Monga, D. (1985) New methods of seed treatment for eliminating *Xanthomonas campestris* pv. *oryzae* from infected rice seed. *Indian Phytopathology* **38**, 629-631.
- Singh, R.N. (1971) Perpetuation of bacterial blight disease of paddy and preservation of its incitant. I. Survival of *Xanthomonas oryzae* in water. II. Survival of *Xanthomonas oryzae* in soil. *Indian Phytopathology* **24**, 140-144, 153-154.
- Stead, D.E. (1989) Grouping of *Xanthomonas campestris* pathovars of cereals and grasses by fatty acid profiling. *Bulletin OEPP/EPPO Bulletin* **19**, 57-68.
- Swings, J.; Van den Mooter, M.; Vauterin, L.; Hoste, B.; Gillis, M.; Mew, T.W.; Kersters, K. (1990) Reclassification of the causal agents of bacterial blight (*Xanthomonas campestris* pv. *oryzae*) and bacterial leaf streak (*Xanthomonas campestris* pv. *oryzicola*) of rice as pathovars of *Xanthomonas oryzae* (ex Ishiyama 1922) sp. nov., nom. rev. *International Journal of Systematic Bacteriology* **40**, 309-311.
- Takahi, Y. (1985) Shirahagen R-S (tecloftalam). *Japan Pesticide Information* No. 46, pp. 25-30.
- Vera Cruz, C.M.V.; Gossele, F.; Kersters, K.; Segers, P.; Van den Mooter, M.; Swings, J.; Ley, J. de (1984) Differentiation between *Xanthomonas campestris* pv. *oryzae*, *Xanthomonas campestris* pv. *oryzicola* and the bacterial "brown blotch" pathogen on rice by numerical analysis of phenotypic features and protein gel electrophoregrams. *Journal of General Microbiology* **130**, 2983-2999.
- Zhu, H.; Gao, J.L.; Li, Q.X.; Hu, G.X. (1988) [Detection of *Xanthomonas oryzae* in rice by monoclonal antibodies]. *Journal of Jiangsu Agricultural College* **9**, 41-43.