Leaf scald

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Cause

Xanthomonas albilineans (Ashby 1929) Dowson 1943, bacterium.

Geographical distribution

Argentina, Australia, Barbados, Belize, Benin, Brazil, Burkina Faso, Burundi, Cameroon, Chad, China, Colombia, Congo, Côte d'Ivoire, Cuba, Democratic Republic of the Congo, Dominica, Dominican Republic, Ecuador, Fiji, Ghana, Grenada, Guadeloupe, Guatemala, Guyana, Hawaii, India, Indonesia, Iraq, Jamaica, Japan, Kenya, Madagascar, Malawi, Malaysia, Martinique, Mexico, Morocco, Mauritius, Mozambique, Myanmar, Nigeria, Pakistan, Panama, Papua New Guinea, Philippines, Puerto Rico, Réunion, St Kitts and Nevis, St Lucia, St Vincent, South Africa, Sri Lanka, Surinam, Swaziland, Tahiti, Tanzania, Taiwan, Thailand, Trinidad, Uruguay, USA, Venezuela, Vietnam, Zambia, Zimbabwe.

Symptoms

There are two different forms of leaf scald symptoms, chronic and acute, and two distinct phases, latency and eclipse (MARTIN and ROBINSON, 1961; RICAUD and RYAN, 1989).

The chronic form is characterized by chlorotic streaks parallel to the main veins on leaves. These are generally white to yellow, narrow 'pencil-line' streaks (Figure 1), but they can also be several millimetres wide (Figure 2). Their colour often becomes reddish with age. They are the only external symptom which develops on resistant cultivars. As the disease progresses, a necrosis of the leaf tissue around the chlorotic streaks may be observed and this extends progressively from the tip towards the base of the leaf. The streaks also tend to widen and become more diffuse on leaves reaching maturity (Figure 2). The fine central line which is characteristic of the disease can, however, always be seen in the centre of the lesion. The widening of lines coincides with the chlorosis or bleaching of the leaf tissue (Figure 3). Chlorosis

or bleaching may affect all the leaves and this discoloration is followed by withering of leaf extremities which curl inwards, giving the shoot or the stalk a tapered aspect (Figure 4). The stalks can be stunted and the leaves wilted, brown and bent at the ends (Figure 5). This process, which looks like a scalding, explains the name given to the disease. A common symptom in mature cane arises from the abnormal development of side shoots on stalks, with the basal side shoots generally being more developed than those higher up, in contrast to the opposite situation commonly observed in healthy stalks (Figure 6). These diseased side shoots may show similar symptoms to those on the main stalk. Longitudinal sections of diseased stalks show reddening of the vessels near the nodes and sometimes in the internodes (Figures 7 and 8). Lysigenous cavities may be observed in severely diseased canes. In susceptible cultivars the whole stalk may die (Figure 9).

The acute form is characterized by a sudden wilting of mature stalks, often without the earlier development of symptoms associated with the chronic form. Previously symptomless sugarcane dies as if it had been killed by drought. This acute form often occurs after a period of rain followed by a period of prolonged dry weather, but seems to be limited to highly susceptible cultivars.

Leaf scald is also characterized by a latency phase. Plants can tolerate the pathogen for several weeks or even months without exhibiting any symptoms at all, or the symptoms are so inconspicuous as to escape detection. This latency phase comes to an end for reasons which are as yet unknown, but the commonly given explanation is that of stress, particularly climatic or nutritional. An eclipse phase can occur at the same time as latency. Indeed, the chronic form is most often observed at the beginning of a ratoon or just after the appearance of shoots after planting the cuttings (Figure 10). A few stalks die, others survive with a few symptoms, and others seem to overcome the disease. However, the symptoms can reappear on seemingly cured stalks, either at harvest, or because the environmental conditions favour the disease, or on the shoots produced by cuttings sampled from these stalks.

Diagnosis

The frequent occurrence of latent infections greatly limits the usefulness of diagnosis based on visual symptoms. Furthermore, the fastidious nature of the pathogen complicates the use of isolation on culture medium as a means of diagnosis. To overcome these problems, serological methods (immunofluorescence, FI ISA, etc.) and polymerase chain reaction (PCR) procedures have been developed for detection and identification of the pathogen (Comstock and Irey, 1992; Davis *et al.*, 1998; Pan *et al.*, 1999). Because at least three serovars of *X. albilineans* exist, serological variability of the pathogen must be taken into consideration (Rott *et al.*, 1994). Nevertheless, isolation can be a useful

Figure 1. Leaf showing a white 'pencil-line' parallel to the midrib (P. Rott).

Figure 2. Varying intensity of leaf symptoms (P. Rott).

Figure 3. Bleaching of leaves (P. Rott).

Figure 4. Inward curling and drying of leaf tips (P. Rott).

Figure 5. Withering of leaf extremities (P. Rott).

Figure 6. Stalk side shoots showing leaf scald symptoms (P. Rott).

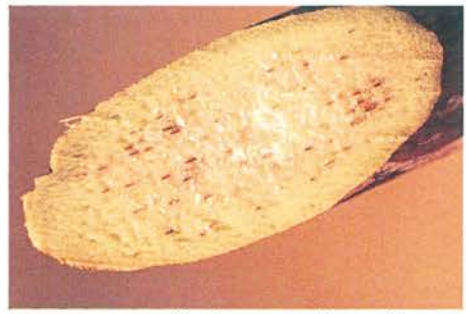

Figure 7. Cut stalk showing red vascular bundles colonized by the pathogen (P. Rott).

Figure 8. Longitudinally cut stalks showing healthy and diseased (red vascular bundles) tissues (P. Rott).

Figure 9. Scalded stools (P. Rott).

Figure 10. Young shoot showing leaf chlorosis and necrosis (P. Rott).

approach. To aid in isolation, selective media were developed (DAVIS *et al.*, 1994). One of the medium of choice consists of a modification of Wilbrink's medium (sucrose 10 g, peptone 5 g, yeast extract 5 g, K_2HPO_4 0.50 g, $MgSO_4 \cdot 7H_2O$ 0.25 g, $Na_2SO_3 \cdot 7H_2O$ 0.05 g, agar 15 g, distilled water 1 l) supplemented with 5 g/l of KBr, 50 mg/l of cycloheximide, 2 mg/l of benomyl, 25 mg/l of cephalexin, 30 mg/l of novobiocin and 50 mg/l of kasugamycin. Isolates of *X. albilineans* can be obtained from all infested parts of the sugarcane plant (leaves, stalks and roots) but the bacteria are most frequently isolated from the pencil-line leaf streaks. The leaf scald pathogen is a slow growing bacterium. Confluent growth on Wilbrink's medium becomes visible after 3 days, and minute colonies appear after 4–5 days at 28°C. Colonies are circular, convex, smooth, shining, translucent, non-mucoid, and produce a honey-yellow pigment which imparts a darker coloration upon ageing. As a species, *X. albilineans* can be readily distinguished from other xanthomonads (VAN DEN MOOTER and SWINGS, 1990).

Strains of the pathogen

Breakdown of varietal resistance to leaf scald has sometimes been attributed to the development or introduction of new strains but has never been unequivocally proven. Because of the latent phase, symptoms can go unseen in the field until the chronic or acute form of the disease occurs; this may leave the impression that a sudden epidemic took place, possibly due to the appearance of a more virulent strain. However, variation in virulence among strains of *X. albilineans* is known to occur, and published data support the possible existence of different races in Mauritius (AUTREY *et al.*, 1995). The recent outbreak of leaf scald in Florida was closely associated with the appearance of a genetically new strain of the pathogen (DAVIS *et al.*, 1997).

Transmission

The leaf scald pathogen is thought to be mainly spread by infected cuttings and transmitted by cutting implements such as knives and harvesting machines (RICAUD and RYAN, 1989). Aerial transmission of *X. albilineans* has recently been reported in Guadeloupe and Mauritius (KLETT and ROTT, 1994).

Host range

Sugarcane is the main host of *X. albilineans* but maize and several grasses (*Brachiaria piligera, Imperata cylindrica, Panicum maximum, Paspalum* sp., *Pennisetum* sp., *Rottboellia cochinchinensis*) have been reported as natural hosts of the pathogen (MARTIN and ROBINSON, 1961; RICAUD and RYAN, 1989).

In particular, the bacteria can survive in *I. cylindrica* for a long period of time and, therefore, this species could be a long-term source of infection. In general, when these grasses are diseased, they exhibit only narrow leaf stripes or the more characteristic white, pencil-line symptom.

Epidemiology

Leaf scald is generally of lesser importance in areas with mild oceanic climates. It seems to be more severe in locations with continental climates and significant variations in temperature and humidity. In particular, the disease is favoured by strong precipitation during cyclonic periods. Symptoms appear especially at the start of rains after a dry period. Low temperatures also increase the severity of the disease (RICAUD and RYAN, 1989).

Economic importance

Leaf scald can cause large yield losses and totally destroys plantations of susceptible cultivars within a few months or years. Spectacular drops in cane yields have been noticed in association with the acute form of the disease (MARTIN and ROBINSON, 1961; RICAUD and RYAN, 1989).

Control

Use of resistant varieties is the most effective means of control and, therefore, susceptible cultivars should be eliminated (RICAUD and RYAN, 1989).

The behaviour of varieties that are only moderately susceptible can be improved by planting healthy, i.e. disease-free material, produced in nurseries. Cuttings used to plant the mother nurseries can be disinfected by a long hot water treatment: soaking of cuttings for 2 days in running water at 18–25°C and then in water at 50°C for 3 h (STEINDL, 1972). This technique can easily be applied in quarantine or in other situations with a limited amount of selected materials. Its application on a large scale can be problematic because it requires a strategy for treatment which among other considerations, takes into account the possible reduction in germination due to treatment.

Further prophylactic measures are also required to control the disease, especially in nurseries: destruction of volunteer sugarcane shoots and diseased stools, disinfection of cutting tools by brushing or soaking them in bactericides, and control of weeds. Additionally, as leaf scald is a latent disease, phytosanitary measures (quarantine) prior to introducing new plant material are indispensable.

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