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**BS172S PATHOGEN RISK ANALYSIS TO  
PRIORITISE RESEARCH AND QUARANTINE  
NEEDS OF THE AUSTRALIAN SUGAR INDUSTRY**

**A REVIEW OF SUGARCANE DISEASES  
OF QUARANTINE RISK  
TO THE AUSTRALIAN SUGAR INDUSTRY**

by

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## 1.0 SUMMARY

In this paper, the major diseases of economic importance to sugarcane have been identified and their quarantine risk for Australia has been reviewed. Twelve high to moderate risk quarantinable diseases were identified (Table 1). Sugarcane smut must be considered the highest risk disease for Australia. It has a history of spread to new countries, is a major disease in all countries where it is present, both tropical and sub-tropical. Smut has recently spread to the island of Sulawesi in Indonesia and Indonesian plans to commence new sugarcane plantations on East Timor and Irian Jaya will increase the risk of smut entering Australia. Other diseases of serious risk are downy mildew, Fiji disease, Ramu stunt, mosaic and leaf scald. The first three are of particular concern because of their presence in Papua New Guinea and because of reported illegal imports of sugarcane cuttings and related species from Papua New Guinea into the Cairns region. Restriction of the movement of these diseases into or within Australia is essential for the continued competitiveness of the Australian sugar industry. All of these diseases should be considered quarantinable for Australia.

The Ord River district has recently established a sugar industry which is free of most diseases of sugarcane. Particular care should be taken to prevent movement of sugarcane diseases from the eastern states or from overseas into this region.

**Table 1 Sugarcane diseases of significant quarantine risk to Australia**

<b>Disease</b>	<b>Causal Agent</b>	<b>Quarantine risk</b>
Brown spot	<i>Cercospora longipes</i>	Moderate
Downy mildew	<i>Peronosclerospora sacchari</i>	High
Downy mildew	<i>Peronosclerospora philippinensis</i>	High
Downy mildew	<i>Peronosclerospora spontanea</i>	Uncertain
Fiji disease	Fiji disease virus	High
Grassy shoot	Phytoplasma	Moderate
Gumming	<i>Xanthomonas campestris</i> pv <i>vasculorum</i>	Moderate
Leaf scald	<i>Xanthomonas albilineans</i>	High
Leaf scorch	<i>Stagonospora sacchari</i>	Moderate
Mosaic	Sorghum mosaic virus	High
Mosaic	Potyvirus from Pakistan	High
Mosaic	Sugarcane mosaic virus	High
Ramu stunt	Suspected virus	High
Sugarcane smut	<i>Ustilago scitaminea</i>	High
White leaf	Phytoplasma	Moderate
Yellow leaf syndrome	Sugarcane yellow leaf virus and a phytoplasma	Uncertain

## 2.0 INTRODUCTION

Sugarcane (*Saccharum* L. interspecific hybrids) is the second largest export crop in Australia with total earnings of AU\$1.7 - 2 billion. Sugarcane is grown along the coastal strip from Grafton in New South Wales to Mossman in Queensland, and a new industry has recently been established in the Ord River district in Western Australia. Within Queensland the sugar industry has been expanding at 3-5% per annum since 1990 and the total production in 1995 was 4.9 million tonnes of sugar produced from 382,000 ha.

Sugarcane is a traditional crop of the inhabitants of the Torres Strait islands and is grown in gardens throughout these islands. Islanders who have moved to the Australian mainland continue to cultivate sugarcane in their gardens. It is not uncommon to see sugarcane growing in home gardens in many of the coastal cities and towns north of Sydney. Sugarcane and its relatives are native to Papua New Guinea and there has been traditional trade between Papua New Guinea and the Torres Strait in sugarcane as well as other crops.

Until recently trade in sugarcane products has been restricted to the highly processed crystalline sugar, molasses and to a much lesser extent by-products made from the sugarcane fibre. These products present negligible quarantine risk. In recent years there has been a growing interest in trade of cane pieces for traditional cooking, trade in second-hand sugarcane machinery and importation of germplasm of close relatives of sugarcane for ornamental use (eg *Miscanthus spp.*) or use as a vegetable (eg *S. edule*). Germplasm exchange for traditional plant breeding purposes is a high priority of the Australian sugar industry (Hogarth and Berding, 1996).

Diseases of sugarcane cause considerable losses in many countries (Hughes, 1978). The important diseases of sugarcane in Australia have recently been reviewed by Croft and Smith (1996). Apart from the losses from the complex sugarcane yield decline syndrome (Magarey and Croft, 1995), losses from diseases in sugarcane in Australia are below 1% of total production (McCleod, 1996). This is a low level of loss compared to the 10-15% loss which is reported from some countries (Alexander & Viswanathan, 1996) and is an important factor in the competitive advantage of the Australian sugar industry. Losses are generally low in the Australian sugar industry because of the absence of some major diseases and active control programs for those diseases which are present.

The International Society of Sugar Cane Technologists (ISSCT) Pathology Sectional Committee publishes an updated list of the diseases and pathogens of sugarcane and their distribution every three years in the proceedings of the ISSCT's triennial conference. In 1992, the list of diseases included 98 diseases caused by microbes (Autrey *et al*, 1992). The diseases of sugarcane and the pathogens of sugarcane have been reviewed in detail (Ricaud *et al*, 1989; Sivanesan and Waller, 1986; Hughes *et al*, 1964; Martin *et al*, 1961). An assessment of the relative importance of the then known diseases was compiled by Hughes (1978), and a list of diseases of quarantine significance was compiled by Frison and Putter (1993). In this paper a limited pest risk analysis of sugarcane pathogens of importance for quarantine in Australia is described. The paper identifies pathogens of significant risk to Australia from natural spread, illegal movement of sugarcane plants and by authorised movement of sugarcane germplasm, sugarcane products or contaminated equipment. The paper does not detail the protocols available to limit the risk of spread of diseases through authorised germplasm exchange.

### 3.0 SUGARCANE DISEASES, THEIR PRESENCE IN AUSTRALIA AND THEIR IMPORTANCE

The most recent lists of sugarcane diseases and their distribution published by the ISSCT Pathology Sectional Committee (Autrey *et al*, 1992 and Autrey, 1995) were reviewed. The economic importance of the diseases was rated as low, intermediate or high based on available literature. Where no recent or readily available literature was available for the disease, the importance was considered low. The occurrence of the disease in Australia was based on the ISSCT list except where more recent information was available. A list of the 32 most important sugarcane diseases is presented in Table 1. The importance of eight diseases was listed as uncertain because of lack of information on extent of yield loss, distribution and occurrence. The majority of these diseases have all been identified in the last 10 years. Downy mildew caused by two *Peronosclerospora* species have been listed as of uncertain importance because of possible confusion with the downy mildew caused by *P. sacchari* which is known to be a serious disease. Of these 32 diseases, 19 could be considered of possible quarantine significance to Australia because they have not been reported in Australia, strains of the pathogen are not present in Australia or they are under active control. These 19 diseases were reviewed using the pest risk analysis procedure outlined by Singh (1996) except that particular emphasis was placed not on the risk through movement of 'commodities' as the source of risk but on the overall risk from natural, illegal or legal means of entry of the pathogen. Detailed descriptions are given for 12 diseases which were rated moderate to high risks and brief descriptions are given of the remaining seven diseases as well as three other diseases which have some significance for quarantine.

Surveillance for diseases in the Australian sugar industry is conducted by local Cane Protection and Productivity Boards and the Bureau of Sugar Experiment Stations (BSES). Many thousands of hectares of on-farm plant sources are inspected each year as well as random surveys of commercial fields. The results of these surveys are compiled by the BSES and reported in the Biannual Conference of the Cane Protection and Productivity Boards. The distribution of diseases in Australia was based on information from these reports.

The Ord River district of Western Australia has been growing experimental crops of sugarcane for 20 years but a commercial sugar industry commenced operation in 1996. This district is free of many sugarcane pathogens which are present in the eastern states. The distribution of diseases in the Ord River was based on personal communications with Mr Brian Egan, consultant pathologist to the Western Australian sugar industry.

### 4.0 SUGARCANE DISEASES OF QUARANTINE SIGNIFICANCE TO AUSTRALIA

#### 4.1 Brown Spot

**Causal Agent:** *Cercospora longipes* E Butler

**Distribution:**

Thirty-four countries including Papua New Guinea and Indonesia.

***Economic Importance:***

Brown spot is generally considered to be of minor economic importance (Abbott, 1964) but one report from Louisiana measured yield losses of up to 12% (Abbott, 1951). On a recent study tour of South Africa by BSES pathologists many fields were observed with severe leaf scorching caused by a heavy infestation of brown spot.

***Biology:***

Brown spot causes red-brown oval shaped lesions on the leaf blade. The spots are surrounded by a narrow yellow halo. Severely affected leaves die prematurely giving fields a scorched appearance. Spores of the fungus are produced on both sides of the leaf and are spread by wind blown rain.

Brown spot has been reported to cause significant loss of leaf area in tropical and sub-tropical climates and it is likely that the disease would be suited to a wide range of districts within the Australian sugar industry.

It is unlikely that brown spot would reach Australia by natural spread. Illegal movement of sugarcane is the most likely means of entry into Australia. Brown spot is not a risk in germplasm exchange since the standard hot water treatment would kill any spores adhering to the surface of imported cuttings. Brown spot could be controlled by resistant varieties if it did enter Australia and overseas experience is that there are ample sources of resistance in modern hybrid sugarcanes.

***Quarantine status:***

Brown spot should be considered a moderate quarantine risk to Australia.

**4.2 Downy Mildew**

***Causal Agents:***      *Peronosclerospora sacchari* (T Miyake)  
                                  Shirai & K Hara  
                                  *Peronosclerospora philippinensis* (Weston)  
                                  C G Shaw  
                                  *Peronosclerospora spontanea* (Weston)  
                                  C G Shaw

***Distribution:***

Downy mildew (*P. sacchari*) was present in Australia up until approximately 1960 (it was maintained for experimental purposes at an isolation site in Brisbane until 1972). There have been no records of the disease since this time. The obvious symptoms of the disease and the widespread growth of susceptible varieties for many years means that it can be confidently assumed that downy mildew no longer occurs in Australia.

**Table 2 Sugarcane diseases of significant economic importance, their presence in Australia and their relative importance**

<b>Disease</b>	<b>Causal Agent</b>	<b>Presence In Australia</b>	<b>Importance</b>
Bacilliform virus	Sugarcane bacilliform virus	Yes	Uncertain
Brown spot	<i>Cercospora longipes</i>	No	Intermediate
Chlorotic streak	Unknown	Yes	High
Downy mildew	<i>Peronosclerospora philippinensis</i>	No	Uncertain
Downy mildew	<i>Peronosclerospora spontanea</i>	No	Uncertain
Downy mildew	<i>Peronosclerospora sacchari</i>	No	High
Eye spot	<i>Drechslera sacchari</i>	Yes	Intermediate
Fiji disease	Fiji disease virus	Yes(limited distribution)	High
Grassy shoot	Phytoplasma	No	High
Gumming	<i>Xanthomonas campestris</i> pv <i>vasculorum</i>	No	Intermediate
Leaf blight	<i>Leptosphaeria taiwanensis</i>	No	Intermediate
Leaf scald	<i>Xanthomonas albilineans</i>	Yes(one serotype)	High
Leaf scorch	<i>Stagonospora sacchari</i>	No	High
Mild mosaic	Sugarcane mild mosaic virus	Yes	Uncertain
Mosaic	Potyvirus from Pakistan	No	High
Mosaic	Sugarcane mosaic virus	Yes(one strain)	High
Mosaic	Sorghum mosaic virus	No	High
Pachymetra root rot	<i>Pachymetra chaunorhiza</i>	Yes	High
Pineapple disease	<i>Ceratocystis paradoxa</i>	Yes	High
Pokkah boeng	<i>Gibberella fujikuroi</i>	Yes	Intermediate
Pokkah boeng	<i>Gibberella subglutinans</i>	Yes	Intermediate
Ramu leaf scorch	Unknown	No	Intermediate
Ramu streak	Unknown	No	Uncertain
Ramu stunt	Suspected virus	No	High
Ratoon stunting disease	<i>Clavibacter xyli</i> subsp. <i>Xyli</i>	Yes(active control)	High
Red leaf mottle	Peanut clump virus	No	Intermediate
Red rot	<i>Glomerella tucumanensis</i>	Yes	High
Red stripe/top rot	<i>Burkholdia rubrilineans</i>	Yes	Intermediate
Root rots	<i>Pythium</i> spp.	Yes	Intermediate
Rust (common)	<i>Puccinia melanocephala</i>	Yes	High
Sereh	Unknown	No	Uncertain
Striate mosaic	Sugarcane striate mosaic virus	Yes	Intermediate
Sugarcane smut	<i>Ustilago scitaminea</i>	No	High
White leaf	Phytoplasma	No	High
Wilt	<i>Gibberella subglutinans</i>	No	High
Yellow leaf syndrome	Luteovirus and Phytoplasma	Uncertain	Uncertain
Yellow spot	<i>Mycovellosiella koepkei</i>	Yes	High

***Downy mildew occurs in:***

*Peronosclerospora sacchari*: Fiji, India, Indonesia, Japan, Papua New Guinea, Philippines, Taiwan, Thailand

*Peronosclerospora philippinensis*: India, Philippines

*Peronosclerospora spontanea*: Philippines, Thailand

***Economic Importance:***

Downy mildew is reported to be a very severe disease with extensive yield losses in susceptible varieties (Leu and Egan, 1989; Suma and Pais, 1996; Tamanikaiyaroi and Johnson, 1996). In Papua New Guinea, losses were estimated at up to 15% in susceptible varieties (Suma and Pais, 1996). Up to 36% of clones imported to Papua New Guinea are too susceptible for commercial production and 50% of Australian clones are susceptible (Suma and Pais, 1996). Restrictions on the use of susceptible varieties would affect the yield potential in areas where the disease is present.

***Biology:******P. sacchari***

*P. sacchari* is the primary cause of sugarcane downy mildew (Leu and Egan, 1989). The disease is characterised by pale to light yellow leaf streaks which turn reddish-brown to dark red on ageing. Affected plants are stunted. In late autumn-early winter oospores are produced in leaves causing the leaves to shred. Some stalks can abnormally elongate in early winter, standing out well above the rest of the crop.

Downy mildew is fully systemic within plants and cuttings from infected plants will reproduce the disease. Conidia are produced on leaves during warm nights with high humidity. Conidia generally do not travel more than 400 m and do not survive for any significant period after sunrise of the morning on which they were formed. Infection is through very young developing leaf tissue and through lateral buds. The role of oospores in disease transmission is unclear.

*P. sacchari* will infect maize, *Zea mays* L. Maize can be more susceptible than sugarcane and the pathogen can cause serious losses in maize crops. *Sorghum bicolor* (L) Moench is less susceptible.

Spread of downy mildew to Australia by wind-blown spores is not considered possible because of the delicate nature of the conidia. Downy mildew could be introduced into Australia in illegally imported plants or cuttings. This is a relatively high risk as there have been a number of cases of sugarcane cuttings being illegally imported to Australia from Papua New Guinea in recent years. The importance of spread of oospores on contaminated equipment is difficult to assess because of the uncertain role of these spores in the epidemiology of the disease.

When downy mildew occurred in Australia it was present and caused significant yield losses in all districts of the Australian sugar industry. The disease therefore has potential to significantly affect all districts if an incursion occurs.



Downy mildew is unlikely to be a major risk for authorised germplasm exchange since symptoms are obvious and a high percentage cure is obtained with the standard hot water treatments used in quarantine. Cuttings from suspect sources can also be dipped in met alaxyl which eliminates the disease.

***P. philippinensis* and *P. spontanea***

Both these pathogens have been reported on sugarcane causing similar symptoms to *P. sacchari*. Few definitive studies have been conducted to determine the exact proportion of disease caused by each species. *P. philippinensis* is a serious pathogen of maize in the Philippines (Husmillo and Reyes, 1980).

***Quarantine Status:***

*P. sacchari* and *P. philippinensis* must be considered high quarantine risks to Australia, not only for sugarcane but also for maize. The close proximity of sources of infection in Papua New Guinea, the Philippines and Fiji and the extensive travel between Australia and these countries increases the risk. The importance of *P. spontanea* is uncertain.

**4.3 Fiji Disease**

***Causal agent:*** Fiji disease virus, Reoviridae

***Distribution:***

Fiji disease occurs in Australian sugarcane producing districts south of Proserpine (approximately half of the industry). It has never been recorded north of Proserpine and strict quarantine procedures are in place to prevent the risk of further spread. Within the major canegrowing districts of Mackay and Bundaberg, extensive control programs have been implemented for many years and the disease has not been reported in the past five years. Districts south of, and including, Maryborough continue to report the disease on a regular basis.

Fiji disease is also present in:

Fiji	Malaysia
Indonesia (limited to native gardens and wild canes on eastern islands and not in commercial crops which are currently restricted to Sumatra, Java, Sulawesi and Kalimantan.)	New Caledonia
Malagasy Republic (now thought to be eradicated)	Papua New Guinea
	Philippines
	Samoa
	Solomon Islands
	Thailand
	Vanuatu

***Economic Importance:***

Fiji disease has caused devastating losses and has threatened the existence of the sugar industry in areas of Fiji and southern Queensland (Egan *et al*, 1989). In individual fields, losses of 100% can occur. Fiji disease is potentially one of the most serious diseases of sugarcane when susceptible varieties are present and conditions are suitable for the insect vectors.

***Biology:***

Fiji disease causes severe stunting, short dark green leaves, often with a ragged, bitten-off appearance and diagnostic galls on the underside of leaves (Egan *et al*, 1989). The virus is transmitted by planthoppers of the genus, *Perkinsiella* (*P. saccharicida*, *P. vastatrix*, *P. vitiensis*). *P. saccharicida* is the only vector present in Australia.

Early instars of the insect vectors acquire the virus and can transmit the virus for the rest of their lives. Swarms of the vector can occur under ideal conditions and it is thought the disease was spread by insects distances greater than 100 kms during the epidemic in southern Queensland.

The incubation period in plants is from 15 days to 6 months. Early symptoms are difficult to detect with only a few small leaf galls occurring in some clones. Cuttings from infected plants produce a high level of infected plants.

Other than *Saccharum* species, alternative hosts of both the virus and the vector have little importance in epidemiology of the disease.

It is highly probable that Fiji disease would be an important disease throughout the regions where it is not currently present in Australia. The vector is already present in these regions.

It is possible that Fiji disease could spread to Australian territory in the Torres Strait from Papua New Guinea by natural spread of the insect vector. *Saccharum officinarum* is grown widely in native gardens in the Torres Strait and in some communities on Cape York. Further spread to commercial canegrowing districts would be unlikely but may be feasible during abnormal weather conditions (eg cyclones).

The illegal movement of sugarcane cuttings (and related *Saccharum* species) from Papua New Guinea presents a major risk of the disease entering northern Queensland. The risk of movement of infected cuttings from southern districts has been reduced by the highly successful control programs but some risk still exists. Quarantine boundaries under Queensland State legislation are used to prevent movement of cane from Proserpine south to northern districts except when it has been held in quarantine for at least one year. Authorised germplasm exchange presents a significant risk of spread of Fiji disease. In some clones the symptoms are difficult to distinguish and the disease has a long latency period. Indexing plants with new PCR assays can reduce the risk of escape of the disease through authorised germplasm exchange. The movement of the planthopper vector in vehicles or airplanes must also be considered a risk.

***Quarantine Status:***

Fiji disease virus is a major quarantine risk to northern canegrowing districts of Queensland and to the Ord River district. Currently a major variety being grown in the Ord River is the variety involved in the epidemic in the Bundaberg district.

**4.4 Grassy Shoot**

***Causal agent:*** Phytoplasma

***Distribution:***

Bangladesh	Malaysia	Nepal
India	Myanmar	Sri Lanka

***Economic Importance:***

Grassy shoot disease can cause losses of up to 70% in some fields. Affected plants produce little or no millable cane (Rishi and Chen, 1989). Alexander and Viswanathan (1996) rated grassy shoot the third most important disease of sugarcane in India.

***Biology:***

Grassy shoot produces severe stunting, profuse tillering and chlorotic stripes on the leaf blade (Rishi and Chen, 1989). In some cases the chlorotic stripes coalesce to produce complete chlorosis of shoots.

Grassy shoot is transmitted by planting infected cuttings. The method of secondary transmission has not been conclusively determined. Sorghum, *Sorghum bicolor* (L) Moench, and elephant grass, *Pennisetum purpureum* Schum., are possible alternative hosts but this has not been confirmed by definitive tests.

Because of the confusion about transmission of grassy shoot disease, it is difficult to assess the risk of natural spread. Illegal import of cuttings represents a significant risk. Grassy shoot is partially controlled by long hot water treatment. The risk of the disease escaping from authorised quarantine is probably small.

***Quarantine Status:***

Grassy shoot phytoplasma is a moderate quarantine risk for Australia. The distance of known sources of infection and the limited history of movement of the disease reduce the risk. The assumed requirement for a vector (all known phytoplasmas have insect vectors) may limit spread in Australia unless the vector is already present or is introduced with the disease.

## 4.5 Gummy

**Causal Agent:** *Xanthomonas campestris* pv. *vasculorum*  
(Cobb) Dye  
Distinct strains have been reported from Mauritius and in South Africa a distinctly different pathovar of *X. campestris* is associated with gummy disease.

**Distribution:**

Thirty countries. Gummy disease was present in Australia until 1950 but there have been no reports since this time and the disease can therefore be considered eradicated (Ricaud and Autrey, 1989). Gummy does not occur in Papua New Guinea or Indonesia and has been eradicated from Fiji.

**Economic Importance:**

In the late 1890s and early 1900s gummy was a major disease in Australia and a number of other countries (Cobb, 1893). With the replacement of the noble canes (*S. officinarum*) with interspecific hybrids the disease decreased in significance. A recent epidemic occurred in Mauritius in the 1980s which caused significant yield losses (Ricaud and Autrey, 1989).

**Biology:**

Gummy causes yellow to orange leaf streaks on the leaf blade, general chlorosis of the leaves, stalk death and reddening and gum pockets internally within stalks (Ricaud and Autrey, 1989). The bacterium is spread by wind-blown rain. The disease can be spread by cutting implements and by planting infected cuttings. The bacterium has been found in a few grasses and causes a serious disease of palms in Mauritius (*Dictyosperma album*, *Roystonea regia* and *Areca cathecu*).

Gummy disease was widespread in all canegrowing districts of Australia when it was present earlier in this century.

It is considered unlikely that gummy disease will spread to Australia by natural means. Spread by illegal import of cuttings is possible but of low risk due to the limited occurrence of the disease. In authorised germplasm exchange there is some risk of introduction of the bacterium but the low incidence and the obvious symptoms reduce the risk. The disease is not fully controlled by hot water treatments.

**Quarantine Status:**

*Xanthomonas campestris* pv *vasculorum* should be considered a moderate quarantine risk for Australia.

#### 4.6 Leaf Scald

**Causal Agent:** *Xanthomonas albilineans* (Ashby) Dowson  
(3 distinct serotypes, at least 8 DNA groups)

**Distribution:**

Fifty-seven countries including Australia. Leaf scald has been recorded in all canegrowing districts in Australia except the Ord River district. Only one serotype of the bacterium has been reported from Australia.

**Economic Importance:**

Leaf Scald is a serious disease which can cause significant yield losses and loss of highly susceptible varieties (Ricaud and Ryan, 1989). Severe losses can occur if there are high levels of disease and moisture stress (Hoy and Grisham, 1994).

**Biology:**

Leaf Scald has a wide range of symptoms but the diagnostic symptom is the white, well defined, pencil-line streaks on the leaf blade (Ricaud and Ryan, 1989). The disease also causes burning of the leaf tips giving the plant a scalded appearance, shooting of lateral buds, general chlorosis of the leaves and complete death of stalks. The disease can remain latent for months or longer.

Infected cuttings produce a high percentage of infected plants. The bacterium can be spread by wind-blown rain, particularly during severe weather events such as cyclones. The disease is also readily spread by cutting implements such as knives and mechanical harvesting and planting equipment. The bacteria cannot survive for long in the soil but a number of common weed species can act as alternative hosts.

A number of distinct variants of *X. albilineans* have been reported (Alvarez *et al*, 1996; Rott *et al*, 1994) with differing aggressiveness. A recent upsurge and spread of the disease in North, Central and South America has been reported as being associated with a genetic variant of the bacterium (Davis *et al*, 1997). Only one serotype of *X. albilineans* has been reported from Australia but this is based on a small number of isolates.

The possibility of natural spread of the bacterium in wind-blown rain into Australia must be considered very unlikely. Illegal importation of infected cuttings could be a source of the disease. Transmission on contaminated equipment is possible but unlikely as the bacteria cannot survive outside the host for long periods.

Escape of the bacterium through authorised germplasm is an important risk because of the latent period which can occur. Spread of the disease through authorised quarantine is thought to have occurred in the past (Alvarez *et al*, 1996). Soaking cuttings in cold water for two days followed by heat treatment at 50°C for three hours can eliminate the bacteria from a high percentage of cuttings. It is also reported that *X. albilineans* can be passed through some tissue culture procedures.

***Quarantine Status:***

*X. albilineans* is a high risk quarantine pathogen of sugarcane for Australia because of the existence of aggressive strains overseas that do not occur in Australia. It is also an important quarantine pest for the Ord River district.

Leaf scald is under active control in Australia, with extensive disease-free seed schemes and plant breeding for disease resistance.

**4.7 Leaf Scorch**

***Causal Agent:*** *Stagonospora sacchari* Lo and Ling

***Distribution:***

Argentina	Japan	South Africa
Bangladesh	Nigeria	Taiwan
Cuba	Panama	Thailand
India	Papua New Guinea (doubtful)	
Indochina	Philippines	

***Economic Importance:***

Leaf scorch is an important disease in Taiwan, the Philippines (Lo and Leu, 1989) and more recently Indonesia (Sumatra) (Mirzawan *et al*, 1996). Yield losses of up to 30% have been reported.

***Biology:***

Leaf scorch causes large reddish-brown to straw coloured spindle shaped streaks on the leaf blade with a definite yellowish halo (Lo and Leu, 1989). The streaks often coalesce giving the leaf a scorched appearance. Spores of *S. sacchari* are formed during periods of free moisture on the affected leaf and are dispersed by rain splash or wind-blown rain. Spores do not spread significantly during dry, windy weather. Exposed spores can survive for two weeks but spores enclosed in pycnidia can survive for several months. The disease is not systemic but spores can adhere to cuttings on pieces of leaf material. The only control measure for leaf scorch is planting resistant varieties.

Leaf scorch can infect wild *Saccharum* species and *Miscanthus spp.*

The epidemiology of leaf scorch disease would suggest that the disease would be more severe in the wet tropical regions but it could also cause some losses in other regions when environmental conditions are favourable.

The natural spread of leaf scorch to Australia is unlikely. Further spread in Indonesia or from the Philippines to Papua New Guinea would increase this risk. Spread on illegally imported cuttings or leaf pieces is possible. The recent spread of the disease to Sumatra is thought to have been associated with an unauthorised import of cane from Taiwan. Transmission by leaf residues on machinery is a definite risk for entry of this pathogen.

Leaf scorch presents no risk for authorised germplasm exchange since the disease is not systemic in cuttings and the standard hot water treatment would kill any spores adhering to the surface of the cuttings.

***Quarantine Status:***

*S. sacchari* is a moderate quarantine risk to Australia. Further movement of the disease in Indonesia would increase the risk for Australia.

**4.8 Mosaic**

***Causal Agents:*** Sugarcane mosaic virus (SCMV) (Potyvirus)  
Sorghum mosaic virus (SrMV) (Potyvirus)  
(possible new potyvirus from Pakistan)  
Many well documented strains exist.

***Distribution:***

Sixty-nine countries including Australia.

In Australia, only strain A of SCMV and the closely related Johnson grass mosaic virus (previously SCMV strain J) (Buchen-Osmond *et al*, 1988) have been reported. The detailed location of strains of SCMV and SrMV (previously SCMV strains, H, I and M) are reported in Koike and Gillaspie (1989). Strain F of SCMV is now thought to be a separate potyvirus (Jensen and Hall, 1993) and has been found in cane imported to the USA from Pakistan.

***Economic Importance:***

Mosaic has caused serious losses in many countries particularly in sub-tropical areas. Losses have been measured at up to 50% in susceptible varieties (Koike and Gillaspie, 1989). Greatest losses appear to be associated with SrMV (SCMV strains H & I). In Pakistan, mosaic, possibly strain F, is extremely common and is causing significant losses (James, personal communication).

***Biology:***

Mosaic produces contrasting shades of green on the leaf lamina and a mosaic pattern on the stem, particularly in sugarcane clones with a reddish stalk colour. Leaf symptoms appear as normal green on a background of paler green or yellow chlorotic areas. Affected plants are generally unthrifty.

Both SCMV and SrMV are transmitted by at least seven species of aphid in a non-persistent manner (Koike and Gillaspie, 1989). *Rhopalosiphum maidis* (Fitch) and *Dactynotus ambrosiae* Thos. are efficient vectors. Mosaic can also be spread by planting infected cuttings.

The mosaic viruses can infect a wide range of cultivated and wild grasses from at least 23 genera.

Sugarcane mosaic generally only causes significant disease losses in the sub-tropical regions of the world. In Australia, SCMV has only rarely been reported north of Mackay. It is likely that any new strains would also be most important in the central and southern canegrowing districts.

Natural spread of other strains of SCMV or SrMV to Australia is unlikely. Entry of mosaic on illegally imported cuttings of sugarcane or a wide range of other grasses is a high risk. Mosaic symptoms have been detected in authorised introductions of *Cynodon dactylon* and *Miscanthus sinensis* recently imported into Australia (Davis and Gillings, 1996). *Miscanthus* is valued as an ornamental plant, often with variegation of the leaves, which makes detection of mosaic symptoms difficult. Authorised germplasm exchange presents a risk of entry of mosaic viruses because of the wide host range and therefore many species involved in the risk and the widespread occurrence of the viruses in nearly all the major sugarcane producing countries and other countries where grasses may be imported from. Current protocols to reduce this risk in Australia are discussed in Davis and Gillings (1996).

***Quarantine Status:***

Sorghum mosaic virus, strains of SCMV other than strain A and the potyvirus from Pakistan (SCMV strain F) are high risk quarantinable pathogens for Australia.

#### **4.9 Ramu Stunt**

***Causal Agent:*** Suspected virus.

***Distribution:***

Ramu stunt has only been reported from the Ramu Valley in Papua New Guinea but no extensive survey has been conducted in other parts of Papua New Guinea or surrounding islands (Magarey *et al*, 1995).

***Economic Importance:***

Ramu stunt caused a severe epidemic in the small Ramu Sugar Plantation in Papua New Guinea in 1985/86 with 40% reduction in yield over the whole plantation (Suma and Pias, 1996). Drastic measures had to be taken to limit the damage or yield losses would have increased in subsequent years.

Up to 30% of all clones imported to Ramu Sugar Plantation from overseas are susceptible to Ramu stunt.

***Biology:***

Ramu stunt causes severe stunting, and chlorotic striping on the leaf blade, general yellowing of the leaves and stool death (Magarey *et al*, 1995). Initial studies have identified a planthopper, *Eumetopina flavipes* Muir as the vector. This insect does not occur in commercial sugarcane in Australia but is common in the Torres Strait islands and



has been reported from Cape York (Allsopp, 1991). Nothing is known about the persistence of the putative virus in the vector. The disease can be transmitted by infected cuttings. Similar symptoms to Ramu stunt have been observed in a few grasses but because no definitive diagnostic procedure has been developed the presence of the disease cannot be confirmed.

Because of the limited distribution of this disease it is difficult to speculate on the likely distribution in Australia if an incursion occurred.

Natural spread of the planthopper vector of Ramu stunt to commercial sugarcane fields is considered to be a high risk because of its current common occurrence in the Torres Strait and Cape York. Because the distribution of the virus outside the Ramu Valley is unknown, the risk of the virus being present in the vector cannot be determined. Ramu stunt could be introduced into Australia in illegally imported plants or cuttings. This is a relatively high risk as there have been a number of cases of sugarcane cuttings being illegally imported to Australia from Papua New Guinea in recent years. The difficulty in diagnosing the disease and the lack of any diagnostic procedure make it difficult to detect the disease in authorised germplasm exchange. For this reason *Saccharum* spp. should not be imported to Australia from the Ramu Valley in Papua New Guinea until sensitive diagnostic procedures are developed.

***Quarantine Status:***

The causal agent of Ramu stunt and its vector, *E. flavipes* are high risk quarantine pests for Australia.

**4.10 Sugarcane smut (Culmicolous)**

***Causal agent:*** *Ustilago scitaminea* H Sydow

***Distribution:***

Smut occurs in almost all sugarcane producing countries. Smut has never been reported from Australia or Papua New Guinea and the report from Fiji by Parham (1953) is believed to be incorrect (Tamanikaiyaroi and Johnson, 1996). In 1979, smut was reported for the first time for 50 years in Indonesia but its distribution throughout Indonesia is restricted to Java, Sumatra and Sulawesi (Mirzawan *et al*, 1996).

***Economic Importance:***

Sugarcane smut has caused serious economic losses in nearly all countries where it occurs. The economic importance of the disease is through direct yield losses (15-30% in susceptible varieties, Ferreira and Comstock, 1989), cost of control programs (Bailey, 1996) and through restrictions on the use of germplasm (Comstock *et al*, 1983). Because Australian sugarcane germplasm has never been subject to selection for smut resistance, there is a high probability that a large percentage of the germplasm is susceptible. In Hawaii, 80% of clones in breeding trials were found to be susceptible to smut when it was first reported in that country (Comstock *et al*, 1983).

**Biology:**

Smut infection of sugarcane is characterised by the production of a whip-like structure from the apex of the cane stalk. This whip is the sorus of the fungus and is black with a silver-grey membrane. Infected plants are severely stunted, have profuse tillering and stalks are thin giving the plant a grassy appearance. Teliospores are well adapted to wind dispersal and the spread of the fungus to the Americas in the 1970s is believed to have occurred by wind dispersal across the Atlantic Ocean (Simmonds, 1994). Teliospores only infect through lateral buds on standing cane stalks or buds on cuttings planted into infested soil. The fungus will remain dormant within the bud until the bud germinates. The fungus grows in association with the developing plant meristem and each developing lateral bud primordium is infected. The planting of systemically infected cane stalks gives rise to infected plants. *U. scitaminea* can infect other *Saccharum* species and a few grasses (*Rottboellia cochinchinensis* and *Imperata arundinacea*). Teliospores survive for up to 2-3 months in moist soil but for longer periods in dry conditions (Hoy *et al.*, 1993).

Smut is a major disease in tropical and sub-tropical climates and has the potential to severely affect all districts of the Australian sugar industry.

It is quite possible that smut may naturally spread to Australia from another country by wind dispersal. Illegal import of infected sugarcane or import of contaminated farm machinery could introduce the disease. Introduction of smut through authorised germplasm exchange is unlikely since the disease is readily recognised by the obvious whip symptom and standard quarantine hot water treatment protocols give a high level of cure of infected stalks.

**Quarantine Status:**

*Ustilago scitaminea* must be considered a high risk quarantine pest of sugarcane. Further movement of the fungus in Indonesia, particularly into Irian Jaya, would greatly increase the risk of it entering Australia. The Ord River district is significantly closer to sources of inoculum in Indonesia than sugarcane in the eastern states. It is likely that smut disease will occur in Australia in the future and it could cause losses of in excess of AUS \$100m per annum. A detailed contingency plan for this pathogen should be prepared.

**4.11 White Leaf**

**Causal Agent:** Phytoplasma

**Distribution:**

Taiwan  
Thailand

**Economic Importance:**

White leaf is a serious disease in Thailand and Taiwan (Rishi and Chen, 1989). Yield losses in severely affected fields can be so great that it is no longer viable to harvest the fields. White leaf is considered the most serious disease of sugarcane in Thailand (Koike,

1986). In Taiwan, the disease was important in the past but extensive control programs have reduced its importance.

***Biology:***

White leaf disease is characterised by white stripes on the leaves, mottling or total chlorosis (Rishi and Chen, 1989). The symptoms are masked in older plants by low temperatures. Stalks of affected plants are thin. White leaf disease can be spread by planting infected cuttings and by the planthopper, *Matsumuratettix hiroglyphicus* Matsumura. The vector carries the phytoplasma in a persistent manner, becoming infectious 14-40 days after feeding on an infected plant. The disease symptoms in plants develop 3-6 months after transmission by the vector. White leaf disease can infect *Saccharum spontaneum* and possibly other grass species (Nakashima *et al*, 1994).

The suitability of environments in Australian canegrowing districts for the white leaf phytoplasma and its vector, *M. hiroglyphicus* is unknown.

Natural spread of white leaf disease by spread of infectious planthoppers is possible but the limited reports of spread outside the countries in which it occurs suggests that this is a low risk. Spread by illegal import of cuttings is possible. The widespread occurrence in Thailand would suggest this is the most likely source of the disease. Authorised germplasm exchange could present a risk for entry of the disease. Even if the disease did escape through quarantine the absence of the vector would mean the disease would not be able to spread from the infected plants. Hot water treatment does not appear to be effective for white leaf disease.

***Quarantine Status:***

White leaf disease should be considered a moderate quarantine risk for Australia. If the disease and the vector became established in Australia the disease could cause significant losses but the risk of introduction to Australia is low.

**4.12 Yellow leaf syndrome**

***Causal Agent:*** Sugarcane yellow leaf virus (Luteovirus) and a phytoplasma have been reported to be associated with this disease.

***Distribution:***

Australia	USA (including Hawaii)
Brazil	Venezuela
South Africa	

***Economic Importance:***

Yellow leaf syndrome has caused significant losses in Hawaii and Brazil (Burnquist and Vega, 1996). Major varieties have been withdrawn from production because of their susceptibility to this syndrome.

***Biology:***

Yellow leaf syndrome (YLS) is characterised by yellowing of the mid-rib of the first few fully expanded leaves (Lockhart *et al*, 1996) with yellowing and reddening sometimes extending out onto the leaf blade. Sugarcane yellow leaf virus has been transmitted by aphids. The vector of the phytoplasma is unknown. Both the virus and the phytoplasma are carried in infected cuttings.

The introduction of YLS to Australia in illegal imports of cuttings is possible. YLS symptoms were detected in clones imported from Florida to Australia in 1994 (Croft and Smith, 1996). These clones were destroyed. Symptoms of the disease are brought on by stresses such as cold temperatures, moisture stress or nitrogen deficiency. PCR assays are being developed for the virus and phytoplasma associated with YLS. Symptoms like those of the disease have been seen in commercial fields in Australia. Limited surveys have detected both the yellow leaf virus and phytoplasma in Australia.

***Quarantine Status:***

The causal agent of yellow leaf syndrome must be considered a high risk pest for Australia until further information is available about the causal agents and the distribution of the agents in Australia.

**5.0 OTHER DISEASES OF POSSIBLE QUARANTINE SIGNIFICANCE****Bacilliform virus (Badna virus)**

Sugarcane bacilliform virus (SCBV) is widespread in noble canes (*S. officinarum*) and to a lesser extent in commercial hybrids (Irey *et al*, 1992). Recent research suggests the disease can cause losses in some varieties (Comstock and Lockhart, 1996). SCBV is spread by mealy bugs but spread is reported to be slow (Comstock and Lockhart, 1996). SCBV can be considered a variant of Banana streak virus (BSV). Both SCBV and BSV have been reported in Australia. Distinct strains of BSV have been reported from Africa which cause severe symptoms on Cavendish bananas. SCBV cannot at this stage be eliminated from infected sugarcane cuttings. Noble canes in Papua New Guinea do not appear to be infected. The quarantine status of this pest is difficult to determine. The Australian Quarantine and Inspection Service considers SCBV non-quarantinable but BSV is quarantinable. Because noble sugarcane was imported for 200 years before the discovery of SCBV and most noble canes present in Australia are infected, as well as a number of commercial clones, SCBV is considered a low risk quarantine pest of sugarcane.

**Leaf blight**

Leaf blight is caused by the fungus, *Leptosphaeria taiwanensis* Yen and Chi. It has been recorded from India, Philippines, Japan and Taiwan.

Leaf blight causes yellow spindle shaped spots on leaves which turn into reddish brown streaks, the streaks can coalesce to give the leaf a scorched appearance (Yen, 1964). The

disease develops during wet weather. The disease is not carried systemically within cuttings of sugarcane. The risk of natural spread of the disease or spread in authorised imports of germplasm would be negligible. Spread on illegal import of cuttings could occur. Leaf blight causes significant loss of green leaf area in affected areas, but no study of the effect of the disease on yield has been reported (Yen, 1964). The disease is only a serious problem in high rainfall areas. Overall losses from the disease are probably small.

*Leptosphaeria taiwanensis* is a low quarantine risk for Australia.

### **Mild mosaic (Closterovirus)**

Sugarcane mild mosaic virus was recently identified in sugarcane in association with SCBV infection (Lockhart *et al*, 1992). The virus has been found in Australia in a hybrid cultivar. Its affect on sugarcane has not been fully determined but initial observations suggest it is not a major pathogen. The quarantine status of mild mosaic virus must be considered low.

### **Ramu Leaf Scorch**

The cause of Ramu leaf scorch (Papua New Guinea) has not been determined but recent research suggests an insect of the genus *Lophops* may be involved. It is currently considered of minor importance at the Ramu Sugar Plantation (Suma and Pais, 1996). Ramu leaf scorch is only a minor quarantine risk for Australia.

### **Ramu Streak**

A chlorotic streak symptom distinguishable from other known sugarcane diseases has been observed at a relatively high incidence in some fields on the Ramu Sugar Plantation in Papua New Guinea (Magarey *et al*, 1995). Nothing is known about the cause, transmission, distribution or economic importance of the disease. Quarantine risk must be considered low at this stage.

### **Ratoon Stunting Disease**

Ratoon stunting disease (RSD) is the most economically important disease of sugarcane (Gillaspie and Teakle, 1989). It occurs in almost all countries but has not been reported from Papua New Guinea. The disease is caused by *Clavibacter xyli* subsp. *xyli* (Davis *et al*) and is highly infectious on cutting implements and spreads easily in diseased cuttings. The disease causes no external symptoms which makes diagnosis difficult. RSD is widespread in established canegrowing districts of Australia but has not been reported from the Ord River district. In excess of \$2 million is spent in Australia each year on control of this disease. No strains of the bacterium have been reported but there has been limited research in this area. Hot water treatment at 50°C for three hours which is a standard procedure for quarantine of sugarcane gives a high percentage of disease-free plants.

*C. xyli* subsp. *xyli* is a low quarantine risk for all areas of Australia except the Ord River where it is a high risk pest.

### **Red Leaf Mottle**

Red leaf mottle is caused by the Peanut clump virus (Furovirus). Peanut clump virus has been reported in sugarcane from Burkina Faso, Senegal and Sudan on peanuts in India. Red leaf mottle can cause significant yield losses of up to 6% in the plant crop but losses are less in ratoon crops (Baudin *et al*, 1994).

Red leaf mottle causes a range of symptoms in different clones (Rott, 1996). The symptoms include chlorotic stripes with red-brown mottling, wine red leaf spots or white streaks or patches. The disease is transmitted in soil by the fungus, *Polymyxa graminis*, and by planting infected cuttings. Peanut sorghum and wheat have been reported as alternative hosts.

The vector of peanut clump virus is a common soil inhabitant and therefore there is a potential for the disease to spread in many sugarcane districts. However, not enough is known about the disease in sugarcane to determine the likely extent of the disease.

Illegal import of infected cuttings could occur but is unlikely due to the limited occurrence. Importation in authorised germplasm exchange is possible and the symptoms may be confused with genetic effects. The limited distribution and the unlikely need to import sugarcane from the known affected countries would reduce the risk.

Peanut clump virus is of low quarantine risk for sugarcane in Australia but the risk may be greater for peanuts.

### **Sereh**

Sereh was a devastating disease in Indonesia in the early part of this century but seemed to disappear when hybrid varieties were introduced. A recent report of a sereh-like disease in a cane imported to Taiwan from China is the first report of similar symptoms for many years (personal communication reported by Croft, 1996). The quarantine risk of this disease must be considered low because of its rarity.

### **Streak**

Streak disease of sugarcane, caused by sugarcane streak virus (SCSV), is a minor disease of sugarcane in Africa (Bailey, 1996). The rarity of the disease in sugarcane and the clear evidence that SCSV is distinct from maize streak virus (Hughes *et al*, 1991) make this pest a low quarantine risk.

### **Wilt**

Wilt disease is considered a major disease in India and a similar disease complex, red rot wilt, caused major losses recently in Thailand (Alexander and Viswanathan, 1996). These

diseases have not been recorded in Australia but the causal agent of wilt, *Gibberella subglutinans* (*Cephalosporium sacchari* is considered to be identical to *G. subglutinans* by Sivanesan and Waller, 1986), is present in Australia. This pathogen is a low quarantine risk for Australia.

## 6.0 ORD RIVER DISTRICT

The diseases listed in Table 2, have been recorded in Australia and are of economic importance but have not been reported in the Ord River district.

These diseases should be considered quarantinable for Australia in terms of introduction to the Ord River district. Strict quarantine is enforced on plants introduced into the Ord River district.

**Table 3 Sugarcane diseases of quarantine significance to the Ord River district which occur in the eastern states**

<b>Disease</b>	<b>Causal Agent</b>
Chlorotic streak	Unknown
Eye spot	<i>Drechslera sacchari</i>
Fiji disease	Fiji disease virus
Leaf scald	<i>Xanthomonas albilineans</i>
Mosaic	Sugarcane mosaic virus
Pachymetra root rot	<i>Pachymetra chaunorhiza</i>
Ratoon stunting disease	<i>Clavibacter xyli subsp. Xyli</i>
Red rot	<i>Glomerella tucumanensis</i>
Root rots	<i>Pythium spp.</i>
Rust (common)	<i>Puccinia melanocephala</i>
Striate mosaic	Sugarcane striate mosaic virus
Yellow spot	<i>Mycovellosiella koepkei</i>

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