Bakanae

Anamorph: *Fusarium moniliforme* Sheld.
Teleomorph: *Gibberella fujikuroi* (Sawada) Wollenweb.

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April 2005 (reviewed 2008)

Background

Bakanae, caused by *Gibberella fujikuroi* is considered to be a high threat because it causes significant seedling mortality and yield loss.

The pathogen is widespread in all rice-growing countries of the world. It has never been recorded on rice within the rice-growing area of South eastern Australia. In Queensland, the disease has been found on one occasion in a glasshouse but has never been found in rice fields (R. Shivas, personnal communication). Heaton and Morschel (1965) reported a footrot disease caused by the pathogen in the Northern Territory.

Host range

Maize (*Zea mays*), rice (*Oryza sativa*), sorghum (*Sorghum* spp.), sugar cane (*Saccharum officinarum*). Alternate hosts include *Leucaena leucocephala*, *Lycopersicon esculentum* (tomato), *Musa* sp. (banana) and *Vigna unguiculata* (cowpea). In Japan, the pathogen has been found on *Panicum miliaceum*.

Part of plant/commodity affected

Seedlings.

Biology

Identification/Symptoms

Bakanae is a seedling disease, but it can be observed throughout the growing season. The earliest symptoms of bakanae are infected seedlings that appear to be elongated, thinner and slightly chlorotic when compared with healthy seedlings (Figure 1). The rapid elongation of infected seedlings can be up to 3 times taller than healthy seedlings. The rapid elongation of infected plants is due to the production of gibberellin, a plant hormone, by the fungus. Symptom development is influenced by the amount of inoculum present, the strain of the pathogen and the relative quantities of gibberellin and fusaric acid (which causes stunting) produced. Bakanae plants are often visible above healthy rice plants. If infected seedlings often progressively die from the seedling stage through to maturity. Infected plants survive to heading, the panicles they produce are usually sterile. The flag leaf on mature plants is noticeable by its elevated, more horizontal stance.

The fungus sporulates profusely on the stems of diseased plants near the water level, and after the water is drained, noticeable pink to white fungal growth appears at the base of the plants. This cottony growth produces masses of conidia which contaminate the outside of healthy seeds during harvest.

Symptom development is affected by temperature. Symptoms do not appear below 20ºC and 35ºC is optimum for disease development.

***Figure 1**. Infection by* Gibberella fujikuroi *produces elongated, slightly yellow plants, with pronounced projection of the flag leaf (left); infected plants compared with healthy plant (right) (photos, E. Cother)*

Disease cycle

Bakanae is primarily a seed borne disease. The pathogen is known to over-winter as spores on the coat of infested seeds. There is some limited evidence of internal infection of seeds. Severely infected grain can be discoloured. Discoloured seeds give rise to stunted seedlings, whereas infected seeds without discolouration produce seedlings with typical bakanae symptoms. Infection may also take place through spores and mycelium, that are left in the water used for soaking seeds.

Ascospores and conidia adhering to the seed germinate and infect seedlings through the roots and crown. The fungus becomes systemic within the plant but does not enter the floral parts.

There are different mating types of the fungus and their presence influences the composition of the population. The fungus can over-winter in the soil and crop residue as thick walled hyphae or macroconidia. Infection of non-infested seeds by spores in the soil has been demonstrated. The length of time that spores can survive in the soil is unknown but it can over-winter in moist soils.

Dispersal

It is likely that infested seeds are the most important source of inoculum, leading to both infected plants in the field and also introduction of the disease to non-infested fields. Airborne conidia may contaminate seed during harvest.

Surveillance

General surveillance

Rice-growers/agronomists/extension personnel need to be educated about the threat bakanae represent to their industry and should also be encouraged to increase their vigilance for inspecting their crops for unusual symptoms or pests. The extension booklet “maintaining disease-free crops” (Cother and Lanoiselet 2002) was sent to every rice growers of NSW. Comprehensive information about current rice diseases and exotic rice diseases has also being incorporated to the CSIRO software MaNage Rice. Many rice growers are already using this free software. Any unusual symptoms observed by growers/agronomists/extension personnel should be immediately reported to an experienced and trained plant pathologist for formal identification. Alternatively, the Exotic Plant Pest Hotline can be contacted on 1800 084 881.

Targeted surveillance

Strict quarantine vigilance on the bakanae pathogen and other exotic pathogens must be maintained to protect the Australian rice industry. Barrier quarantine is in place in Australia both at the national and state level to prevent the introduction of exotic pests into Australia. The Australian Commonwealth *Quarantine Act 1908* requires an Australian Quarantine Inspection Service (AQIS) permit to import any parts of *Oryza* plants or plant parts and prohibit the importation of unmilled rice. The NSW *Plant Diseases Act 1924* prohibits the importation of rice plant parts, and machinery or packaging that has contacted rice plant parts into the rice quarantine area of NSW without the permission of the Chief of Division of Plant Industries of NSW Agriculture. Second hand agricultural machinery, including headers, are regularly imported from overseas and despite strict Australian quarantine regulation, it cannot be excluded that infected rice trash present in agricultural machinery/headers may have passed through quarantine inspection undetected. The 1996 rice blast outbreak in California (Greer et al. 1997) illustrates that the isolation of one rice-growing region from other rice-growing areas of the world does not guarantee continues freedom from exotic diseases threat. The quarantine vigilance should be maintained in order to protect the Australian rice industry from bakanae and other exotic diseases.

Passengers arriving from overseas, especially if they have visited a farm while overseas need to be monitored very closely by AQIS. Growers returning from an overseas „rice study tour“ need to be aware of the risk of bringing back spores attached to their clothes or footwear. In such case, their clothes and footwear need to be washed/cleaned before coming back to Australia.

Exotic pest survey method

Collection of samples

RICE PLANTS - Bakanae can infect rice plants very early in the season and therefore if monitoring is conducted, it should be conducted throughout the rice-growing season.

RICE GRAIN/BULK - Grain should be samples to give a representative sample of a bulk consignment (1-2 kg minimum is required).

Diagnostics and laboratories

Samples presenting symptoms should be placed into paper bags and taken/sent to the Plant Pathologist as soon as possible. It is recommended to collect samples presenting young, middle stage and mature lesions/symptoms to maximise the chances of a positive identification by the Plant Pathologist. Plastic bags are not recommended, especially during the hot Australian summer as they tend to trigger favourable conditions for the growth of saprophytes. After collection, the samples should be placed into a closed container such as a cardbox to protect the samples from physical damage and dusty conditions. Placing the container into a cooler box is then highly recommended especially if long distance driving is required to take the samples to the Plant Pathologists. If sending the samples by mail, express mail should be used and (they) should not be sent at the end of the week to prevent samples staying in hot conditions over the week end.

The following researchers should be consulted for diagnosis of suspected bakanae:

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Management/control options/R&D

Known in Japan for over a century, bakanae was discovered in California in 1999 and has slowly increased in incidence and importance.

The main inoculum is the spore load carried on paddy. Spores from the massive amounts of inoculum produced on dead plants adhere to seed during harvest. Farmers can mix contaminated seed 1:4 or 1:5 with clean seed and still get the same level of disease in the field due to the massive spore load. The best way to control the disease is to use inoculum-free seed (Cother 2002).

If seed is allowed to stand for 48 h following soaking instead of 24 hours, the incidence of bakanae rises. Various seed treatments have been tried but none of them have been successful under field conditions. The Californian industry is hoping to register the use of bleach as a seed treatment.

Soaking the seeds for 2 hours in a 0.3% solution of sodium hypochlorite reduces the spore load by 80 to 90%. It is important to replace the bleach solution with fresh water after the 2 hour period to avoid a significant reduction in seedling vigour (Katz 2003). To date, the problem of disposal of the soak solution has prevented the technique from being registered.

Rice growers should burn their rice stubble and avoid draining rice fields too early as this practice induces the fungus to sporulate. In California, stubble incorporation has shifted the effects of disease up to a plateau that has levelled off rather than continuing to rise. Stubble incorporation has also increased problems associated with weed seed survival.

Research and development

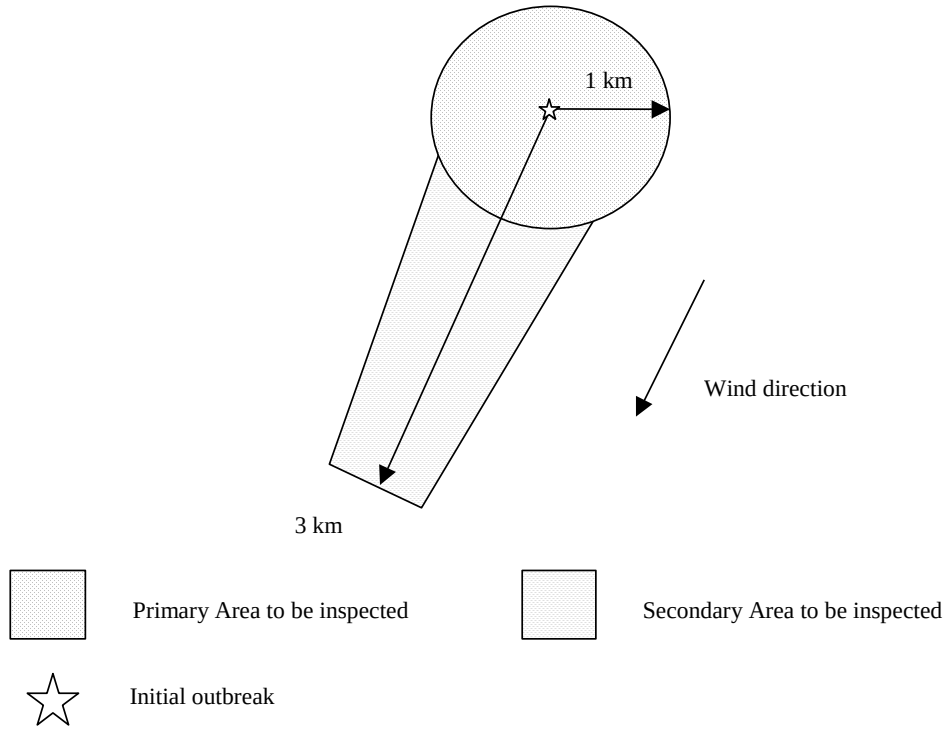
The University of California is investigating the use of ozone as a seed treatment just after presoaking (Deynze 2003). This technique is more expensive than the bleach treatment due to the prohibitive price of the ozone generator (US$70,000 to 80,000).

In the event of a bakanae outbreak

Defining the outbreak zone

The primary area to be inspected should cover a 1000 m radius of the initial outbreak. Once the primary area has been inspected, if no other suspected symptoms have been found, the secondary area (3 km long) should be inspected (Figure 2). If bakanae symptoms are observed, a new primary area and a secondary area need to defined and surveyed. Additionally to this initial survey, the whole rice-growing area should also be surveyed.

Figure 2. *Primary and secondary area to be inspected following a suspected outbreak of bakanae (late detection/sporulation observed).*



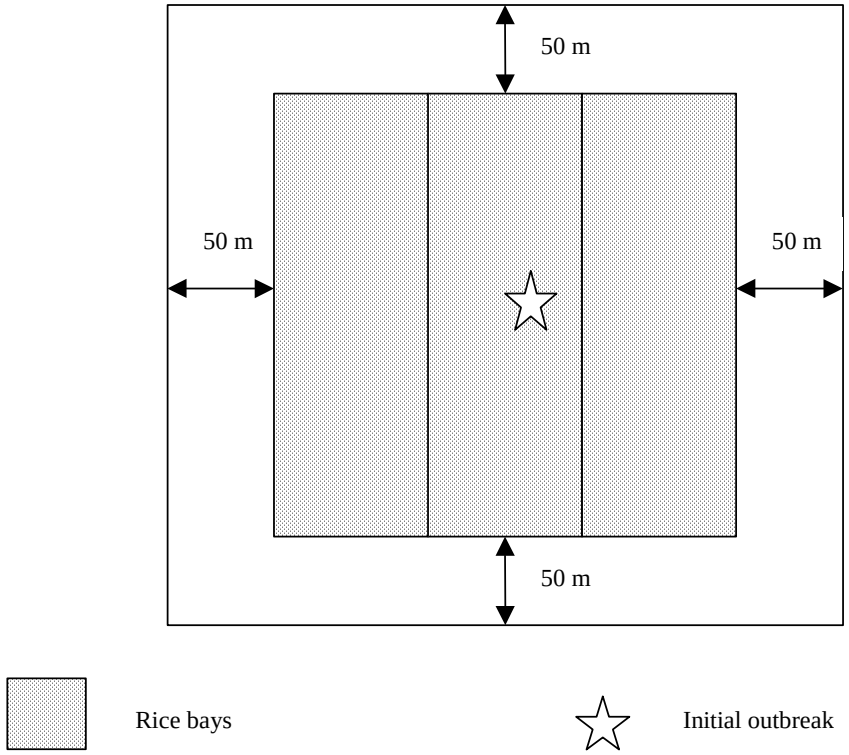
Case 1: Bakanae is found in one or a few rice fields

DEFINING THE QUARANTINE AREA

Once the infected area defined, a quarantine area needs to be set up:

- The infected rice bay and any other contiguous rice bays plus the banks of the rice bays and a dryland boundary area around the block 50 m wide (Figure 3).

Figure 3. *Quarantine area around the initial bakanae outbreak.*



Once bakanae has been confirmed, it is important NOT to drain the affected rice fields (if eradication is to be attempted). Entry into the diseased crop should be strictly monitored and kept to a minimum. Personnel entering the crop must wear disposable overalls which can be destroyed after use.

QUARANTINE AND CONTAINMENT

Once the infected area has been delimited, a quarantine zone should be established to prevent the dissemination of the disease. The quarantine area should extend for 100 m around the infected area. Movement of people, vehicle and farm machinery must be restricted to the minimum required for the monitoring of the situation and the eradication attempt.

Spores and infected rice debris can be accidentally transported by the vehicles/equipment/machinery used within the quarantine area. Therefore, any vehicle/equipment must be cleaned of any plant and soil debris before leaving the quarantine area, ideally with a 2% hypochlorite solution using a high pressure cleaner. Boots, overall and gloves used by the survey and control team must be disinfected using a 2% hypochlorite solution.

DESTRUCTION/ERADICATION

If eradication is to be attempted, it is very important NOT to drain the affected rice fields (as draining can induce the fungus to sporulate). The infected field(s) should be burnt during the winter period. If the climatic conditions prevent burning, the fields should not be drained but should be left to compost. No rice must be grown within the quarantine area for at least 5 years.

Documentation to establish area freedom

Rice should be grown at the end of the quarantine period (5+ years) and the crop should be monitored during the entire rice-growing season. No bakanae symptom indicates disease freedom.

Case 2: bakanae is found in many rice fields within a same rice growing area (i.e: MIA)

This situation could arise if the initial disease outbreak was not detected for some time. At this stage the disease has to be contained within the affected area as eradication would not be an option unless the industry is prepared to stop growing rice in the whole area for at least 5 years.

The whole infected rice-growing area will be declared a Quarantine area (i.e MIA or CIA or MVDI or the Lachlan Valley).

CONTAINMENT

Everything needs to be done to contain the disease within the contaminated area and prevent it spreading to the other rice-growing areas:

- rice grains originating form the infected area must be segregated and should not be delivered to a silo located outside the Quarantine area. The rice industry will have to put a segregation system into place.
- the SunRice pure rice seed production sites will have to be (re-)located in one of the disease free area. These certified seed should always be used by rice-growers.
- movement of people, vehicles and rice farming equipment can potentially spread bakanae spores (especially in attached soil, mud and plant debris) and other pests and therefore must be managed. Harvesters and other farming equipment used to harvest rice within the Quarantine area should not leave the Quarantine area unless cleaned and fumigated. Farm vehicles should be clean of mud, soil and plant debris before leaving a contaminated farm.
- clothing, tool and footwear used on farms located within the infected should not leave the Quarantine area and should never be used on disease-free farms.
- within the Quarantine area, all rice stubbles should be burnt to reduce the amount of inoculum.

Case 3: Bakanae is found widespread in all rice-growing areas

Eradication will not be an option and the industry will have to live with the disease. Bakanae will need to be managed by cultural practices, chemical control (fungicides) and the use of resistant cultivars (if available).

References

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