Kernel smut

Anamorph: *Tilletia horrida*
Synonym: *Tilletia barclayana* (Bref.) Sacc. & Syd.; *Neovossia barclayana* Bref.; *N. horrida* (Tak.) Padw. & Kahn.

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Photo: M. A. Marchetti

Background

Kernel smut is a fungal disease of rice caused by *Tilletia horrida*. This disease is regarded as a threat as it affects both yield and grain quality. Yield losses caused by kernel smut ranges from <1 to 15% and can significantly reduce the grain quality (Templeton et al. 1960; Whitney 1992). In the USA, unmilled rice lots containing more than 3% diseased grain are downgraded and classified as "smutty", thus reducing the price paid to the grower (USDA, 1995). Quality issues with this disease focus on appearance of the rice grains, and especially those used for paraboiling. The dark colour from the teliospores will penetrate throughout a paraboiled rice kernel, so even after milling, these kernels remain grey.

To date, the susceptibility status of the current Australian rice cultivars is unknown.

Host range

The taxonomy of the fungus causing kernel has been subject to controversy. If *T. barclayana* found on weeds is the same organism as *T. horrida* found on rice, the host range could include species of *Brachiara*, *Digitaria*, *Erichloa*, *Panicum* and *Pennisetum*. The latest research suggests that the fungus occurring on rice (*N. horrida*, syn. *T. horrida*) is different from *N. barclayana* (*T. barclayana*) which infects weeds (Whitney 1989).

Part of plant/commodity affected

Rice florets and grains.

Biology

Identification/Symptoms

The disease is noticeable at crop maturity. Most of the infected plants display only a few smutted grains (Figure 1a). Black pustules of teliospores (Figure 1b) push through the glumes, especially if they swell from moisture provided by overnight dew.

Figure 1. *Rice panicles infected with kernel smut; plants display only a few smutted grains (a), black pustules of teliospores oozing through the glumes following dew period (b) (photo a: M. A. Marchetti; photo b: G. Templeton)*

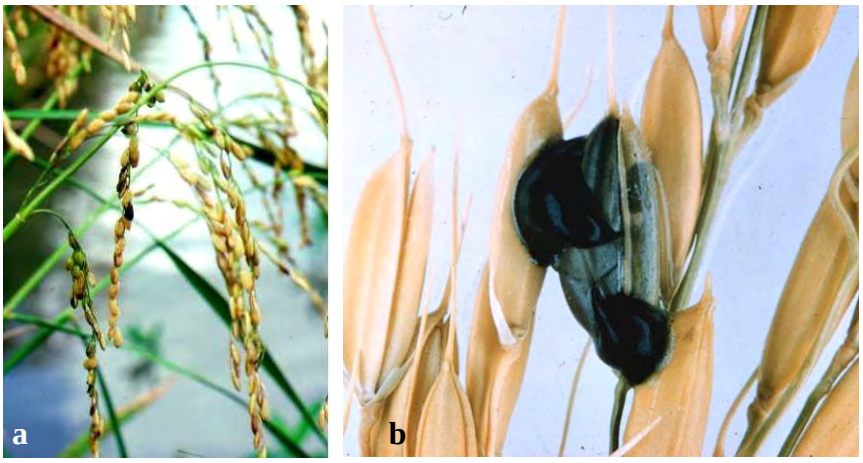
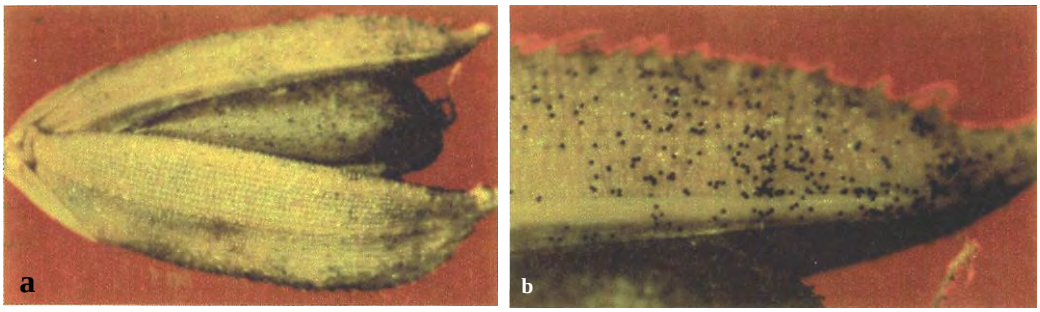


Figure 2. *Rice seeds infected with kernel smut on whole seed (a) and on glumes (b) (photos: IRRI)*

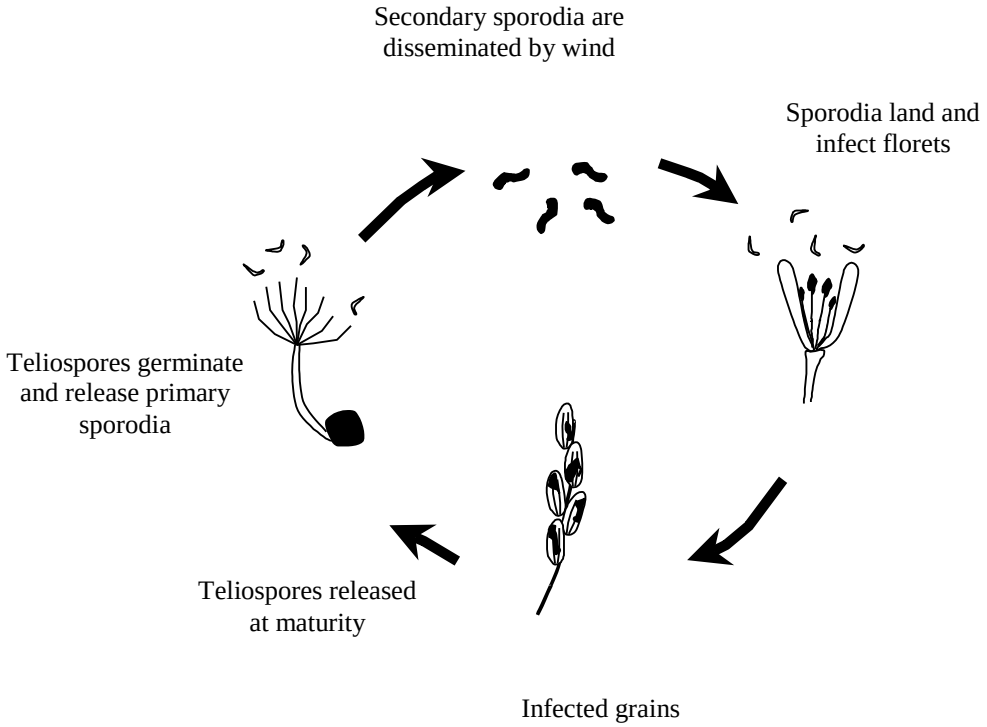


Disease cycle

Unlike other smut diseases, the fungus is not systemic. Flowers are infected individually and only a few florets may be infected in a panicle. Partially infected grain may germinate but seedlings are stunted. Chlamydospores survive for a year or more under normal conditions and in stored grain for up to 3 years.

Spores float on water and germinate to produce a mycelial mat that produces primary sporidia. These primary sporodia produce secondary sporodia which are forcibly discharged and are responsible for floral infection when sufficient moisture is available. Sporidia lodge on the stigma, and then penetrate the style (Figure 3). Hyphae remain between the aleuron layer and the seed coat, digesting the endosperm of immature, developing grain. The embryo is not invaded. The disease is more severe if rain occurs at anthesis. Long grain varieties appear more susceptible than medium or short grained varieties.

Figure 3. *Disease cycle of kernel smut*



Dispersal

The spread potential of kernel smut is high as teliospores can be disseminated by wind, animals and human activities. Research showed that teliospores can survive for at least 3 years on grains and even survive the passage through the digestive track of animals (Ou 1985).

Surveillance

General surveillance

Rice-growers/agronomists/extension personnel need to be educated about the threat kernel smut 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 kernel smut 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 (Figure 4). 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 kernel smut 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.

Grain samplers at every silo receiving rice during harvest time must be aware of the threat kernel smut presents to the industry. Photographs showing infected rice grains should displayed at every point of receival (silos). Operators noticing smutted rice grains should reject the delivery and should immediately contact the NSW DPI and ask for a plant pathologist to examine the suspected sample.

Figure 4. *Header heavily contaminated with teliospores of* Tilletia horrida *(photo: IRRI)*

Exotic pest survey method

Collection of samples

RICE PLANTS – Kernel smut is noticeable at crop maturity.
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. 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 kernel smut:
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Management/control options/R&D

In Arkansas, the increasing popularity of susceptible long grain cultivars has resulted in an increase in kernel smut (Cartwright et al. 2003). A preventive application of Tilt® (propiconazole) at the late-boot stage gives good results in Arkansas but is expensive and sometimes unnecessary (Cartwright and Lee 2001). Rice-growers can chose to grow tolerant cultivars; however, these cultivars generally yield less than the highly susceptible ones (Slaton et al. 2004). Nitrogen management studies suggest that high preflooding applications of nitrogen increases kernel smut severity but only when environmental conditions are favourable for disease incidence (Slaton et al. 2004).

In the event of a kernel smut 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 5). If kernel smut 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.

Case 1: Kernel smut 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 6).

Figure 5. *Primary and secondary area to be inspected following a suspected outbreak of kernel smut*

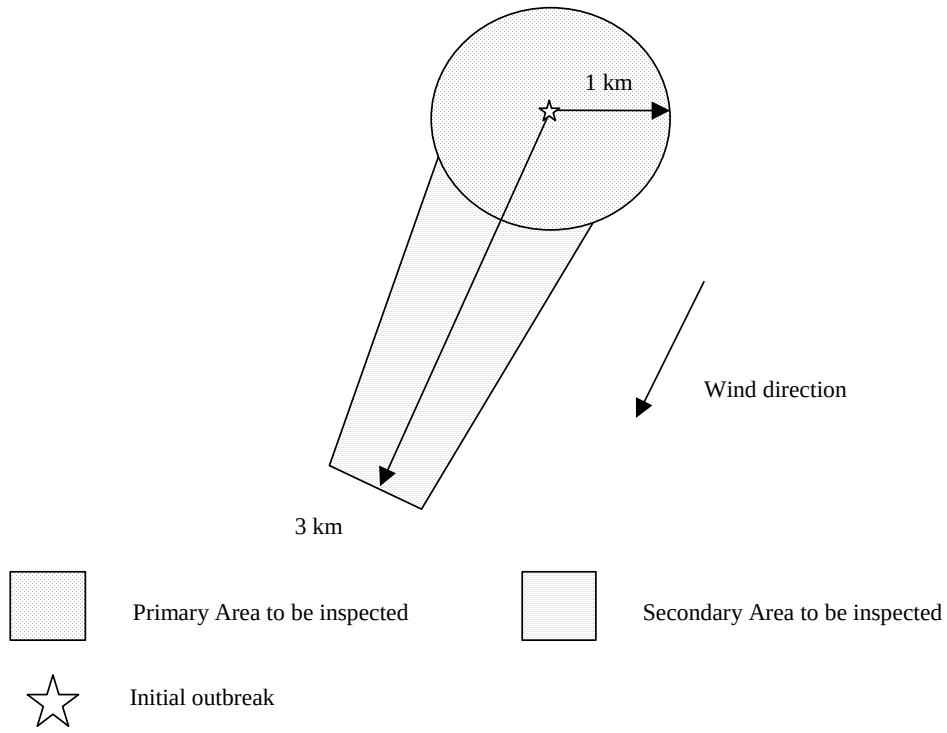
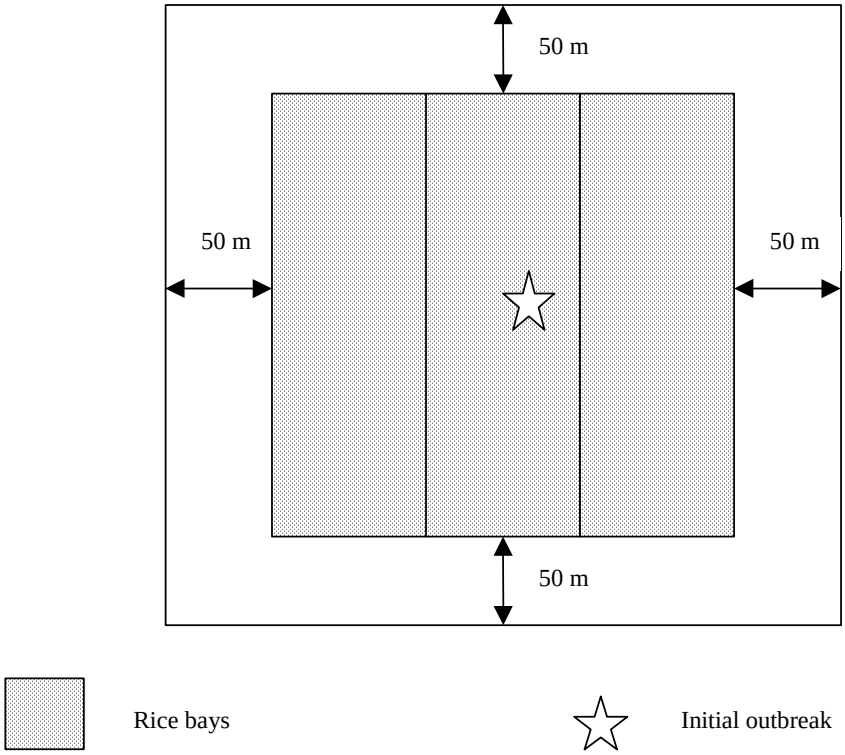


Figure 6. *Quarantine area around the initial kernel smut outbreak*



Once kernel smut has been confirmed, drainage of the area should be blocked in order to let the water evaporate completely. 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

The whole quarantine area must then be burnt. If the quarantine area is not dry enough for a good burn, it should be sprayed with a herbicide containing the active ingredient paraquat. Gramoxone® contains 250 g/L of paraquat and should be used at the rate of 4-8 L/ha[1]. Roundup® (360 g/L of glyphosate) is not recommended in this case as the effect of this herbicide is too slow in such an

[1] In NSW, Gramoxone is registered for „right of way/firebreak" applications at the rate of 1.6 to 4 L/ha.

emergency situation. The use of paraquat is strongly recommended as it has the advantage of being a plant desiccant. The whole quarantine area must then be burnt and 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 kernel smut symptom indicates disease freedom.

Case 2: kernel smut is found in many rice fields within the same rice growing area (i.e: MIA)

This situation could arise if the initial disease outbreak was not detected for some seasons. At this stage the disease has to be contained within the affected area as eradication would not be an option unless if 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 areas. These certified seed should always be used by rice-growers.
- movement of people, vehicles and rice farming equipment can potentially spread kernel smut teliospores (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: Kernel smut is found widespread in all rice-growing areas

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

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