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Red Rot of Sugarcane

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Sugarcane (*Saccharum officinarum* L.) is regarded as one of the essential cash crops because it improves the socio-economic livelihood of many sugarcane growers. The major sugarcane producing countries are Brazil, India, Thailand, Pakistan, China, Mexico, United States of America and Australia. The life cycle of sugarcane plants is affected by approximately 240 sugarcane diseases. Approximately 100 fungi, 10 bacteria, 50 nematodes and 10 viruses have been identified as pathogens of sugarcane world-wide. Out of the many biotic stresses of the sugarcane, the *Colletotrichum falcatum* went causes significant reduction in the quality and yield of susceptible sugarcane cultivars. The red rot occurs in 68 sugarcane producing countries. This disease decreases sugarcane yield by 5–50%. The loss results in only 31% sugar recovery. The red rot reduces the sugarcane juice quality (as sucrose content, purity, Brix) and commercial cane sugar. Red rot disease is the major disease due to the destructive effects of the disease as the main cause for the with drawal of the many sugarcane varieties in the sugarcane cultivation worldwide.

Symptoms red rot disease of sugarcane

(A) External Symptoms

- The third or fourth "spindle" leaf will turn orange, then yellow and begin to dry from the tips and margins.
- Red lesions on leaf midribs.
- Infected canes often become weak and fall over.
- The stalk's outer color becomes dull and it may shrink and crack at the nodes.
- Small, black, dot-like structures called acervuli can develop on the rind and at the nodes.

(B) Internal Symptoms

- The pith can become hollowed out as the disease progresses.
- When the cane is split open longitudinally, you can see a reddish coloration in the internal tissue.
- Irregular white spots interrupt the red coloration, giving a red and white blotchy appearance.
- A distinct sour or alcoholic smell may be noticed when the infected stalk is split open.

Pathogen, Infection and Transmission

Red rot of sugarcane belongs to the Ascomycota phylum. This pathogen is a facultative parasite. The morphological and cultural characteristics of *C. falcatum* include the development of acervuli with setae, presence or absence of teleomorph, pinkish appearance of colony, sporulation and growth rate. This suggests the *C. falcatum* isolates differ in their host infectivity. Thus, it is very important to identify the extent of pathogen diversity and the way infection occurs to develop effective disease control and planting management.

The transmission of the disease is primarily disseminated through soil and diseased setts, whereas secondary distribution is through irrigation water, rainfall splashing, midrib lesion dew brushing, wind dispersal and other field vectors. The pathogen infects stalks through nodes leaf scar, growth ring, root primordial and buds. The pathogen enters the nodes of a sugarcane plant through the inner epidermis of the lower part of the leaf sheath of this plant. In an unfavorable condition, the fungus produces appressoria on rind and leaves. Late in the season, the infection restarts by the placement of healthy plants. During soil borne transmission, latent fungal structures, namely appressoria, dense-walled hyphae chlamydospores, and setae play important roles in the dispersal of disease.

Disease Cycle

Infected Setts / Crop Debris (Survival)
↓
Germination of fungus in favorable conditions
↓
Entry into new plant viz wounds or cut ends
↓
Internal colonization of cane tissues
↓
Sporulation on cane surface (under humidity)
↓
Spread viz tools, water or short-range movement
↓
Infection of nearby healthy plants / setts
↓
Return to survival stage in residues or stubbles.

Management of Red Rot Disease

Integrated disease management (IDM) is one of the excellent practices for disease control approaches. Integrated disease management practices decrease red rot occurrence, increase growth parameters and increase sugarcane performance attributes compared to non-IDM practices. Integrated disease management involves all the methods of disease control.

(A) Cultural practices: The use of healthy planting materials, certified seeds, field sanitation, crop rotation and proper drainage facility could significantly minimize red rot disease. These cultural practices have been suggested not only to reduce the inoculum from the field, but to also reduce crop losses. Mono cultivation of the same crop with the same cultivar increases the inoculum level resulting in the development of the disease. The crop must be rotated after two to three years/cycles in the heavily infested field and the ratooning should be discouraged. Regular field inspection and roughing of diseased plants could minimize the occurrence of red rot disease.

(B) Physical Treatment: Infected planting materials are the primary source of pathogen inoculam for the occurrence of red rot disease in sugarcane fields. The moist hot air therapies (54 °C for 3 h and RH 95%) can completely eradicate sett borne infection. In combination with heat and chemotherapy, mixing synthetic chemicals in a hot water controlled the red rot disease of sugarcane. The advantages of the physical treatment eco-friendly, easy to adopt, cheaper and it kills setts borne pathogens.

(C) Chemical Control: *In-vitro* studies suggest that the chemical control method completely inhibits *C. falcatum* growth. For example, Benomyl 50 WP, Folicar and Radomil 75WP (100%) at a level of 5–50 μgmL^{-1} completely inhibited fungal growth. In the field, the role of sett treatment control the primary source of red rot from setts and the use of fungicides to red rot in the field is usually restricted to setts treatment. It is possible to reduce red rot incidence by treating the infected setts with carbendazim and benomyl for 30–60 min. In some studies, dip treatment of sugarcane setts with 0.25% suspension of thiophanate methyl and carbendazim metabolite effectively controlled red rot disease. Using the thiophanate methyl at 0.25% as sett treatments considerably suppressed incidence of red rot disease of sugarcane. The benefit of the chemical treatment method is its efficacy because the effectiveness is better than other methods, but it is not eco-friendly.

(D) Use of Resistant Varieties: This transgenic resistant and moderately tolerant sugarcane can also be used to develop resistant varieties against *C. falcatum*. For example, Isd 2/54, Isd 39, Isd 40, BSRI Akh 41, BSRI Akh 43, BSRI Akh 44,BSRI Akh 45 and BSRI Akh 46 and Co 8371, Co 85004, Co 86032,Co 94,008 and Co 94,270 are resistant varieties in Bangladesh and India.

(E) Biologic Control and Natural Products: Different bio-control agents have been used either alone or in combination with other management methods to control *C. falcatum* in sugarcane. Among the biocontrol agents, plant growth-promoting rhizobacteria (PGPR) that are allied with root of sugarcane would be useful in sustaining plant growth through developing many plant growth-supporting metabolites. Plant growth-promoting rhizobacteria can also inhabit *C. falcatum*. In recent times, different genera of bacterial such as *Enterobacter*, *Pseudomonas*, *Burkholderia*, *Bacillus*, *Gluconacetobacter* and *Ochrobactrum* are known to effectively inhibit *C. falcatum* in the sugarcane rhizosphere. *Trichoderma harzianum* is another bio-agent which is being used to management red rot disease. The effectiveness of *Trichoderma harzianum* is related its direct parasitic effect on *C. falcatum*. *Trichoderma harzianum* application is reduces the economic losses in susceptible varieties. In addition, the use of *Trichoderma harzianum* increases cane yield because of the increased germination and shooting of biomass. *Trichoderma* bio-pesticide application is eco-friendly, economical, besides improving soil quality. *Trichoderma harzianum* can directly control *C. falcatum* by producing systemic resistance in treated sugarcane plants.