**Japanese ergot of sorghum - *Claviceps sorghicola***

*Claviceps sorghicola* is an ergot pathogen of sorghum (*Sorghum bicolor*) found only in Japan. The risk of its spread and introduction is limited by the small amount of sorghum grown in Japan and by the lack of airborne secondary conidia. The sclerotia are clearly distinct from, and larger than, seed and could be separated if necessary to prevent contamination of exports. The only other host known is the closely related *S. bicolor* subsp. drummondii (Sudan grass). Early sowing and morphologically resistant cultivars of sorghum and Sudan grass were found to control the disease.

### Claviceps sorghicola

**Tsukib., Shiman. & T. Uematsu 1999**

**Sphacelia** elongated, producing conidia in brownish honeydew, ellipsoid to ovoid, hyaline, aseptate, 5–11.3 x 2.5–3.6 µm; no microconidia observed in nature.

**Sclerotia** cylindrical to conical, straight to curved, grooved longitudinally, purple black to black, 2.5–20 mm x 1.9–3.5 mm, with covering and small cap of white sphacelium. Stromata 1–4, with stipes brown to bronze-colored, 3.5–17 mm, capitula globose-subglobose, dark brown, papillate, 0.5–1.6 mm diam.

**Perithecia** in capitula ovoid to pyriform, 21–300 x 105–140 µm, ostioles erumpent. Asci cylindrical, 122–315 x 2.5–3.8 µm, with thickened apex. Ascospores hyaline, filiform, eight per ascus, 92–205 x 0.5–1 µm (Tsukiboshi et al., 1999).

**Host range:** *Sorghum bicolor* (sorghum) and *S. bicolor* subsp. drummondii (Sudan grass).

**Geographic distribution:** Known only from Japan.

### Similarities to Other Species

Similar to other species of ergot, *Claviceps sorghicola* infects the ovaries of sorghum flowers. The fungus replaces the plant tissue with fungal mycelium and produced asexual spores (conidia) in a sugary liquid (honeydew). Eventually the fungus produces a hard survival structure (sclerotium) in the floret that falls to the ground or may become mixed with harvested seed. In the field the following season, the sclerotium germinates to produce stromata with perithecia, the sexual form of the fungus. Perithecia generate and eject ascospores that infect flowers.

Two other ergot species, *C. africana* (Frederickson et al., 1991) and *C. sorghi* (Kulkarni et al., 1976) also infect sorghum, and one of them overlaps in distribution with *C. sorghicola*. *C. africana* is known to be present in most sorghum-growing regions worldwide, including Japan (Bandyopadhyay et al., 1998; Tsukiboshi et al., 2001). *C. sorghi* is found in India and possibly Southeast Asia (Muthusubramanian et al., 2006; Tonapi et al., 2003). In describing the new species, Tsukiboshi et al. (1999) presented detailed comparison of its characteristics with those of the other ergots. Both *C. sorghi* and *C. sorghicola* form elongate sphacelia and sclerotia, whereas those of *C. africana* are smaller, subglobose and project less beyond the glumes of the florets (Frederickson et al., 1991). In *C. sorghicola* and *C. sorghi*, honeydew appears early, before the sphacelia are visible (Frederickson and Mantle, 1988; Tsukiboshi et al., 1999). The conidia of *C. sorghicola* in the honeydew are significantly smaller than the macroconidia of the Indian and African ergots (see Description). Conidia of *C. sorghicola*, like those of *C. sorghi*, do not form secondary conidia in nature (Tsukiboshi et al., 1999), so the honeydew surface does not develop a superficial white layer under humid conditions.

Perithecia, asci and ascospores of *C. sorghicola* are significantly longer than those of the other two sorghum ergots. Most sclerotia of *C. sorghicola* and *C. sorghi* germinate readily to produce the teleomorph, but those of *C. africana* do not (Bandyopadhyay et al., 1998; Tsukiboshi et al., 1999).

Various types of genetic analyses in the genus Claviceps have confirmed that *C. sorghicola* is a distinct species, but also show that the similarities in DNA sequences place it closer to the other ergot fungi on sorghum than to those that occur on other hosts (Tooley et al., 2000, 2001; Pazoutova et al., 2000, 2004). A DNA sequence technique was found that allowed for rapid identification of the species on sorghum, including *C. sorghicola*, in the presence of other fungi (Partridge et al., 2000).

In the absence of the teleomorph, one diagnostic test can be the identification of alkaloids in the sclerotia. *C. africana* uniquely produces the alkaloid dihydroergosine in sclerotial tissues (Frederickson et al., 1991; Mantle and Hassan, 1994). *C. sorghicola* and *C. sorghi* sclerotia contain caffeine (Bogo and Mantle, 2000; Bogo et al., 2003); those of *C. sorghicola* also contain paliclavine (Tsukiboshi et al., 1999; Bogo and Mantle, 2000). Sphacelia are not known to synthesize alkaloids in any species. The sori of covered kernel smut (*Sporisorium sorghi* (= *Sphacelotheca sorghi*) and long smut (*Tolyposporium ehrenbergii*) are sometimes confused with *Claviceps sphacelia*. However, in the smut fungi the sack-like...
sori consist of a smooth, cream to grey outer covering or peridium enclosing the black powdery teliospores (Frederiksen, 1986; Hilu, 1986). The sclerotia of *C. sorghicola* are hard, dark, grooved bodies without but bearing a small cap and surface layer of white sphacelial tissue. Also, smuts do not produce honeydew. *S. sorghi* has been reported from China, Japan, Korea, Taiwan and The Phillipines in eastern Asia, while *T. ehrenbergii* is reported from China (Farr and Rossman, 2009). Pale-brown honeydew is exuded from florets in mid-summer. This often becomes covered by the black growth of the fungus *Cerebella andropogonis* Ces. Later, cylindrical to conical, grooved dark sclerotia, bearing remnant white sphacelial tissue, grow out from the infected florets (Tsukiboshi et al., 1999).

NOTES ON OTHER PLANTS AFFECTED

Tsukiboshi et al. (1999) tested certain species of Poaceae (grasses) by inoculation and found infection of only *S. bicolor*, and "*S. sudanense*" (*S. bicolor* subsp. *drummondii*) (USDA, 2009). Pearl millet (*Pennisetum glaucum*) was not affected. Wild species of Sorghum and related grass genera have been reported as hosts for the other sorghum ergots (Muthusubramanian et al., 2005), but cross-inoculation tests would be the best means of establishing their possible roles in epidemiology of *C. sorghicola*. Escaped plants and ratoon crops of the cultivated species can also have a significant role (Odvody et al., 2002).

BIOLOGY AND ECOLOGY

Tsukiboshi et al. (1999) obtained germination of a large proportion of sclerotia to produce the perfect state (teleomorph), and observed sclerotia germinating under field conditions in July. Therefore, ascospores are presumed to be the primary inoculum for infection of florets. In other ergots, infection of ovaries requires the absence of fertilization (Bandyopadhyay et al., 1998). In South Africa, cool weather at certain times before and after anthesis increases the incidence of sorghum ergot infection due to its effect on pollen viability and fertilization (McLaren and Wehner, 1990, 1992), and this effect may be involved for *C. sorghicola* infection as well. Tsukiboshi et al. (1999) observed infection of field varieties of sorghum (not male-sterile hybrid-breeding lines that are highly susceptible to ergot infection (Bandyopadhyay et al., 1998)), and hypothesized that the temperate weather of Japan might be a factor enhancing susceptibility in the production cultivars.

Although Pazoutova et al. (2000) successfully inoculated a male-sterile line with an isolate of *C. sorghicola*, broader tests of virulence of the species on such varieties have not been reported. The same workers suggest that *C. africana*, due to its greater epidemiological aggressiveness, may displace the Japanese ergot as it apparently displaced *C. sorghi* in India (Pazoutova et al., 2000). In North America, *C. africana* has survived between cropping seasons on escaped, wild or weedy sorghum plants and varieties in wet southern areas and then spread northwards in warmer weather (Odvody et al., 2002). In Texas, it has also been shown to survive in honeydew on dry panicles on or above the ground in an infective condition long enough to provide inoculum the following season (Prom et al., 2005). Such means of survival in a temperate region might also be possible for *C. sorghicola*, but it lacks the production of airborne secondary conidia which facilitates rapid spread for *C. africana*, so that, as suggested, the more fecund species may become predominant in Japan.

MOVEMENT AND DISPERAL

Conidia in the sticky honeydew are transported from plant to plant by wind, rain splash and insects (Tsukiboshi et al., 1999). Insects are known to carry ergot conidia non-specifically on their bodies after feeding on honeydew (Prom et al., 2003). If not cleaned or treated, sorghum seed containing sclerotia can be a means of local transport of the pathogen (Bandyopadhyay et al., 1998). If such seed were exported, this could be a means of introduction from Japan.

MANAGEMENT SECTION

Prevention -- *C. sorghicola* is not mentioned in quarantine lists of major sorghum-growing nations.

Eradication -- Destruction of infected heads bearing honeydew may reduce spread of the fungus between plants, as well as prevent development of sclerotia.

Control -- Early sowing has been shown to permit escape from infection by other sorghum ergots in other countries (Bandyopadhyay et al., 1998). This may be effective if it allows for flowering under weather conditions favorable for pollination and/or unfavorable for spore dispersal and infection. Tsukiboshi et al. (1998, 2001) reported that control by early sowing, so that flowering occurred in early to mid-summer, was feasible in Japan. Where ascospores produced in or near the crop are the primary inoculum, crop rotation could allow for natural exhaustion of sclerotia as sources of the inoculum in a few growing seasons.

Physical/mechanical control: Since ascospores are presumed to be the primary inoculum, burying sclerotia by plowing them under will reduce inoculum from within a field.
Chemical control: Certain chemicals, when applied correctly and at the appropriate time, have been shown to be effective in preventing ergot caused by *C. africana*, but their use may not be economical or practical (Prom and Isakeit, 2003).

Host resistance: Tsukiboshi et al. (1998, 2001) report reduced incidence in some sorghum and Sudangrass cultivars that appears to be due to morphological and/or physiological aspects of their flowering, including short stigma exsertion, greater coverage by glumes and high seed set. Use of these cultivars in combination with early planting could control disease; they could also be used in a breeding program for newer lines.

**References**


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