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Sorghum Ergot

Distinguishing Sphacelia and Sclerotia of *Claviceps africana* in Seed

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The field symptoms of sorghum ergot are familiar to anyone involved in sorghum production, but it is more difficult to identify the fungal pathogen in seed. This is because there is a lack of understanding about the structure and function of sphacelia and sclerotia and because immature, cracked and moldy seed and other foreign objects are frequently misidentified as ergot fungal bodies.

Infections caused by ergot fungi, including *Claviceps africana*, can produce two different structures called the sphacelium (plural, sphacelia) and the sclerotium (plural, sclerotia). The sphacelium is the initial structure produced after infection. In sorghum ergot, the sclerotium develops later from within the sphacelium and generally remains attached to a remnant of the sphacelium.

Sclerotia of *C. africana* are always found in association with sphacelia. However, sphacelia may have no sclerotial tissue to fully formed sclerotia present. In *C. africana*, the sclerotia and sphacelia are so physically associated with one another that it is impossible to distinguish between them using the naked eye when they occur as contaminants in seed. Because of their close association, it is best to think of sclerotia and sphacelia as different tissues of a single unit rather than distinct or independent structures.

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Generally, it is more important to identify the presence of sorghum ergot as a contaminant in seed rather than to specifically distinguish between sclerotial and sphacelial tissues. In this case, use of the term "ergot fungal bodies" or sphacelia/sclerotia is appropriate.

What are sphacelia and sclerotia?

Sphacelia: (Figs. 1 through 3) Germinating spores of *C. africana* produce hyphae (microscopic filamentous growths) that invade the ovary and replace it with a white fungal mass or sphacelium. Sphacelia are the tell-tale white, rounded to egg-shaped structures in the sorghum florets. They exude sticky honeydew and are the first visible sign of *C. africana* infection. The principal function of sphacelia is the rapid reproduction of *C. africana* because sphacelia develop quickly after infection and produce the conidia (spores) that spread the pathogen. The initially clear, sticky honeydew exuded from sphacelia becomes increasingly opaque and orange in color as more primary conidia become suspended in it. Germination of the primary conidia to produce the wind-blown, secondary conidia is indicated by more watery honeydew with an overall white appearance over the surface. The primary conidia can survive in sphacelia for many months, either in the field or away from the sorghum cropping area.

Sclerotia: (Figs. 5 through 7) For many ergot species, the sclerotia are the structures that allow pathogen survival in the interval from harvest to the next crop season. Sclerotia are "resting" or dormancy structures equipped to withstand degradation by the

Figure 1. After soaking, a white "cloud" of conidia has formed around the sphacelia. The red coloration at the base (left sphacelium) comes from the retained floral membranes and is not due to sclerotial tissue.

Figure 2. The sphacelium has a furrowed surface.

Figure 3. Naturally desiccated sphacelia without any sclerotial tissue are oval in shape and do not contain any orange-brown tissue. The patchy red appearance is due to the adherent floral membranes.

Figure 4. Ergot fungal bodies consisting mostly of sphacelial tissues are shown. The orange-yellow patches towards the base (arrows) indicate the slight development of sclerotial tissue. Note again the patchy red appearance imparted by plant membranes.

The actual sizes and shapes of three desiccated ergot fungal bodies from seed for comparison purposes.

Figure 5. The smooth, rounded, orange-brown portion towards the base of this ergot fungal body consists of sclerotial tissues; the more pointed to conical upper portion is the sphacelial tissue.

Figure 6. Examples from Texas (upper picture) and Celaya, Mexico, (picture to the right) show the possible size attained by the sclerotial portion. The sclerotial tissues in the Mexican sample are cracked.

Figure 7. Examples of increasing amounts of sclerotial tissue (right to left) in association with sphacelial tissue. In one case (second from left), the mature sclerotial tissue at the base and the sphacelial tissue on top are delineated by a line of erosion (arrow). Note the short "stem" of plant tissue attached at the bottom of each.

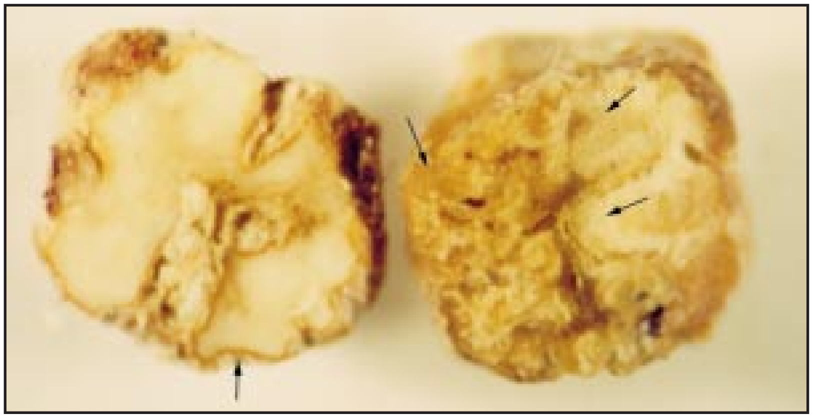

Figure 8. Transverse section of the sclerotial part (left) and sphacelial part (right). Sclerotial tissues are compact and white internally with a thin, red-brown rind (arrow). The sphacelial part has a "powdery" texture and is less uniform in appearance because of the convoluted surface (arrows).

Figure 9. Longitudinal section of immature sclerotial tissues with sphacelial tissues on top. There is still continuity between the two tissues, but the red-brown rind (edges marked with arrows) has almost closed over the sclerotial portion.

Figure 10. Longitudinal section of mature sclerotium with a fully closed rind (arrows); a large amount of conical-shaped, sphacelial tissue persists on top.

Figure 11. Sphacelium with some sclerotial tissue development towards the base. The sclerotial tissue is evident as an orange-brown patch of tissue (arrows) showing through the cream-colored tissues of the lower sphacelium.

Figure 12. A sphacelium with attached glumes (second from left) from a seed lot has a more pointed appearance than a seed with attached glumes (far left). The remaining three examples of cracked and moldy seed have the appearance of ergot to the naked eye.

Figure 13. What looks like ergot by eye is obviously moldy, split seed (right half of picture) or immature seed (yellow-green, bottom center) when viewed at higher magnification. Three sphacelia (top left, arrows) are included for comparison.

Figure 14. Ovary was both colonized by ergot (lowermost; arrows indicate limit of sphacelial tissue) and fertilized and developed into a seed (uppermost).

environment. Activity is resumed only when a favorable climate is restored. Germination of sclerotia leads to the production of yet another type of spore, the ascospores, that can infect the new crop. Infection in this manner is probably of little importance in sorghum ergot disease.

Distinguishing tissue types

If sphacelia and sclerotia exist together, how is sclerotial tissue correctly distinguished from sphacelial tissue? Sclerotia and sphacelia have different biological functions, and therefore have different structures and properties.

A simple soak in water, followed by close observation reveals whether there is only sphacelial tissue present or a mixture of sclerotial and sphacelial tissues. Ensure that all glumes are removed from the suspected ergot fungal bodies and then immerse in water for a few hours, even longer if the samples are very desiccated. Observe at 10 to 40X magnification using a dissection microscope, magnifying glass or hand lens.

To obtain a good sample of ergot for comparison with the cleaned seed fraction, examine the air-blown, screen-cut, gravity table and tailings fractions.

Recognizing sphacelial tissues

- Cream to white in color, comprised of loosely woven “threads” of fungal hyphae (Figs. 1 and 2).
- Furrowed and convoluted surface (Figs. 1 and 2).
- Soft and “spongy” after soaking, absorbing water, swelling and releasing conidia in a “cloud” around them (Fig. 1).
- Conical to pointed tissue at the top of the structure if sclerotial tissue is present as well. Sclerotial tissue at the base is much firmer with an orange-brown surface. (Figs. 5 through 7).

Recognizing sclerotial tissues

- Occur only at the base of the structure (Figs. 5 through 7).
- Rounded in shape when mature (Fig. 5).
- Comprised of tightly compacted fungal “cells,” unlike the “threads” or filaments of sphacelia.
- Remain firm after soaking because of compact structure and lack of water absorbance and swelling.
- Thin, orange-brown to red-brown surface layer (rind); the remaining bulk of the underlying tissue is white (Figs. 9 and 10).
- Develop from within, and at the base of, the sphacelial tissues (Fig. 4) and carry a remnant of sphacelial tissue on top (Figs. 5 through 7 and 10).
- Covered with a thin, white layer of remnant sphacelial tissue that must be scraped away to reveal underlying sclerotial tissue, except where sclerotia are very mature or the surface was naturally abraded (Fig.11).
- Loss of continuity at the intersection of sclerotial and sphacelial tissues is evident as a line of erosion (a crack or fissure) in fully mature sclerotia (Fig. 7). The sphacelial remnant and sclerotial tissues may separate naturally at this point.

Additional tips and cautions

- Tip of structure is pointed to conical and may sometimes have the remains of trapped anthers or stigmas present. Base of structure is rounded, often with reddish membranes and a “stem” of plant tissue attached.
- Adherent floral membranes may cause both sphacelial and sclerotial tissues to have a patchy red or orange surface. Scratch these membranes away to observe the color of underlying tissues (Figs. 1 through 4).
- Sphacelia/sclerotia often retain the host glumes after harvesting so the presence of material with glumes in seed lots always deserves close scrutiny (Fig. 12).
- To the naked eye, a split seed with mold may look suspiciously like an ergot fungal body but the difference is readily apparent at magnifications of 10X and above (Figs. 12 and 13).
- Immature seeds have a more rounded and smoother appearance than sphacelia/sclerotia, and have a flinty or floury interior and retain the characteristic depression near the point of attachment.
- Rarely, an ovary may be partially replaced by the ergot fungus (always lowermost) while the rest develops into a seed (always uppermost) following pollination (Fig. 14). This looks quite different from a moldy seed. Also contrast the usual situation where the true sclerotial tissues (resembling a red-brown seed in color) sit below the sphacelial tissues (Figs. 5 through 7).
- The sodium chloride flotation test is not a fully reliable, fool-proof method of screening seed for the presence of ergot. The floating material may include immature seeds, seeds with glumes, and other light plant debris, as well as ergot fungal bodies with relatively large amounts of sclerotial tissue. Conversely, most sphacelia will sink with normal seeds, including some of those with small amounts of sclerotial tissue. The products of the flotation test should always be inspected at a magnification of at least 10X.

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