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SMALL GRAIN PRODUCTION MANUAL
PART 6

Pest Management of Small Grains—Diseases

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This publication, *Pest Management of Small Grains—Diseases,* is the sixth in a fourteen-part series of University of California Cooperative Extension online publications that comprise the *Small Grain Production Manual*. The other parts cover specific aspects of small grain production practices in California:

- *Part 1: Importance of Small Grain Crops in California Agriculture*, Publication 8164
- *Part 2: Growth and Development*, Publication 8165
- *Part 3: Seedbed Preparation, Sowing, and Residue Management*, Publication 8166
- *Part 4: Fertilization*, Publication 8167
- *Part 5: Irrigation and Water Relations*, Publication 8168
- *Part 7: Pest Management—Insects*, Publication 8170
- *Part 8: Pest Management—Vertebrates*, Publication 8171
- *Part 9: Pest Management—Weeds*, Publication 8172
- *Part 10: Small Grain Forages*, Publication 8173
- *Part 11: Small Grain Cover Crops*, Publication 8174
- *Part 12: Small Grains in Crop Rotations*, Publication 8175
- *Part 13: Harvesting and Storage*, Publication 8176
- *Part 14: Troubleshooting Small Grain Production*, Publication 8177

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) involves coordinating crop management practices with pest management techniques to achieve economical and sustainable control of pest problems. The goal of an IPM program is to protect the crop from economic damage while interfering as little as possible with the long-term viability of the production system. The most reliable way to do this is to anticipate pest problems and prevent them whenever possible. When pesticides are needed, materials and application methods that are effective, economical, and have a minimum of harmful side effects should be used. Key management methods include

- clean and/or certified seed
- resistant cultivars
- field sanitation
- crop rotation
- residue management
- proper cultural practices (timing and amounts of irrigation, fertilization, etc.)

UC PEER REVIEWED

Several diseases and weed seeds can contaminate small grain seed. Sowing clean seed, or seed certified as free from seedborne diseases and weeds, reduces the likelihood of introducing diseases or weeds into a field. Growing pest-resistant small grain cultivars can provide economical, long-term protection from some diseases and pests. Reactions of cultivars of small grains to diseases and pests are updated on an annual basis; the information can be viewed online in *UC IPM Pest Management Guidelines, Small Grains* (http://www.ipm.ucdavis.edu/PMG/selectnewpest.small-grains.html).

Many cultural practices have significant impacts on pest management. Infestations of many pests, particularly weeds, result from contaminated seed, soil, water, or machinery. Precautions for preventing the introduction of pests include using high-quality seed, avoiding irrigation water that may contain weed seeds or pest organisms such as nematodes, cleaning equipment before moving it from infested fields, denying livestock access to fields after they have grazed in weedy areas, and destroying stands of problem weeds along field borders before they produce seed that can infest the cultivated area. Practices that produce the most vigorous, competitive stands possible make control of weed pests easier and reduce the susceptibility of crops to disease and insect pests. Important considerations are crop residues, cropping patterns, leveling of irrigated fields to assure uniform water distribution and drainage to avoid flooding, sowing dates, and fertilization.

Crop rotation and fallow periods between crops are effective pest management practices. The most useful rotations for small grain crops are broadleaf crops because these crops are generally not hosts for most small grain pathogens and insects, and herbicides that cannot be used in small grain crops are available for controlling problem grassy weeds. Cultivation of the rotation crop provides additional weed control. Fallow periods are valuable in rainfed production areas: they allow for tillage or broad-spectrum herbicides for weed control, conserve soil moisture, and allow some accumulation of soil nitrogen.

Full descriptions of the most important diseases and pests of small grains in California and their management can be found in Wiese 1987; Mathre 1997; Strand 1990; and Davis and Jackson 2002. Brief descriptions of important diseases are given in the following sections.

SEPTORIA TRITICI LEAF BLOTCH

Septoria tritici leaf blotch is caused by the fungus *Mycosphaerella graminicola* (= *Septoria tritici*). It can be particularly severe on wheat in the Sacramento and northern San Joaquin Valleys in years of higher than average rainfall. It is especially damaging when late-spring rains persist after emergence of the flag leaf. Symptoms (fig. 1) develop on all aerial parts of the plant. Chlorotic flecks become visible on the lowermost leaves and expand to irregularly shaped lesions. The lesions first appear water-soaked, then become dry, yellow and, finally, red-brown with gray-brown ashen centers. The disease reduces grain yield and/or bushel weight.

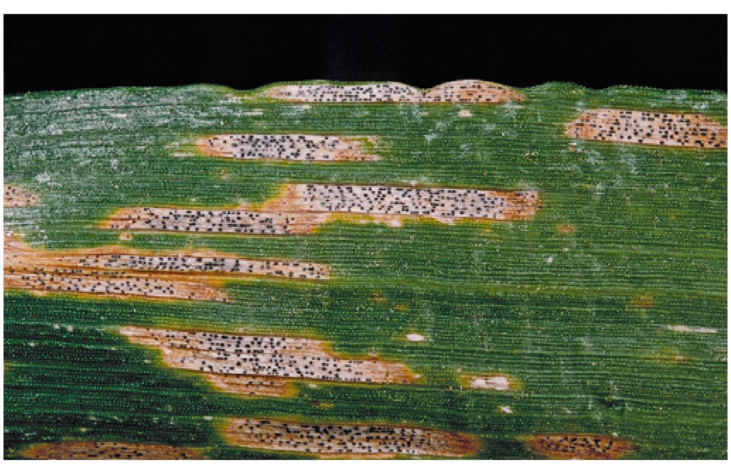

Figure 1. Septoria tritici leaf blotch symptoms. Photo by Jack Kelly Clark.

Residue of previous wheat crops, seed, and volunteer wheat plants are sources of primary inoculum. The fungus survives between cropping seasons on wheat residue. After the first fall rains, the spores (ascospores) of *M. graminicola* are discharged into the air from sexual fruiting bodies (pseudothecia) in wheat residue from the previous crop.

Figure 2. Leaf scald of barley symptoms. Photo by Jack Kelly Clark.

The spores can spread long distances and are carried by wind to infect the developing wheat crop. Lesions containing *Septoria tritici* pycnidia (small, dark structures about the size of pepper grains) appear 3 to 4 weeks later. Spores (conidia) formed within pycnidia are dispersed by splashing and wind-driven rain and spread the disease within fields.

The major factors affecting disease severity are temperature and moisture during the growing season. Spore germination and disease development are optimal at 60º to 77°F (16º to 25°C) when free moisture is present on the foliage. Secondary cycles of infection occur every 21 to 28 days. Dry periods and warm weather prevent infection and disease spread.

The disease is most severe on early-sown (October) wheat. Later sowings (November to December) are less likely to be severely affected. Resistant cultivars and disease-free seed, along with elimination of wheat residue and volunteer wheat plants, help control this disease. Rotations in which wheat appears every third year eliminate most carryover inoculum but do not provide protection from infection by ascospores from distant fields. Fungicides can provide partial disease control. Applications should be made between tillering and heading to protect the flag leaf from infection.

LEAF SCALD OF BARLEY

Leaf scald of barley, caused by the fungus *Rhynchosporium secalis*, is most severe in years of high rainfall. Lesions first appear on foliage as dark, pale, or bluish gray spots. These spots expand into oval lesions with bluish gray centers and dark brown margins (fig. 2). The lesions enlarge and coalesce, giving the appearance of rapid scalding. Entire leaves may be covered and killed if the disease is severe. When conditions favor severe disease, lesions also may develop on spikes.

The fungus survives between seasons primarily on barley residue and volunteer barley plants, and to a lesser extent on some grasses and barley seed. Infection, development, and spread occur during cool, 40º to 77°F (4º to 25°C), wet weather. Spores are formed in a thin layer of slime on the surface of lesions and are spread short distances by splashing and wind-driven rain. Spores that land on plant surfaces germinate and infect the leaf if the surface remains wet for at least 24 hours. Secondary cycles of infection can occur every 21 to 28 days. If infected seed is sown, coleoptiles can be infected after seed germination.

Control measures include crop rotation to any crop other than barley, clean seed and resistant cultivars, and elimination of barley residue, volunteer barley plants, and grass hosts. Avoid early (October to November) sowings that expose the crop to a long period when weather conditions are favorable for disease development. Late (December to January) sowings are less vulnerable.

NET BLOTCH OF BARLEY

Net blotch of barley, caused by the fungus *Pyrenophora teres*, is most severe in years of high rainfall. Symptoms first appear as tiny spots that may be dark green and watersoaked initially, but turn light brown as the spots mature. Later, symptoms appear as narrow brown blotches

Figure 3. Net blotch of barley symptoms. Photo by Jack Kelly

with a netted or cross-hatched appearance (fig. 3). Surrounding tissue becomes yellow. When the disease is severe, lesions spread over the entire leaf and kill it. Lesions may occur on the spikes as the crop matures.

The fungus survives between seasons on barley residue, volunteer barley plants, some grasses, and seed. Barley residue and volunteer barley plants are the main sources of inoculum for new infections each season. After initial infections, spores are produced on lesions when humidity is near 100 percent and temperatures are mild, 60° to 80°F (16° to 27°C). Spores are windblown to other plants for secondary spread. Secondary cycles of infection can occur every 21 to 28 days. If infected seed is sown, coleoptiles can be infected after seed germination. Free moisture and cool spring weather favor disease development.

Control measures include crop rotation (to any crop other than barley), clean seed and resistant cultivars, and elimination of barley residue, volunteer barley plants, and grass hosts. Avoid early (October to November) sowings that expose the crop to a long period when weather conditions are favorable for disease development. Late (December to January) sowings are less vulnerable.

LEAF RUSTS OF WHEAT, BARLEY, AND OAT

Leaf rusts, caused by the fungi *Puccinia triticina* (wheat), *P. hordei* (barley), and *P. coronata* (oat), are late-season diseases that are most severe in years with lower than normal late-spring temperatures and high humidity. The fungi grow only on living host plants and have narrow host ranges (wheat leaf rust does not affect barley; barley leaf rust does not affect wheat). Symptoms on wheat, barley, and oat are similar. Pustules on barley are small, round, and yellowish brown (fig. 4). Pustules on wheat are reddish orange and are scattered or clustered on the upper leaf surface (fig. 5). Pustules on oat are oblong and orange colored (fig. 6). As the plants mature, the pustules turn dark and shiny, indicating

Figure 4. Barley leaf rust symptoms. Photo by Lee Jackson.

Figure 5. Wheat leaf rust symptoms. Photo by Jack Kelly Clark.

Figure 6. Oat crown rust symptoms. Photo by Lee Jackson.

the formation of teliospores. Teliospores do not play a role in disease development or survival in California because they infect only the alternate hosts (different broadleaf shrubs for each rust species), which are rare in California cereal-producing areas.

Volunteer small grain plants and distant small grain fields are the sources of primary inoculum. Spores (urediospores) produced in pustules on leaves are dispersed over long distances—hundreds of miles—by wind and cause initial infections. Urediospores from initial infections are windblown to initiate secondary cycles at 7- to 10-day intervals. Leaf rust is most severe when temperatures are 60º to 72°F (16º to 22°C) and humidity is high or rainfall is intermittent. It causes the greatest reductions in yield if infections occur prior to spike emergence and continue for 30 to 40 days during the grain fill period.

Control is through the use of resistant cultivars. If new races develop that render current resistant cultivars ineffective, fungicides can be used for control. Applications should be made between tillering and heading to protect the flag leaf from infection.

STRIPE RUSTS OF WHEAT AND BARLEY

Stripe rust, caused by the fungus *Puccinia striiformis,* has been responsible for the most devastating disease epidemics on wheat and barley in California. Different forms (*formae speciales*, or f. sp.) of *P. striiformis* affect wheat and barley but symptoms are identical. Rust pustules are yellow-orange, occur mostly on leaves, and are oriented linearly between vascular bundles, forming conspicuous stripes (fig. 7). Glumes also can be infected. Stripe rust symptoms usually appear earlier in the season than symptoms of leaf rust because the stripe rust fungus develops at lower temperatures. As the plants mature, the pustules turn dark and shiny as teliospores are formed. These spores do not play a role in disease development or survival because unlike other cereal rust pathogens, the stripe rust pathogen does not have an alternate host for the teliospores to infect.

The fungus grows only on living host plants and survives between seasons on volunteer wheat or barley, some wild grasses, and distant small grain fields. Spores (urediospores) produced in pustules are spread over long distances by wind to initiate infections. Disease development is most rapid at cool temperatures of 50º to 60°F (10º to 16°C) with intermittent rain and dew; secondary cycles occur at 7- to 10-day intervals. The disease can continue to develop where daytime temperatures are higher than this as long as nighttime temperatures are not higher than about 60°F (16ºC).

Control is through the use of resistant cultivars. If new races develop that render current resistant cultivars ineffective, fungicides can be used for control. Applications should be made between tillering and heading to protect the flag leaf from infection.

Figure 7. Stripe rust symptoms. Photo by Jack Kelly Clark.

POWDERY MILDEW

Powdery mildew, caused by the fungi *Blumeria graminis* (*Erysiphe graminis*) f. sp. *tritici* (wheat), *B. graminis* f. sp. *hordei* (barley), and *B. graminis* f. sp. *avenae* (oat), is most severe when winter weather is mild and damp. Symptoms are most apparent on lower leaves. Patches of white, cottony fungal growth (mycelium and spores) develop opposite chlorotic spots on leaf surfaces. These patches later turn dull gray-brown. As plants mature, small, dark brown structures (cleistothecia) develop

Figure 8. Powdery mildew symptoms. Photo by Jack Kelly Clark.

among the cottony patches (fig. 8). Infected plants are low in vigor. Growth, heading, and seed filling are affected. If disease is severe, entire plants can be killed.

Volunteer wheat, barley, and oat plants serve as hosts between summer and fall, when the crop is sown. Spores (ascospores formed within cleistothecia and conidia) serve as primary inoculum. Infections produce superficial sporulating colonies. Spores (conidia) are wind-dispersed to initiate secondary infections. The spores germinate over a wide temperature range without requiring free moisture. Disease development is optimal at 59º to 72°F (15º to 22°C) and is retarded above 77°F (25°C). Secondary cycles occur at 7- to 10-day intervals. Dense stands, excess nitrogen, high humidity, and cool temperatures favor disease development.

Control measures include resistant cultivars; elimination of crop residue, volunteer small grain plants, and weed hosts; and crop rotation. Fungicides also can be used for control. Applications should be made between tillering and heading to protect the flag leaf from infection.

BARLEY YELLOW DWARF

Barley yellow dwarf is an aphid-transmitted viral disease of wheat, barley, oat, and other grasses. Symptoms include uneven, blotchy leaf discoloration in various shades of yellow, red, or purple, progressing from leaf tip to base and margin to midrib (fig. 9). Wheat and barley leaves usually turn yellow, while oat leaves usually turn red. Plants can be stunted, and those infected as seedlings may be killed. Infected plants have less flexible leaves and less developed root systems than healthy plants. Oat panicles can be blasted (florets become sterile).

The virus survives in most common grain aphids (including bird cherry-oat aphid, English grain aphid, rose grass aphid, corn leaf aphid, and greenbug) and on numerous cereal and grass hosts. The Russian wheat aphid is not a vector of the virus. The virus is spread through vector movement. Aphids can acquire the virus in a feeding period as short as 30 minutes, although 12 to 30 hours is more typical. Transmission can occur 1 to 4 days after acquisition following a feeding period of 4 hours or more. Epidemics are most likely to occur in cool, moist seasons that favor grass and cereal growth and aphid multiplication and migration. Plants can be infected throughout the growing season.

Control is through resistant cultivars and avoiding very early (September to October) or very late (February to March) sowing dates for fall-sown small grains. Sowing the crops during these times exposes plants to active aphid populations when plants are most vulnerable (early growth stages) to damage from infection. Seed treatment with imidacloprid can prevent early-season buildup of aphid infestations and can minimize subsequent transmission and spread of the virus.

Figure 9. Barley yellow dwarf symptoms. Photo by Lee Jackson.

Figure 10. Loose smut symptoms. Photo by Jack Kelly Clark.

LOOSE SMUT

Loose smut, a flower-infecting disease, is caused by different species of the fungus *Ustilago: U. tritici* infects wheat, triticale, and rye; *U. nuda* infects barley; and *U. nigra* infects barley and oat. Symptoms are most visible at heading, but before heading infected plants show dark green erect leaves, sometimes with chlorotic streaks. Infected spikes emerge slightly earlier than healthy spikes. Normal spike tissue is replaced by olive-black masses of spores (teliospores) that are enclosed in a fragile gray membrane (fig. 10) that ruptures near flowering time, releasing the spores and leaving only a bare rachis at maturity.

The fungus survives as dormant mycelium inside infected seed (the black loose smut fungus, however, survives as teliospores on the surface of contaminated seed). When infected seed germinates, the previously dormant mycelium resumes growth and becomes systemic in the plant. When smutted spikes emerge at heading, the fungal membrane soon ruptures, and windborne spores land on healthy plants, where they infect developing kernels (no symptoms are visible). Infection is most likely during cool, moist conditions. Plants are most vulnerable to infection from flowering to about 8 days later.

Control is through seed treatment with systemic fungicides and/or certified smut-free seed. Hot water treatment can eliminate smut fungi from contaminated seed, but it must be used carefully to avoid reducing seed vitality.

COVERED SMUT

Covered smut of wheat, caused by the fungi *Tilletia caries* and *T. foetida*, is a flower-infecting disease that also is called common bunt or stinking smut. Covered smut of barley and oat is caused by different races of *Ustilago hordei*. Infected plants are slightly stunted, and spikes emerge later than normal. Bunted spikes are slender and maintain a green color longer than healthy spikes. Glumes on infected spikes spread apart as kernels are replaced by bunt balls (spherical gray-brown masses of spores encased in fragile pericarps) (fig. 11). The spore masses have a distinctive odor, similar to that of decaying fish, when crushed.

Figure 11. Covered smut symptoms. Photo by Jack Kelly Clark.

Covered smut spore masses burst during harvest, dispersing spores and contaminating healthy grain and soil. The fungi survive between seasons on the surface of infested seed or in the soil. Spores germinate in response to moisture and infect coleoptiles before seedlings emerge.

Control is through seed treatment and/or certified smut-free seed. Hot water treatment can eliminate smut fungi from contaminated seed, but it must be used carefully to avoid reducing seed vitality.

KARNAL BUNT OF WHEAT

Karnal bunt, caused by the fungus *Tilletia indica* (= *Neovossia indica*), infects only wheat and triticale, not other small grains such as barley and oat. Symptoms are first visible at the soft dough stage in the form of blackened areas surrounding the base of the grain; however, the disease is usually not noticed until the grain is threshed and the partially smutted kernels are exposed

Figure 12. Karnal bunt symptoms. Photo by Lee Jackson.

Figure 13. Root and foot rot symptoms. Photo by Jack Kelly Clark.

(fig. 12). Usually only a few florets per spike are affected, and diseased spikes are not conspicuous because the glumes are not noticeably distorted. In severely infected spikes, however, the glumes spread apart near maturity, exposing the infected seed. Diseased seed usually retain a partial seed coat, but the embryo and part of the endosperm are converted to masses of black spores that emit a fishy odor. Karnal bunt has a minimal affect on yield and grain quality, but many countries have a zero tolerance for its presence; consequently, the disease has regulatory significance.

The fungus survives as spores (teliospores) on infected seed and in soil contaminated by the previous crop. A delicate outer membrane that encloses the spore mass on infected seed is easily broken during harvest, dispersing the spores and contaminating healthy seed and soil. Teliospores require a dormant period of up to 6 months before they can germinate and can remain viable in the soil for up to 45 months. Teliospores germinate in response to moisture and produce numerous sporidia at the soil surface. Sporidia are forcibly ejected and dispersed by wind, splashing water, and insects to plants, where they cause infections. Plants are most susceptible to infection when spikes emerge from the boot, but infection can occur throughout the flowering period. Rainy, cool weather and high humidity are ideal for spread of Karnal bunt.

Disease-free seed and seed treatments are important to prevent the introduction of Karnal bunt to noninfested areas. In areas where the soil has become infested, rotate to crops other than wheat and triticale for at least 5 years. Sowing dates also can be adjusted so that heading does not occur when weather conditions are conducive to infection.

ROOT AND FOOT ROT

Root and foot rot, also called common root rot, crown rot, and culm rot, has a complex etiology. In California the fungi *Bipolaris sorokiniana (Helminthosporium sativum), Fusarium culmorum,* and *F. graminearum* (*F. roseum*) are most important. Diseased plants occur randomly or in irregular patches and appear stunted and lighter green than nondiseased plants. Lower leaf sheaths, culms, crowns, subcrown internodes, and roots are discolored and rotted (fig. 13). Diseased plants are brittle; when pulled, they break off easily near the soil level. Severely affected plants may senesce prematurely and produce few tillers and small white or bleached heads that contain shriveled kernels. Early infections can result in pre- and postemergence seedling blight.

The fungi survive on host residue and in soil as mycelium and/or resting spores and are favored by warm weather. Primary infections occur on coleoptiles, primary roots, and subcrown internodes. Moisture or high relative humidity is required for root infection, but subsequent disease development depends on warm temperature and moisture stress. Scab, or head blight, is caused by strains of the same *Fusarium* species that cause root rot. Spores splash onto spikes and infect flower parts if the parts remain continually wet for several days. Blighted spikes

Figure 14. Take-all symptoms. Photo by Jack Kelly Clark.

appear prematurely bleached and usually are sterile or contain only partially filled seed. Scab is rare in California, but it is an important disease in humid areas, especially where rainfall is common during heading, flowering, and grain development stages.

Planting clean or treated seed can reduce seedling infections. Planting fall-sown small grains late in the fall decreases exposure of seedlings to warm soil temperatures. Disease is minimized if adequate soil fertility is maintained for vigorous root and shoot growth. Provide adequate nitrogen but avoid excessive fertilization. Avoid oversaturated soil conditions by providing for adequate drainage for fields subject to flooding during heavy rains. Irrigate to avoid moisture stress. Elimination of crop residue and volunteer small grain plants and crop rotation help reduce inoculum levels.

TAKE-ALL

Take-all, caused by the fungus *Gaeumannomyces graminis* f. sp. *tritici*, is a basal stem, crown, and root disease. Symptoms first appear as stunting and reduced tillering early in the growing season. Later, infected plants prematurely form white (sterile) heads. Roots and crowns are darkened. The presence of a layer of dark brown or black fungal mycelium underneath the lowest leaf sheaths (fig. 14) distinguishes take-all from common root rot.

The fungus survives on crop residue and on roots of certain grass weeds, including bentgrass, quackgrass, and some species of brome. Under conditions of high soil moisture, the fungus spreads to adjacent plants by root contact. Infection is favored by cool weather. Take-all is more severe on plants grown on alkaline soil or soil deficient in nutrients.

Control is through crop rotation and by providing good field drainage and optimal soil fertility. Avoid excessive nitrate fertilizer, which aggravates take-all. Oat and rye are acceptable rotation crops because they are not hosts for the take-all pathogen.

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