Introduction

Winter wheat in the Pacific Northwest (PNW) has a long, troublesome association with dwarf bunt. Dwarf bunt, also known as TCK smut, dwarf smut, and stubble smut, is one of four smut diseases that affect the region's wheat. In general, all four diseases have been suppressed in the PNW by sanitation and cultural practices, and by environmental constraints. In addition, loose smut, common smut, and flag smut have been effectively controlled by the use of resistant varieties and seed treatments. Dwarf bunt, however, has been more difficult to control and many winter wheat varieties in the PNW are susceptible to infection.

Dwarf bunt is similar to common bunt and was not distinguished from it until 1935. Dwarf bunt, more closely associated with snow cover, is less widely distributed than common bunt. Yet, dwarf bunt draws more attention in the PNW than other smut diseases. It has a troublesome persistence and reduces wheat yields usually in localized areas. Since 1973, when the Peoples Republic of China imposed a quarantine against importing PNW grain because of potential infestation with the dwarf bunt fungus, it has also attracted wide attention as an international trade barrier.

Incidence and Economic Impact

Dwarf bunt occurs almost exclusively on winter wheat. It may occasionally occur on grasses, but spring seeded wheat and other cereals are unaffected. Where it occurs, its incidence is usually erratic and associated with wheat that has been beneath snow for a minimum of 60 days. In any given year, fields with a history of dwarf bunt may remain free of the disease or exhibit a trace to greater than 50 percent bunted heads.

Surveys during 1990 to 1993 identified dwarf bunt in the following northwestern states and counties:

Montana - Basin, Big Horn, Carbon, Fergus, Flathead, Gallatin, Judith, Mineral, Missoula.
Oregon - Baker, Union, Wallowa, Sherman, Wasco.
Utah - Box Elder, Cache, Juab.

Dwarf bunt's economic impact includes yield and quality reductions, a discount in market price, and market exclusion. In the field, dwarf bunt replaces
Dwarf Bunt developing kernels in wheat heads with a smut (bunt) ball, a kernel-like structure filled with fungal spores. This inflicted yield loss equates to approximately 0.8 times the percentage of smutted heads in the field. A loss in wheat quality and grade is also imposed when harvested grain is contaminated with bunt spores, smut balls, and/or the fishy odor they emit. Healthy grain associated with dwarf bunt is graded “light smutty” when it has the unmistakable odor of smut or contains 15 to 30 smut balls or portions of smut balls in a 250 g sample. Wheat is graded “smutty” when a 250 g sample contains more than 30 smut balls or portions of smut balls. Currently, the grades “light smutty” and “smutty” equate to a loss of approximately 10 and 20 cents per bushel, respectively.

Another economic impact of dwarf bunt is the loss of export markets for PNW wheat. Using common harvest, transport, and storage equipment puts most PNW wheat at risk for contamination with dwarf bunt spores even though most fields are free of the disease. Current seed assay techniques permit even trace levels of spores to be detected. Contaminating spores of dwarf bunt are specifically responsible for the loss of PNW wheat exports to the Peoples Republic of China.

**Symptoms**

Symptoms of dwarf bunt become most distinctive after heading. Prior to heading in the spring, dwarf bunt may produce additional tillers and small, yellow (chlorotic) flecks on expanding leaves. Diagnostic symptoms after heading include one or more dwarfed stems, increased numbers of tillers, shortened spreading heads, and smut balls that replace the kernels and emit a fishy odor.

The height of individual stems may be reduced by 25 percent to nearly 70 percent (Fig. 1) depending on the wheat variety, strain of the dwarf bunt fungus, severity of infection, and climatic conditions. The number of tillers on fully infected plants typically exceeds those on uninfected plants by about 50 percent.

The heads of plants affected by dwarf bunt typically are altered in size and shape. Infected heads of club wheats tend to elongate while those of common wheats usually are shortened. Expanding smut balls normally become larger than the wheat kernels they replace. This forces glumes and awns to spread and gives the head a feathered or ragged appearance (Fig. 2). In highly susceptible varieties, all kernels of infected heads may be replaced by plump brown smut balls. In resistant varieties, only a few kernels or tillers may be affected and stem height may not be reduced. Such symptoms and infections may be difficult to detect. When mature smut balls are crushed by finger pressure or during harvest, their dusty, dark, fishy-smelling masses of fungal spores (teliospores) are released (Fig. 3).

**Cause**

Dwarf bunt is caused by the fungus *Tilletia controversa* Kühn from which the name TCK smut originated. Although the dwarf bunt fungus can occasionally infect barley, rye, and grasses, its usual host is winter wheat. Host plant infections almost exclusively originate from spores borne in soil rather than on seed. Spores of the dwarf bunt fungus are highly adapted to persist in soil and to germinate under prolonged cool, humid conditions.

Spore germination is followed by the formation of microscopic bodies called sporidia that fuse, produce infectious hyphae and eventually penetrate developing tillers (Fig. 4). This process of sporidia fusion provides the fungus with a mechanism for genetic variation. When compatible sporidia fuse, new
Dwarf Bunt

Disease Development

Dwarf bunt completes a single disease cycle during a cropping season. It is initiated when soilborne spores germinate at or near the soil surface and produce sporidia and infectious hyphae that invade wheat seedlings. The cycle ends with the production and release of new spores from wheat heads (Fig. 4).

In the field, young wheat plants in unfrozen soil beneath snow are especially prone to infection. Spore germination is initiated in soil when temperatures of 30 to 41°F (-1 to 5°C), aerobic conditions, and free moisture are sustained for at least 5 weeks. In some parts of the PNW, such conditions occur during most winters. After spore germination, host infection requires 4 weeks or more to complete.

Spore germination and tiller infection occur anytime from midwinter through early spring. If the soil freezes in the late fall and remains frozen through the winter, the incidence of dwarf bunt will be reduced because both the fungus and the wheat seedlings remain relatively dormant. In the spring, soil temperatures often rise too quickly to accommodate spore germination and subsequent infection. Apparently, for this reason, spring wheat escapes infection.

Even under optimum conditions only a portion of the soilborne spores germinate and produce infectious hyphae. This character contributes to the remarkable persistence of the spores for 10 years or more before being induced to germinate. The coincidence of persistent moisture, oxygen, low temperature, and low light required for spore germination and wheat infection is normally met only on the soil surface.
beneath snow. Spores within soil tend to remain dormant until brought near the surface by tillage and other cultural operations.

The dwarf bunt fungus infects the developing tillers of wheat plants and eventually invades the growing point of the stem, the developing head, and kernels. As infected heads mature, the fungus within developing kernels separates into masses of spores that eventually darken. Dark spores, numbering between 5 and 12 million, replace the contents of the kernel. Such spores together with the remaining fragile pericarp of the kernel comprise a smut ball.

Smut balls are easily broken (Fig. 3). At harvest, spores from broken smut balls are released to infest healthy kernels and harvest and grain handling equipment. The released spores also are readily dispersed by wind. Sowing smut-infested seed also may spread the fungus to new fields and other growing areas.

**Controls**

**Resistant varieties.** Most winter wheat varieties in the PNW are susceptible in varying degrees to dwarf bunt. Some formerly resistant varieties have become susceptible because of the development of new strains of the dwarf bunt fungus. The use of wheat varieties resistant to dwarf bunt remains the most cost effective means to control this disease (Table 1). In areas with a history of severe dwarf bunt, resistant varieties have nearly eliminated the disease.

Dwarf bunt resistant varieties vary in their reaction to local environmental conditions and to other diseases. Normally, dwarf bunt resistant varieties also are resistant to common bunt. Some also are resistant to snow molds. In some areas, it may be beneficial to select varieties that also resist diseases such as rusts, viruses, strawbreaker foot rot, snow molds, and Cephalosporium stripe that may pose a greater threat than dwarf bunt.

**Fungicide seed treatments.** Several commonly used fungicide seed treatments (Vitavax 200, Baytan, etc.) control common smut, loose smut and flag smut but are generally ineffective against dwarf bunt. Gustafson LSP (30 percent thia­bendazole) is registered for dwarf bunt control but its efficacy is inconsistent. In contrast, the systemic fungicide, CIBA Dividend (difenoconazole), has been highly effective in field trials in the PNW (Table 2).

**Early or late winter wheat seeding** reduces the severity of dwarf bunt. Wheat plants are most susceptible to infection when they have developed 3 to 8 leaves (1 to 3 tillers) prior to winter snow cover or dormancy. Timing wheat seeding in autumn to ensure less than 3 or more than 8 leaves prior to winter dormancy can be beneficial. Early autumn seeding permits most plants to grow beyond the most susceptible 1-3 tiller stage prior to winter. Late autumn seeding reduces the amount of susceptible plant tissue exposed to germinating spores and may permit seed treatment fungicides to be more effective on smaller overwintering plants. However, altered seeding dates have associated risks. Late seeding increases the risk of soil erosion and weed infestation. Early seed may be complicated by low soil moisture, a late maturing crop on the same site, and increased susceptibility to diseases such as Cephalosporium stripe, strawbreaker foot rot, and barley yellow dwarf.
Table 1. Pacific Northwest winter wheat varieties with resistance\(^1\) to dwarf bunt.

| Soft white and club varieties | Eltan | Resistant | Luke | Resistant | Lewjain | Resistant | Basin | Moderately Resistant | Madsen | Moderately Resistant | Moro | Moderately Resistant | Hyak | Moderately Susceptible | Km6or | Moderately Susceptible | Sprague | Moderately Susceptible |
|-------------------------------|-------|-----------|------|-----------|---------|-----------|-------|----------------------|--------|----------------------|------|----------------------|------|----------------------|--------|----------------------|
| Hard red varieties            | Weston | Very Resistant | Blizzard | Very Resistant | Ute | Very Resistant | Manning | Very Resistant | Bonneville | Very Resistant | Hansel | Very Resistant | Survivor | Very Resistant | Winridge | Very Resistant | Andrews | Moderately Susceptible | Meridian | Moderately Susceptible | Batum | Moderately Susceptible |

1 Degree of resistance may vary from location to location. Typical incidence of dwarf bunted heads relative to a fully susceptible variety under severe disease pressure: Very Resistant <5%; Resistant 5-10%; Moderately Resistant 11-25%; Moderately Susceptible 26-40%.

Deep seeding tends to suppress dwarf bunt while shallow seeding tends to enhance the disease. In compacted soils positioning seed below 1 inch (2.5 cm) may protect susceptible seedling tissues from direct exposure to germinating spores.

Depth of seed furrows. Deep seed furrows result when hoe-type openers or deep furrow drills are used. Such furrows may limit soil erosion and collect moisture, however, they also may promote dwarf bunt by collecting and retaining snow.

Persistent snow cover. Planting in open areas away from fences, wind breaks, or other barriers that trap snow can limit disease development. Dwarf bunt is most severe on north-facing slopes and in lowlands where snow persists for prolonged periods.

Destroying heavily smutted wheat may reduce subsequent soil and seed infestation. Harvesting smutty wheat efficiently distributes spores and smut balls to grain, machinery, and wind. Burning heavily infested fields or areas may reduce dwarf bunt inoculum for future crops. However, burning crop residues reduces soil organic matter and increases the risk of soil erosion.

Grassy weeds may harbor smut diseases and/or serve as alternative hosts for the dwarf bunt fungus. Controlling grassy weeds can limit the quality and quantity of inoculum available to infect or infest wheat.

Spring wheat sown in dwarf bunt prone areas is unaffected by the disease. Warm soil temperatures do not support spore germination and seedling infection. Crop rotations that include winter wheat/spring wheat are not effective controls for dwarf bunt because of the long-term survival of soilborne spores and their availability for infection of winter wheat.

Quarantines attempt to reduce the distribution of dwarf bunt spores on infested grain. However, the wide distribution of wheat in domestic and international commerce may have already introduced dwarf bunt spores to all wheat-growing regions.

Integrated dwarf bunt management. Combinations of one or more control practices are more effective than single strategies to reduce the incidence and severity of dwarf bunt. For example, combining a seed treatment with a resistant variety and seeding relatively late and deep offers more protection than utilizing any single control measure by itself.

Table 2. Effect of seeding date and Dividend 3FS (difenconazole) seed treatment on the percentage of dwarf bunted heads in winter wheat\(^1\) at selected locations in 1993.

<table>
<thead>
<tr>
<th>Location</th>
<th>Seeding date</th>
<th>Untreated check</th>
<th>Dividend Rates</th>
<th>Rates(^2)</th>
<th>%</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logan, UT</td>
<td>4 Oct</td>
<td>0</td>
<td>Dividend 0.06</td>
<td>0.12</td>
<td>(0.25)</td>
<td>(0.50)</td>
<td></td>
</tr>
<tr>
<td>Kalispell, MT</td>
<td>18 Sep</td>
<td>82</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Oct</td>
<td>68</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 Oct</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pullman, WA</td>
<td>11 Sep</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 Oct</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavendish, ID</td>
<td>21 Sep</td>
<td>93</td>
<td>27</td>
<td>trace</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 Oct</td>
<td>94</td>
<td>6</td>
<td>trace</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19 Oct</td>
<td>93</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flora, OR</td>
<td>22 Sep</td>
<td>24</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Dwarf bunt susceptible varieties Hatton, Nugaines, and Hill 81.

2 Grams active ingredient per 100 kilogram seed (ounces formulation per 100 pounds seed).
The Authors

University of Idaho
Jerry Sitton, former support scientist, Moscow.
Maury Wiese, professor of plant pathology, Moscow.
Robert Forester, professor of plant pathology, Kimberly.

Montana State University
Don Mathre, professor of plant pathology, Bozeman.

USDA Agricultural Research Service
Blair Goates, research scientist, Aberdeen, Idaho.
Roland Line, research scientist, Pullman, Washington.

Washington State University
Clarence Peterson, professor of crop science, Pullman.
Jackson Waldher, former support scientist, Pullman.

Oregon State University
Richard Smiley, professor of plant pathology, Pendleton.

For More Information


Pacific Northwest Extension publications contain material written and produced for public distribution. You may reprint written material, provided you do not use it to endorse a commercial product. Please reference by title and credit Pacific Northwest Extension Publications. To reproduce material used with permission in this publication, please contact the original source.

Pacific Northwest Extension publications are jointly produced by the three Pacific Northwest states—Idaho, Oregon, and Washington. Similar crops, climate, and topography create a natural geographic unit that crosses state lines. Since 1949, the PNW program has published more than 400 titles. Joint writing, editing, and production have prevented duplication of effort, broadened the availability of faculty specialists, and substantially reduced costs for the participating states.

Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the University of Idaho Cooperative Extension System, LeRoy D. Luft, director; the Oregon State University Extension Service, Lyla Houglum, director; and Washington State University Cooperative Extension, Harry B. Burcalow, interim director; and the U.S. Department of Agriculture cooperating.

The three participating Extension services offer educational programs, activities, and materials without regard to race, color, religion, national origin, gender, age, disability, or status as a Vietnam-era veteran as required by state and federal laws. The University of Idaho Cooperative Extension System, Oregon State University Extension Service, Washington State University Cooperative Extension, and the USDA are Equal Opportunity Employers.

11-95 3,000

$1.00/$1.00/$1.00