Susceptibility of Barley to Tilletia controversa

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ABSTRACT

Dwarf bunt was observed in winter barley *(Hordeum vulgare)* in northern Utah in 1971. Symptomatology, teliospore morphology and germination, and pathogenicity identified the causal organism as *Tilletia controversa,* race D-6. Cross-inoculation resulted in the transfer of dwarf bunt from barley to wheat, and from wheat to barley. This apparently is the first recorded occurrence of *T. controversa* on barley in the western hemisphere. The infrequency with which dwarf bunt was induced in barley cultivars suggests that genes for susceptibility in barley are not widespread.

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Dwarf bunt caused by *Tilletia controversa* Kühn is a disease of major economic importance in winter wheat (*Triticum aestivum* L.) in the northwestern United States. In addition to attacking wheat, the fungus also occurs on many other grasses. A current host list for *T. controversa* includes fives tribes, 18 genera, 68 species, and two varieties of the Gramineae (5, 7, 10, 11). Species of *Hordeum,* including cultivated barley (*Hordeum vulgare* L.), were added to the host list when *T. pancicii* Bub. & Ranoj. and *T. hordei* Koern. were reduced to synonymy under *T. controversa* (2, 3). In addition, a bunt from *H. murinum* resembling *T. controversa* was transferred to both wheat and barley (8), and *T. controversa* from wheat was transferred to *H. brachyantherum* and back to wheat (7) by artificial inoculation. However, to our knowledge, natural or artificial infection of cultivated barley with *T. controversa* from wheat has not been reported.

What appeared to be dwarf bunt was observed on winter barley at the Blue Creek Dryland Experiment Station in northern Utah in July 1971. Bunt which occurred in 3-5% of plants of two entries in a barley winterhardiness nursery apparently resulted from natural soilborne inoculum. The infected barley entries were a hull-less line, Beltsville 69-1157nn, and a hulled line, Oklahoma S-654833-7R. The field where the infection occurred had been in a wheat-fallow cropping system for many years and had a long history of dwarf bunt; thus, the level of dwarf bunt inoculum in the soil was high. Environmental conditions were near optimum for dwarf bunt development in 1971, as shown by the high dwarf bunt incidence (about 50%) in surrounding wheat plots.

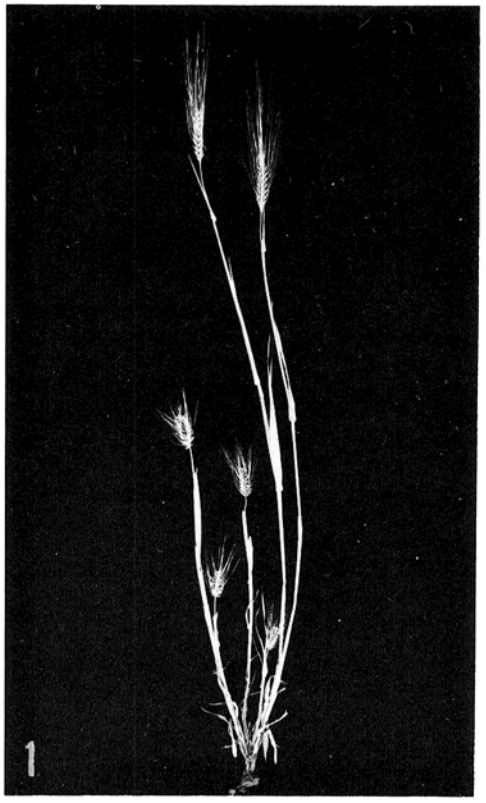
Studies were begun in the fall of 1971, to establish that the bunt on barley was *T. controversa,* and that it was pathogenic on both barley and wheat.

MATERIALS AND METHODS.—*Teliospore morphology and germination.*—Teliospores were collected from the originally infected barley plants, and from barley and wheat later infected by natural and artificial inoculation. The teliospores were examined microscopically, and the diameter, height of the reticulum, and thickness of the hyaline sheath were measured. These characters were measured also on teliospores of *T. controversa* collected from wheat naturally infected at Blue Creek and Logan, Utah. The teliospores were mounted in a modified (4) Shears mounting fluid; measurements were taken on 25 teliospores selected at random on each of two mounts per collection.

The same bunt collections from barley and wheat were compared for germination requirements and germination rate by incubation of the teliospores on soil-extract agar (SEA) at 5 C or 15 C in continuous low-intensity (430-650 lx) light or in the dark. The experiment was repeated three times with three replications per treatment.

RESULTS.—*Symptom expression and teliospore morphology and germination.*—Symptoms expressed by smutted barley plants were like those typically produced by *T. controversa* on wheat. Infected tillers were reduced one-fourth to one-half the normal height (Fig. 1). The appearance of infected heads was typical of dwarf bunt and differed markedly from the loose- and covered smuts of barley (Fig. 2). The bunt sori from barley were spherical and granular in texture like those from wheat (Fig. 3). The teliospores were reticulate with a hyaline sheath extending beyond the reticulations. Teliospores from barley (Fig. 4) and from wheat that had been inoculated with bunt from barley, averaged 18.0-22.5 μm in diameter; the reticulations were 0.5-2.0 μm high; and the sheath was 1.0-3.0 μm thick. Comparison collections of *T. controversa* from wheat had teliospores (Fig. 5) averaging 19.0-22.5 μm in diameter; reticulations 0.5-2.0 μm high; and sheaths 1.0-2.5 μm thick. Thus, the teliospores which originated from barley were essentially like those of *T. controversa* from wheat, and were within the size range of characters described for that species (2, 3).

Fig. 1-5. 1) Dwarfing induced by *Tilletia controversa* in infected culms (left) of winter barley. 2) Sorus characteristics of (from left to right) loose smut, *Ustilago nuda;* covered smut, *U. hordei;* and dwarf bunt, *Tilletia controversa* on barley.) Sori (bunt balls) of *Tilletia controversa* from barley (left) and wheat (right). **4-5**) Teliospores of *Tilletia controversa* from barley and wheat, respectively. Note presence of hyaline sheath extending beyond reticulations (× 1,500).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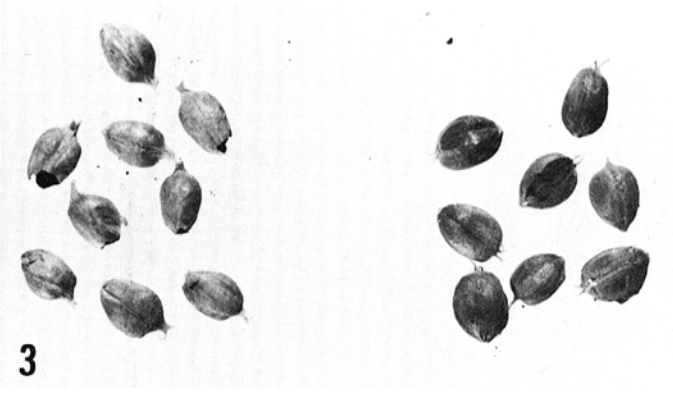
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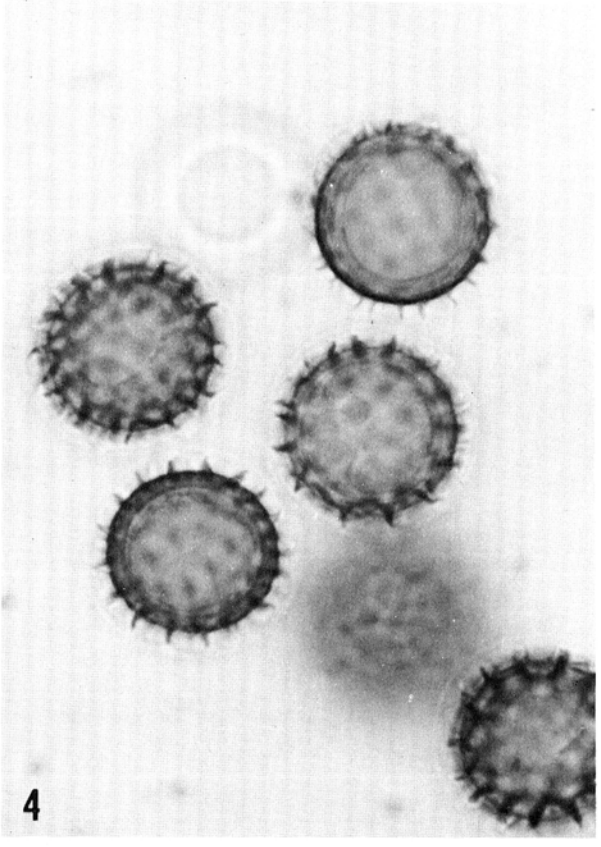
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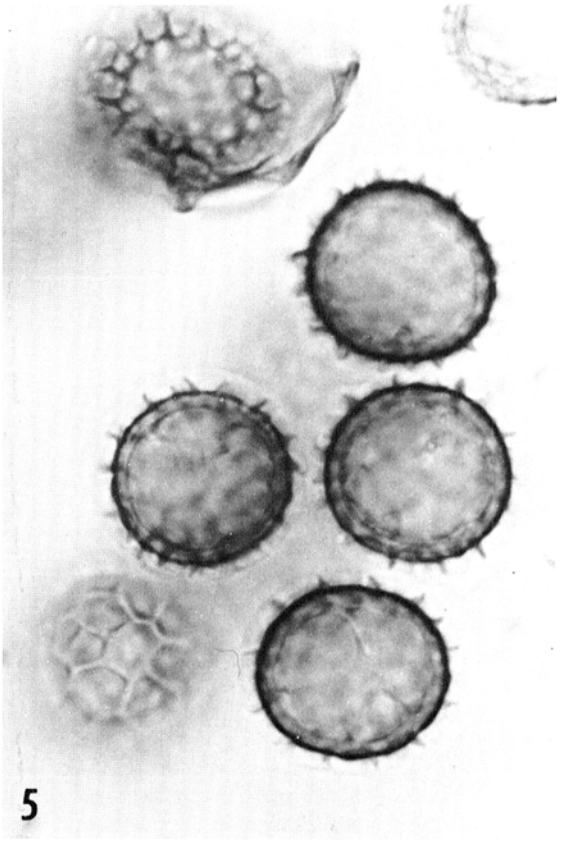
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Teliospores germinated at 5 C, but not at 15 C. Germination of teliospores which originated from barley attained 90% in continuous light and 40-80% in darkness after 35 days at 5 C. Under the same conditions, germination of teliospores from wheat was slower, attaining 50-90% in light and germinating in only trace amounts in darkness.

Pathogenicity.—Of the 74 winter-barley lines exposed to soil-surface inoculum of dwarf bunt from wheat, only three plants of Oklahoma S-654833-7R were smutted. This winter-barley line was one of the two lines in which bunt was originally observed. No bunt occurred in Beltsville 69-1157nn, the other line originally infected. In contrast, infection levels in check rows of the susceptible wheat cultivar, Cheyenne, ranged from 85-100%, indicating favorable conditions for disease development.

Inoculation of seedlings of Cheyenne wheat with a suspension of germinating teliospores of the bunt pathogen from barley resulted in only one smutted plant. The infected tiller was typically dwarfed, and the teliospores were characteristic of *T. controversa.* However, the bunt sori were longer and more elliptical than is usual with *T. controversa.*

Inoculation of seeds of the differential wheat selections with germinating teliospores of bunt from barley resulted in moderate levels of infection on several of the wheat differentials. Symptoms and teliospore characteristics were uniformly typical of *T. controversa.* A virulent reaction (more than 10% infection) was produced on differentials carrying the *Bt1, Bt2, Bt4, Bt5, Bt6,* or *Bt7* bunt-resistance genes. This reaction pattern on the bunt differentials is characteristic of dwarf bunt, race D-6 (6). No bunt developed in plants of the barley selection, Oklahoma S-654833-7R, which had been inoculated with germinating spores of the eight different pathogenic races, including race D-6, of *T. controversa* from wheat.

Pathogenicity studies.—To determine the susceptibility of barley to dwarf bunt from wheat, 74 barley lines comprising the 1972 U.S. Department of Agriculture Barley Winterhardiness Nursery were grown in an artificially inoculated nursery at Logan. The barley entries were seeded shallow in deep furrows in 1-m rows. A water suspension of *T. controversa* teliospores (collected from wheat at Logan) was sprayed on the soil surface over the seed at the rate of 6 g of finely ground spore material per row. The furrows were filled with 5 to 7 cm of vermiculite in early December to enhance dwarf bunt development (1).

The limited amount of teliospore material available from barley precluded cross-inoculation from barley to wheat on a field-plot scale. Therefore, inoculations were performed by methods using germinating teliospores as inoculum. Teliospores were germinated on SEA at 3-5 C under continuous, low-intensity (400-600 lx) light. When primary sporidia were abundant (about 5 weeks), a water suspension was prepared by rinsing the germinating teliospores from the agar surface. In an initial experiment, a suspension of germinating teliospores from barley was atomized on seedlings of the susceptible wheat cultivar Cheyenne. The seedlings were grown from surface-disinfested seed sown in autoclaved soil in 12.7-cm pots, four seedlings per pot. They were inoculated in the two-leaf stage when they were 10-12 cm tall. After inoculation, the potted seedlings were placed in plastic bags for 8 days at 10-15 C. Then, the bags were removed and the plants were vernalized in a lighted chamber at 1-3 C for 6 weeks (until mid-February). The plants were then placed in an unheated (5-15 C) greenhouse. On 1 March, a set of eight pots of seedlings was moved to a 25-C greenhouse section, and another set was transplanted to the field. Three other eight-pot field plants were made at 3-week intervals.

In a later experiment, seeds of the barley line Oklahoma S-654833-7R and of 15 wheat cultivars and lines used in differentiating dwarf bunt races were inoculated with germinating teliospores as described previously (6). The barley was inoculated with eight dwarf bunt collections of differing pathogenic types from wheat. The differential wheats were inoculated with the bunt from barley from the artificially inoculated nursery at Logan.

DISCUSSION.—The bunt observed on cultivated barley in northern Utah has the same morphological and physiological features that characterize *T. controversa* on wheat and other grasses. Certain differences in teliospore morphology and germination requirements were observed between collections on or originating from barley and those selected for comparison from wheat. Nevertheless, these differences were not great enough to establish the bunt from barley as a distinct species.

Examination of numerous collections of *T. controversa* from wheat and wild grasses has shown this species to vary greatly in symptomatology and teliospore morphology. Indeed, its only consistent characteristics are the long incubation period (minimum 21 days) and the low temperature (< 15 C) required for teliospore germination.

The observation of *T. controversa* on barley in the United States, and the transfer of this bunt pathogen from barley to wheat supports the conclusion of Duran and Fischer (2, 3) that *T. hordei* and *T. pancicii* are synonymous with *T. controversa.* Examination of more recent collections from bunted *H. murinum* L. and *H. marinum* Huds. in Turkey (9) also supports this conclusion.

The lack of previous reports of dwarf bunt on barley in America has two probable explanations. Although considerable barley acreage occurs in regions where dwarf bunt is a chronic problem, the greater part of this acreage is seeded to spring barley. Perhaps because of the very specific low-temperature requirement for spore germination, dwarf bunt does not occur in spring-sown wheat. Therefore, its occurrence would likewise not be expected in spring barley. Dwarf bunt is limited to areas with relatively severe winters and persistent snow cover. Winter barley lacks enough hardiness to be a reliable crop in such areas; thus, only a limited acreage of winter barley is grown in areas where dwarf bunt occurs. Secondly, genes for susceptibility appear not to be widespread in barley. The U.S. Department of Agriculture Barley Winterhardiness Nursery represents a wide cross-section of barley genotypes. That dwarf bunt was induced in only one or two entries under conditions highly favorable for infection, suggests that susceptibility to dwarf bunt is rare in barley.

Therefore, it seems unlikely that dwarf bunt will become a significant disease problem in barley. On the other hand, the increased culture of winter barley in dwarf

bunt-infested areas could result in biotypes of dwarf bunt that are more virulent and aggressive on barley.

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