Botryodiplodia hypodermia and *Tubercularia ulmea* in Cankers on Siberian Elm in Northern Great Plains Windbreaks

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ABSTRACT

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Cankers were collected from Siberian elms in 56 counties in Minnesota, Montana, North Dakota, and South Dakota. Of 609 cankers analyzed for fungi, 66% were small branch, 29% were basal, and 5% were large branch cankers. *Botryodiplodia hypodermia*, *Tubercularia ulmea*, *Cytospora* sp., and other fungi were recovered from 42, 17, 28, and 13% of the cankers, respectively. Cankers developed only on trees inoculated with *B. hypodermia* and *T. ulmea*. *B. hypodermia* was the most important pathogen. *T. ulmea* was isolated from only 17% of the cankers, and 82% of these were small branch cankers.

Siberian elm, *Ulmus pumila* L., has been widely planted in windbreaks in the northern Great Plains because it grows rapidly and is able to survive in this region. A canker disease has severely limited the usefulness of this species in windbreaks in the eastern half of South Dakota (7). Cankers occurred in 2–40% of 4-yr-old and 14–78% of 8-yr-old Siberian elm trees. *Botryodiplodia hypodermia* (Sacc.) Petr. and Syd. was demonstrated as the causal agent of this disease by H. Randall (*unpublished*); it was confirmed as a canker pathogen of Siberian elm in 1978 (10). Herbicide drift was mentioned as a possible factor predisposing Siberian elms to infection (7). Applications of 2,4-dichlorophenoxyacetic acid reduced stem growth and produced bark abnormalities in Siberian elm, but these changes were not shown to increase susceptibility to fungal invasion (6).

Seventy-two percent of 769 Siberian elms examined by Dooling in 1973 in North Dakota had cankers (3). *Cytospora* sp., *Dothichiza* sp., *Camarosporium* sp., and *Tubercularia ulmea* Carter were isolated from 31 cankers. However, herbicide injury rather than fungi was considered to be the primary cause of windbreak decline (3). In a 1973 survey of 18 windbreaks in southeastern North Dakota, Riffle found that 70% of 473 trees were cankered (10). *B. hypodermia* was isolated from 15 of 60 cankers and was confirmed as the causal agent. *B. hypodermia* also causes a dieback and canker disease on American elm in North Dakota (1).

T. ulmea was described in Illinois as the cause of canker and dieback of Siberian elm in 1947 (2). It has also been reported as causing cankers on Russian-olive, *Elaeagnus angustifolia* L. (8). *T. ulmea* was isolated from Siberian elm and Russian-olive in one windbreak in North Dakota by Dooling (3).

Should a genetic improvement program for Siberian elm include tests for resistance to *B. hypodermia* and *T. ulmea*? The present study was undertaken to help answer this question and to determine how serious the canker problem is over a large region of the northern Great Plains.

MATERIALS AND METHODS

Survey. In 1979, I collected cankers from Siberian elm trees in 8 windbreaks from 5 counties of northeastern Montana, 7 windbreaks from 6 counties of west central Minnesota, 11 windbreaks from 9 counties of northeastern South Dakota, and 58 windbreaks from 36 counties of North Dakota. The area, which represents the Siberian elm windbreak plantings in the northern Great Plains, included plantings in cultivated croplands, rangelands, and near farmsteads. Small branch cankers were defined as those on branches less than 2.5 cm in diameter, large branch cankers as those on branches 2.5–12.5 cm in diameter, and basal cankers as those on the lower main trunk of a recently killed tree.

Cankers were cut from branches with pruning shears or a saw. Bark and wood samples from basal cankers were obtained with a hatchet or hunting knife. All tools were disinfected with 95% ethanol between cuts.

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Before isolations were made, all samples were surface sterilized by being swabbed with 70% ethanol. The bark of branch cankers was cut back with a sterile scalpel, and eight wood chips were cut from canker margins and placed on 2% water agar or on Siberian elm extract agar. Siberian elm extract agar was prepared by cooking 100 g of small branches in 1 L of distilled water for 10 min at 100 C, straining the extract through four layers of cheesecloth, adding 20 g of agar, and bringing the volume up to 1 L with distilled water before autoclaving. Isolations were made from basal cankers by cutting wood chips from below the surface of necrotic tissue.

Plates containing wood chips for isolation were kept at 22 ± 2 C under cool-white fluorescent light for 1–2 wk before the fungi were transferred to V-8 juice agar for identification. Fungal cultures were maintained on V-8 juice agar at 20 ± 1 C. Spore measurements were made on nine isolates randomly selected from North Dakota and three isolates each from Minnesota, Montana, and South Dakota.

Pathogenicity tests. I inoculated 165 two-year-old Siberian elm trees, obtained as common 2-0 nursery stock (Lincoln-Oakes Nursery, Bismarck, ND), with pure cultures of isolated fungi. The trees were grown in a mixture of peat moss and vermiculite (1:1). Inoculation procedures were similar to those used by Riffle (10), except that I used a 5-mm mycelial disk of the fungus grown on V-8 juice agar. After inoculation, the bark flap was pressed back and covered with parafilm.

RESULTS

Survey. Isolations of fungi were made from 609 cankers, of which 66% were small branch, 29% basal, and 5% large branch cankers. At least four cankers were examined in the laboratory from each of 4 counties in Minnesota, 5 in Montana, 26 in North Dakota, and 9 in South Dakota. *B. hypodermia*, *T. ulmea*, and *Cytospora* sp. were isolated from cankers originating in 86, 64, and 95%, respectively, of these 44 counties.

B. hypodermia was isolated from 30% of the 404 small branch cankers, 67% of the 176 basal cankers, and 55% of the 29 large branch cankers. *T. ulmea* was isolated from 21% of the small branch, 10% of the basal, and 7% of the large branch cankers. *Cytospora* sp. was isolated from 36% of the small branch, 10% of the basal, and 14% of the large branch cankers. Other fungi were found in 13% of the small branch, 14% of the basal, and 24% of the large branch cankers.

When all cankers are considered, *B. hypodermia* was isolated from 42%, *T. ulmea* from 17%, *Cytospora* sp. from 28%, and other fungi from 13%. *B. hypodermia* and *T. ulmea* were isolated together from 3% of the cankers, as were *B. hypodermia* and *Cytospora* sp.

The 528 cankers from which either *B. hypodermia*, *T. ulmea*, or *Cytospora* sp. was isolated accounted for 87% of the cankers processed. The fungi can be analyzed in terms of the type of canker from which they were isolated. Basal cankers yielded 46% of the *B. hypodermia* isolations, 16% of the *T. ulmea* isolations, and 10% of the *Cytospora* isolations. Small branch cankers yielded 48% of the *B. hypodermia* isolations, 82% of the *T. ulmea* isolations, and 88% of the *Cytospora* isolations. Thus, more than 80% of the *T. ulmea* and *Cytospora* isolations were from small branch cankers, whereas *B. hypodermia* was isolated almost equally from small branch and basal cankers.

The mean spore sizes of the 18 *B. hypodermia* isolates collected in North Dakota, Montana, South Dakota, and Minnesota were 30 × 17 μm, 31 × 16 μm, 30 × 18 μm, and 31 × 17 μm, respectively. These are within the range of measurements by Petrak and Sydow (9), who reported sizes of 20–32 μm (usually 25 μm) × 15–18 μm (rarely to 21 μm). They are also similar to spore sizes from an isolate (290) supplied by Riffle (10), from which 100 spores were measured as having a range of (23) 24–32 (33) × (15) 16–22 (24) μm. Spores from 16 of the 18 isolates were nonseptate.

Pathogenicity tests. Cankers developed only on trees inoculated with *B. hypodermia* and *T. ulmea*. Although *Cytospora* sp. was isolated from many cankers, it was not shown to be pathogenic under present inoculation conditions.

DISCUSSION

The study confirmed the presence of *B. hypodermia* and *T. ulmea* in windbreak trees over a larger area than previously reported. Because the survey included areas of major windbreak plantings, results indicate that cankers probably occur wherever Siberian elm windbreaks are located in the northern Great Plains. Although other fungi were isolated, *B. hypodermia* and *T. ulmea* were the only fungi capable of producing cankers, and they were isolated from cankers from 87 and 56% of the counties for which at least four cankers were processed.

The pathogenicity of *T. ulmea* was confirmed, but it was isolated from only 17% of the cankers processed; 82% of these were small branch cankers. *B. hypodermia* was considered the most important pathogen because it was isolated from 42% of all the cankers processed, including 67% of the basal and 55% of the large branch cankers. These two types of cankers are the most damaging to the tree: major sections of trees are killed by cankers that girdle large branches, and the entire tree is killed by girdling basal cankers.

Canker development may have been encouraged by stress, including herbicide drift, drought, winter injury, and the fungal pathogen stresses mentioned by Otta (6), as well as by cankerworm defoliation (4). *Platanus occidentalis* L. is highly vulnerable to *B. theobromae* during drought and when planted on unusually dry sites (5). *Rhamnus frangula* L. is vulnerable to *T. ulmea* with freezing stress (11). Both drought and freezing are present in the northern Great Plains, and their effects on tree disease should be studied.

A genetic improvement program for Siberian elm should include the selection of trees resistant to *B. hypodermia* and *T. ulmea*. Little is known about the genetic variation of *B. hypodermia* or *T. ulmea*. Therefore, mixtures of fungal isolates from different areas could be used to determine their differences more thoroughly.

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