Postharvest Fungi of Lowbush Blueberry Fruit

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ABSTRACT

The major fungi isolated from 50 processor or market samples of lowbush blueberry fruit were Botrytis cinerea (3.7%), Glomerella cingulata (3.0%), Gloeosporium minus (2.5%), Alternaria spp. (1.0%), and Penicillium spp. (0.8%). Gloeosporium, an incitant of leaf spots, stem cankers, and blossom-end rot on highbush blueberries, has not been previously reported as a disease of lowbush blueberry. The incidence of Glomerella and Alternaria, but not of Botrytis and Gloeosporium, was significantly higher in fields pruned by mowing than in those pruned by burning. Heat-tolerant fungi isolated included Eupenicillium lapidicostum, another sclerotial Eupenicillium sp., Talaromyces striatus, an isolate resembling Humicola sp., and two unidentified species.

Lowbush blueberry (Vaccinium angustifolium Aiton) is a major crop in Maine and the eastern provinces of Canada. Production of highbush blueberry (V. corymbosum L.) is concentrated in Michigan, New Jersey, North Carolina, and the Pacific Northwest. Lowbush plants establish naturally, growing as a ground cover of genetically diverse clones. Fields are usually managed on a 2-yr cycle, with a single year of fruit production followed by mowing or burning and a year of vegetative growth (3). These cultural, genetic, and geographic differences suggest that the diseases of the two species differ, if only in relative severity. In Maine, where half the lowbush crop is produced, only mummy berry disease, caused by Monilinia vaccini-corymbosi (Reade) Honey, and Botrytis blossom blight warrant control measures. Such measures are often not used if history of these diseases or current weather suggests that they will be unlikely or if the grower prefers not to use pesticides in the crop year. Fungicides are rarely applied after late bloom and do not prevent infection of developing or mature fruit.

Because 98% of the lowbush crop is immediately frozen for sale or for subsequent canning, little attention has been given to postharvest diseases. Heat-tolerant fungi have, however, been recovered from canned blueberries (12,16). With increased interest in fresh marketing and a desire to maximize quality of processed berries, a study of such fungi was undertaken to answer several questions: 1) What are the important fungi present in or on lowbush blueberry and does their incidence differ from that of highbush berries? 2) Does burning reduce the incidence of disease organisms? 3) Which heat-tolerant fungi are most commonly associated with the crop?

MATERIALS AND METHODS
Fruit survey. In 1988, 50 fruit samples were obtained over a period of 3 wk from three major blueberry processors and from several roadside stands and supermarkets. Processors' berries were taken from boxes received from the field within the previous day. Half of each cooled sample was rinsed for 2 min in 0.5% sodium hypochlorite with swirling. Surface-disinfested and nondisinfested subsamples of 216 berries each were placed in moist chambers (cake pans with plastic lids containing wet paper towels) on 0.6-cm mesh wire screens and incubated at room temperature for 3 wk. Infected fruit were removed two times per week, and filamentous fungi growing from them were identified. In 1989, six samples of highbush blueberry fruit from three New Jersey growers were obtained in local markets, and 300 berries per sample were incubated, without rinsing, as above. Infected berries were removed daily, identified, and recorded. This small survey was designed to recover highbush fruit with blossom-end rot, which could be compared to lowbush fruit infected with Gloeosporium minus Shear.

Effects of burning. In 1989, fruit samples were collected at two research field sites in eastern Maine. These sites (6) were designed as split plots with pruning treatment either by mowing or by burning. At site 1, 36 samples were taken from each of the two adjacent treatments. At site 2, 30 samples were taken from each treatment. One hundred berries per sample were placed without rinsing in moist chambers and incubated at room temperature for 3 wk. During this period, infected berries were recorded and removed two times each week. Data for Botrytis, Glomerella, Alternaria, and Gloeosporium were evaluated by regression analysis with site and pruning treatment as variables to determine if the incidence of each disease was affected by the method of pruning.

Identification of heat-tolerant fungi. Strains of heat-tolerant fungi were isolated from the 50 fruit samples obtained in 1988 and from additional berry samples. The times and temperatures selected were similar to those used during canning. After being frozen at -20 C for 6 mo, 25-g samples were thawed in sterile 50-ml centrifuge tubes to which 25 ml of hot (80 C) sterile water was added. These were placed in an 82-83 C water bath and incubated for 20 min after the samples had come to 81 C (approximately 30 min total). The tubes were inspected for fungal growth over a 1-mo period, and fungi that survived the heat treatment were isolated. In addition, isolates of Penicillium spp. that formed sclerotia or ascospores were saved from the fresh fruit survey.

RESULTS AND DISCUSSION
Fruit survey. The frequencies of major fruit-inhabiting fungi in 1988 are listed in Table 1. Surface disinfestation had no consistent effect on frequency of isolations, and therefore results for disinfested and nondisinfested berries were combined. Incidence of fruit-infecting fungi in samples of lowbush blueberry fruit in 1988 was highest for Botrytis cinerea Pers.:Fr., Glomerella cingulata Spauld. & Schrenk, G. minus, and Alternaria spp. Botrytis causes a blossom blight as well as a fruit rot (3,9,11). Glomerella cingulata (= Colletotrichum gloeosporioides) causes anthracnose or ripe rot, affecting primarily blossoms and ripe fruit (14). G. minus is the major leaf spot fungus of highbush blueberries in the Southeast (7,9,15). Alternaria is considered the most serious of highbush blueberry pathogens (8,9,11).

The relative frequency of these fungi was similar to that reported in a three-state survey of highbush fruit (2), in which incidences were Botrytis 3.2%, Glomerella 2.6%, and Alternaria 2.0%. Gloeosporium (2.5% incidence in our survey) was not reported in the highbush survey, but blossom-end rot was reported in North Carolina (2.8%), New Jersey (0.5%), and Michigan (0.8%). This anomaly and the high incidence of blossom-end rot in North Carolina (where Gloeosporium predominates)
suggests that the causal organism of this rot is actually Gloeosporium. Our subsequent (1989) sampling of highbush fruit from New Jersey detected a 3.3% incidence of G. minus, with three of six samples affected. In contrast to Glomerella, Gloeosporium acervuli were centered around the calyx (blossom end), fitting the common disease name. The size of spores recovered directly from the New Jersey fruit (5–6 × 9–11 μm) was similar but not identical to that previously reported for G. minus (3–4 × 9 μm) (7,9) and to that produced by low-bush fruit fung (3–4 × 7–10 μm). The colony color and morphology of cultures from lowbush and highbush fruit were similar. No other unidentified acervular fungi were found in the New Jersey samples, strongly implying that blossom-end rot is the fruit symptom of G. minus. When spores from a lowbush isolate were used to inoculate the highbush cultivar Jersey, typical symptoms were obtained. Damaged leaves developed large lesions with adjoining vascular discoloration, nondamaged leaves became crinkled with red flecks, and cankers with acervulus developed around fresh leaf scars. G. minus has not been previously reported on lowbush blueberry. It has been reported on fruit of highbush blueberry (7) and cranberry (V. macrocarpon Aiton) (4).

In addition to the major fruit-rotting fungi listed above, Penicilium (at least six species), Mucoa, Aspergillus, and several unidentified fungi were obtained less frequently in the 1988 survey.

**Effects of burning.** The relative incidence of major fruit-inhabiting fungi in fields pruned by mowing or by burning is given in Table 2. Isolations of Glomerella and Alternaria were significantly but not substantially higher in the mowed plots, implying that periodic burning reduces inoculum levels of these organisms. This is, presumably, a residual effect from the year prior to fruit production, since both treatments accumulate inoculum in dead leaves and winter-killed stems between the vegetative and fruit-bearing seasons. At site 1, where the pruning treatment had been maintained for 12 yr, mummy berry disease (M. vaccinii-corymbosi) was 90-fold higher in the mowed treatment than in the burned treatment (6). At site 2 (trials maintained for 4 yr), the treatment differential for the disease was only sixfold. This compounding of disease with time was not evident for Glomerella and Alternaria. Isolations of Botrytis were somewhat more frequent in mowed treatments, but the difference was not statistically significant. Gloeosporium was recovered only twice at site 1. At site 2, nearly all isolates were from the burned treatment. Although the fungus was widely distributed in this treatment (12 of 30 samples), lack of a rational explanation and of confirming data from site 1 advise caution in interpretation of the results.

**Heat-tolerant strains.** Eupenicillium lapidosum Stolk & Scott, or a closely related species, was recovered from several samples of heat-treated berries and was also the most common ana-

<table>
<thead>
<tr>
<th>Species</th>
<th>Average incidence (%)</th>
<th>0%</th>
<th>&lt;1%</th>
<th>1–5%</th>
<th>5–10%</th>
<th>&gt;10%</th>
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<tr>
<td>Botrytis cinerea</td>
<td>3.7</td>
<td>2</td>
<td>15</td>
<td>19</td>
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<td>2</td>
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<td>Glomerella cingulata</td>
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<td>11</td>
<td>7</td>
<td>21</td>
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<td>4</td>
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<td>Gloeosporium minus</td>
<td>2.5</td>
<td>9</td>
<td>11</td>
<td>21</td>
<td>9</td>
<td>0</td>
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<td>Alternaria spp.</td>
<td>1.0</td>
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<td>26</td>
<td>17</td>
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<td>Penicillium spp.</td>
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<td>18</td>
<td>4</td>
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<td>1</td>
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<td>Trichoderma spp.</td>
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<td>39</td>
<td>10</td>
<td>1</td>
<td>0</td>
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</tr>
</tbody>
</table>

*Table 1. Percent incidence of fruit-infecting fungi in 50 samples of Maine lowbush blueberry fruit in 1988*

*Fruit were incubated on 0.6-cm grid mesh in moist chambers (enclosed cake pans) at room temperature for 3 wk; infected fruit were removed and recorded biweekly. Values are the means of 50 samples of 432 berries.*

<table>
<thead>
<tr>
<th>Species</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Treatment significancea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botrytis cinerea</td>
<td>3.9 (Mowed)</td>
<td>3.1 (Burned)</td>
<td>5.5 (Mowed)</td>
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<tr>
<td>Glomerella cingulata</td>
<td>5.1 (Mowed)</td>
<td>2.9 (Burned)</td>
<td>13.3 (Mowed)</td>
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<tr>
<td>Alternaria spp.</td>
<td>1.5 (Mowed)</td>
<td>0.9 (Burned)</td>
<td>1.2 (Mowed)</td>
</tr>
<tr>
<td>Gloeosporium minus</td>
<td>0.0 (Mowed)</td>
<td>0.1 (Burned)</td>
<td>0.1 (Mowed)</td>
</tr>
</tbody>
</table>

*Table 2. Percent incidence of major fungi infecting Maine lowbush blueberry fruit at two sites in 1989 as affected by pruning treatment (mowing vs. burning)*

*Non-disinfected fruit were incubated on 0.6-cm grid mesh in moist chambers (enclosed cake pans) at room temperature for 2 wk; infected fruit were removed and recorded biweekly. Values are the means of 36 samples of 100 berries from site 1 and 30 samples of 100 berries from site 2.*

*LITERATURE CITED*