Colletotrichum acutatum Found on Apple Buds in Norway

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Bitter rot causes important pre- or postharvest losses in apple (Malus × domestica) worldwide. Preharvest loss is important for example in the southeastern USA (14), New Zealand (7), and Brazil (5), while postharvest loss has been reported from e.g., Sweden (10) and Norway (3). In Norway, only Colletotrichum acutatum Simmonds ex. Simmonds is found on apple (classified by PCR) (13), while in USA and Brazil both C. acutatum and C. gloeosporioides (Penz.) Penz. & Sacc. in Penz, and its teleomorph Glomerella cingulata (Stoneham.) Schrenk & Spaulding, cause bitter rot on apple fruits (5,8). In Norway, visible symptoms of bitter rot in apple orchards occur occasionally prior to or at harvest; however, the disease normally develops following cold storage. Symptoms in cold storage can be diverse (Fig. 1), and are not easily distinguished from bulls eye rot (caused by Pezicula malicorticis, anamorph Cryptosporiopsis curvispora) and lenticell rot (caused by Pezicula alba, anamorph Phlyctaena vagabunda). All three diseases cause brown, circular, sunken lesions that develop during storage. Conidia of C. acutatum are often formed in orange masses, as opposed to the whitish to creamy sporulation of the other two fungi.

Possible inoculum sources for C. gloeosporioides and G. cingulata are cankers (G. cingulata only), mummified fruits, old fruit stems, and mycelium, perithecia, or acervuli on dead wood (2,12,14). Sources of inoculum for C. acutatum in apple have not been studied in detail (11). In Brazil, both C. acutatum and C. gloeosporioides were found on apple buds during the winter (1,5). C. acutatum was also found on apple buds in New Zealand, but at a lower level than on dormant twigs (7). In Sweden, P. vagabunda was found on apple buds during the winter and they were suggested as a possible inoculum source during the spring (10).
Old fruit spurs (spurs that had borne fruit for one year or more) or young fruit spurs (developed during the previous season, which had not borne fruit before) with one to three generative buds were collected from five apple cultivars in 11 orchards (two experimental and nine commercial orchards located in Ullensvang and Kvam, in the Hardanger region, in southwestern Norway) (Table 1) prior to bud break. The buds were incubated in saturated air at 20°C for 2 to 3 weeks. Some vegetative shoots also were collected, cut in pieces (each containing one bud), and incubated as the generative buds. After incubation, the buds were assessed for sporulation of *C. acutatum* with a stereo magnifier. The fungus sporulated in orange horn-like structures on bud scales (Fig. 2) and in one case also on the wood below an infected bud (Fig. 3).
Table 1. Number of generative apple buds infected with *Colletotrichum acutatum* from different orchards in Ullensvang and Kvam (in the Hardanger region) in southwestern Norway.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cultivar</th>
<th>Orchard</th>
<th>Material</th>
<th>Buds with <em>C. acutatum</em></th>
<th>Total no. of buds assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Aroma</td>
<td>Løeflaten</td>
<td>old spurs</td>
<td>1</td>
<td>76</td>
</tr>
<tr>
<td>2005</td>
<td>Aroma</td>
<td>Fykse 1</td>
<td>old spurs</td>
<td>2</td>
<td>45</td>
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<td></td>
<td>Aroma</td>
<td>Steinstø</td>
<td>old spurs</td>
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<td>41</td>
</tr>
<tr>
<td></td>
<td>Aroma</td>
<td>Fykse 2</td>
<td>old spurs</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Aroma</td>
<td>Opedal</td>
<td>old spurs</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Elan</td>
<td>Munkagard</td>
<td>young spurs</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Elstar</td>
<td>Opedal</td>
<td>young spurs</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Daytona</td>
<td>Munkagard</td>
<td>young spurs</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>2006</td>
<td>Aroma, red mutant</td>
<td>Munkagard</td>
<td>old spurs</td>
<td>1</td>
<td>22</td>
</tr>
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<td></td>
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<td>Munkagard</td>
<td>old spurs</td>
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<td>40</td>
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<td>old spurs</td>
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<td>old spurs</td>
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<td>30</td>
</tr>
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<td>Reiseter</td>
<td>old spurs</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td></td>
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<td>Munkagard</td>
<td>old spurs</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Sunrise</td>
<td>Munkagard</td>
<td>old spurs</td>
<td>0</td>
<td>76</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>9</strong></td>
<td><strong>689</strong></td>
</tr>
</tbody>
</table>

x Løeflaten and Munkagard were experimental orchards at Ullensvang Research Centre, while the others were commercial orchards.

y Old spurs had borne fruit in one or more years prior to sampling; young spurs were developed in the season prior to sampling and had not borne fruit.

Infections were found on buds from both experimental orchards (at Ullensvang) and in four of the commercial orchards. Two orchards in southeastern Norway were assessed in 2006, but the fungus was not found (data not shown). Sporulation were found on zero, one, and two generative buds in each sample (0 to 7%) on fruiting spurs (Table 1). In total 9 of 689 (1.3%) buds...
examined were infected. No sporulation was observed on the 230 vegetative buds assessed (data not shown). *C. acutatum* was found on buds from two (cvs. Aroma and Elan) of the five cultivars examined. Aroma is the main late ripening cultivar grown in Norway, and it is known to be highly susceptible to storage decay. The number of infected buds was much lower in apple than was found in sweet cherry in Norway, when investigated at a similar developmental stage (4). Apple buds have previously been reported as hosts for *C. acutatum* only in the southern hemisphere (1,5,7). Apple buds were examined for presence of *C. gloeosporioides* in Brazil by placing bud parts on agar plates, and 12 to 33% of the buds contained the fungus (1). The fungus was detected on both the outer bud scales and on the inner scales and floral parts, and the frequency of infections did not differ between outer and inner parts of the buds. In a more recent investigation in Brazil, apple buds contained *Colletotrichum* spp. (no clear distinction between *C. acutatum* and *C. gloeosporioides*) during the dormant period (5). The lower frequency of infected buds found in Norway vs. Brazil may be explained by differences in methods of detection. We incubated the buds in moist air and did not attempt to isolate the fungus on an artificial growth medium.

Even if the number of infected buds seemed low in these investigations, they may be a potential inoculum source in spring as was found for blueberry (6,15) and sweet cherry (4). Further investigations are needed in order to determine when fruit infections occur and whether or not *C. acutatum* is present asymptomatically on flowers and leaves during the growing season such as in strawberry and citrus (9,16).

**Literature Cited**


