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Biology and integrated control of internal fruit rot of sweet pepper in Alberta greenhouses

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Background:
Greenhouse sweet pepper (*Capsicum annuum* L.) is a high cash value greenhouse vegetable crop in Canada. Several fungal diseases have caused economic losses in sweet pepper production in Canadian greenhouses. Fusarium disease on the stem- and fruit rot of pepper caused by Fusarium solani (Mart.) Sacc. (Howard et al. 1994) was reported from Ontario, and British Columbia (B.C.) in 1991. During the 2003 growing season, an unusual fruit rot of sweet pepper was observed in a commercial greenhouse in central Alberta, Canada. The mature fruit was infected internally by a fungus. Seeds and the inner surface of the fruit wall were covered with white mycelia. Greenish to dark brown lesions formed on the outer surface of some fruits. Unless severely infected, rotted fruits could be seen, most infected fruits were difficult to cull before delivery to market because external symptoms were not readily visible. Growers tried to screen the fruit based on external observations, but were not successful and a significant amount of fruit had to be destroyed. Consequently, marketable yields were reduced from 24 kg/m^2 to approximately 20 kg/m2, causing a loss of around \$20/m^2.
Following the initial observation of internal fruit rot in 2003, this disease became a major problem of sweet pepper in 2004, and its incidence increased annually thereafter in Alberta greenhouses. Information on the causal agent(s), etiology, infection process, disease development, and control of this disease are not available. Research was conducted to identify the causal agent(s), and to develop an efficient disease management strategy from 2004 to 2006, and to investigate the etiology, epidemiology and mycotoxin production of the *Fusarium* on sweet pepper from 2006 to 2008.

Objective:
The objectives of this study were to understand the etiology of the primary causal agent of internal fruit rot of greenhouse sweet pepper, to identify the pathogen, to determine the infection process, mycotoxin productions, interactions among host, pathogen and environmental factors, and to develop a disease control method.

What we did:
Four major activities were accomplished: molecular identification of Fusarium isolates by using DNA sequencing techniques, mycotoxin detection by using high-performance liquid chromatography (HPLC) method, an infection process study by using light, fluorescence, and scanning electron microscopy, and an epidemiology study by spore trapping in the greenhouse. Disease control methods has been evaluated and recommended.

Key results:
1. We confirmed that Fusarium species causing internal rot of sweet pepper belonged to *F. lactis* (Pirotta & Riboni) Nirenberg & O'Donnell by using analysis of partial translation elongation factor 1-α, mitochondrial small subunit ribosomal DNA, and β-tubulin gene sequences.

2. Production of mycotoxins by Fusarium isolates from pepper was detected in the culture and in infected pepper fruit tissues using HPLC technique. *Fusarium lactis* produced moniliformin (0.2 – 181.9 ppm), beauvericin (13.3 – 1072.9 ppm) and trace amounts of fumonicin B1 (0 – 0.3 ppm).
3. The infection process was confirmed that Fusarium spores landed on the stigma and anther, and germinated to produce mycelium that colonized the surface of stigma and pollen grains. Infection hyphae penetrated into the stigma, grew intracellularly in through the style, and then invaded the ovary. Hyphae successfully reached the ovule and established further growth, development and sporulation, leading to internal fruit rot. Fusarium hyphae could penetrate into pepper seed coats and endosperms. Results provide evidence that infected pollen grains could spread the disease in a greenhouse and the infected seeds could be the means for long distance disease dispersal.
4. The monthly pattern of airborne Fusarium spores fitted a polynomial model. Fusarium spore populations in air in the greenhouse had a high peak in June-July in both 2006 and 2007. Disease control practice should be applied before or on this time to prevent and reduce the disease development.

Take home message for the industry:
The internal fruit rot of sweet pepper is caused by *Fusarium lactis* that starts the initial infection on flowers. The pathogen can produce mycotoxins in infected tissues that are harmful to human beings. The disease management should include seed treatment, using disease tolerant cultivars, thorough sanitation between and during each crop season, and applying biological and integrated control methods.

Value to the industry:
This project has reported a new Fusarium species that causes disease on sweet peppers for the first time. Information generated will help researchers to develop disease control strategies and provide knowledge to growers to clearly understand and effectively manage this disease.

Value to the team:
One graduate student (M. Sc.) was trained at the University of Alberta under this project funding.