Fusarium dry rot and seed-piece decay in Canada

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Fusarium spp. are important pathogens of potato that cause yield losses at planting and in storage following harvest. Spores of the fungus are found in all soils where potatoes are grown and can survive for many years. Seed potatoes infected with *Fusarium* can rot after planting (seed-piece decay) causing "misses" in the field. Even if plants grown from infected seed do emerge, they often have reduced vigour and yield. The fungus can spread from infected to healthy seed during the cutting and handling process. After harvest, *Fusarium* spp. cause a dry rot in storage which reduces crop quality.

Potatoes infected with *Fusarium* spp. develop a spreading external decay that usually becomes shrunken and wrinkled in appearance (Fig.1.). When diseased tubers are cut open, the brown decay can be seen spreading into the internal tissues of the tuber (Fig.2.). The internal decay is usually marked by open cavities which contain the white mycelium of the fungus. *Fusarium* spp. can only infect potatoes through wounds. Thus, infection can occur when inoculum is spread from diseased to healthy seed during seed cutting and handling. As well, inoculum in soil attached to the surface of tubers can infect potatoes through wounds made during harvest and handling operations prior to storage.

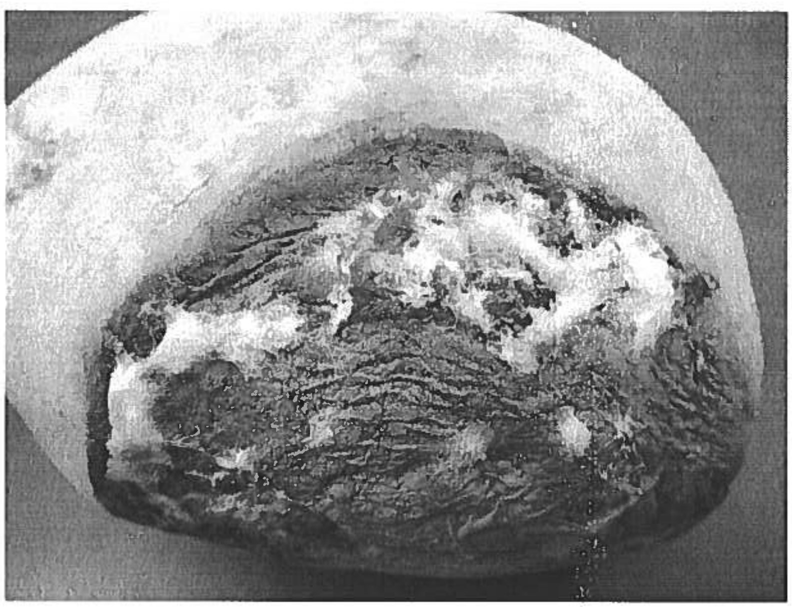


Figure 1. External symptoms of Fusarium dry rot.

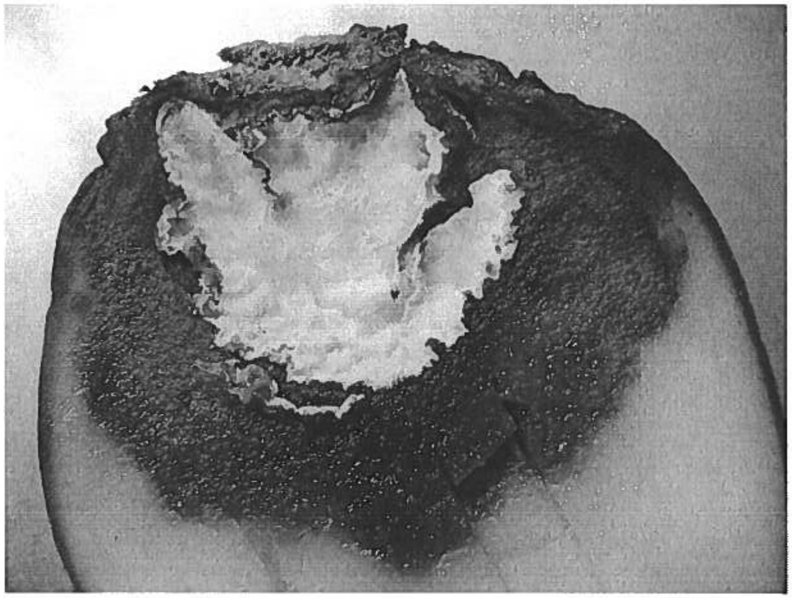


Figure 2. Internal symptoms of Fusarium dry rot showing cavities filled with white mycelium of the fungus within the tuber tissue.

Although spores of *Fusarium* spp. can be found in all soils where potatoes are grown, our research has shown that diseased seed is the most important source of inoculum to infect daughter tubers. High levels of seed infection does not always translate into high levels of dry rot in storage, because the amount of tuber wounding at harvest is normally the biggest factor determining post-harvest dry rot. However, high levels of seed infection can lead to significant seed-piece decay with resulting yield impacts.

***Fusarium* species causing dry rot and seed-piece decay**

Our research has shown that the predominant *Fusarium* species found on seed pieces provide inoculum for infection of daughter tubers and therefore, these species are also the predominant ones found in storage. Surveys from 2007-2010 in Canada indicate that three *Fusarium* spp. are the most common as causal agents of seed-piece decay and dry rot. Results from these surveys showed that *Fusarium sambucinum* is the most predominant pathogen, followed by *Fusarium coeruleum* and *Fusarium avenaceum*. Although mixed infections of several *Fusarium* spp. did commonly occur, one species was usually clearly predominant in a particular sample of tubers (either seed tubers or samples taken from storage). Some other *Fusarium* spp. that were pathogenic to tubers were also recovered in the surveys including *Fusarium acuminatum*, *Fusarium crookwellense*, *Fusarium sporotrichiodes, Fusarium oxysporum* and *Fusarium graminearum. Fusarium graminearum,* an important pathogen of wheat, was found for the first time in Canadian potatoes in several provinces in 2008. It is an aggressive pathogen of potato tubers, and we are continuing our monitoring to see if it becomes a more important potato pathogen in Canada, as it has in North Dakota, USA.

Potatoes are commonly grown in rotation with cereal and forage crops. To test the potential of these crops to harbour *Fusarium* spp. that are pathogenic to potato, a study was initiated where isolates of *Fusarium* spp. obtained from cereal and forage crops were inoculated into wounded potato tubers which were subsequently stored for 5 weeks to allow disease symptoms to develop. We found that some species of *Fusarium* from cereal and forage crops could indeed cause disease in potatoes. In particular, *Fusarium avenaceum* and *Fusarium oxysporum,* isolated from forage crops, and *Fusarium sporotrichiodes* and *Fusarium graminearum,* isolated from cereal crops, could cause disease in potato tubers. Thus, crops grown in rotation with potato may harbour *Fusarium* spp. that cause disease in potato tubers, although the importance of this inoculum source in a production system is unknown.

Resistance to control products

Isolates of the various *Fusarium* spp. collected during Canadian surveys have also been tested for their sensitivity to thiophanate-methyl (Senator ® PSPT) and fludioxonil (Maxim® PSP - common potato seed piece treatments) and thiabendazole (Mertect ® SC- a common post-harvest treatment). About 50-65% of the isolates of *Fusarium sambucinum*, the major dry rot pathogen, recovered in surveys across Canada in 2008 and 2009 were resistant to all products. By contrast, most other *Fusarium* spp. were sensitive to these products. Isolates of *Fusarium oxysporum* recovered in these surveys were always sensitive to thiabendazole and thiophanate-methyl, but resistant to fludioxonil. Therefore, species composition in a tuber lot plays a large role in determining how effective a chemical treatment will be. In Alberta, resistance to fludioxonil in various *Fusarium* spp. was more common than in other parts of the country. Results of chemical sensitivity testing for various species of *Fusarium* isolated from potato seed pieces in Alberta in 2009 can be found in Table 1.

Table 1. Results of chemical sensitivity testing of isolates of various *Fusarium* spp. isolated from potato seed pieces from Alberta in 2009.*

		Fludioxonil (Maxim®PSP)		Thiabendazole (Mertect®SC)	
Species	No. of isolates	Sensitive	Resistant	Sensitive	Resistant
F. sambucinum	11	1	10	5	6
F. coeruleum	5	5	0	5	0
F. avenaceum	3	0	3	3	0
F. oxysporum	2	0	2	2	0
F. acuminatum	2	0	2	2	0

* Note: isolates resistant to thiabendazole (Mertect®SC) are also resistant to thiophanate-methyl (Senator®PSPT)

Potato seed treatment trials

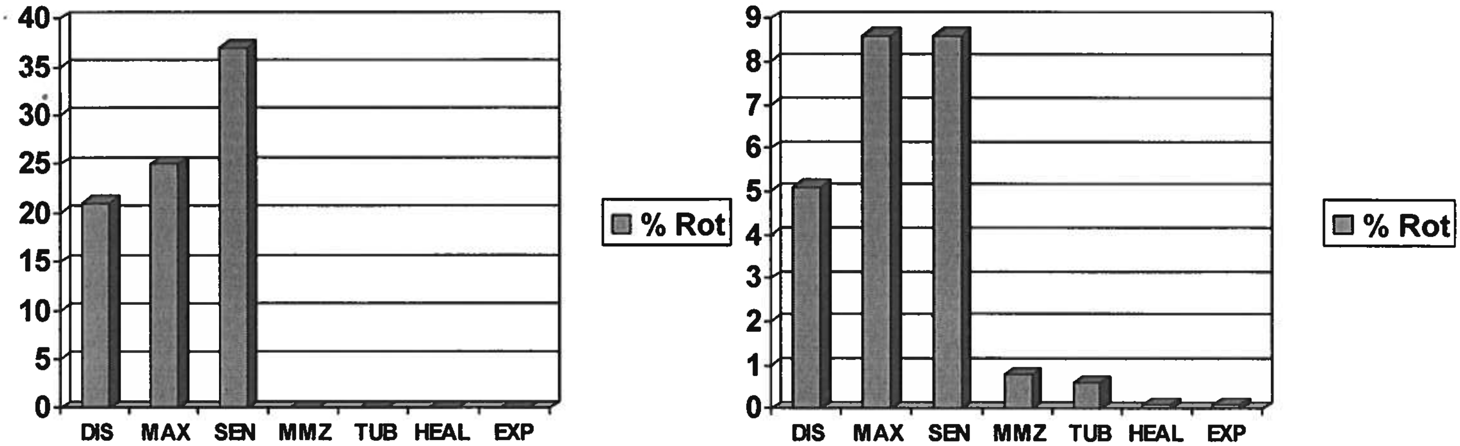
Field and storage studies were conducted in Prince Edward Island, Canada to ascertain the impact of fungicide-resistant strains on crop loss and to define potential management strategies. Potato seed-pieces were inoculated with a fungicide resistant strain of *F. sambucinum* and then treated with various seed treatments including:

1. Healthy control = not inoculated [HEAL]
2. Diseased control = inoculated but no seed treatment [DIS]
3. Senator (10% thiophanate-methyl) [SEN]
4. Maxim PSP (0.5% fludioxonil) [MAX]
5. Maxim MZ PSP (0.5% fludioxonil; 7% mancozeb) [MMZ]
6. Tuberseal (16% mancozeb) [TUB]
7. Difenoconazole [EXP=experimental product, not registered for potato seed treatment in Canada]

Seed pieces were then incubated at 10°C for 6 weeks after which they were rated for disease (Figure 3). In summary, inoculation of potato seed pieces with an isolate of *F. sambucinum* possessing multi-class fungicide resistance followed by application of thiophanate-methyl or fludioxonil as seed treatments, resulted in the complete loss of efficacy of both products. In all cases, treatment of potato seed pieces with mancozeb or difenoconazole completely controlled seed-piece decay caused by this isolate of *F. sambucinum* (Figure 4). We are also exploring the use of difenoconazole as a post-harvest treatment as potatoes enter storage to control Fusarium dry rot in storage.

A. **B.**

Figure 3. Inoculation of potato seed-pieces with fungicide resistant *F. sambucinum* followed by seed-piece treatment. **A.** good disease control **B.** poor disease control



A. B.

Figure 4. Percentage of rot in potato seed-pieces after inoculation with fungicide resistant *F. sambucinum* followed by application of various seed treatments. **A**=2008 trial; **B**=2009 trial

Disease management

Based on our research, knowing the predominant *Fusarium* spp. in a particular seedlot and their sensitivities to various chemical products would provide growers with important information to use to make disease management decisions. Thus, diagnostic testing of samples of tubers from seedlots could be a useful tool in the management of this important disease. Since fungicide resistance is a concern, alternating products from different chemical classes becomes an important strategy. In our trials, mancozeb used as a seed treatment was able to control fungicide resistant strains. Down the road, difenoconazole and other products may become available for seed treatment and post-harvest application.

Ultimately, the management of Fusarium dry rot and seed-piece decay depends upon an integrated approach that takes advantage of a number of control options and information generated by research studies. A summary of some of these control options would include:

At planting:

1. Use clean seed; store seed in a facility that has been properly disinfected
2. Warm seed tubers prior to cutting to promote rapid healing
3. Remove any diseased seed tubers prior to cutting
4. Disinfect seed cutting and handling equipment often and ensure that cutters are sharp to make a clean cut that heals quickly
5. Don't store cut seed for more than 10 days before planting
6. Determine the *Fusarium* spp. present by having seed tested by a diagnostic clinic if available
7. Use a registered fungicide seed treatment and access any available local information on pesticide resistance; rotate products of different chemical classes; mancozeb has been shown to control fungicide resistant strains; new seed treatment products are in development

8. Plant when soil and temperature conditions promote rapid sprout growth and emergence

At harvest and in storage:

1. Reduce tuber injury during harvest and handling operations
2. Provide conditions for rapid wound healing early in storage, then drop temperatures
3. Monitor storage conditions
4. Post-harvest treatments with thiabendazole will control most *Fusarium* spp., but not thiabendazole-resistant *Fusarium sambucinum*, therefore, access any available local information on pesticide resistance
5. New post-harvest treatments to manage dry rot in storage are in development and should be available in the next few years

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