Influence of Pesticides on Pathogen Populations and Biological Control Agents

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Root and crown rots are important and widespread cereal diseases present in most parts of the world, including the Canadian Prairies. In Saskatchewan, the main root and crown rot pathogens in wheat, barley, and oat are *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dast. [anamorph *Bipolaris sorokiniana* (Sacc.) Shoemaker] and *Fusarium* spp. (Bailey et al., 2000; 2001; Fernandez and Holzgang, 2009; Fernandez and Jefferson, 2004; Fernandez et al., 2009).

Among *Fusarium* spp. associated with root and crown rot, *F. culmorum* (Wm. G. Sm.) Sacc. and *F. pseudograminearum* O'Donnell & T. Aoki were reported as the most pathogenic and most common causal agents of crown rot of barley and common and durum wheat in the eastern Australian grain belt (Backhouse et al., 2004). In Saskatchewan, in the mid- to late-1980s, *Fusarium* isolates from the subcrown internodes of wheat sampled in different locations in the province were identified as *F. culmorum* (Tinline and Spurr, 1991). *Fusarium avenaceum* (Fr.:Fr.) Sacc. (teleomorph *Gibberella avenacea* Cook) was commonly isolated from crowns and roots of winter wheat in Manitoba, but rarely from spring wheat in 1985-1986 (Sturz and Bernier, 1991). However, *F. avenaceum* was one of the most common and widespread *Fusarium* spp. in discoloured subcrown internodes and/or crowns of durum and common wheat, barley, and oat crops throughout Saskatchewan in 1998-99 (Fernandez and Holzgang, 2009; Fernandez and Jefferson, 2004; Fernandez et al., 2009), and in subcrown internodes of common wheat in southwestern Saskatchewan in the early 2000's (Fernandez and Zentner, 2005). In greenhouse trials, *F. avenaceum* caused as much crown rot in winter wheat as *F. culmorum* or *F. pseudograminearum* (Smiley et al., 2005).

Many of the *Fusarium* spp. isolated from discoloured subcrown internodes and crowns of cereal crops have also been associated with Fusarium head blight (FHB) in eastern Saskatchewan, which is the area of the province where the latter disease has been present at highest levels (Fernandez et al., 2005, 2007c). *Fusarium avenaceum* has been the most, or one of the most, commonly isolated pathogens from blighted heads in Saskatchewan, an area where FHB severity has been overall lower than in the eastern Prairies. Colonization by *Fusarium* pathogens of underground- and ground-level plant tissue, and their subsequent survival and multiplication in those tissues after harvest, might play a role in the future development of important cereal diseases such as FHB and contribute to its westward expansion.

Recent studies have shown that colonization of subcrown internodes and crop residues by *Fusarium* species and *C. sativus* were affected by pesticide use. Previous glyphosate applications were associated with lower *C. sativus* and higher *Fusarium* spp. levels in subcrown internodes of barley grown under minimum-till management, while associations of fungal isolations with previous glyphosate use in wheat subcrown internodes were negative for *C. sativus* and positive for *F. avenaceum,* with these effects varying with tillage system (Fernandez et al., 2007a, b). In general, *C. sativus* was isolated from moderately severe or severe lesions more frequently with the saprophyte/weak pathogen *F. equiseti* (Corda) Sacc. than with most of the other fungi.

In addition, a parallel study on fungal communities on crop residues was conducted in 2000-01 in eastern Saskatchewan to determine how populations of *Fusarium* and other fungal species on crop residues might be affected by agronomic practices (Fernandez et al., 2008). Under zero-till, previous glyphosate applications were correlated positively with *F. avenaceum* and negatively with *F. equiseti* and *C. sativus*. These observations generally agreed with results from the above-mentioned previous FHB and root rot studies of wheat and barley in the same region.

Results from a recent input level and cropping diversity study conducted in west-central Saskatchewan (Fernandez et al., 2011) also indicated a differential effect of input system on the most common *Fusarium* spp. The pathogens *F. avenaceum* and *F. culmorum* were most associated with the non-organic input systems, especially under reduced tillage, whereas the saprophyte/weak pathogen *F. equiseti* was favored by organic management. The low frequencies of *F. avenaceum* and *F. culmorum* in the organic input system agree with reports from research conducted in Europe. Conversion to organic systems was shown to affect the relative prevalence of *Fusarium* spp. in roots and crowns of wheat in European studies (Elmholt, 1996; Hannukkala and Tapio, 1990; Knudsen et al., 1995). Hannukkala and Tapio (1990) detected less foot rot in winter wheat caused by *F. avenaceum* and *F. culmorum* in organic than non-organic systems. Elmholt (1996) reported less frequent isolation of *F. culmorum* from the soil of organic farms that had been under organic management the longest. Lower FHB levels and concentrations of the mycotoxin DON in winter wheat were also observed in organic than in non-organic systems (Meister, 2009). The results from the study in west-central Saskatchewan also agree with results by Elmholt (1996) who reported a more frequent isolation of *F. equiseti* from soil of organic farms that had been under organic management the longest. Knudsen et al. (1995) also reported that the density of non-pathogenic *Fusarium* spp. (including *F. equiseti*) in soil and straw was higher in an established organic farm than in a neighboring non-organic farm, suggesting that pathogenic isolates may be suppressed by antagonistic isolates to a greater extent in the organic fields.

Observations by Fernandez et al. (2011) also showed that *C. sativus* infections of subcrown internodes and crowns occurred at the highest levels under intensive tillage, including organically-managed treatments. In European studies, infection of stem bases and roots of barley and winter wheat by *C. sativus* was also greater in organic than in non-organic cropping systems (Baturo, 2007; Hannukkala and Tapio, 1990).

Other studies have demonstrated the antagonistic potential of *F. equiseti*. Fernandez and Vujanovic (unpublished) showed that isolates of *F. equiseti* had the ability of significantly suppressing the growth of *F. avenaceum* on durum wheat straw. Luongo et al. (2005) reported

that *F. equiseti* showed strong antagonism against pathogenic *Fusarium* spp., including *F. graminearum* Schwabe [teleomorph *G. zeae* (Schwein.) Petch] and *F. culmorum*, when tested on wheat straw under controlled conditions. Similarly, Dawson et al. (2004) reported that of all the organisms tested, *F. equiseti* was overall the best competitor of *F. culmorum* and *F. graminearum* on winter wheat spikes.

Further studies to identify the mechanism(s) involved in the suppression of *Fusarium* pathogens and increase in saprophytic *Fusaria* in conventional crop production systems that do not rely on the use of glyphosate, and in organic management systems, are warranted. Exploring interactions among cereal pathogens and saprophytes on roots and crowns might explain how these practices result in differences in fungal populations. A better understanding of fungal interactions in underground/ground level cereal tissue could be exploited for the biocontrol of important diseases caused by *Fusarium* spp. in cereal crops.

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