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Identification and pathogenicity of *Fusarium* spp. in row crops in Nebraska

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ABSTRACT

Fusarium spp. comprise multiple pathogenic fungi that cause root rot in row crops, including corn, soybean, and wheat, and have wide geographic and host ranges. Studies to identify which *Fusarium* spp. are the prevalent disease-causing pathogens in a given region are important for developing disease management strategies. This study aimed i) to isolate, identify, and determine the intraspecific diversity of *Fusarium* spp. associated with root rot in corn, soybean, and wheat crops in Nebraska and ii) to determine the cross-pathogenicity of recovered isolates among these crops. In 2015 and 2016, 137 isolates were obtained from 20 counties in Nebraska and 62 of which represented all morphological groups were selected and identified by sequencing of the internal transcribed spacer regions of rDNA and the beta tubulin. The pathogenicity of 28 isolates in corn, soybean, and wheat crops was evaluated. Among the 11 phylogenetically distinct species identified, *F. oxysporum* was the most abundant, followed by *F. graminearum* and *F. acuminatum*, and these species are found in all geographic regions of Nebraska. However, *F. graminearum* was considered to be the most virulent species because five of the eight most virulent strains that demonstrated cross-pathogenicity among the three crops were *F. graminearum* strains. Other identified species were *F. solani*, *F. equiseti*, *F. redolens*, *F. fujikuroi*, *F. avenaceum*, *F. culmorum*, *F. verticillioides*, and *F. sporotrichioides*.

1. Introduction

Fusarium is a genus in the Ascomycota division of fungi and is one of the most important soil-borne pathogens that causes root rot in row crops, particularly corn, soybean, and wheat crops. *Fusarium* spp. have wide geographic and host ranges (Al-Sadi et al., 2014; Rahman and Punja, 2005; Stefańczyk et al., 2016). Several species of *Fusarium* are usually present on a single plant (Liu et al., 2012; Warren and Kommedahl, 1973), suggesting that a *Fusarium* spp. complex causes root rot. Some species may be saprophytes, which hampers disease diagnosis (Broders et al., 2007). In addition, it is difficult to analyze the impact of *Fusarium* root rot on yield because it frequently occurs in combination with other diseases. The knowledge of the disease-causing pathogenic species prevalent in a region is important for developing effective management strategies.

The frequency of isolating different *Fusarium* spp. from plants with root rot varies based on the host crop, time of sample collection during the growing season, environmental conditions during a survey, and geographic locations (Dufault et al., 2006; Leslie et al., 1990). *Fusarium* spp. that are frequently isolated from corn and soybean include *F. graminearum*, *F. oxysporum*, *F. solani*, *F. verticilliodes*, *F. equiseti*, *F. fujikuroi*, and *F. culmorum*. *Fusarium graminearum* has been identified as a disease-causing species in corn, soybean, and wheat crops in several regions in the United States (Broders et al., 2007; Carter et al., 2002; Jones, 1999; Diaz Arias et al., 2013). The most common species that cause root rot in wheat are *F. culmorum*, *F. equiseti*, *F. oxysporum*, *F. acuminatum*, *F. avenaceum*, and *F. graminearum* (Bailey et al., 1995; Fernandez and Jefferson, 2004; McFadden-Smith, 2001; Smiley and Patterson, 1996). *Fusarium oxysporum* and *F. solani* was reported to be predominant in root rot in wheat and corn in Canada and Minnesota (Ellis et al., 2014; Warren and Kommedahl, 1973).

Nebraska is a leading state in the production of row crops in the United States and ranks third in corn production, fourth in soybean production, and eighth in wheat production nationwide. In Nebraska, *Fusarium* root rot is a serious disease, similar to that in other corn-, soybean-, and wheat-growing regions of the United States (Leslie et al., 1990; Wrather and Koenning, 2006). Nebraska exhibits conditions that favor root rot development, which include cool temperatures of 14°C–23 °C and soil saturation during the time of planting, followed by hot and dry weather conditions during later growth (Farias and Griffin, 1990; Ellis et al., 2014). In Nebraska, the disease occurs every year and is known to reduce the yields of these three row crops. However, there is limited information on the diversity of *Fusarium* spp. that cause root rot in these crops and on the species abundance and geographical distribution. This information is important to design management strategies, especially in rotation planning. Corn–soybean or

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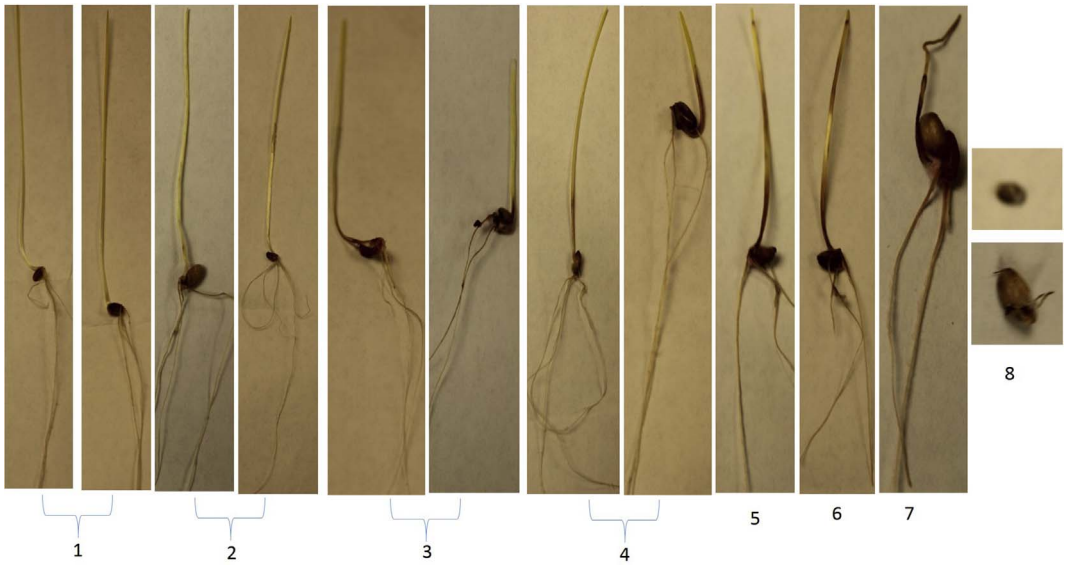

Fig. 1. An 8-point disease assessment scale.

Table 1
Fusarium isolates recovered from corn, soybean, and wheat crops in Nebraska in 2015 and 2016.

Species	Number of Isolates			Total
	Corn	Soybean	Wheat	
F. oxysporum	17	14	6	37
F. graminearum	15	12	7	34
F. acuminatum	5	9	12	26
F. solani	8	7	1	16
F. equiseti	9	3	3	15
F. redolens	5	0	0	5
F. sporotrichioides	0	1	0	1
F. avenaceum	0	0	1	1
F. culmorum	1	0	0	1
F. fujikuroi	0	0	1	1
F. verticillioides	0	1	0	1

corn–soybean–wheat rotations are common in Nebraska, and the effectiveness of a rotation may be impacted by the disease, especially because residues are left in some fields as part of the cultural practices and may serve as a source of inoculum for subsequent crops.

Symptoms of *Fusarium* root rot include chlorosis and necrosis of cotyledons, water-soaked lesions on the crown and lower stem, stunting, pre- and post-emergence damping off, wilting and brown-to-black rot in the lower taproot and lateral roots with decay in the cortical region, and discoloration (Backmand et al., 1993). When corn, soybean, or wheat crops are infected, patches of seedlings that have failed to emerge or that have died after emergence are commonly observed. In recent years, such disease symptoms have been frequently observed in Nebraska, with favorable conditions present earlier in the season. This study aimed i) to isolate, identify, and determine the intraspecific diversity of *Fusarium* spp. associated with root rot in corn, soybean, and wheat crops in Nebraska and ii) to determine cross-pathogenicity of recovered isolates among these crops.

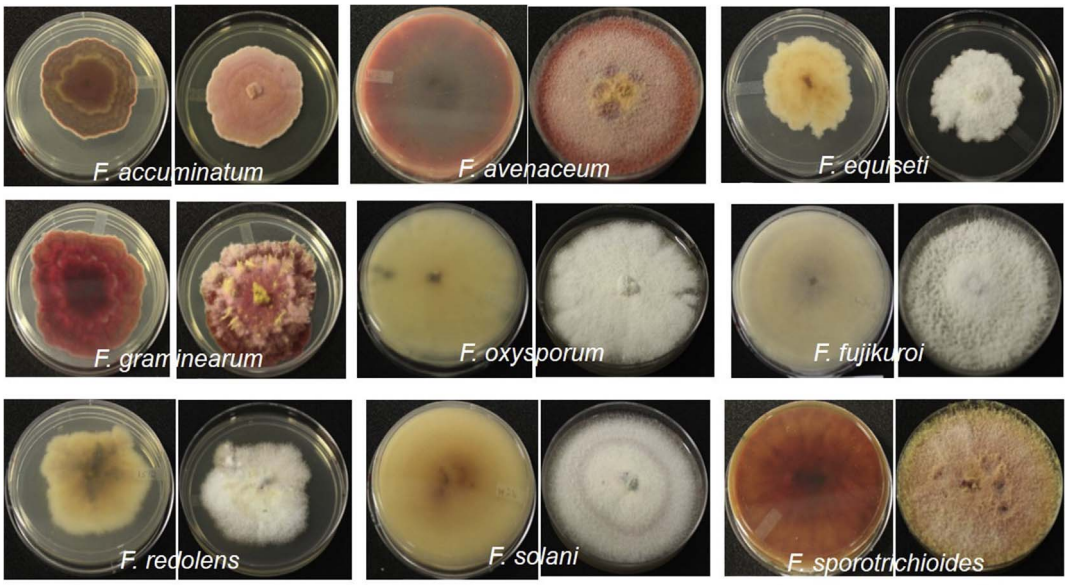

Fig. 2. Back and front pictures of representative isolates of 10 *Fusarium* species cultured on potato dextrose agar amended with tetracycline. They included *F. acuminatum*, *F. avenaceum*, *F. culmorum*, *F. equiseti*, *F. graminearum*, *F. oxysporum*, *F. fujikuroi*, *F. redolens*, *F. solani*, and *F. sporotrichioides*.