Endophytic Root Colonization by *Fusarium* Species: Histology, Plant Interactions, and Toxicity

Charles W. Bacon, Ida E. Yates

8.1 Introduction

*Fusarium* species have adapted to a wide range of geographical sites, climatic conditions, ecological habitats, and host plants, and species of this polyphyletic genus have been documented to occur worldwide (Backhouse et al. 2001). In spite of the information available on the extremes in geographic distribution and climatic conditions, appropriate data to predict the center of origin(s) or the mode(s) of dispersion of this genus have not been obtained. Much of the information on distribution patterns has been determined from analyses of soil samples, a common habitat, in addition to colonization of many plant species. The diversity of plant species colonized by members of the genus *Fusarium* is amazing. A recent literature survey determined that *Fusarium* species have been isolated from plants belonging to the gymnosperms and the monocotyledonous and dicotyledonous angiosperms (Kuldau and Yates 2000). They are the primary incitants of root, stem, and ear rots in many agriculturally important crops. For example, *F. verticillioides* (= *F. moniliforme*) is capable of colonizing well over 1,000 plant species, including maize (*Zea mays* L.), one of the world’s most important food crops. Another species, *F. oxysporum*, is cosmopolitan; certain strains are usually host specific and pose a severe threat to most of the world’s supply of food crops. Furthermore, species such as *F. graminearum*, along with *F. verticillioides* and related species within the *Liseola* section, are notorious for the production of mycotoxins on wheat, maize, barley, rice and other cereal grains and foodstuffs (Marasas et al. 1984). Consequently, studies on the association of *Fusarium* species with plants are critical in order to develop control measures for this group of fungi that affects the quality and quantity of the world’s food supply.
The discussion of *Fusarium* root endophytes in this chapter is based on, and will be discussed relative to, our knowledge of fungal endophytes of grasses. Noted examples of fungal endophytes include the species of the Balansieae that show various degrees of tissue specificity and often display evidence of infection by the production of sporulation structures on the adaxial or abaxial leaf surface of grasses (Diehl 1950), as well as the production of characteristic toxic secondary metabolites (Bacon et al. 1986). For example, fungi of the genus *Neotyphodium* (teleomorph = *Epichloë*) are found only in the stems, leaves and seed of grasses but are not found in roots, while species of *Myriogenospora* are restricted to the leaves, and species of *Balansia* are restricted to stems or leaves, but all produce ergot alkaloids.

Some research suggests that there are similar positive interactions of endophytic *Fusarium* species with plants (Damicone and Manning 1982; Hallmann and Sikora 1994a, 1994b; Blok and Bollen 1995). We use the definition of fungal endophytes as indicated by Stone et al. (2000) to include those *Fusarium* species that are associated with roots as intercellular, symptomless fungi (Fig. 8.1a–e), although the endophytic association may extend to above ground plant parts and there may be a differential expression of infection with different host tissue types (Bergman and Bakker-Van der Voort 1979; Fisher et al. 1992; Foley 1962; Yates and Jaworski 2000). In addition to grass endophytes, specific attention will be directed to our past and present toxicological, physiological, and morphological studies on *Fusarium verticillioides* [synonym *F. moniliforme*, teleomorph *Gibberella fujikuroi* (Sawada) Ito in Ito & K. Kimura] and its association with maize. Thus, species of *Fusarium* endophytes include those fungi that occupy the intercellular spaces of plants, and the intercellular infections may be localized to roots. However, localization to roots is not mutually exclusive as some *Fusarium* species, while living as root endophytes, may also infect above ground plant organs, although the foliage origin of such hyphae from the endophytic infections in the roots has not been established for all species. Indeed, secondary infections from aerial spores are suspected of contributing to most foliage infection (Adams 1921; Boshoff et al. 1996; Kang and Buchenauer 2000) and, as discussed below, there is the possibility of different specific fungal strains that infect specific tissue types, especially the flower infections.

### 8.2 Plant and Fungus Interactions

Contrary to the association found in *Neotyphodium* grass species, *Fusarium* species are not necessarily obligate endophytes. Indeed, as presented