Breeding turfgrasses with *Epichloë* endophytes for abiotic and biotic stress tolerance

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Breeding objectives for turfgrass species include continued improvement of aesthetics and persistence while minimising inputs such as water, fertilizers, and fungicides. In order to achieve the objectives, breeders must evaluate large amounts of germplasm for multiple traits in multiple environments to develop resilient grasses suitable for sport, lawn, and landscape uses. Fungal endophytes of the genus *Epichloë* develop a mutualistic relationship with many turfgrass species, including ryegrass (*Lolium* spp.) and fescues (*Festuca* spp.), imparting a high tolerance to biotic and abiotic stresses. The development of improved turfgrasses with endophyte is of great value to reduce maintenance costs and conserve resources. It has been reported that red thread disease (caused by the pathogen *Laetisaria fuciformis*) and dollar spot disease (caused by *Sclerotinia homoeocarpa*) can be suppressed in fine fescues that are infected with endophytes. Grasses colonised by *Epichloë* endophytes have shown high tolerance to foliar feeding insects such as billbugs (*Sphenophorus* spp.). Several studies have also demonstrated that endophytes confer protection to perennial ryegrass and tall fescue from water stress by increasing the availability of primary metabolites, e.g. concentrations of glucose and fructose. Breeders can use established immunological tests to determine if *Epichloë* endophytes are present in plant seed, but there is no guarantee that the endophyte is viable. To determine viability, the same immunological tests (commonly known as growouts) can be performed on grass seedlings to determine viable endophyte infection frequencies across grass populations. To deliver grass cultivars with high (>70%) endophyte infection frequencies, these cultivars must be developed with endophyte infection frequencies near 100%. Many grass breeders in the United States maintain high endophyte frequencies in the live plant material to ensure the mutualistic relationship between the plant genotype and endophyte genotype is maintained throughout the breeding cycle. However, viable endophyte infection frequencies can decrease over time depending on the environment and cultural practices deployed. Maintaining breeder seed of a cultivar with a high endophyte infection frequency requires cold storage with low humidity in addition to an established endophyte assessment protocol. However, delivering this quality endophyte-seed product for commercial production requires a quality assurance program that is not currently available on an industry wide scale in the United States.

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