Breeding for Snow Mold Resistance in Low Input Turfgrass

Yinjie Qiu, Ph.D. Student Advised by Dr. Eric Watkins

Creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) are the major turfgrass species on golf courses while Kentucky bluegrass (*Poa pratensis*) dominates home lawns in Minnesota. These grasses all have desired color, traffic tolerance, and good shoot density. However, they are vulnerable to abiotic stress like drought and biotic stress such as the diseases dollar spot and snow mold (Warnke et al., 2003, Line 2002). Additionally, they consume large amount of fertilizer per year. Breeding turfgrass species for disease resistance can be difficult because most disease resistance mechanisms involve multiple genes interaction and novel gene resources. For this reason, it is challenging to develop new cultivars when existing germplasm cannot provide sufficient resistance. In addition, most turfgrass species do not have whole genome sequences available which limits the use of bioinformatics based breeding methods.

Fine fescues (*F. festuca* spp.) show high potential as low input turfgrasses. Classification of fine fescue is typically done using flow cell cytometry (Huff et al., 1998). Fine fescues include hard fescue (*F. brevipila*), slender creeping red fescue (*F. rubra* ssp. *trichophylla*), Chewings fescue (*F. rubra* ssp. *fallax*), sheep fescue (*F. ovina* spp.) and strong creeping red fescue (*F. rubra* L. ssp. *rubra*). Interestingly, each of these five closely related species has its own unique characteristics. For example, strong creeping red fescue can quickly form a dense turf under low to high fertility, Chewings fescue has excellent shade tolerance, and slender creeping red fescues tolerate low mowing heights and have good salt tolerance. For these reasons, fine fescues are usually seeded as mixture. Different mixtures have different performance under stress, if we are able to quantify the species proportions within the mixture, we can have a better understanding towards fine fescue stress performance. Unfortunately, researchers can hardly quantify species components in the mixture at this time, due to the high similarity across five species.

Many fine fescues have exceptional disease resistance. Hard fescue has excellent resistance to dollar spot, rust, and snow mold (Pfender et al., 2001, Paul Koch, personal communication). The use of fine fescues can reduce herbicide applications. In field trials, some fine fescues are able to inhibit the weed growth (Long Ma, unpublished data). Fine fescues also have great drought tolerance (Malinowski et al., 2000). The fine fescues planted in Living Laboratory areas at University of Minnesota haven't been watered in years and they are remaining exceptional. The main drawbacks of the fine fescues are low heat and traffic tolerance.

Most fine fescue species are infected by fungal endophytes (Saha et al., 1987). The interaction between fungal endophytes and grass species is not clear: it could be beneficial, neutral or harmful (Cheplick et al., 1997). Clarke et al. (2005) observed that the presence of fungal endophytes enhances the dollar spot (*Sclerotinia homoeocarpa*) disease resistance in fine fescue. A contrasting study showed the fungal endophyte decreased the speckled snow mold resistance in meadows fescue (Wali et al., 2006). Altogether, in order to maximize the use of fungal endophyte to improve turfgrass performance, it is necessary to study the host and microbe interaction and its potential benefit for fine fescue resistance and tolerance. Fungicide is often used by researchers to removal fungal endophyte in order to create endophyte free plants (Clay et al., 1993, Dinkins et al., 2017). However, no research has been done to prove that this method would not affect downstream studies and results.

Pink snow mold (*Microdochium nivale*) is a devastating winter crops and grass species disease in areas like Minnesota, Wisconsin and Michigan (Tronsmo et al., 2003). Current cool season golf course grass species, such as creeping bentgrass (*Agrostis stolonifera*) and perennial type of annual bluegrass (*Poa annua* var. reptans), are vulnerable to *M. nivale*. Present understanding of the pink snow mold resistance is not clear. It is likely the resistance is induced by cold hardening (Kovi et al., 2016). However, in wheat a QTL on chromosome 6B is unique to pink snow mold resistance and demonstrated the genetic aspect of snow mold resistance (Kruse et al.2017). Hard fescue has excellent pink snow mold resistance and could be a potential genetic resource used to breed grass species for pink snow mold resistance.

My research goals are to:

1. Develop molecular marker system that could help us identify fine fescue species
2. Address the effects of fungicide application for fungal endophytes removal on snow mold resistance in hard fescue
3. Discover the genetic mechanism of pink snow mold resistance in hard fescue

At the end of my research, we would be able to identify fine fescue species at molecular biology level, gain a better understanding of fungal endophyte and host interaction under the snow mold disease pressure, and ultimately we would be able to develop a marker assisted selection program to breed turfgrass for pink snow mold resistance

References

Clarke, Bruce B., et al. "Endophyte-mediated suppression of dollar spot disease in fine fescues." *Plant Disease* 90.8 (2006): 994-998.

Clay, Keith, Susan Marks, and Gregory P. Cheplick. "Effects of insect herbivory and fungal endophyte infection on competitive interactions among grasses." *Ecology* 74.6 (1993): 1767-1777.

Cheplick, Gregory P. "Effects of endophytic fungi on the phenotypic plasticity of Lolium perenne (*Poaceae*)." *American Journal of Botany* (1997): 34-40.

Dinkins, Randy D., et al. "Transcriptome response of *Lolium arundinaceum* to its fungal endophyte *Epichloë coenophiala*." *New Phytologist* 213.1 (2017): 324-337.

Huff, David R., and Antonio J. Palazzo. "Fine fescue species determination by laser flow cytometry." *Crop Science* 38.2 (1998): 445-450.

Kovi, Mallikarjuna Rao, et al. "Global transcriptome changes in perennial ryegrass during early infection by pink snow mould." *Scientific reports* 6 (2016).

Kruse, Erika B., et al. "Genomic Regions Associated with Tolerance to Freezing Stress and Snow Mold in Winter Wheat." *G3: Genes, Genomes, Genetics* 7.3 (2017): 775-780.

Line, Roland F. "Stripe rust of wheat and barley in North America: a retrospective historical review 1." *Annual review of phytopathology* 40.1 (2002): 75-118.

Malinowski, Dariusz P., and David P. Belesky. "Adaptations of endophyte-infected cool-season grasses to environmental stresses: mechanisms of drought and mineral stress tolerance." *Crop Science* 40.4 (2000): 923-940.

Pfender, W. F. "Host range differences between populations of *Puccinia graminis* subsp. *graminicola* obtained from perennial ryegrass and tall fescue." *Plant disease* 85.9 (2001): 993-998.

Saha, D. C., et al. "Occurence and significance of endophytic fungi in the fine fescues." *Plant Disease* 71.11 (1987): 1021-1024.

Tronsmo, Anne Marte, et al. "Low temperature diseases caused by Microdochium nivale." *Low temperature plant microbe interactions under snow. Hokkaido National Agricultural Experiment Station, Sapporo* (2001): 75-86.

Wäli, Piippa R., et al. "Susceptibility of endophyte-infected grasses to winter pathogens (snow molds)." *Botany* 84.7 (2006): 1043-1051.

Warnke, Scott. "Creeping bentgrass (*Agrostis stolonifera* L.)." *Turfgrass biology, genetics, and breeding. Wiley, New Jersey* (2003): 175-185.