**Introduction**

Climate change is rapidly altering environmental conditions at the local level in particular, temperature and precipitation regimes and the severity of weather events. A major question for researchers throughout the world is how will plants, a mostly sessile organism, cope with these rapid changes? Given the rapid change in local conditions, there are three ways plants can respond while avoiding extinction; quickly adapt, have the plasticity in phenotype that allows acclimation to the new conditions, or shift ranges. For the sake of this study, we focus on the variation within populations that selection can act on to locally adapt. The conditions across a species range are heterogeneous and typically have different selective pressures that act on the populations. Divergent selection in two different locations can result in differing trait optima in separate populations, which is known as local adaptation (Kawecki & Ebert, 2004). How a species adapts or acclimates to separate locations provides a clue to how a species in one location could respond as global warming changes local conditions. Temperature is a prominent variable that determines species distribution and varies greatly with geographic region in both severity and consistency. There have been many adaptations in different species to improve survival in extreme temperatures, but how do populations of the same species persist in different temperature regimes? To understand local adaptation to diverging temperature regimes, we must understand the biology of plants and ways in which they are vulnerable to extreme temperatures.

Temperature stress can impact plant physiology and cell structure in a few ways. High temperatures decrease the affinity of rubisco, the enzyme responsible for carbon fixation in photosynthesis, to CO2 and increase its affinity to O2 (Bauwe et al., 2010; Zhu et al., 2018). The fixation of O2 produces compounds that are needless and requires photorespiration to recycle components necessary for photosynthesis, in the process, reducing the efficiency of photosynthesis (Bauwe et al., 2010). In extreme temperatures, hot and cold, proteins and enzymes can be damaged or rendered inactive. This can have an immense effect on photosynthesis because the protein complexes in photosystem II and the electron transport chain can unfold (Zhu et al., 2018). The degradation of integral proteins and enzymes can also lead to the production of reactive oxygen species (ROS) through the excess absorption of light energy and prolonged excitation of chlorophyll molecules (Mishra et al., 2019; Wahid, 2007; Wahid et al., 2007). Plants respond by breaking down or reconfiguring pigments such as chlorophyll to reduce light absorption and the production of ROS when temperature stressed. Oxidative stress due to ROS hinders physiological mechanisms such as photosynthesis, metabolism, and cellular structure directly or indirectly by reacting with metabolites or damaging macromolecules. Some of these cellular processes are not unique to diploid cells of the plants (sporophyte), but also occur in the haploid cells such as pollen and ovules (gametophyte). Extreme temperatures can limit pollen production, tube growth rate, and viability (Gajanayake et al., 2011; Kakani et al., 2002; Singh et al., 2008).

There is variation in the sensitivity to temperature stress and thus adaptations do lead to populations that are less sensitive. For example, cell membrane stability can be maintained in high or low temperature stress with the incorporation of fatty acids (Zhu et al., 2018) or sterols . The production of heat shock proteins, a chaperone protein, also reduces temperature stress by preserving the shape of other proteins and enzymes required for normal function. For these adaptations to occur, temperature must be a selective pressure that influences the survival or reproduction of the species. In angiosperms, selection can act independently in the two life stages, the sporophyte (diploid; full plants, vegetation) and the gametophyte (haploid; ovules, pollen). It has been shown that there is a substantial overlap in genes and gene expression between the two stages (Beaudry et al., 2020; Pedersen et al., 1987; Tanksley et al., 1981; Willing & Mascarenhas, 1984). There is also evidence of a correlation between the gametophytic and sporophytic stages in temperature tolerance traits (Hedhly et al., 2005; Poudyal et al., 2019).

In this study, we compared plants from Minnesota and Texas in temperature tolerance to extreme hot and cold conditions. Since temperature-based selection in the two life stages has the potential for inter-generational adaptations, we incorporated variables from both stages. Sporophytic tolerance was measured using leaf measurements including net photosynthesis, chlorophyll fluorescence, and cell membrane stability. The gametophytic variables were pollen germination (viability) and pollen tube growth rate. The first objective was to 1) determine if local thermal conditions have selected for temperature tolerance traits fitting the environmental conditions in the north and south. We hypothesized that if the temperature regimes in the north and south have resulted in divergent selection and local adaptation of temperature tolerance, then the plants in the north would be more tolerant of cold stress and plants from the south would be more tolerant of heat stress. The second objective was to 2) determine if there is a correlation between temperature tolerance in the gametophyte and sporophyte. If temperature stress is similar in both stages and gene expression patterns in the gametophytic and sporophytic life stages overlap, then there would be a correlation between temperature tolerance in the gametophyte and sporophyte.

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