Early Physiological Changes Associated in Cold Deacclimation of Annual bluegrass and Creeping bentgrass

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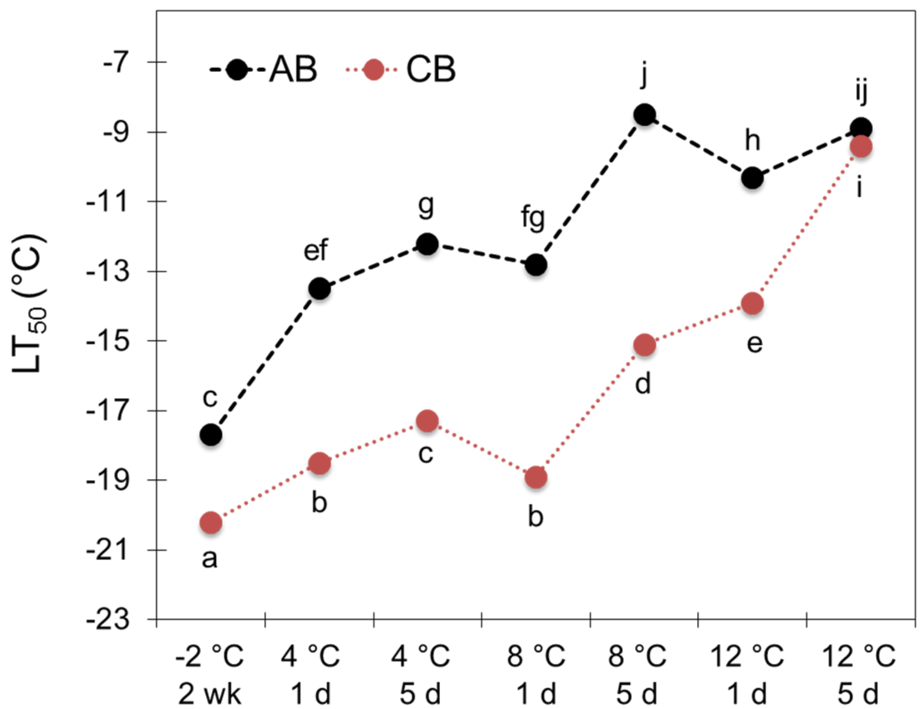
Objectives:

1. *Determine the effects of different above–freezing temperature and duration combinations that result in a loss in freezing tolerance of creeping bentgrass and annual bluegrass.*
2. *Examine early physiological changes associated with deaclimation sensitivity of creeping bentgrass and annual bluegrass, with a focus on carbon and protein metabolism parameters.*

Premature deacclimation associated with warming periods during winter and early spring can negatively impact turfgrass freezing tolerance and lead to winterkill. Field observations suggest that annual bluegrass (Poa annua L.) (AB) and creeping bentgrass (Agrostis stolonifera L.) (CB) differ in their capacity to resist deacclimation, which can contribute to interspecific differences in winter injury potential. Therefore, research is necessary to understand the factors that trigger deacclimation in grasses and to identify plant traits that contribute to enhanced deacclimation resistance and freezing tolerance. The specific objectives of our research were to (i) determine the effects of different above–freezing temperature and duration combinations that result in deacclimation of CB and AB, and (ii) examine early physiological associated with deacclimation sensitivity of CB and AB, with a focus on carbon and protein metabolism parameters.

Figure 1. Changes in the freezing tolerance (LT_{50}) levels of creeping bentgrass (CB) and annual bluegrass (AB) in response to cold deacclimation.



We compared one AB ecotype (previously shown to exhibit freezing sensitivity) and one CB cultivar ('L–93'). Plants were exposed to a cold acclimation at 2°C followed by –2°C in controlled environment chambers. Plants were then exposed to one of six deacclimation treatments that consisted of different temperatures and durations as follows: 4°C for 1d or 5d, 8°C for 1d or 5d, and 12°C for 1d or 5d. We found that AB had a significantly lower freezing tolerance, (lethal temperature at which 50% of plants were killed (LT50) of –17.7 °C) compared to CB (–21.2 °C). Along with a lower cold acclimation capacity, AB exhibited a 2.5–fold greater loss in freezing tolerance in response to exposure at 4 °C (Fig.

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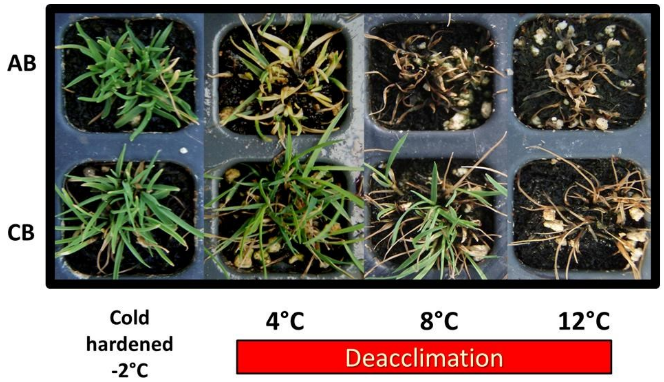
Figure 1. Losses in freezing tolerance and resulting injury to annual bluegrass (AB) and creeping bentgrass (CB) following exposure to deac-



1). Conversely, at later stages of deacclimation and greater warming, CB also exhibited significant deacclimation and loss in freezing tolerance (Fig. 2). Therefore, although both AB and CB exhibited deacclimation in response to above freezing temperatures, the threshold temperature required to induce greater losses in freezing tolerance was lower for AB compared to CB.

In subsequent experiments, we compared creeping bentgrass ('L–93') to a freezing–tolerant AB ecotype (AB–T) and a freezing–sensitive AB ecotype (AB–S) from Agriculture and Agri–Food Canada, Québec City, Québec. Following cold acclimation, plants were exposed to 8°C for 0.5, 1, 3, and 5 d to induce deacclimation. At each duration of deacclimation, plants were assessed for their freezing tolerance (LT50), concentrations of soluble sugars and amino acids, and changes in dehydrin–like proteins in overwintering crowns. Fully acclimated CB achieved a higher freezing tolerance (LT50 of –21.5°C) compared to AB–T (–19.8°C), followed by AB–S (–15.3°C). Total soluble sugars, mainly high molecular weight (HMW) fructans, increased during cold acclimation for all plants, with higher levels accumulated in CB. Dehydrin–like proteins were present in each species, but were cold–inducible and associated with freezing tolerance changes only in CB. In response to deacclimation, CB maintained higher freezing tolerance compared to both AB ecotypes, which was associated with the maintenance of higher concentrations of total soluble sugars, and in particular the HMW fructans (Fig. 3). These results support our previous observations that AB can exhibit a more rapid capacity to restore carbon metabolism compared to CB, especially photosynthesis and respiration.

Summary Points

- Increased susceptibility of AB to winter injury may be associated with both its lower cold acclimation capacity and deacclimation sensitivity.
- AB generally exhibited a greater loss in freezing tolerance at lower temperatures and shorter durations compared to CB, but the extent of deacclimation sensitivity varies according to AB ecotype.
- The more rapid shift in AB carbon and nitrogen metabolism may lead to greater susceptibility of this species to freezing injury in response to mid–winter warming events, in particular the depletion of HMW fructans.

Figure 3. Changes in the concentrations of high molecular weight (HMW) fructans in crowns of creeping bentgrass, a freezing tolerant annual bluegrass ecotype (AB–T) and a freezing sensitive annual bluegrass ecotype (AB–S) in response to cold deacclimation.