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Title: Excessive Winter Crown Dehydration Affects Creeping Bentgrass Cold Hardiness

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Winter desiccation injury observed in the northern Great Plains was particularly widespread during the winter of 2013-2014. The loss of turf left many golf course superintendents re-evaluating their winter desiccation prevention plans. However, a scientific backing to support agronomic decision-making regarding desiccation prevention is lacking in the literature. Since winter desiccation injury is likely in the future, it is important to understand how desiccation prevention treatments influence the winter survival of turfgrass by sustaining crown moisture content and improving spring recovery.

While no preventative practices can guarantee complete survival of turf, several of the tested treatments can reduce desiccation pressure and increase the likelihood of survival. The impermeable covers tested in this study consistently provided the greatest level of crown moisture content retention regardless of location. However, the recovery results varied greatly between years at Mead. In 2014-2015 the turf quality declined when freezing temperatures injured the turf following cover removal whereas this was not observed in 2015-2016 where temperatures remained above freezing following cover removal. Both the permeable cover and sand topdressing treatments also effectively sustained crown moisture contents throughout the winter at both sites and both years. The sand topdressing and permeable cover recovered similarly to the impermeable cover by the end of the study, but at a slower rate. Interestingly, the slight reduction in crown moisture content from the impermeable cover did not result in freezing injury following cover removal in 2014-2015. It is very likely that turf under the impermeable cover lost

significant cold hardiness from soil warming and heat accumulation, and pre-maturely deacclimated. The turf under the permeable cover and sand topdressing were less effected by heat accumulation and retained a greater level of cold hardiness.

While the use of both covers typically resulted in quicker recovery in the spring, their labor requirements to employ limit their uses while aggressive sand topdressing provides a labor effective means of sustaining crown moisture content in desiccating conditions for large scale applications. Sprayable products were ineffective at sustaining crown moisture content in harsher desiccating environments. When desiccation pressure was less severe at Axtell in 2015-2016, the use of an anti-transpirant did result in an acceptable turf quality while many other treatments did not.

Since complete survival is highly dependent on the winter environment, a plan must be prepared in the event of turf loss. This thesis evaluated several commonly practiced techniques superintendents implement to ensure rapid recovery such as germination blankets and fertilizer programs. Surprisingly, the results indicate that these practices are not as effective as previously believed. Germination blankets did not result in accelerated emergence or quicker re-establishment. It has been shown that germination blankets can increase soil temperatures and accelerate re-establishment in some instances, but due to the low sun-angle and short day lengths observed in the spring, solar-induced soil heating was likely limited. Aggressive fertilization is also believed to accelerate re-establishment but in this study, the practice did not result in the anticipated results. Pre-existing nutrient sources present in the soil may have supplied adequate fertility for young seedlings.

While the results from this thesis answer many questions regarding the effectiveness of desiccation prevention treatments and maximizing re-establishment of putting greens from superintendents and in the literature, many questions remain. Specifically, future studies investigating the relationship between crown moisture content and cold hardiness of creeping bentgrass (*Agrostis stolonifera* L.) would provide more clarity when selecting desiccation prevention treatments. Understanding the ideal crown moisture content range which maximizes cold hardiness allows superintendents to select desiccation prevention treatments which minimize pressure from both desiccation and freezing temperatures. Since practitioners are lacking the necessary tools to accurately measure crown moisture content, diagnostic tools should be developed to which will allow managers to visually estimate crown moisture content and viability of turf crowns. Additionally, annual bluegrass (*Poa annua* L.) is often considered to be more susceptible to desiccation and freezing temperatures. Identifying crown moisture contents in which desiccation injury occurs in annual bluegrass as well as how annual bluegrass' crown moisture impacts cold hardiness would improve our understanding of how and when turf dies. Similarly, superintendents could formulate winter management plans around ensuring ideal crown moisture contents in which desiccation pressure is reduced while cold hardiness is maximized.

Summary Points:

•Impermeable covers, permeable covers, and sand topdressing consistently increased crown-moisture retention during winter, and recovery in spring was greatest with impermeable covers.

•Sprayable products did not improve crown-moisture retention when desiccation pressure was most severe, but the anti-transpirant used improved quality under milder conditions.

•Germination blankets and fertilizer are commonly used in early spring to encourage recovery following desiccation injury, but were not effective strategies in this research.

•Sand topdressing requires fewer labor hours compared to installing and removing covers, and may be preferred on golf courses where labor is limiting.

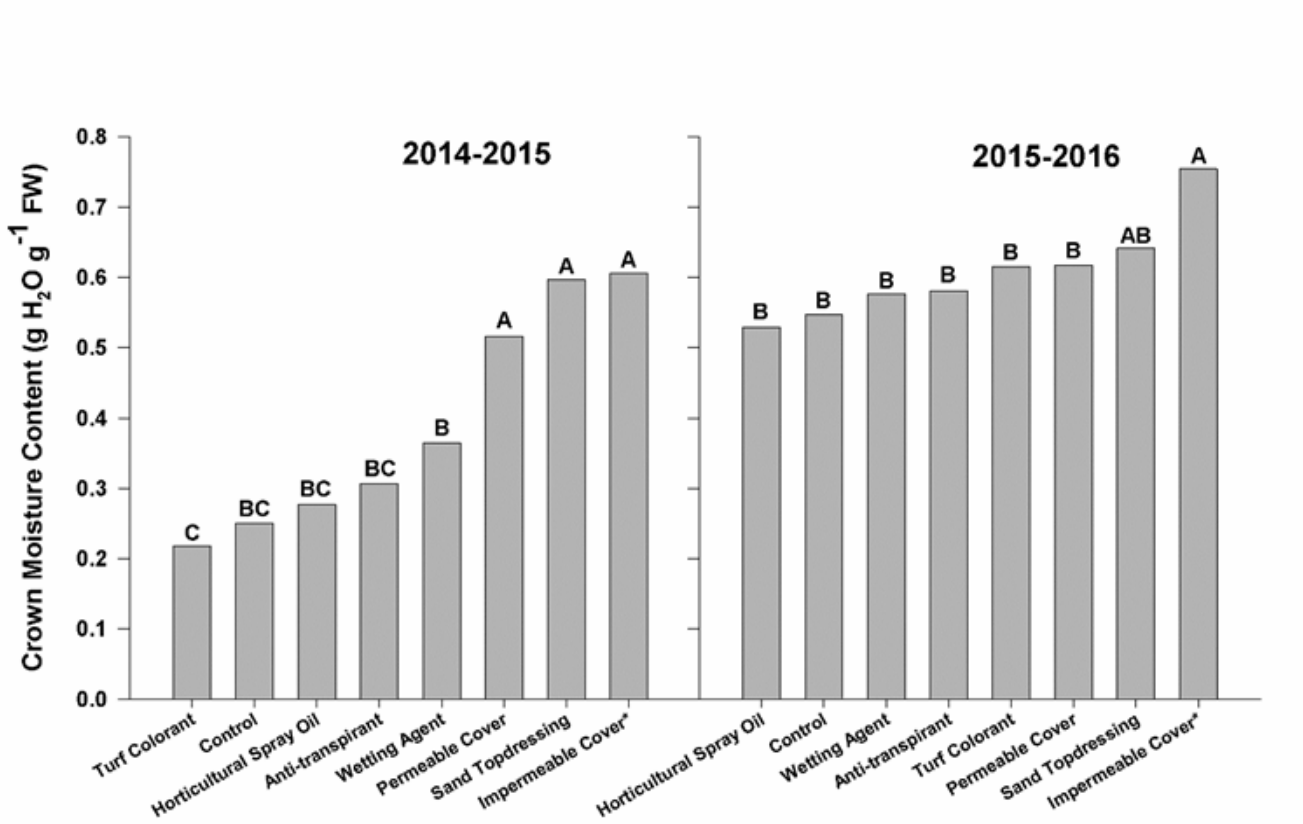

Figure 1. Crown moisture content as affected by spray-applied and cover treatments in Axtell, NE 13 March, 2015 and 2016 ($p<0.001$). Different letters above bars within a year denote a statistical difference at the 0.05 probability level. *White impermeable cover.

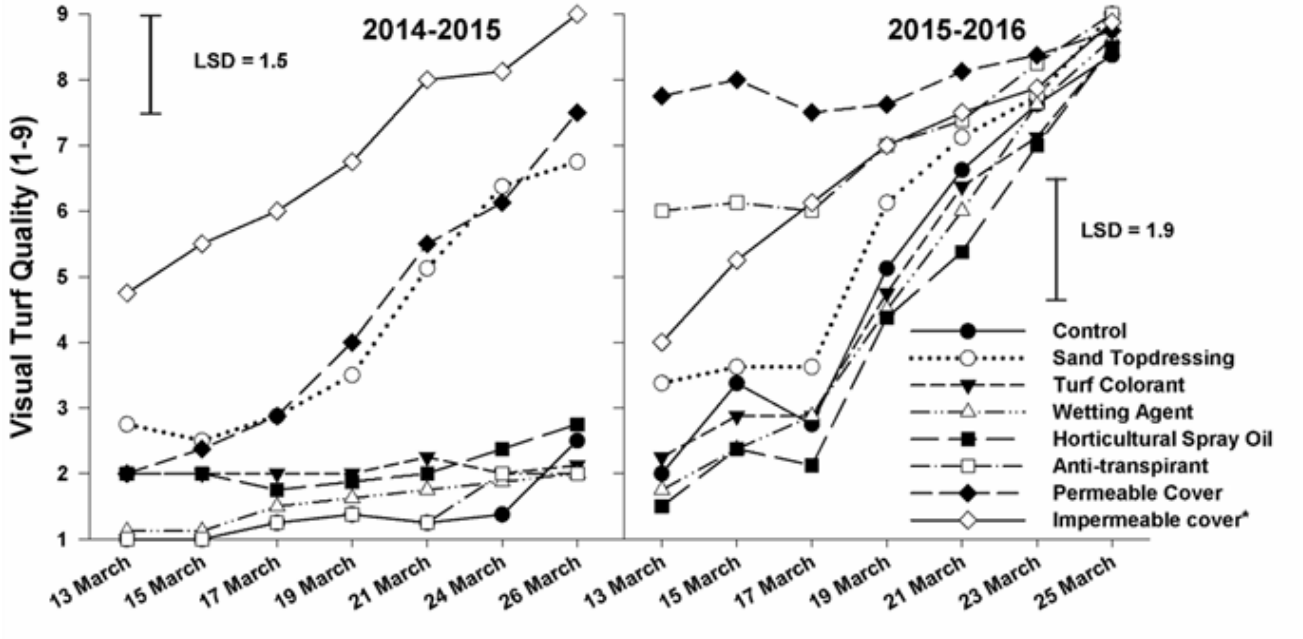

Figure 2. Visual turf quality as affected by spray-applied and cover treatments in Axtell, NE after removal of covers. Samples were evaluated in the greenhouse for recuperative capacity and rate of green-up ($p<0.001$). *White impermeable cover.