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Title: Effects of Ethylene Inhibition on Creeping Bentgrass and Annual Bluegrass Survival of Ice Cover Stress

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Start Date: 2015
Project Duration: Two years
Total Funding: $5,000

Objectives:
1. Evaluate the effects of ethylene regulation on annual bluegrass fall performance and survival of ice cover

2. Determine whether respiration rates (metabolic activity), antifreeze proteins, antioxidants, carbohydrate content, and fatty acid profiles are affected by ethylene regulatory treatments

Summary Text:

Ice damage to annual bluegrass (*Poa annua;* ABG) and creeping bentgrass (*Agrostis stolonifera;* CBG) golf course putting greens is a significant problem in many parts of the world. ABG and CBG are both susceptible to ice cover, with ABG being more susceptible (killed at approximately 45 to 70 d) and CBG being more tolerant (killed after 100+ day). The primary cause of death to turfgrass under ice sheets is most likely from oxygen depletion and toxic gas accumulation. Ethylene, a gaseous hormone, is known to play a role in regulating metabolic activity rates during dormancy. CBG and ABG are known to produce different amounts of ethylene. Faster growing species of ABG produce more ethylene when compared to slower growing ABG species (Fioriani et al., 2002). Ethylene improves plant tolerance of freezing stress by increasing antifreeze protein expression in winter rye plants (Yu et al., 2001) but reduces freeze tolerance in other species (Shi et al., 2012). Ethephon (effective ethylene) treatment in the fall has been proposed as one alternative to mefluidide, which is being phased out in the turfgrass market, for controlling ABG flowers. To our knowledge, whether ethylene may be associated with the difference in tolerance to various winterkill stresses, particularly ice stress, of cool-season turfgrasses has yet to be investigated. Since ABG is less tolerant of ice stress, we hypothesize that high levels of ethylene production or ethylene treatment products may have negative effects on ice stress survival and treatments that inhibit ethylene production may improve survival under ice stress.

In the field, turf plots were treated with one of the following treatments throughout the late fall (weekly) starting on 10/3/16 and then naturally acclimated to cold temperatures. Treatments included 1) negative control 2) ethephon (Proxy) as an ethylene application (8 L ha^{-1}) 3) ethylene precursor aminocyclopropane- 1-carboxylic acid (100 μmol L^{-1}) as an ethylene application 4) aminoethoxyvinylglycine (AVG; 25 μM) to inhibit ethylene 5) ReTain (226 g ha^{-1}) to inhibit ethylene and 6) urea at 12.2 kg N ha^{-1}. Due to availability of AVG, it was only able

to be applied twice during the acclimation period. Prior to freezing of the soil, plugs of ABG turf (10 cm diameter x 10 cm depth) were taken and placed in a low temperature growth chamber (-4°C) and subjected to either ice (1.27 cm thick) or no ice cover treatment. Plants were exposed to two ice treatments 1) no ice 2) ice cover (1.27 cm thick). Plants were sampled at 0, 10, 20, 40 and 80 days in the low temperature chamber. Half of the plugs went towards a regrowth assay in a greenhouse and percent regrowth will be documented weekly or on an as needed basis. The other half went towards antioxidant enzyme activity, antifreeze protein content, total nonstructural carbohydrate content (TNC), and fatty acid profiles.

Based on two years of field research and one year of growth chamber results, turfgrass managers that may be using ethephon for control of annual bluegrass flowering in the fall or for other purposes may see a slight decrease in turf performance and quality. More importantly, this research indicates that ethephon treatments could significantly reduce spring recovery following winter conditions either under no ice or ice-covered conditions. Primarily, ethephon research on annual bluegrass flowering control is being performed in southern states. Research done in these states are suggesting that ethephon application (in combination with other treatments) may be a viable alternative to mefluidide (Askew, 2016). Thus, turfgrass managers in northern climates need to be cautious of recommendations originating from southern research and should use caution with using ethephon during the fall, since a reduction in annual bluegrass survival over winter could occur. Thus far, our ethylene inhibition treatments showed some promise for not causing any major changes in turf physiology or performance in either creeping bentgrass or annual bluegrass, which is important if a mixed stand putting green is treated with any of these chemicals. Before making any claims about ethylene inhibition or urea application on winter survival we need to first complete our second year of growth chamber results.

Summary Points:

- Ethylene evolution from annual bluegrass plots was enhanced due to ACC and ethephon treatments. Ethylene levels were not significantly different than untreated controls for ethylene inhibition treatments.
- Ethephon treatments reduce some attributes associated with fall turf performance and reduced recovery of annual bluegrass following simulated low temperature and ice cover conditions.
- It is not yet clear how urea and ethylene inhibition treatments played a role in winter survival of annual bluegrass.

Literature Cited

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Fiorani F, Bögemann G, Visser EJ, Lambers H, and Laurentius A, Voesenek CJ. 2002. Ethylene emission and responsiveness to applied ethylene vary among Poa species that inherently differ in leaf elongation rates. Annu Rev Plant Physiol 129(3):1382-90.

Shi Y, Tian S, Hou L, Huang X, Zhang X, Guo H, Yang S. 2012. Ethylene signaling negatively regulates freezing tolerance by repressing expression of CBF and type-A ARR genes in Arabidopsis. Plant Cell. 24(6):2578-95.

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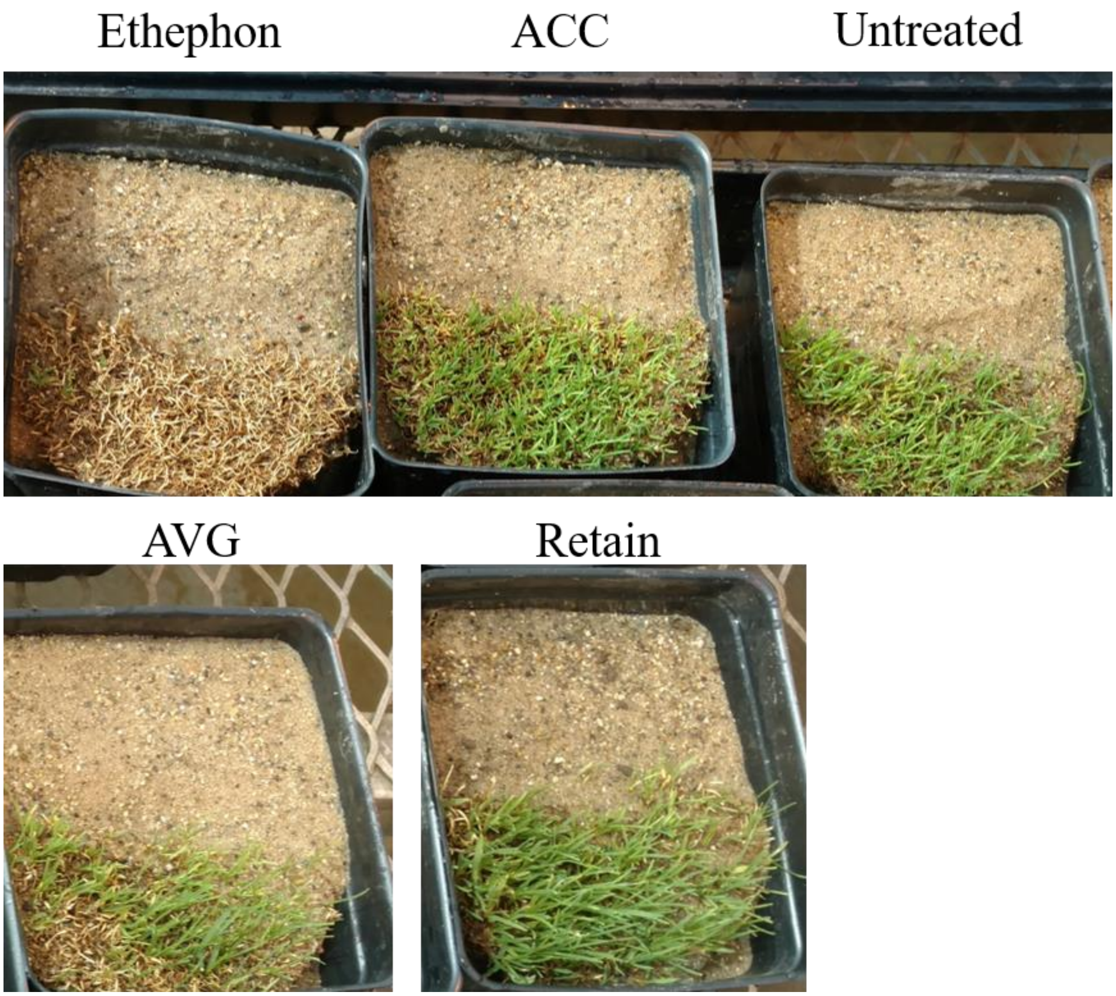

Figure 1. Annual bluegrass plants in the greenhouse recovery period following 80 days of low temperature treatment (no ice cover). Plants were untreated or treated in the field with ethephon, aminocyclopropane- 1-carboxylic acid (ACC), aminoethoxyvinylglycine (AVG), or Retain prior to simulated winter conditions in a low temperature growth chamber.

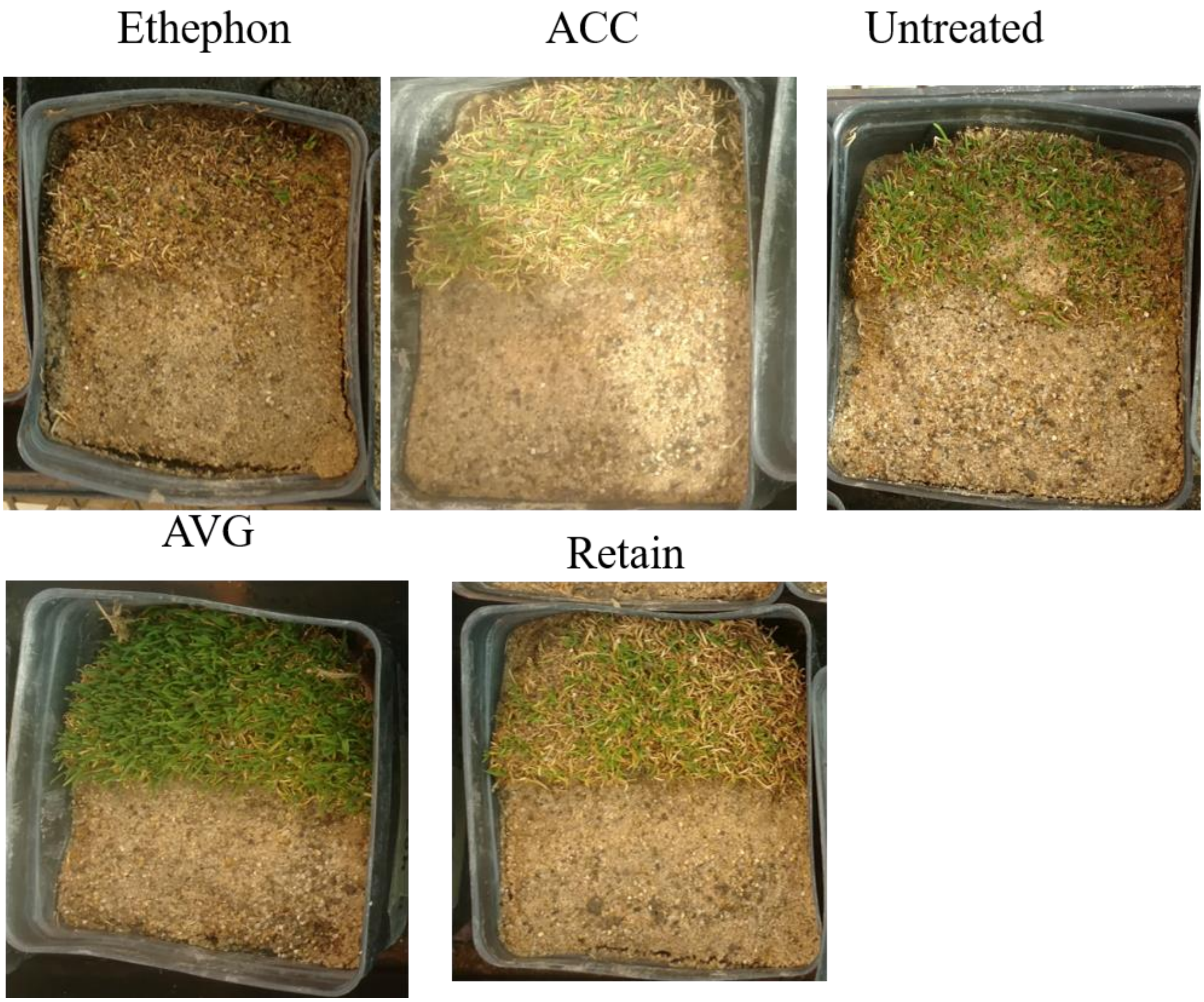

Figure 2. Annual bluegrass plants in the greenhouse recovery period following 80 days of low temperature and ice treatment. Plants were untreated or treated in the field with ethephon, aminocyclopropane- 1-carboxylic acid (ACC), aminoethoxyvinylglycine (AVG), or Retain prior to simulated winter conditions in a low temperature growth chamber.

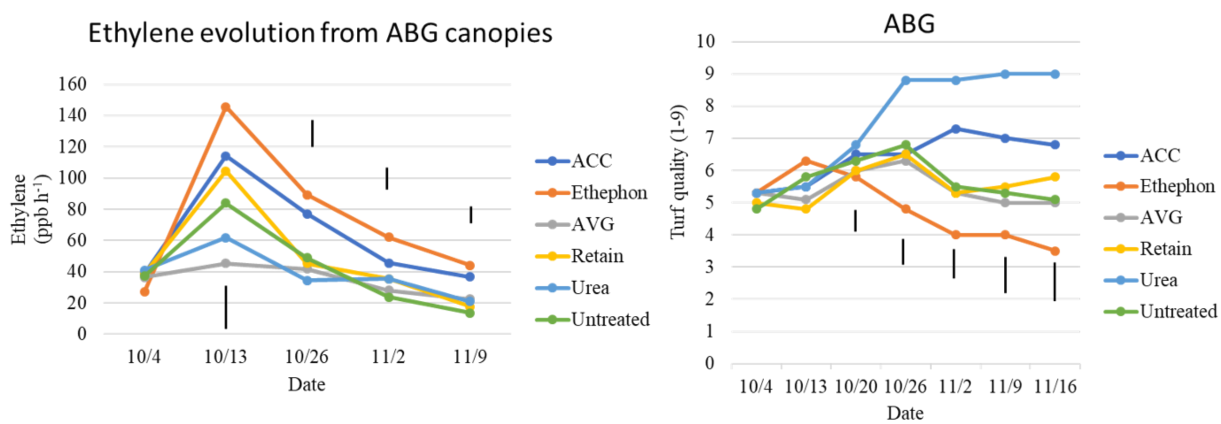

Figure 3. Ethylene evolution from annual bluegrass field plot canopies for each chemical treatment (left). Turf quality ratings for annual bluegrass field plots during the fall in response to chemical treatments. Chemical treatments included no treatment, ethephon, aminocyclopropane-1-carboxylic acid (ACC), aminoethoxyvinylglycine (AVG), or Retain.

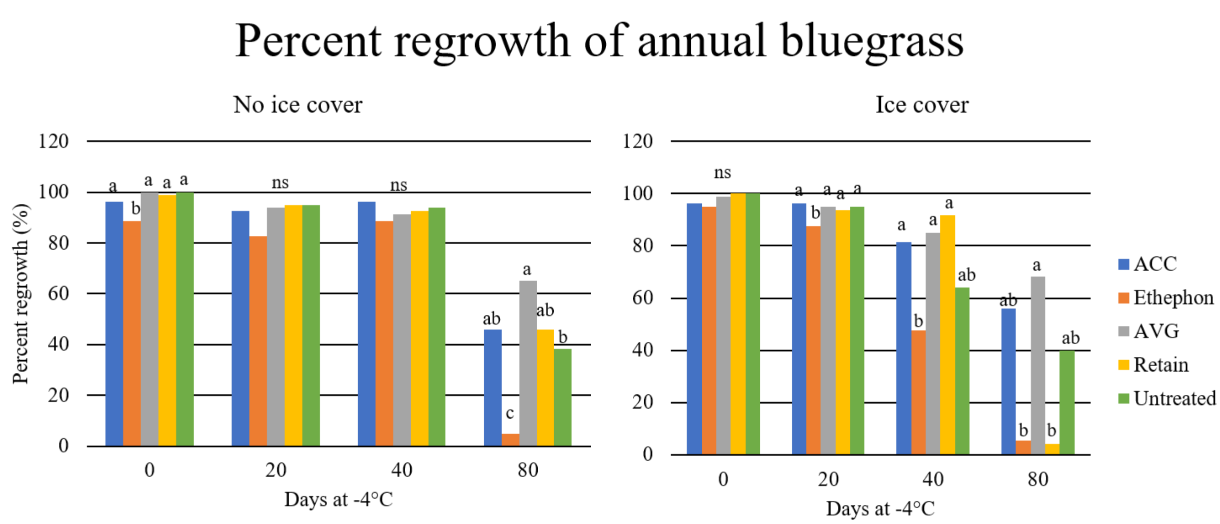

Figure 4. Greenhouse recovery ratings of annual bluegrass plugs following 0, 20, 40 or 80 d under no ice or ice conditions in a low temperature growth chamber. Chemical treatments included no treatment, ethephon, aminocyclopropane- 1-carboxylic acid (ACC), aminoethoxyvinylglycine (AVG), or Retain.