



Environmental and Genetic Interactions with Ethylene Sensitivity in Crop Plants



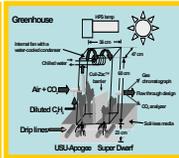
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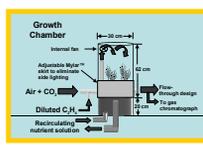
Abstract

Elevated levels of C_2H_4 gas cause a variety of abnormal responses in plants including shortened height, leaf rolling, premature senescence and sterility. Levels as high as 1000 ppb (1 ppm) have been measured in space studies and were implicated as the cause of sterility in wheat grown on MIR (Campbell et al., 2001). Catalytic air scrubbing systems will reduce C_2H_4 levels in space environments but will not likely be sufficient to maintain levels low enough for normal plant growth and reproduction. In these studies we compared the ethylene sensitivity of wheat, rice, lettuce, tomato. Yields of these crops were reduced at an C_2H_4 level of 50 ppb. However, there were significant differences in the C_2H_4 sensitivity of closely related wheat cultivars. Ethylene induced sterility was also found to decrease with increasing temperature in wheat. Overall, our studies suggest that genetic screening and control of environmental factors affecting C_2H_4 sensitivity and production will help reduce C_2H_4 induced problems in space. (Supported by NASA Advanced Life Support Program)

Materials and Methods



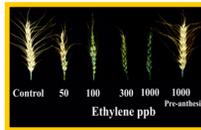
- USU-Apogee and USU-Perigee wheat, and Micro Tina tomatoes were grown in our 12-chamber greenhouse system
- Equal sized plots of two cultivars were planted in each chamber so that they shared a common environment
- Water cooled heat exchangers and computer controlled electric heaters provided independent temperature control in each chamber



- Salad crops, wheat, and Super Dwarf rice were grown in our 6-chamber hydroponics system inside a growth chamber
- Individual chambers shared a common recirculating nutrient solution so they have identical rooting zones
- The growth chamber provided control of light and temperature

Wheat and Rice

50 ppb reduced seed set in USU-Apogee wheat by 40%
Wheat was most sensitive at anthesis

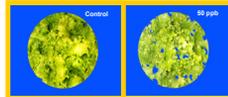


50 ppb C_2H_4 reduced seed set in Super Dwarf rice by 60%



Salad Crops

50 ppb C_2H_4 reduced the fresh weight of Grand Rapids lettuce by 20%



Bibb lettuce responded similarly

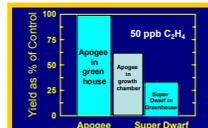
25 ppb C_2H_4 significantly inhibited seedling growth in several salad crops



50 ppb C_2H_4 inhibited leaf expansion and flowering in Micro Tina tomato

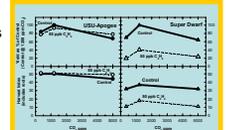
Genetic and Environmental Interactions

Differences between the relative yields (percent of control) of Apogee wheat grown in our greenhouse and growth chamber systems suggested that C_2H_4 sensitivity interacts with the environment

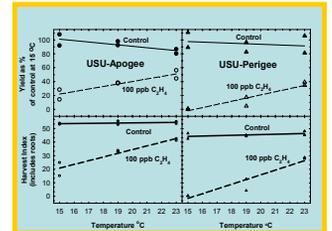


Interactions with CO_2 and Cultivar in Wheat

C_2H_4 sensitivity of wheat was not influenced by elevated CO_2 but was significantly different between cultivars (Klassen and Bugbee, 2002)

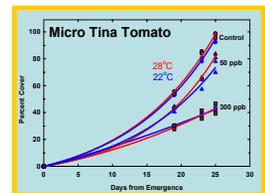


Temperature Interactions in Wheat and Tomato



Wheat yield was significantly reduced in both cultivars at all three temperatures but C_2H_4 sensitivity decreased with increasing temperature

USU-Apogee was less C_2H_4 sensitive than USU-Perigee at all three temperatures and both cultivars had twice the yield reduction at 15 °C than at 23 °C as compared to controls



Temperature did not interact with C_2H_4 sensitivity in Micro Tina tomato at the levels used in this study

Conclusions

Short term environmental manipulations can significantly reduce C_2H_4 induced sterility in wheat

Genetic screening and control of environmental factors affecting ethylene sensitivity and production are needed to reduce C_2H_4 induced problems in space

References

- Klassen, S., and B. Bugbee (2002) Sensitivity of Wheat and Rice to Low Levels of Atmospheric Ethylene. *Crop Science* 42: 746-753.
- Campbell, W.F., F.B. Salisbury, B. Bugbee, S. Klassen, et al. (2001) Comparative floral development of Mir-grown and ethylene-treated earth-grown Super Dwarf wheat. *J. of Plant Physiology* 158: 1051-1060.
- Klassen, S., B. Bugbee, and W.F. Campbell (1999) Effects of low ethylene levels on USU-Apogee and Super Dwarf wheat. *Proceedings of the International Conference on Environmental Systems (ICES)*, July 12-15. SAE Paper # 1999-01-2025.



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