2013 NCERA-101 Station Report - Crop Systems and Global Change Laboratory (CSGCL)*
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1. New Facilities and Equipment:

-Six new plexiglas chamber tops (Precision Plastics, Inc, Beltsville, MD) were constructed and installed to replace aging soil-plant-atmosphere Daylit growth chambers at Bldg 052. Blowers, heaters, and plant support structures were redesigned in-house to replace obsolete system. Pneumatic linear actuators and sliding plastic grates were installed to prevent build-up of CO_2 as a result of night-time plant respiration.

-Six TC2 controllers were installed to replace obsolete and malfunctioning C3 style controllers on the same Daylit SPAR chambers (EGC, Chagrin Falls, OH).

2. Unique Plant Responses:

-A study conducted in SPAR chambers found that short-term water-withholding periods on potato growth resulted in higher harvest index when grown under elevated versus ambient CO_2. This suggests elevated CO_2 may mitigate water stress effects on yield in potato. An additional study evaluated effects of CO_2 and heat stress during grain filling period in corn in SPAR chambers.

-Leaf-level photosynthetic responses for eight day-neutral strawberry varieties saturated under both plasticulture and growth chamber conditions with PAR levels in excess of 500 µmol m^{-2} s^{-1}, suggesting PAR is typically not the limiting growth factor for strawberry yield in mid-Atlantic states.

-In separate open-top and growth chamber experiments, studies involving plant CO_2 responses were conducted: a) growth and reproductive response of weeds (ragweed, mugwort, and plantain) in response to projected increases in temperature and CO_2, b) peanut varietal quantitative and qualitative responses to elevated CO_2, and c) sensitivity of growth and seed yield for cultivated and wild rice lines to CO_2 and temperature (with Cornell University).

-Studies evaluating drought response of barley roots showed an immediate cessation in root growth during drought and an increased allocation of carbon to shoots following rewatering. Elevated CO_2 was found to increase sugar production in soybean apices influencing plant development.

-Two experiments were conducted to study soybean growth and yield response to phosphorus nutrition under current and projected carbon dioxide in six growth chambers. Results investigated mesophyll and stomatal conductance and photosynthetic responses mediated by P nutrition and CO_2 levels.

-Open top and growth chamber studies indicated that dandelion species will adapt rapidly to rising CO_2 levels due to presence of several genotypes which show positive adaptive responses as compared to current CO_2 conditions.

3. Accomplishment Summaries.

-The energy efficiency of lighting systems is a major concern to growers. A comparison of day-neutral and june-bearing strawberry varietal growth responses was conducted under three different lighting systems. No significant yield differences were observed when grown under traditional systems consisting of (a) HID lighting with a 400W HPS and MH bulbs or (b) CWF lighting with eight 54W T5 bulbs and 2 100W incandescents, versus (c) an induction bulb setup with a single 400W 5000K lamp. For plants with relatively low lighting requirements, growth under induction lamps can potentially save 50% or more on energy costs due to higher efficiency.

-Scientific inquiry into crop response of climate change factors is often limited by the technological capabilities of growth chambers. A new method based on instrumentation and analysis was developed to more accurately measure the plant's conductance to CO_2 (and thus quantify the effects on photosynthetic rate) in response to water stress and climate change factors. The methodology can be easily adopted in any controlled environment that provides CO_2 control and can provide a better understanding of how growth under elevated CO_2 may protect crops from severe drought.

4. **Impact Statements**.

-Assessment of climate change impacts requires the ability to accurately control CO_2 concentrations around the plants to be measured. Recent studies at USDA-ARS have indicated that large hourly variations in CO_2 levels around the crop can result in substantially different plant responses, including yield, than what would be obtained under better controlled systems. This can lead to erroneous conclusions related to climate change impacts. The study shows that more precise CO_2 control is needed to obtain the most accurate climate change assessments on agricultural systems.

- More frequent droughts are anticipated with global climate change, but there is little information on how rising atmospheric carbon dioxide concentrations may affect crop responses to drought. Study of carbon dioxide effects on responses to drought has been limited by inability to precisely control soil water deficits. A new method of controlling soil water deficits was developed and tested, and is based on using a vacuum to ceramic cups to maintain a consistent level of soil moisture stress. The method can be used to evaluate mitigation effects of elevated CO_2 on drought for various plants.

-The growing season for strawberry production in Mid-Atlantic states, especially for day-neutral varieties, is largely limited by temperature. Plastic hoop tunnels were successfully used to extend this growing season in Maryland for eight different varieties. The tunnels had the added benefit of increasing yield and reducing disease as compared to traditional no-tunnel growing methods. Analyses are being conducted to quantify bio-environmental differences inside and outside the plastic tunnels, and develop decision support systems for growers interested in adopting the new technology. The technology is also useful for strawberries breeders as well who need a longer growing season for their test varieties.

5. **Published Written Works**.

Barnaby, J.Y., Ziska, L.H. 2012. Plant response to elevated CO_2. Encyclopedia of Life Sciences.

Bunce, J.A. 2012. Elevated carbon dioxide alters the relative fitness of *Taraxacum officinale* genotypes. American J. of Plant Sciences 3: 202-208.

Bunce, J.A. 2012. Using new gas exchange methods to estimate mesophyll conductance and non-stomatal inhibition of photosynthesis caused by water stress. HortScience 47: 687-690.

Bunce, J.A., Nasyrov M. 2012. A new method of applying a controlled soil water stress, and its effect on the growth of cotton and soybean seedlings at ambient and elevated carbon dioxide. Environ. Exp. Bot. 77: 165-169.

Bunce, J.A., Nasyrov M. 2012. A new method of applying a controlled soil water stress, and its effect on the growth of cotton and soybean seedlings at ambient and elevated carbon dioxide. Environ. Exp. Bot. 77: 165-169.

Bunce, J.A. 2012. Responses of cotton and wheat photosynthesis and growth to cyclic variation in carbon dioxide concentration. Photosynthetica 50: 395-400.

Fleisher, D.H., J. Barnaby, R. Sicher Jr., R.P. Resop, D.J. Timlin, V.R. Reddy. 2013. Cyclic drought and atmospheric CO2 effects on potato agronomic response. Ag Met For., 171-172: 270-280.

Fleisher, D.H., Q. Wang, D.J. Timlin, J.-A. Chun, V.R. Reddy. 2013. Effects of carbon dioxide and phosphorus supply on potato dry matter allocation and canopy morphology. J. Plant Nutrition, (in press).

Fleisher, D.H., Q. Wang, D.J. Timlin, J-A Chun, V.R. Reddy. 2012. Response of potato gas exchange and productivity to phosphorus deficiency and carbon dioxide enrichment. Crop Sci, 52: 1803-1815.

Kim, S-H, Y. Yang, D.J. Timlin, D.H. Fleisher, A. Dathe, V.R. Reddy, K. Staver. 2012. Modeling temperature response of leaf growth, development, and biomass in Maize with MAIZSIM. Agron J., 105: 1523-1537.

Sicher, R. 2012. Responses of metabolites in soybean shoot apices to changing atmospheric carbon dioxide concentrations. International J. Agron., v2012, ID: 309153.

Sicher, R., D.J. Timlin, and B. Bailey. 2012. Responses of growth and primary metabolism of water-stressed barley roots to rehydration. J. Plant Phys., 169: 686-695.

Valerio, M., Tomecek, M.B., Lovelli, S., Ziska, L.H. 2011. Quantifying the effect of drought on carbon dioxide-induced changes in competition between a C3 crop (tomato) and a C4 weed (Amaran thus retroflexus). Weed Research. 51(6):591-600. DOI:10.1111/J.1365-3180.2011.00874.

Wang, Q., D.H. Fleisher, D. Timlin, V.R. Reddy, J.A. Chun. 2012. Quantifying the measurement errors in a portable open gas-exchange system and their effects on the parameterization of Farquhar et al., model for C3 leaves. Photosynthetica, 50: 223-238.

Ziska, L.H., Gealy, D.R., Tomecek, M.B., Jackson, A.K., Black, H.L. 2012. Recent and projected increases in atmospheric CO2 concentration can enhance gene flow between wild and genetically altered rice (Oryza sativa). PLoS One. 7(5).

Ziska, L.H., Bunce, J.A., Shimono, H., Gealy, D.R., Baker, J.T., Newton, P.C., Reynolds, M.P., Jagadish, K.S., Zhu, C., Howden, M., Wilson, L.T. 2012. Food security and climate change: On the potential to adapt global crop production by active selection to rising atmospheric carbon dioxide. Proceedings of the Royal Society of London B.

6. **Other relevant activities or information.**