Purdue University
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Plant-Growth Facilities Website.
http://www.hort.purdue.edu/hort/facilities/greenhouse/101exp.shtml) was modified to include new studies of "101 Ways to (try to) Grow *Arabidopsis*". The goal is to improve methods to grow Arabidopsis that are repeatable and scalable. We grew plants under different light intensities, concluding that 200 µmol/m^2/s of PAR provided best results. We did not use a barrier between plants and lamps, which may allow higher PPFs to be used without damage to plants. We also determined that, within 170-250 µmol/m^2/s, high-intensity discharge lamps are suitable for growing Arabidopsis. Growth and flowering were hastened under 24-h illumination using fluorescent/incandescent lighting. Days until 50% of plants flowered: 19 for 24-h light in growth chamber; 18 for summer sunlight in greenhouse; 26 for spring sunlight in greenhouse; 26 for 16-h light in growth chamber; and 39 for winter sunlight in greenhouse supplemented to 16 hours. There was no damage to plants grown under 24-h days at 100 µmol/m^2/s, but damage did occur at 300 µmol/m^2/s. We also air-conditioned a greenhouse table to maintain temperatures suitable for Arabidopsis during hot summer months. An air-conditioned light shelf was built for $540 and an air-conditioned table for $470 (See Materials and Methods for *Modifying a greenhouse table and greenhouse light-shelf with portable air-conditioners for improved cooling*). The cost estimates do not include components on hand such as greenhouse table, extension cords, timers and thermometers. The shelf and table were co-located close to exhaust fans used to purge heat created by the a/c units before they added to the heat load of the greenhouse. Other advantages of building ac benches in greenhouses is the presence of drains and an ability to safely apply pesticides. Both systems grew healthy *Arabidopsis* crops with no signs of stress when greenhouse temperatures reached a maximum of 85˚F (29.4˚C) or higher on 9 days in July. Temperature on the air-conditioned table was less than 70˚F (21.1˚C), and less than 75˚F (23.9˚C) on the shelf. The website has high resolution images, descriptions of materials and methodology, media and solution analyses, environmental graphs, and links to excellent references.

LED Lighting. After conducting side-by-side intracanopy and overhead LED lighting experiments with vegetative cowpea and demonstrating that the light-utilization efficiency of IC was greater than that of OH lighting, we next wanted to to compare reproductive yields. We chose dwarf pepper to look at fruit set. 'Triton' pepper was used for small plant size and continuous productivity. We harvested pepper fruits three times with a total 37 grams for the intracanopy and 46 grams for the overhead-lit plants over 9.5 months of growth. However, at either 10% or 15% blue (440 nm), dramatic intumescence (oedema) growth developed on leaves, sepals, and meristematic tissues of plants in both treatments. In addition to the large growths, leaves were epinastic and brittle. Intumescence growths transitioned to necrotic lesions, and productivity and growth were low compared to non-intumescent plants. This led us to explore measures for reducing intumescence. Fifteen-centimeter-long fluorescent blacklights (365 nm) were mounted in 4 sub-divided compartments within the LED arrays and set to run on

various energized intervals. Even with continuous blacklight illumination, intumescences formed. Under higher blue levels (50%), intumescence was reduced but not absent. It is likely that either a shorter wavelength than 365 nm UV-A is necessary to mitigate intumescence in 'Triton" pepper, or that the intensity of UV is too low to have an effect even on a small canopy area.

Over the past year, our collaborators at Orbitec have developed, through a Phase II SBIR from NASA, an automated plant-detection LED lighting system called HELIAC (high efficiency lighting with integrated adaptive control). This system consists of 16 lightsicles that can be operated in OH or IC lighting configurations. Each of the 20 light engines on each lightsicle can independently sense reflection and energize in proximity to plant material. Testing on this prototype has begun with crop plants at Purdue.

Corn Experimentation in Controlled Environments. Corn experiments in the tall chamber and the high-bay growth room have been progressing. Recently, an HID lamp-type study in the high-bay room compared dense stands of a semi-dwarf corn cultivar grown under either 3:2 HPS:MH, 1:1 HPS:MH, or all HPS or all MH. All lamps used were basic and not spectrum enhanced for plant growth. Plants grown under HPS-only lighting produced more seed and biomass and had fewer growth abnormalities than any other treatment. This experiment is being repeated with the lamps rearranged to discount any positional effects of the room.

In the tall chamber, pot size and planting density were studied using the same semi-dwarf corn line. Interestingly, the medium (1.5x) pots at 9.1 plants/m^2 produced the same amount of seed and more total biomass than larger (2x) pots spaced at 7.6 plants/m^2. Small pots (1x) at 9.1 plants/m^2 produced a slightly smaller amount of seed. The next chamber experiment has begun using only the small and medium pot sizes at 9.1 plants/m^2, with larger sample sizes to allow statistical significance. In the initial teat of these two pot sizes, DIF conditions will be days set at 80˚ F and Nights set at 65˚ F and then a 2-h DIP period when the lights first energize so that temperature becomes 60˚ F. A second round of experimentation will repeat with all conditions the same except no morning DIP interval.

Both the plants from the growth room and the tall chamber experiments demonstrated a high correlation between average stem diameter and grams of seed produced (r=0.98). This relationship was much stronger than that of plant height or total biomass. Therefore, in the next experiments, stem diameter will be monitored at intervals and the correlation will be further tested.

Related research on height control of corn has begun in the greenhouse. Since we have had difficulties growing tall corn varieties in the growth chamber and the growth room, an undergraduate research assistant has begun a project looking at growth regulator effects on BT corn to see if chemical dwarfing, either by foliar spray or soil-drench, is a viable option for reducing the height of non-dwarf corn without inhibiting seed production. He will examine five different commercially available plant-growth retardants. He has already determined a way to drastically increase seed germination uniformity in corn, by pressing the seeds gently into wetted profile prior to adding the turface over the top. He got 98.9% germination and great seedling uniformity.

Corn pollination has also been studied. We compared effectiveness of differing pollination techniques on open-pollinated tall BT corn in the greenhouse to find a method

less labor-intensive than typical hand-pollination, which involves ladder climbing and bagging of silks and tassels. Treatments were hand-pollination, fan-blown pollination using a fan installed vertically above the crop, stem-shaking for 7 seconds daily, and one passive treatment where we allowed existing greenhouse air currents to distribute the pollen. Statistics are pending, but no differences are apparent between treatments, suggesting that hand-pollination was not necessary.

Strawberry Cultivar Selection. Strawberry temperature and photoperiod experiments leading to cultivar selection have been proceeding in three reach-in growth chambers. Initially, the effects of temperature were examined for four day-neutral cultivars. The three most productive and best tasting cultivars were then subjected to 3 different long-day photoperiods. 'Seascape' subsequently was found to be the most productive and generally the best tasting strawberry cultivar. In addition, 'Seascape' was equally productive at all photoperiods tested. This led to the present study that examines only 'Seascape' plants under three photoperiods of shorter duration, *viz.*10 h, 12 h, and 14 h days. The present goal is to determine the optimum photoperiod for production of 'Seascape' with the minimum amount of light energy input.

Sweetpotato Cultivation. In tests comparing sweetpotatoes maintained as single vines wrapped around conical or cylindrical frames, cylindrical frames consistently produced the largest root yield, especially when containers have two plants crowded into them. Another vine-limiting strategy that was examined compared downward growth from a hanging basket of branching vines to the same containers but with the vines allowed to grow upwards on angled screens. Neither of these cultivation techniques demonstrated root growth as much as that of single vines trained around cylindrical frames, however. vertically –upward-growing vines produced almost twice as much storage root biomass as their downward growing counterparts. Current studies are focusing on using 2 vines per pot of cylindrically-trained vines at two different fertilization regimes.

Greenhouse Improvements. We continue to make improvements to our plant- growth facility to reach the goal of having it "better than the day it opened" by our 10^{th} anniversary in March 2008. Shade-curtain fabric for our motorized curtain systems in 24 greenhouse zones was replaced in June. The new fabric is Ludvig Svensson XLS15 Firebreak with 50% shading. The project required coordination to empty 2-3 greenhouses of all plants and tables while maintaining crop health and order. Two weeks were required for completion. No problems have arisen since the installation. Our greenhouse computer environmental controls were upgraded to Priva Office version 4.3.1 in November, including new computer host hardware. Graphing, programming, and functionality are all greatly enhanced. We also completed a plumbing project to allow us to acidify our greenhouse clear water to pH 6.1. This acidification reduces alkalinity, thereby improving plant nutrition and reducing potential scale build-up on equipment such as evaporative-cooling pads. Fertilizer water to the greenhouses has been acidified since 1998. The acid-injection equipment allows for programming and display of measured pH using an in-line probe.

Publications

Massa GD, Emmerich JC, Morrow RC, Bourget CM and CA Mitchell (2006) Plant-growth lighting for space life support: A review. Gravit. Space. Biol. 19 (2): 19-29

Massa GD, Mick ME, Mitchell CA (2006) Strawberry cultivar analysis: temperature and pollination studies. ICES, Paper # 2006-01-2030

Russell JF, Massa GD, Mitchell CA (2006) Water and energy transport of crops under different lighting conditions. ICES, Paper # 2006-01-2028