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101 Ways to Try to Grow Arabidopsis: Should a Greenhouse, Light Shelf, or Growth Chamber Be Used?

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Purdue Methods:



Should a greenhouse, light shelf or growth chamber be used?

Short answer:

Growth chamber, if temperature is limiting factor

Results:

We conducted experiments in both spring season greenhouse lighting (May-June), considered ideal by Arabidopsis researchers at our facility, and winter greenhouse lighting (Nov-Jan), and compared to plants grown in growth chambers with the same environmental setpoints. In the winter study, we also compared with plants grown on light shelves. Light shelves are defined here as shelves in an environmentally-controlled room with fluorescent light suspended above the plants.

Results of this study indicate that, given that temperature is not limiting, greenhouse tables and light shelves grew plants of equal or greater quality 'Columbia' plants than growth chambers. This is in agreement with Ernst et al (5), though they were using 'Landsberg' Arabidopsis. Early in the production cycle of our winter study, plants grown on light shelves were equal in quality to other plants. This is significant to note due to the cost of this equipment, installation and its maintenance of these units was a tiny fraction of the other two environments. At flowering, light shelf plants were a few days behind the other two environments, shorter, but of excellent quality. In spring season, plants grown under natural days in greenhouse (no supplementation with metal halide lamps) were indistinguishable from plants grown in a growth chamber under 16 hour photoperiod. In the winter study, plants grown with 16-hour photoperiods were again indistinguishable from plants grown in a growth chamber under some photoperiod.

Discussion:

Commercially manufactured growth chambers are the "easiest" answer to this question, as success is more likely across many mutant lines and the conditions controlled uniformly all year long. Our pest scouting records indicate growth chambers also tend to have fewer insect pests than other environments (data not shown). Given the expense of these machines, however, other environments definitely have value in Arabidopsis production. Arabidopsis 'Columbia' will grow in any of these growth environments as long as temperature is can be kept lower than 26C and the plants receive at least 80 μ mol/m2/s illumination from sunlight, metal halide lamps, high pressure sodium lamps, fluorescent lamps, a combination of any of the above, or a combination of fluorescent and incandescent lamps. Limiting factors of using light shelves could more accurately be described as the limiting factors of the room they are placed in. Obviously, the room needs access to water and drains, have electrical circuits enough to power the number of fixtures used, and should be suitably ventilated for restricted-use pesticide application if that is part of pest management program. Other technical concerns are the heat produced by the fixtures and humidity control of the room. Fluorescent fixtures that utilize thin T8-style lamps and electronic ballasts produce less heat. We strongly recommend researchers work with their physical facilities personnel to confirm utilities, and help find cooling solutions such as Koldwave units that utilize water to transfer heat out of the room rather than using refrigerant. Refrigerant "air-conditioners" such as used for offices dry the air, often to the detriment of plant growth.

It is interesting that some researchers viewing results of our formal study were surprised that Arabidopsis can be grown in a greenhouse; no doubt part of the "lablore" surrounding this plant. From our experience and as reported by others (2), the only limiting factor for Arabidopsis production in greenhouses is excessive heat during summer months, and daylength in winter months. Greenhouses in many regions of the United States cannot be cooled to 25C in the hottest part of the summer due to the limitations of evaporative cooling in humid environments, and few institutions can afford to air-condition their greenhouses. Above 25C, we've seen some mutant lines die and wild-type plants exhibit wispy, stress-induced flowering that often does not produce large amounts of seed. Other researchers have reported the maximum temperature for Arabidopsis as 28C (10), 30C for older plants (1), and even 34C (2) given adequate moisture. Purdue produces over 6,000 square feet Arabidopsis year-round in greenhouses, using evaporative cooling in summer and photoperiod extension to 16 hours using metal halide lamp supplementation in winter. Greenhouse light intensity can be as high as 1500 μ mol/m2/s during summer months. This does not kill plants absent of temperatures exceeding 25C, but could possibly contribute to the stress-related early flowering response.



Figure 1. From left to right: Natural day (winter) greenhouse; 16-hour fluorescent light shelf; 16-hour HID supplementation in greenhouse; 24-hour HID supplementation in greenhouse; 24-hour illuminated growth chamber with fluorescent/incandescent lighting



Figure 2. From left to right: 8-hour, 16-hour and 24-hour illuminated growth chamber with fluorescent/incandescent light, respectively; Natural day greenhouse (spring season)