Energy efficiency and increased light spectrum control have driven many plant growth facilities to switch from fluorescent light bulbs to light-emitting diodes (LEDs). We were interested to learn whether seemingly equivalent conditions between fluorescent lights and LEDs were functionally equivalent for plant growth.

To test this, we fitted half of a walk-in chamber with LumiGrow LumiBar LED lamps (red, blue, and white lights) and maintained the other half of the chamber with the traditional fluorescent lighting (cool white bulbs). We measured plant growth traits in six Arabidopsis genotypes selected for their light-sensitive phenotypes: the wild-type Columbia-0, and two natural accessions, Kondara and Knox18, with extreme and mild shade response phenotypes, respectively. The light signaling mutants phyB, cry1/2, and hy5 were selected for their sensitivity to varying light conditions. Plants were grown under four different light conditions at a photosynthetic photon flux density (PPFD) of approximately 150 micromoles/m2/sec where the light conditions were adjusted for different light ratios: Red (143 red, 0 blue, 7 white), High Blue (73 red, 80 blue, 7 white), Mid PPFD Red Blue (113 red, 30 blue, 7 white), and fluorescent light. Plants were also grown with the Maximum PPFD output for the LED light, approximately 350 micromoles/m2/sec PPFD where the light ratio was 75% red: 20 % blue: 5% white.

Our analysis of leaf size, shape, and number, as well as days to flowering, indicated differences in growth patterns between light conditions. Mid PPFD and max PPFD LEDs also showed some phenotypic growth differences compared to fluorescent lighting. However, the LED lighting did not cause the same temperature increase as fluorescent lights (~5 degrees Celsius cooler); many of the major growth differences might therefore be due to differences in temperature, rather than light. Overall, our findings suggest no reason to delay a transition to LEDs, even for studies involving light signaling.
Figure 2. Arabidopsis growth traits are similar under fluorescent light and maximum-PPFD LEDs. A, Leaf number and rosette diameter of plants at 24 days of growth. B, Log2-ratios of leaf number and rosette diameter under LEDs, compared to growth in fluorescent lights at 24 days. C, Proportion of plants flowering each day in each light condition. Even light-sensitive mutants do not display overt growth differences in LEDs. Bars indicate standard error of the mean. Stars indicate significant difference from growth in fluorescent lights. *** p < 0.001; ** p < 0.01; * p < 0.05.

Figure 1. The Arabidopsis accessions Col-0, Kondara, and Knox18 and the mutants phyB, cry1/cry2, and hy5 were each grown under fluorescent lights (~200 μmol/m²/s) and LEDs with maximum PPFD (350 μmol/m²/s), mid PPFD (150 μmol/m²/s), red light (150 μmol/m²/s), and high blue light (150 μmol/m²/s).
Figure 4. Within the same growth chamber, fluorescent lights are 5°C warmer than LEDs. A, LumiGrow LumiBar LED strip lights in a retrofitted fluorescent growth chamber. Control boxes allow precise adjustment of LED-emitted wavelengths. B, Temperature measurements plotted every two hours for 10 days indicate that fluorescent lights produce growth conditions 5°C warmer than those with LED lights.
Conclusions

All growth traits examined were very similar between plants grown with fluorescent lights or maximum-PPFD LEDs; many traits were also comparable in mid PPFD conditions, as well. Shape traits measured using LeafJ do not show dramatic difference between light treatments, especially when considering leaf size ratios. No light-based differences in yield were seen in seeds of Col-0 or phyB plants; differences between genotypes were maintained across light conditions.

Traits including flowering date and leaf number may appear different between fluorescent lights and LEDs due to the 5°C temperature difference. If necessary, this temperature difference will be simple to account for and address in chambers fitted with LEDs.

At advanced stages of growth, Arabidopsis plants under maximum-PPFD LEDs developed anthocyanins, suggesting stress (data not shown); maximum PPFD may be too intense for Arabidopsis plants adapted to the low light of laboratory growth. However, LED light emissions are easy to adjust with the precisely adjustable control boxes.

All told, this analysis of the growth of Arabidopsis accessions and light-responsive mutants suggests the change from fluorescent lights to LEDs will be an easy shift to make.

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References

