TEXAS MASTER GARDENER
TEXAS A&M AGRILIFE EXTENSION
Bastrop County

What's Growing On?

BASTROP COUNTY MASTER GARDENER ASSOCIATION

January 2022

Fluorescent versus LED Lighting for Indoor Growing Systems

By Howard Nemerov

Is it feasible to convert your indoor growing station from fluorescent tubes to light emitting diode fixtures (LEDs)? Depending on the size of your operation and how much you use it, with recent price drops, you may reach replacement ROI (Return on Investment) in less than four years because LEDs consume less electricity.

Power Consumption

[Note: If you're not a Gardenerd, you can skip to the next section discussing plants' lighting needs. Suffice to say that LEDs are cheaper to buy and cheaper to operate, and there's no benefit to buying fluorescents for a new growing system.]

Since before winter storm Uri, electricity costs have been rising here, making energy efficiency more important. The 2021 monthly average cost for Bastrop City residents was 9.49 cents per Kilowatt-hour (kWh). One T-12 fluorescent fixture consumes 80 watts per hour (two 40-watt bulbs), compared to a two-strip (LED equivalent of a 2-bulb fluorescent fixture) LED fixture's 60 watts. That may not seem significant, but two LED fixtures (4 strips total) are brighter than three fluorescent fixtures (6 bulbs total). For every hour of operation, the LED saves you 20 watts, 0.19 cents less than the fluorescent fixture (see Table 1).

Table 1: Hourly Cost to Operate

	T-12 Fluorescent	*LED*	*Difference*
Watts/Fixture	80	60	20
Cost/Hour	$0.0076	$0.0057	$0.0019

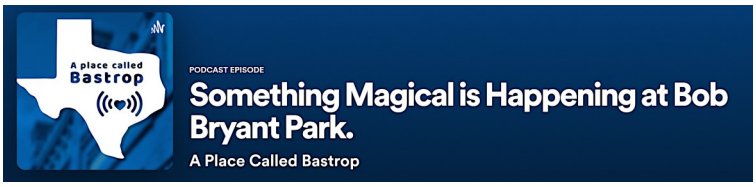
(*Continued on page 2*)

Something Magical is Happening at Bob Bryant Park

Podcast by "A Place Called Bastrop"

"Flowers, fruits, vegetables, birds and bees will soon flourish in Bob Bryant Park. And residents along with their children will be able to learn from Bastrop's Master Gardeners how to grow their own plants and food at the community garden being created there or in their own spaces. Join host, Olga Maystruk to find out what's in store at this park for 2022."

This podcast features Bob Bryant Park project leads Rebecca and Rudy Zuniga, as well as other Bastrop County Master Gardeners working on the project. The podcast production is high quality, and moves along so well it seems 17 minutes may be too quick. Click on the graphic below to listen.



Inside this issue:

(*Continued from page 1*)

Next, we can calculate operating cost based upon the number of lighting hours per day. For vegetable transplants, University of Maryland Extension recommends a duration of 14–16 hours per day, to keep seedlings "stocky and strong."[1] University of Arizona Extension recommends 12–14 hours of light per day.[2] I've been growing vegetable and flower starts under lights for over a decade, and have found 14 hours per day produces healthy starts—suitable for planting outside—while 16-hour days accelerates growth to produce larger starts four days earlier.

Table 2 below shows daily operating cost per shelf, using three fixtures per shelf: LEDs save 8–9 cents per day, depending on how long your lights run. Keep in mind that if electricity gets more expensive, the cost differential increases, making LEDs even more economical. (One shelf is 48" long and 18" deep.)

Table 2: Daily Cost to Operate

	T-12 Fluorescent	*LED*	
Hours/day	*Cost*	*Cost*	Difference
14	$0.319	$0.239	$0.080
15	$0.342	$0.256	$0.085
16	$0.364	$0.273	$0.091

However, Table 2 doesn't include initial hardware costs. For the following analysis, we'll use manufacturers' estimated service life: 20,000 hours for T-12 fluorescent bulbs; 45,000 hours for LEDs. As of this publication, initial costs for each fixture are as follows.

- T-12 Fluorescent: $34.87 with Texas sales tax (fixture,[3] plus one each daylight[4] and cool white[5] bulbs).
- Full-spectrum LED: $32.47 with tax.[6]

Looking at initial hardware investment, one LED fixture currently costs $2.40 less than one T-12 fixture with two bulbs: At current prices, you're already paying a premium for heavier, larger fluorescent fixtures.

Table 3 shows annual total cost of ownership per shelf. At 16 hours per day, LEDs can pay for themselves in energy savings in about 3.5 years, compared to running fluorescents.

Table 3: Total One-Year Cost of Ownership, per Shelf

	T-12 Fluorescent		*LED*	
Hours/day	*Cost*	*Total Hours*	*Cost*	Difference
14	$143.94	5,110	$119.75	$24.19
15	$152.25	5,475	$125.98	$26.27
16	$160.56	5,840	$132.21	$28.35

Another cost comparison method is via the estimated life of each fixture. Over the LED fixture's 45,000-hour lifespan, the T-12 fixture will need 2 bulb replacement cycles. LED lifespan is 8.8 operating years at 14 hours per day, 365 days per year, compared to a fluorescent bulb rating of 3.9 operating years.

Table 4: Total Cost of Ownership - LED Fixture Life 45,000 Hours (One LED Fixture)

Type	*T-12 Fluorescent*	*LED*	Savings
Tubes	6	1	
Materials	$49.48	$32.47	$17.01
Electricity	$341.58	$256.19	$85.40
Total	$391.06	$288.66	$102.40

With current technology, LED fixtures do not have replaceable bulbs: at the end of its lifespan, you must replace the entire fixture. With T-12 fluorescent fixtures, you only need to replace bulbs. While we can't guarantee the T-12 fixture will last nine years, Table 4 shows the "best-case" scenario where you must replace the LED fixture while only replacing fluorescent bulbs in the same T-12 fixture. Over one LED fixture's lifespan, savings versus fluorescents will pay for about three replacement LED fixtures.

(*Continued on page 3*)

(*Continued from page 2*)

What About Newer T-5 Fluorescent Technology?

T-5 fluorescent bulbs can put out over 25% more light than T-12, making them better for growing plants, but comparable T-5 fixtures are more expensive than older T-12 technology, and they use more energy: over 55 watts per T-5 bulb compared to 40 watts per T-12 bulb.[7] One T-5 grow-light fixture including two high-output bulbs sells for $42.21 including Texas sales tax.[8] One 4-foot T-5 fixture costs $9.73 more than one LED, and costs over half a cent more to operate each hour.

Table 5: Hourly Cost to Operate

	T-5 Fluor	*LED*	*Difference*
Watts/Fixture	115	60	55
Cost/Hour	$0.0109	$0.0057	$0.0052

Table 6: Total One-Year Cost of Ownership, per Shelf

	T-5 Fluorescent		*LED*	
Hours/day	*Cost*	*Total Hours*	*Cost*	Difference
14	$209.48	5,110	$119.75	$89.74
15	$221.43	5,475	$125.98	$95.45
16	$233.38	5,840	$132.21	$101.16

Table 6 shows how LEDs can pay for themselves in about one year, when compared to the cost of operating T-5 fluorescents (at $32.47 per LED fixture).

What Kind of Light Do Plants Need?

You want fixtures that produce optimal **Photosynthetically Active Radiation (PAR)**, the technical term for light in 400-700 nanometer (nm) range that powers photosynthesis.[9] This would be a minimum standard, as plants also use light below 400 nm (ultraviolet) and above 700 nm (far-red).

The McCree curve in Figure 1 "shows how efficiently plants use wavelengths between 300 and 800 nm."[10] Plants are more efficient with blue and red light, but also use green and yellow light. Note the dashed lumens graph showing how human eyes experience light. Lighting that's best for reading isn't ideal for plant growth: human eyes are more efficient with green light.[11] In my experience, it's easier to read by light produced by the fluorescents described above, meaning that they are less efficient for plant growth. Replacing all my fluorescents with LEDs produced stockier plants.

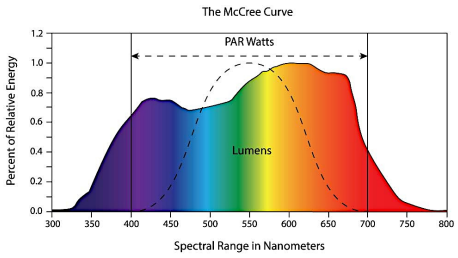


Figure 1: Plant photosynthetic efficiency wavelength graph. (Courtesy of Dimlux Lighting)

Even newer T-5 fluorescents are being promoted based upon lumens rather than how well the light supports photosynthesis (PAR). Along with their higher cost, this point underlines how fluorescents are not the future of indoor growing.

As with most things in the natural world, there's a caveat explaining why red/blue LED fixtures I initially used as fluorescent replacements were less effective because of the lower ratio of green diodes (Figure 2). Eric Runkle from Michigan State is one of the country's leading researchers on plant lighting. Here's what he has to say about green light:

> *"Sometimes one may hear that plants don't use green light for photosynthesis, they reflect it. However, this is only partly true. While most plants reflect more green than any other in the visible spectrum, a relatively small percentage of green light is transmitted through or reflected by the leaves. The majority of green light is useful in photosynthesis."*[12]

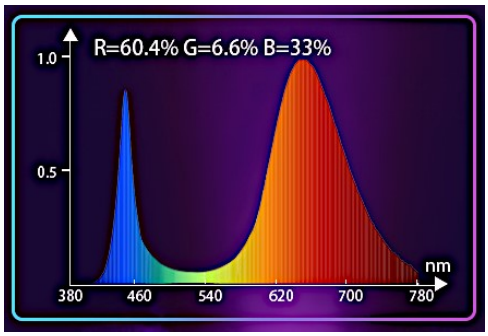


Figure 2: Red/Blue LED fixture's wavelength graph. (Courtesy of Monios)

When creating grow lights, LED manufacturers select ratios of red, green, and blue diodes to produce

(*Continued on page 4*)

(Continued from page 3)

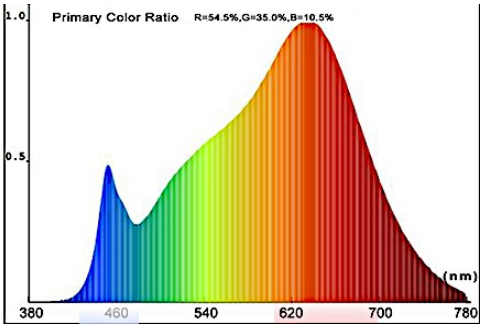


Figure 3: Full-spectrum LED wavelength graph. (Courtesy of Monios)

a certain output spectrum. Figure 3 shows a graph of the full-spectrum lights I use. It lists the ratio of red, green, and blue diodes incorporated into the fixture. Note how it roughly follows the light efficiency graph in Figure 1.

It's important to understand the terms "photosynthetic photon flux" (PPF) and "photosynthetic photon flux density" (PPFD) in order to become a savvy grow-light customer.

Photosynthetic photon flux" (PPF) "measures the total amount of PAR produced by a light in a given second," or usable light intensity.[13] LEDs produce at least twice the usable light of fluorescents.[14]

Photosynthetic photon flux density (PPFD) "measures the amount of PAR that actually lands on the plant, rather than the PAR emitted from the lighting system" and explains why LEDs are more efficient—and less costly to operate—than fluorescents.[15] The closer you place lights to plants, the higher the PPFD. However, you can over-expose plants by placing high-PPF lights too close. I've burned plants this way, learning that LEDs do not need to be placed as close to plants as fluorescents.

A final, but important, term is **daily light integral (DLI)**: "the total amount of photosynthetic light delivered to plants each day."[16] Plants need a certain amount of daily photosynthetic light to become viable plants in the garden, and DLI increases with PPFD and hours of light. Different plants need different daily light amounts, which explains why higher-PPF LEDs could remain on for less time each day and still provide as much or more usable photosynthetic light than fluorescents.[17] This means LEDs are even more cost-effective: they use less electricity and may need shorter time periods to grow healthy starts.

In my experience, LEDs running 14 hours per day outperform fluorescents running 15 hours per day, increasing annual energy savings while producing better starts.

It should be noted that the LED's used in this study generated a surprising amount of heat: They ran at 100° F; the T-12 fluorescent fixtures ran at 85° F.

Conclusion

LED light fixtures save money over fluorescents because:

- They use less energy.
- Comparable LED fixtures produce more photosynthetically usable light.
- LEDs can run for less time each day and still grow healthy plants.
- Despite having to replace the entire LED fixture, it still saves money over its lifespan because of price reductions and energy savings.

This analysis is based upon current technology and prices. As LEDs become more popular, future economies of scale and technological improvements may make LEDs even cheaper and more energy efficient than fluorescents, creating more savings and making LED grow lights even more compelling.

(Endnotes on page 5)

(Continued from page 4)

Endnotes

[1] "Growing and care of vegetable seedlings (transplants)." University of Maryland, August 10, 2021. Accessed January 15, 2022. https://extension.umd.edu/resource/care-vegetable-seedlings

[2] Schalau, Jeff. "Starting Seedlings for the Garden." University of Arizona Cooperative Extension, February 1, 2017. Accessed February 8, 2020. https://cals.arizona.edu/yavapai/anr/hort/byg/archive/startingseeds2017.html

[3] "40-Watt 2-Light White 4 ft. Fluorescent Strip Light by Metalux" Home Depot. Accessed January 11, 2022. https://www.homedepot.com/p/Metalux-40-Watt-2-Light-White-4-ft-Fluorescent-Strip-Light-SSF240/305016129

[4] "GE 40-Watt 48-in Medium Bi-pin (T12) 6500 K Natural Daylight Fluorescent Light Bulb (12-Pack)." Lowes. Accessed January 11, 2022. https://www.lowes.com/pd/GE-40-Watt-48-in-Medium-Bi-pin-T12-6500-K-Natural-Daylight-Fluorescent-Light-Bulb-12-Pack/1000437201

[5] "GE 40-Watt 48-in Medium Bi-pin (T12) 4100 K Cool White Fluorescent Light Bulb (12-Pack)." Lowes. Accessed January 11, 2022. https://www.lowes.com/pd/GE-40-Watt-48-in-Medium-Bi-pin-T12-4100-K-Cool-White-Fluorescent-Light-Bulb-12-Pack/1000428267

[6] "Monios-L T5 LED Grow Light, 4FT Full Spectrum Sunlight Replacement with Reflector – 4-Pack." Amazon.com. Accessed January 11, 2022. https://www.amazon.com/gp/product/B07ZCQQLW5/

[7] Hovey, Jim. "T12 vs T8 vs T5: "T-12"...As Outdated As Your Granparents Bingo Game?" Hovey Companies. Accessed January 11, 2022. http://hoveyelectric.com/hovey-electric-power-blog/bid/84918/T12-vs-T8-vs-T5-T-12-As-Outdated-As-Your-Granparents-Bingo-Game

[8] "Durolux DL842SR T5 4Ft 2 Fluorescent Lamps Grow Lighting System." Amazon.com. Accessed January 11, 2022. https://www.amazon.com/Durolux-Fluorescent-Lighting-Spectrum-Reflector/dp/B0821XTG7Z/

[9] Runkle, Eric, et al. "Lighting Young Plants Indoors." Grower Talks: The Lighting Guide 2021, page 4. Accessed July 21, 2021. https://www.canr.msu.edu/floriculture/uploads/files/Indoor%20lighting%20guide-low.pdf

[10] Wollaeger, Heidi and Runkle, Eric. "Green light: Is it important for plant growth?" Michigan State University Extension, February 6, 2014. Accessed July 21, 2021. https://www.canr.msu.edu/news/green_light_is_it_important_for_plant_growth

[11] Schubert, EF, "Human eye sensitivity and photometric quantities." Rensselaer Polytechnic Institute. Accessed August 8, 2021. https://ecse.rpi.edu/~schubert/Light-Emitting-Diodes-dot-org/Sample-Chapter.pdf

[12] Wollaeger, Heidi and Runkle, Eric. "Green light: Is it important for plant growth?" Michigan State University Extension, February 6, 2014. Accessed July 21, 2021. https://www.canr.msu.edu/news/green_light_is_it_important_for_plant_growth

[13] "Horticulture Lighting for Growers: PAR, PPF, PPFD Explained." Dimlux North America. Accessed August 8, 2021. https://www.dimluxlighting.com/knowledge/blog/horticulture-light-terms-explained/

[14] Runkle, Eric. "Light Fixtures and Their Photon Fluxes." Greenhouse Production News, May 2021. Accessed August 8, 2021. https://www.canr.msu.edu/floriculture/uploads/files/Lamp%20PPF.pdf

[15] "Horticulture Lighting for Growers: PAR, PPF, PPFD Explained." Dimlux North America. Accessed August 8, 2021. https://www.dimluxlighting.com/knowledge/blog/horticulture-light-terms-explained/

[16] Runkle, Eric. "How Much Supplemental Lighting Do You Need?" Greenhouse Production News, December 2019. Accessed August 8, 2021. https://www.canr.msu.edu/floriculture/uploads/files/How%20much%20light.pdf

[17] Runkle, Eric. "DLI 'Requirements'". Greenhouse Production News, December 2019. Accessed May 8, 2021. https://www.canr.msu.edu/floriculture/uploads/files/dli%20requirements.pdf

Volunteering

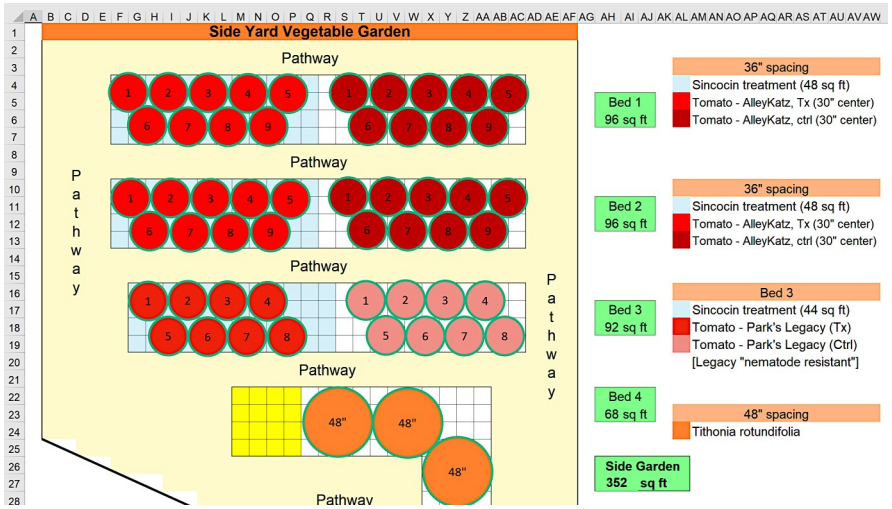
Master Gardeners volunteer in the community to teach others about horticulture. We follow the research-based recommendations of Texas A&M AgriLife Extension. Members who complete 50 hours of volunteer service in the year after training earn the designation "Texas Master Gardener." We use our title only when engaged in Texas A&M AgriLife Extension activities.

You *Are* Planning Your Spring Garden, right?

By Howard Nemerov

For Bastrop County, spring planting is about 2 months away. Here's a quick and easy design option to help you plant what goes where, and how many plants will fit in a bed.

There are fancy, easy-to-use landscape programs out there. Being a Gardenerd, I prefer to use my favorite spreadsheet program, Excel (on right). She Who Must Be Pleased will tell you that I become despondent if I haven't an excuse to build a new spreadsheet at least once a week.



Format functions help create nearly-perfect squares for graph-paper background; they work for creating plant spacing of various sizes, too. Add some color to make it purdy, and voila! It's this year's research project on root knot nematodes.

I start tomato seed 10 weeks before planting date to ensure large, #1 plants already flowering. Summer heat and humidity bring bugs and sterilized pollen, halting fruit set. The science in a previous newsletter explains how our local climate warms up in spring—fast.[1]

It's getting late! If you haven't started your tomato seeds, you're running out of time.

[Those blue shaded areas? I'm working under Dr. Joe Masabni's direction, trialing Soncocin, a natural root knot nematode treatment suitable for backyard gardening. More about that later.]

Endnote

[1] Howard Nemerov. "Tomatoes: Don't Miss the Best Tomato Season." What's Growing On? Accessed September 29, 2019. https://txmg-wpengine.netdna-ssl.com/bastropcounty/files/2019/02/2019-03_newsletter_Final-r2-BP.pdf

Right: Root Knot Nematode damage on Roma tomato.

Bottom: Tomato season started on January 5.

TEXAS MASTER GARDENER
TEXAS A&M AGRILIFE EXTENSION
Bastrop County