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Double-Ended High Pressure Sodium Fixtures Decline less than 6% over 2 years and 5000 hours

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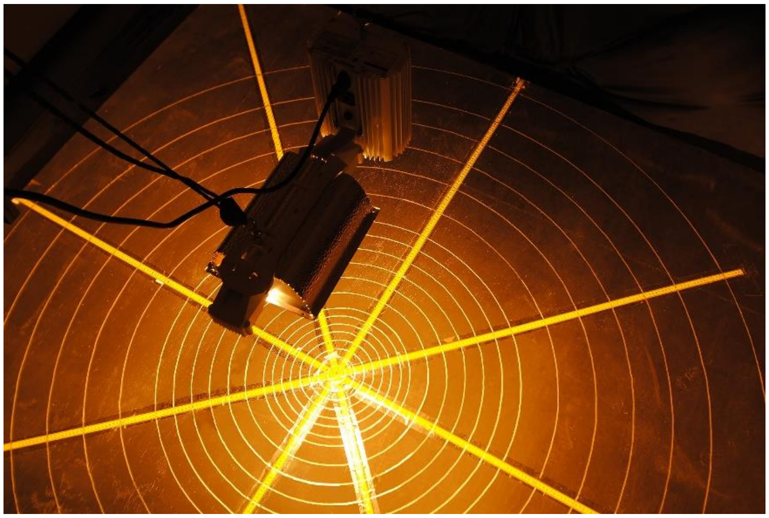
Introduction

Double-ended (DE) high pressure sodium (HPS) lights with electronic ballasts are reported to age more slowly than the old mogul base technology with magnetic ballasts, but aging has not been well studied in a greenhouse environment. Both dirt accumulation and age can decrease output.

Materials and Methods

Efficacy of new and used Gavita 1000W DE-HPS fixtures was determined from the ratio of photon output ($\mu mol \cdot s^{-1}$) to electrical input (W or $J \cdot s^{-1}$) in units of micromoles of photons per joule ($\mu mol \cdot J^{-1}$). Three new fixtures were burned in for 100 hours before testing. Five fixtures had been operated in the USU Research Greenhouse for an estimated 5000 hours (3000 hours per year). An additional two used fixtures had been operated for an estimated 2000 hours (1200 hours per year). Both groups of used fixtures were 21 months old.

The total photon output was calculated using flat plane integration as described by Nelson and Bugbee (2014)[1]. The fixtures were suspended 0.45 m from the floor in a 3 m × 3 m room with flat black walls. photosynthetic photon flux density (PPFD, $\mu mol \cdot m^{-2} s^{-1}$)[2] was measured with a recently calibrated quantum sensor (LI-COR model 190R). Measurements were made 2.5 cm apart near the center, increasing to 10 cm near the edge. PPFD was extrapolated to infinity using an exponential decay function.



[1] Nelson, J. A., & Bugbee, B. (2014). Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures. Plos ONE, 9(6), 1-10. doi:10.1371/journal.pone.0099010

[2] Photosynthetic Photon Flux is defined as $\mu mol \cdot s^{-1}$, PPFD (density) is defined as $\mu mol \cdot m^{-2} s^{-1}$.

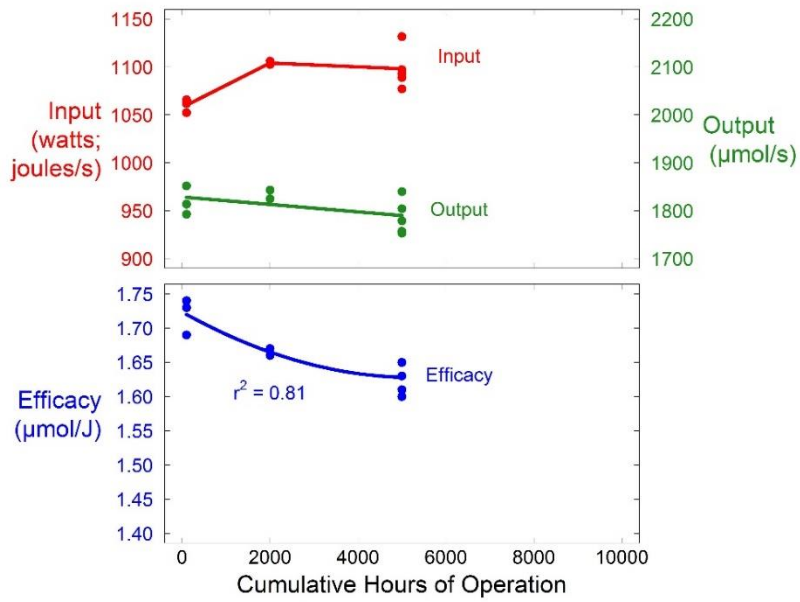
Results

Efficacy of New and Used Fixtures

There was a 2.9% decrease in efficacy of fixtures used for 2000 hours and a 5.4% decrease in efficacy of fixtures used for 5000 hours (Figure 1)[3]. The decrease in efficacy primarily came from increased wattage rather than decreasing light output.

There was no significant change in light output between the new and old fixtures ($p = 0.23$), but there was a 3.6% increase in wattage as the fixtures aged ($p = 0.01$).

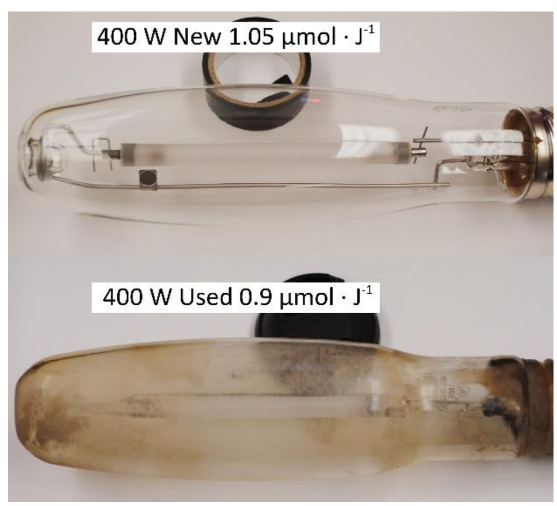
Figure 1: Effect of Age on Gavita DE-HPS Fixtures Efficacy, Input, and Output



Effect of Dust on Output

To determine the effect that dirt accumulation had on the efficacy of HPS bulbs, we compared a new 400 W HPS bulb to a bulb that had been used in a production greenhouse environment for approximately 5 years. Both bulbs were tested in the same new 400 W electronic ballast fixture.

A new bulb had an efficacy of 1.05 $\mu mol \cdot J^{-1}$ and an old dirty bulb had an efficacy of 0.9 $\mu mol \cdot J^{-1}$. We were surprised that the efficacy decreased only 14%, and based on our previous findings we estimate that half of the decrease was caused by aging and half was caused by dirt accumulation.



[3] r squared may not be the best method for goodness-of-fit for a non-linear model.
Spiess, A.-N., & Neumeyer, N. (2010). An evaluation of R^2 as an inadequate measure for nonlinear models in pharmacological and biochemical research: a Monte Carlo approach. *BMC Pharmacology*, *10*, 6. http://doi.org/10.1186/1471-2210-10-6

Discussion

Effect of the Environment on Dust Accumulation

The small decrease of efficacy caused by dirt on the bulb could be associated with a relatively clean research greenhouse environment. More research needs to be done to determine light output and efficacy decrease in production facilities.

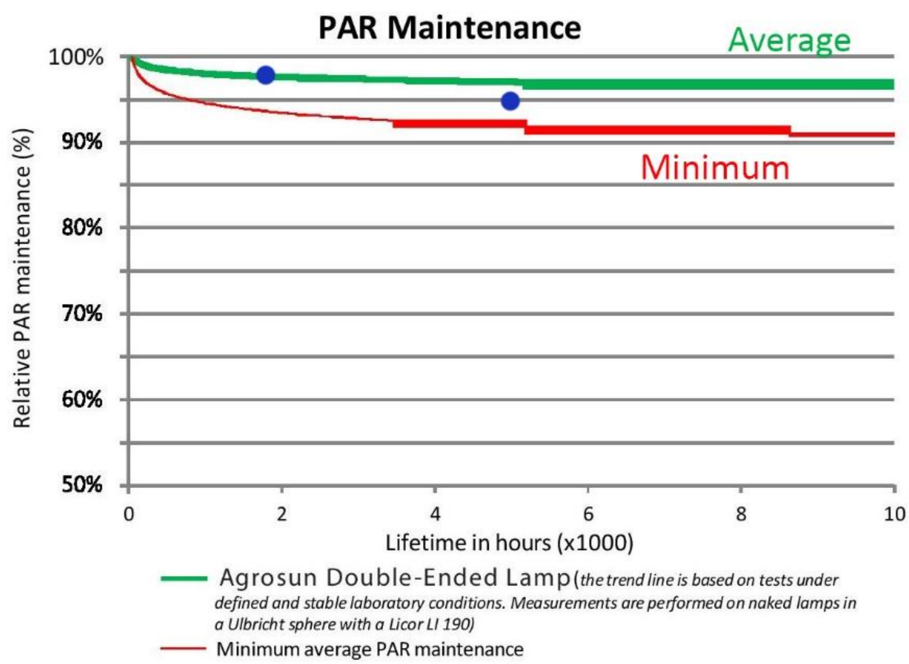
Comparison with Manufacturer Data

The data we collected are similar to the data from PARsource with Agrosun bulbs in a laboratory environment[4], however our data suggest that fixtures may age slightly faster.

Figure 2:

Relative PAR maintenance ($\mu mol \cdot s^{-1}$) vs time for a PARsource fixture with an Agrosun bulb

Blue dots represent data from this study from Gavita fixtures with Gavita bulbs.



Economic Analysis

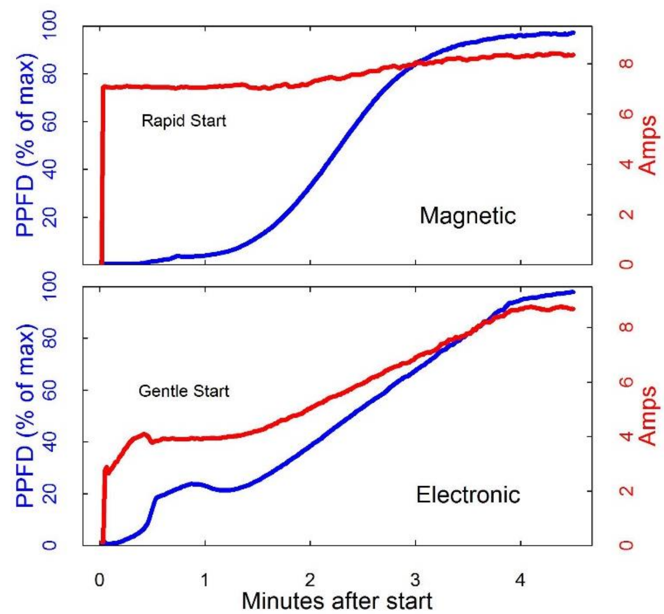
If we assume the decrease of efficacy is linear, and that operation of a fixture costs $0.10 per hour (1 kW fixture at $0.10 per kWh); at approximately 10,000 hours $60 will have been unproductively used because of decreased efficacy. This is the cost of a new DE HPS bulb.

[4] http://parsource.com/sites/default/files/downloads/PSS_AgrosunDE_BUSD1DEAG_C1012_FINAL_0.pdf

Magnetic vs Electronic Ballasts

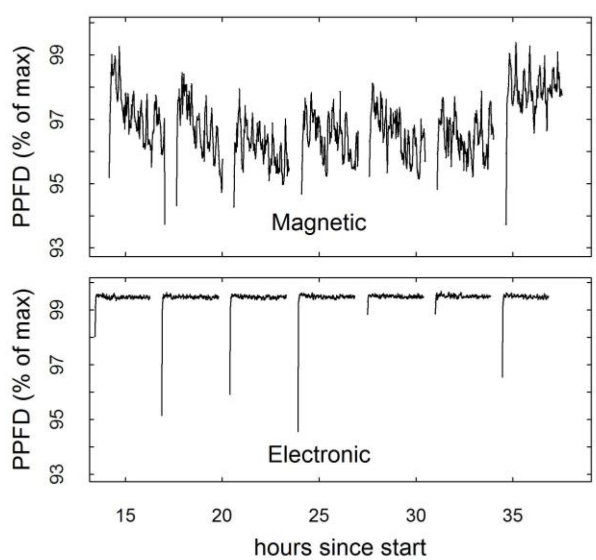
Electronic ballasts, have a “soft start” feature that should help extend the life of the bulb and fixture. The current to magnetic ballasts jumps up quickly to near its final value. On the electronic ballast, the current slowly increases leading to a more gradual startup (Figure 3).

Figure 3: Start up of Magnetic and Electronic Ballast Fixtures, Amperage and PPFD



Another difference between the technologies is the stability of the output during operation. In spite of the constant input current, the magnetic ballast fixture was 10 times more variable ($\sigma^2 = 6.01$) than the electronic ballast fixture ($\sigma^2 = 0.48$) (Figure 4).

Figure 4: Cycling of Magnetic and Electronic Ballast Fixtures, 1 minute running average



Conclusion

The slow start and steady output of the electronic ballasts likely contributes to the increased longevity of double-ended HPS fixtures.