

December 29, 2015

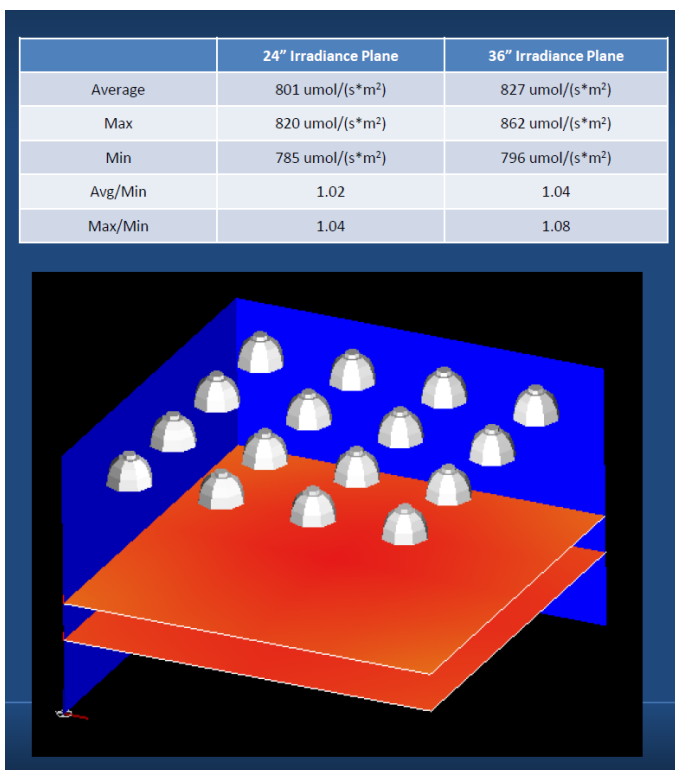
Tim,

Thank you for contacting me about your interest in using Greenbeams 315W CMH lighting. Based upon our conversation here is a recap of your lighting needs:

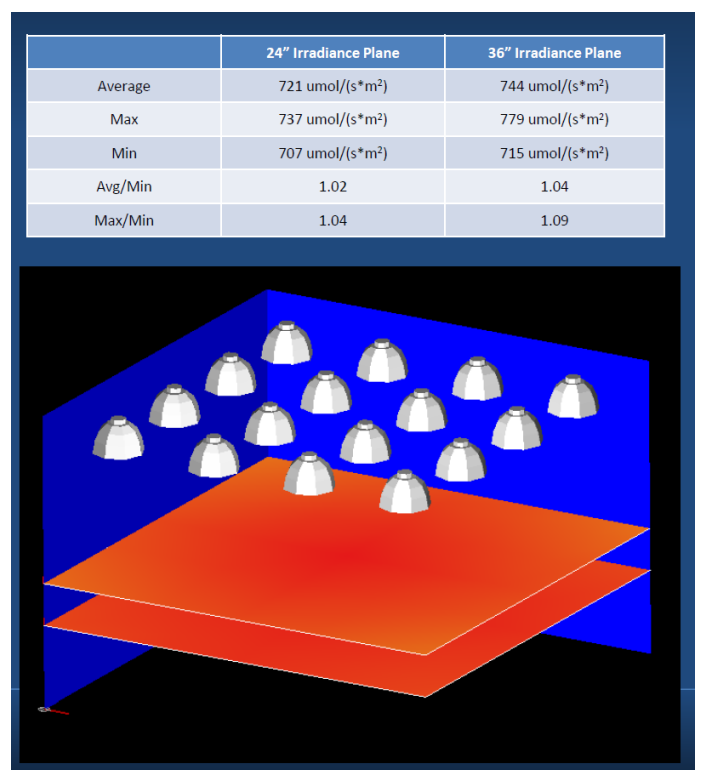
- Room Dimensions: 8x10x8H
- Wall covering: Orca grow film
- Ceiling covering: *Recommend Orca to boost average irradiance and uniformity*
- Average starting canopy height off the floor: 12"
- Average ending canopy height off floor: 64"
- Target Minimum average intensity at 12" off the floor: 500 PPF ( $\mu\text{mol}/\text{m}^2/\text{s}$ )
- Target Minimum average intensity at 64" off the floor: 1000 PPF ( $\mu\text{mol}/\text{m}^2/\text{s}$ )

#### **Computer Modeling of 10x10x7H – 97% Specular Reflective Walls**

The average irradiance employing 16 Greenbeams in a 10x10x7H room with 97% reflective specular walls is 801 and 827  $\mu\text{mol}/\text{m}^2/\text{s}$  respectively at 24" and 36" above the floor with the Agro 3100K 315W CMH lamp; and 721 and 744  $\mu\text{mol}/\text{m}^2/\text{s}$  with the 4200K 942 lamp.



**AGRO 3100K 315W CMH Lamp**



**942 4200K 315W CMH Lamp**

Based upon the 3.2% increase in the Average PPF for both the Agro and 942 lamps from 24" to 36", the extrapolated averages at 72" above the floor (20" below Greenbeams) would be 910 PPF for the Agro lamp and 816 with the 4200K.

## Cycloptics Estimator Tool for 10x10x8H – 94% Orca Diffuse White Walls and Ceiling

Cycloptics internal estimating tool for a 10x10x8H room with Orca walls and ceiling calculates that ten and nine Greenbeams operating the 4200K or Agro lamp respectively will deliver wall to wall average irradiance of 525 umol/m<sup>2</sup>/s. The wall to wall estimated average irradiance of 16 Greenbeams at the ending canopy height of 72” off the floor is 1013 and 1132 PPF with the 4200K and Agro lamps respectively.

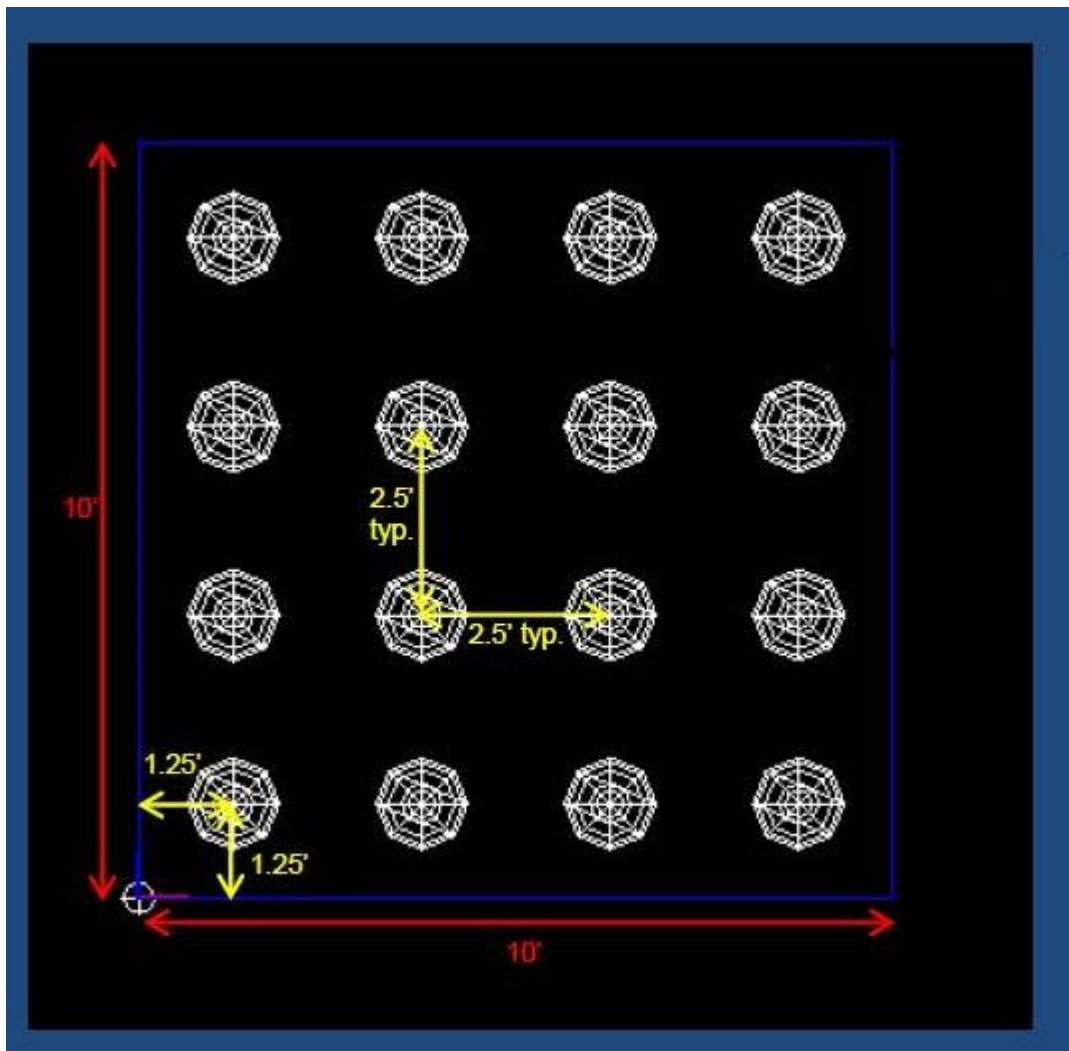
| Inputs                            |               |                          |
|-----------------------------------|---------------|--------------------------|
| Target Plane Width                | 10.0          | feet                     |
| Target Plane Length               | 10.0          | feet                     |
| Ceiling Height                    | 8.0           | feet                     |
| Mounting Height off Floor         | 8.0           | feet-inches              |
| Aperture Distance off Floor       | 7.0           | feet-inches              |
| Canopy Distance Below Apertures   | 72            | inches                   |
| Minimum Avg PPF Target            | 500           | umol/(s*m <sup>2</sup> ) |
| 315W Lamp CCT                     | 4200K         | 942 Lamp                 |
| Greenbeams umol/s Output          | 501           | umol/s each              |
| Wall Covering                     | Diffuse White | Orca                     |
| Wall Reflectivity                 | 94%           |                          |
| Ceiling: Diffuse White            |               |                          |
| CALCULATIONS                      |               |                          |
| Target Efficiency - High Estimate | 1.39          |                          |
| Target Efficiency - Low Estimate  | 0.98          |                          |
| Target Plane Area                 | 9.3           | m <sup>2</sup>           |
| Desired Flux                      | 4645          | umol/s                   |
| OUTPUT - HIGH ESTIMATE            |               |                          |
| Number of Greenbeams              | 7             |                          |
| Approximate Avg PPF               | 523           | umol/(s*m <sup>2</sup> ) |
| OUTPUT - LOW ESTIMATE             |               |                          |
| Number of Greenbeams              | 10            |                          |
| Approximate Avg PPF               | 527           | umol/(s*m <sup>2</sup> ) |

| Inputs                            |               |                          |
|-----------------------------------|---------------|--------------------------|
| Target Plane Width                | 10.0          | feet                     |
| Target Plane Length               | 10.0          | feet                     |
| Ceiling Height                    | 8.0           | feet                     |
| Mounting Height off Floor         | 8.0           | feet-inches              |
| Aperture Distance off Floor       | 7.0           | feet-inches              |
| Canopy Distance Below Apertures   | 20            | inches                   |
| Minimum Avg PPF Target            | 1000          | umol/(s*m <sup>2</sup> ) |
| 315W Lamp CCT                     | 4200K         | 942 Lamp                 |
| Greenbeams Output                 | 501           | umol/s each              |
| Wall Covering                     | Diffuse White | Orca                     |
| Wall Reflectivity                 | 94%           | Reflectivity             |
| Ceiling: Diffuse White            |               |                          |
| CALCULATIONS                      |               |                          |
| Target Efficiency - High Estimate | 1.58          |                          |
| Target Efficiency - Low Estimate  | 1.17          |                          |
| Target Plane Area                 | 9.3           | m <sup>2</sup>           |
| Desired Flux                      | 9290          | umol/s                   |
| OUTPUT - HIGH ESTIMATE            |               |                          |
| Number of Greenbeams              | 12            |                          |
| Approximate Avg PPF               | 1025          | umol/(s*m <sup>2</sup> ) |
| OUTPUT - LOW ESTIMATE             |               |                          |
| Number of Greenbeams              | 16            |                          |
| Approximate Avg PPF               | 1013          | umol/(s*m <sup>2</sup> ) |

| Inputs                            |               |                          |
|-----------------------------------|---------------|--------------------------|
| Target Plane Width                | 10.0          | feet                     |
| Target Plane Length               | 10.0          | feet                     |
| Ceiling Height                    | 8.0           | feet                     |
| Mounting Height off Floor         | 8.0           | feet-inches              |
| Aperture Distance off Floor       | 7.0           | feet-inches              |
| Canopy Distance Below Apertures   | 72            | inches                   |
| Minimum Avg PPF Target            | 500           | umol/(s*m <sup>2</sup> ) |
| 315W Lamp CCT                     | 3100K         | AGRO Lamp                |
| Greenbeams Output                 | 560           | umol/s each              |
| Wall Covering                     | Diffuse White | Orca                     |
| Wall Reflectivity                 | 94%           | Reflectivity             |
| Ceiling: Diffuse White            |               |                          |
| CALCULATIONS                      |               |                          |
| Target Efficiency - High Estimate | 1.39          |                          |
| Target Efficiency - Low Estimate  | 0.98          |                          |
| Target Plane Area                 | 9.3           | m <sup>2</sup>           |
| Desired Flux                      | 4645          | umol/s                   |
| OUTPUT - HIGH ESTIMATE            |               |                          |
| Number of Greenbeams              | 6             |                          |
| Approximate Avg PPF               | 501           | umol/(s*m <sup>2</sup> ) |
| OUTPUT - LOW ESTIMATE             |               |                          |
| Number of Greenbeams              | 9             |                          |
| Approximate Avg PPF               | 530           | umol/(s*m <sup>2</sup> ) |

| Inputs                            |               |                          |
|-----------------------------------|---------------|--------------------------|
| Target Plane Width                | 10.0          | feet                     |
| Target Plane Length               | 10.0          | feet                     |
| Ceiling Height                    | 8.0           | feet                     |
| Mounting Height off Floor         | 8.0           | feet-inches              |
| Aperture Distance off Floor       | 7.0           | feet-inches              |
| Canopy Distance Below Apertures   | 20            | inches                   |
| Minimum Avg PPF Target            | 1000          | umol/(s*m <sup>2</sup> ) |
| 315W Lamp CCT                     | 3100K         | AGRO lamp                |
| Greenbeams umol/s Output          | 560           | umol/s each              |
| Wall Covering                     | Diffuse White | Orca                     |
| Wall Reflectivity                 | 94%           |                          |
| Ceiling: Diffuse White            |               |                          |
| CALCULATIONS                      |               |                          |
| Target Efficiency - High Estimate | 1.58          |                          |
| Target Efficiency - Low Estimate  | 1.17          |                          |
| Target Plane Area                 | 9.3           | m <sup>2</sup>           |
| Desired Flux                      | 9290          | umol/s                   |
| OUTPUT - HIGH ESTIMATE            |               |                          |
| Number of Greenbeams              | 11            |                          |
| Approximate Avg PPF               | 1050          | umol/(s*m <sup>2</sup> ) |
| OUTPUT - LOW ESTIMATE             |               |                          |
| Number of Greenbeams              | 16            |                          |
| Approximate Avg PPF               | 1132          | umol/(s*m <sup>2</sup> ) |

The optimized fixed mounting positions of the 16 Greenbeams is shown below in the 4x4 array. To deliver the targeted average irradiance of 500 PPF onto the starting canopy 12" above the floor the outside 2 columns of 4 luminaires each can be turned off. The computer modeled wall to wall Avg/Min uniformity of 1.04 will increase to probably 1.40-1.50.



Please give me a call with any questions. I will inform Nate Lipton at Growers House of our conversation and will share this information with him.

Sincerely,

Flip Sheridan