How to design an optimal growroom for your lights

Most people start with a room, and then ask a lighting manufacturer how to position their lights in there. Actually that is a bit the wrong way around: lights with specific reflectors have a very specific throw and field. You can tweak the uniformity and light levels for a room to some degree by changing the positions of the lights and using different reflectors, but you need to be a bit lucky to get an optimal uniformity from scratch.

To position the lighting optimally, lighting manufacturers use special software. It is a fable that a HPS fixture covers square surface. A 4x4 or a 5x5 grid is never optimal for a uniform lighting. To support this article I made three calculations with an industry standard reflector, the Gavita HR96. I made a calculation for 2, 4 and 10 fixtures. You will see that I used a standard measurement of about 1.1x1.8m per fixture for these samples. In reality in a multi-fixture room you can even optimize this, but as a rule of thumb this is a good starting point for a good room dimensional design this reflector. For other reflectors of other manufacturers, that are based on this reflector (even if they look alike), measurements or uniformity figures will be different! As these reflectors are made for overlapping plans we have skipped the single reflector rooms. There are special reflectors available for single fixture rooms.

What is a good calculation?

There are a few important things you need to look for in a calculation.

1. Light levels: average, minimal and maximum levels
2. Uniformity (minimum/average is the standard: a few small peaks are never a problem)
3. What scale is used in a diagram

1. Light levels

Some crops really need very high levels, but it depends on the skill of the grower how high these levels average should be. For a novice grower for example this can be 7-800 µmol s^{-1} m^{-2} average or less, for a savvy grower using CO_2 this can be more than 1000 µmol s^{-1} m^{-2}. For this calculation we went for around 900 µmol s^{-1} m^{-2}. Savvy growers can always boost their fixtures for higher levels and get up to 15% higher levels.

The lowest and highest value should not be far apart, because high peaks of light also come with high peaks of radiant heat. Radiant heat is a percentage of the total output of a lamp. So high intensity light spots have more radiant heat. Always be sharp for peaks that are more than 10% higher than the average levels, specifically in high intensity calculations.

In a smaller room you will probably adjust the distance of your light to the crop. This is a good thing, because the ratio of wall surface compared to floor surface is very high, and you will lose a lot of light to your walls over distance. In large rooms that is not so much an issue: Double the distance to the light will probably only cost you about 8-10% less light, so the lights do not need to be lowered or raised.

2. Uniformity

Uniform lighting creates a uniform crop, specifically if you have many plants. We strive to have at least 90% uniformity in a room. The uniformity percentage is defined as the minimal/average ratio. We calculate this uniformity over the complete room, minus a small perimeter near the walls, as near the walls the light levels have an extreme influence on the average uniformity. It is always better to keep your crop in the middle of the room than to keep them at the walls with a path in-between.

In greenhouses we calculate the uniformity by taking sample grids between 4 lamps in the center of the greenhouse and at the sides. Beware of calculations that only show you a very small sample of a climate room to indicate light levels and uniformity: That is misleading and an incorrect way of calculation climate room uniformity.

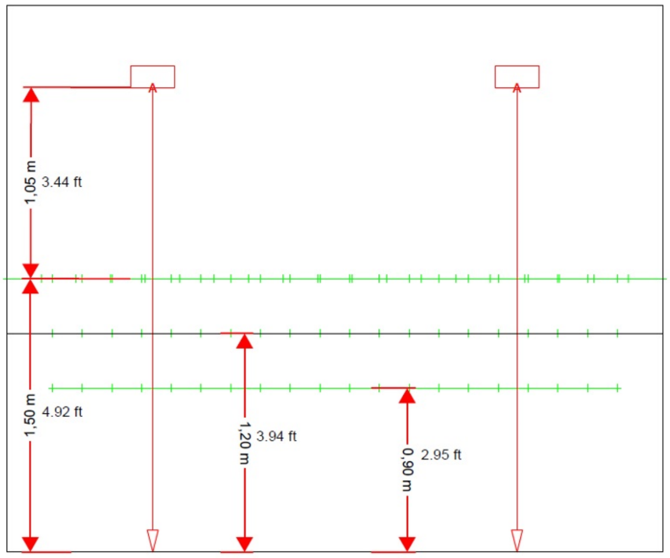
3. What scale is used?

Always look at the scale next to a calculation: it is hard to even measure 50 μmol s^{-1} m^{-2} difference if you check the levels with a meter. A fine scale means more uniformity, though a different calculation can use the same colors in a much wider scale. If every different color stands for 25 μmol s^{-1} m^{-2} difference that is already very uniform and precise.

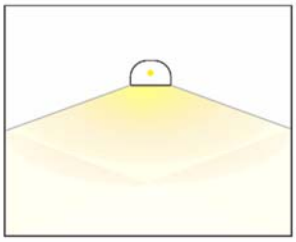
How to read a calculation a calculation

In a calculation we position the lamps at a fixed height. In the example calculations that is 1.05 m / 3.44 ft above the maximum crop height.

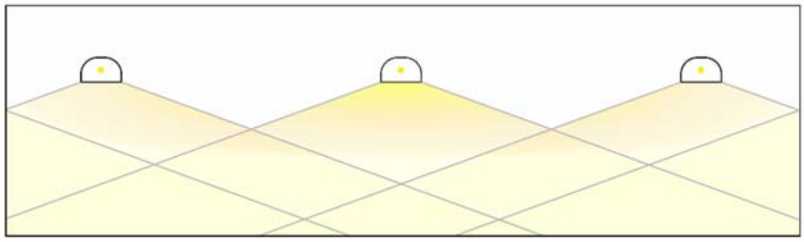
In a small room with just a few fixtures you will see that with more distance to the crop you will lose more light than in a larger room with more lights. When you move further away from a fixture, the light is spread over a larger surface. In a small room that will result in lots of wall losses. How much light you lose over distance you can see in the calculation results for the different crop heights. In these calculations we choose 0,9 m, 1.2 m and 1.5 m as crop height (about 3 ft, 4 ft and 5 ft). These measuring heights you see in the calculation as the green layers, with the measuring points in a grid where the light intensity is calculated.



Let's take a look at how light depreciates in a multi-light room. First of all, you do not *lose* light over distance: you just spread it over a larger surface, decreasing each single fixture light intensity, but enlarging the footprint. In fact the only light you really lose is the light that is not reflected by your walls to your plants (absorbed by the wall) or reflected back into the room where no plants are.



1 fixture: depreciation of light over distance and wall reflection



Multiple fixtures: overlapping light enables vertical light maintenance, less wall losses.

There are two more advantages of using somewhat wider overlapping lights: horizontal penetration and distance to your crop. If you light your plants by a narrow beam from the top you only light the top canopy of leafs. Having light come in at an angle penetrates the plants much better. Remember the sun is also never straight above your plants. A narrow beam (a deep reflector) results in very high intensity light levels in a narrow field. All air cooled reflectors are by definition somewhat deep reflectors, as the light can not exit the glass at a high angle (critical angle is 42 degrees). This results in a need to keep the reflectors at a bigger distance from your plants to get the correct uniformity and light levels.

It is much more difficult to get a good horizontal or vertical uniformity with a deep reflector. Overlapping light also gives you a better vertical uniformity. I can illustrate that by taking the intensity measurements (ppfd) at the different heights in the different rooms:

2 lamps - 2.2x1.8m room

Calculation	Type	Unit	Ave	Min	Max	Min/Ave	Min/Max	Result
0.9m / 3ft	PPFD	µmol	706	635	743	0.90	0.86	Total
1.2m / 4ft	PPFD	µmol	791	718	831	0.91	0.86	Total
1.5m / 5ft	PPFD	µmol	888	823	920	0.93	0.89	Total

4 lamps - 2.2x3.6m room

Calculation	Type	Unit	Ave	Min	Max	Min/Ave	Min/Max	Result
0.9m / 3 ft	PPFD	µmol	772	710	822	0.92	0.86	Total
1.2m / 4ft	PPFD	µmol	848	772	901	0.91	0.86	Total
1.5m / 5ft	PPFD	µmol	923	864	962	0.94	0.90	Total

10 lamps - 5.5x3.6m room

Calculation	Type	Unit	Ave	Min	Max	Min/Ave	Min/Max	Result
0.9m / 3ft	PPFD	µmol	854	779	888	0.91	0.88	Total
1.2m / 4ft	PPFD	µmol	906	820	951	0.91	0.86	Total
1.5m / 5ft	PPFD	µmol	963	889	1008	0.92	0.88	Total

In this table you see the calculated results of the three rooms we discuss. You will see the average, minimal and maximum intensity at a certain height (grid) in a room in the first three data columns. Then you see two quality figures: average uniformity calculated between minimal and average value (so this is the guaranteed average uniformity) and the average uniformity between minimum and maximum value (indicating how far the peaks are apart). 0.92 means 92% uniformity. The Min/Ave uniformity is the basis of the uniformity specification.

The uniformity of a climate room is calculated over the complete room surface, minus a perimeter of less than a foot from the wall. Near the wall the light levels drop, and taking the complete room into account does not give you a good representation of the actual uniformity. Keeping your plants in the middle of the room on rolling benches is the best way to optimize your light utilization.

Really important is also to evaluate the maximum values, because those are your light and infra-red spots in the room. Almost 60% of the energy emitted by a lamp is infra-red. So high light peaks result in high infrared peaks. The peaks should be as low as possible, preferably less than 10% more than the average value you are aiming for.

Now in all rooms I projected one fixture per 2 square meters surface. The uniformity in all rooms is similar, around 92% at all levels of the room. But the light intensities are quite different!

Light losses

Let's evaluate the light levels in the room, starting with the average value at 1.5 m/5 ft high (crop height). Using the same amount of fixtures per surface you see a difference of 75 µmol s^{-1} m^{-2} between the 2 lamp room (888 µmol s^{-1} m^{-2}) and the 10 lamp room (963 µmol s^{-1} m^{-2}). That's 8,5% more light in the 10 lamp room, using the same wattage per square meter.

At the lowest level, 0.9 m/3 ft , the difference is even much bigger: 148 µmol s^{-1} m^{-2} or 20% more light in the large room at that level.

The reason for that difference in losses is caused by your walls. In a small room the ratio wall surface to floor surface is much higher than in a large room. A 1x1m room has a 4:1 wall to floor surface ratio (4 meters of wall to 1 square meter of surface). A 5x5m room has a 1:1.25 wall to floor ratio (20 meters of wall against a 25 square meters of surface) which makes all the difference. More walls mean more losses. Larger rooms are more efficient than small rooms.

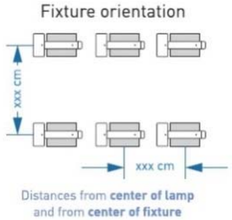
But there is more interesting stuff you can read from this data: Over 2 ft distance you lose 181 µmol s^{-1} m^{-2} in the small room (5 ft intensity minus 3 ft intensity). In the largest room you only lose 109 µmol s^{-1} m^{-2} over that distance. So you see that penetration of light / vertical uniformity of light is much better in a large room. As from 10-20 lamps you can choose to not even lower your lights any more but install them at a fixed height. The bigger the room, the smaller the vertical losses.

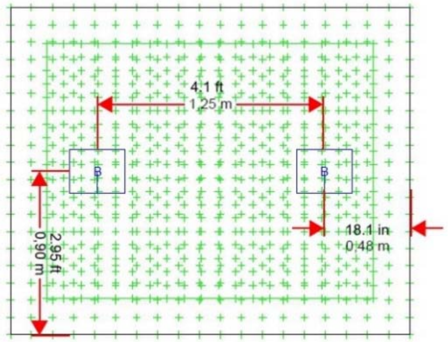
Now for those who scream "inverse square law": as you see it is not suitable to use here. We work with reflectors, overlapping light and reflecting walls, not with naked burning point sources of light.

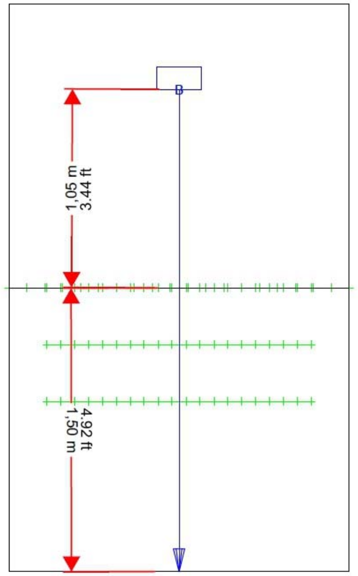
The results

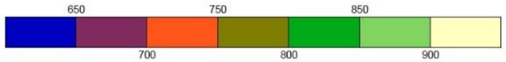
You can see by the spreading of the fixtures in the room that they are not positioned in a 4x4ft or 5x5 ft grid. Horizontal reflectors with horizontal lamps do not have a square field: they are wide and rectangular. Also you can see that the distances between the fixtures are different for every room. The last fixtures are very close to the walls, in order to create uniformity and the right light levels near those walls. The distance between the rows of fixtures and the walls is less than half the distance between the rows of fixtures, because the walls result in light losses as they do not reflect all the light back into the room.

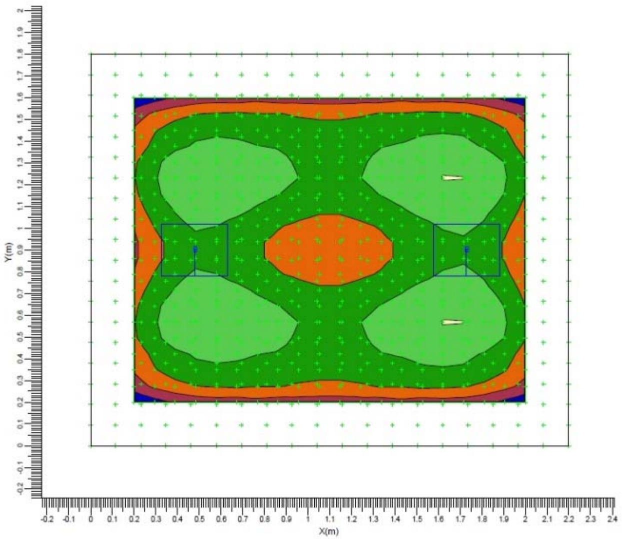
You understand now why you should light rooms instead of rows of plants, and light them completely, to get the right levels of light and the right horizontal and vertical uniformity. The reflective material on your walls is incredibly important when using this type of lighting, as some of that light will be reflected from your walls. Keep a perimeter around your crop and use as much center surface as possible. Think about the type of lighting you are going to use before you design your room. Now the measurements in this article are rules of thumb, but as you see they work very well for the average room. Remember that light equals yield in well maintained climate rooms.

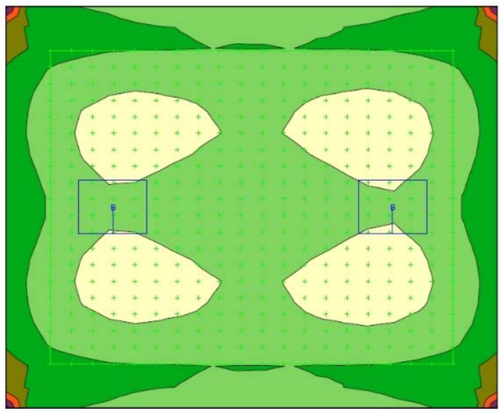






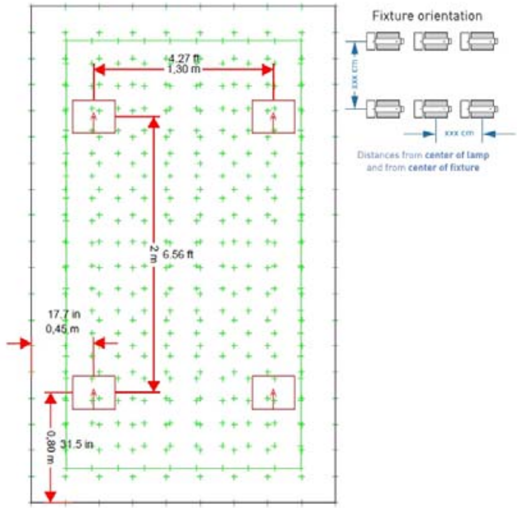


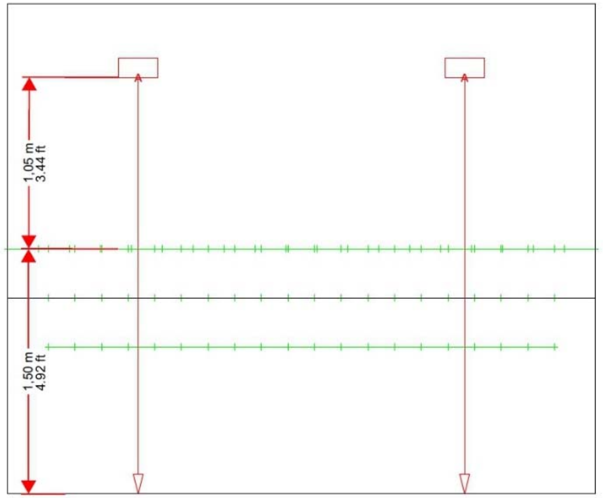


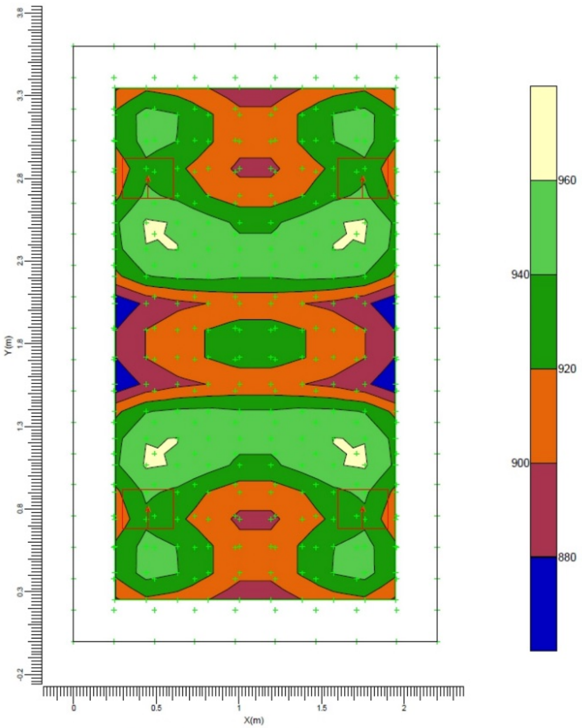


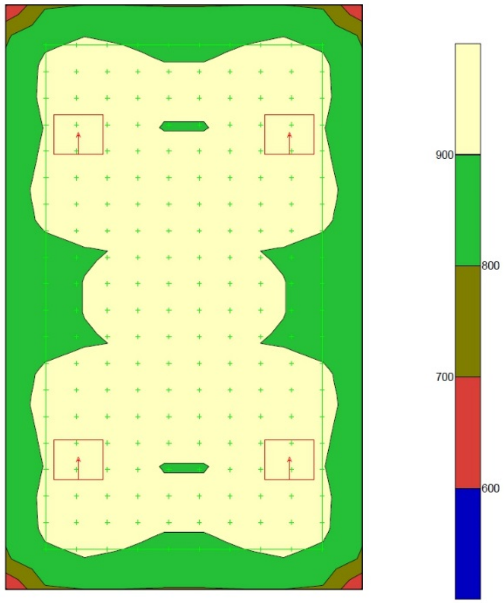
B → Gavita Pro 1000 DE HortiStar HR 96

Average	Minimum	Maximum	Min/Ave	Min/Max	Project maintenance factor	Scale
888	823	920	0.93	0.89	1.00	1:15



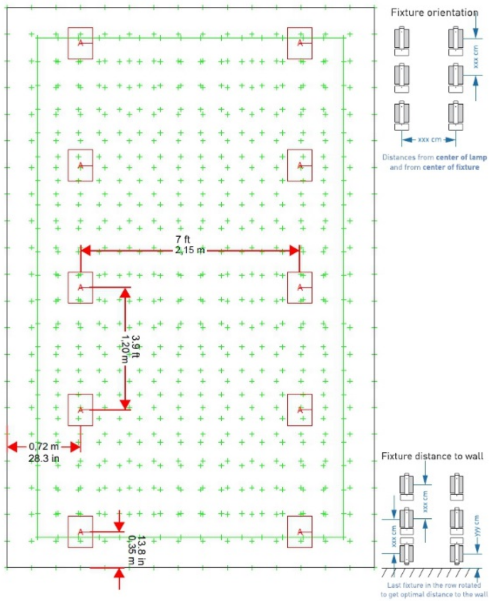


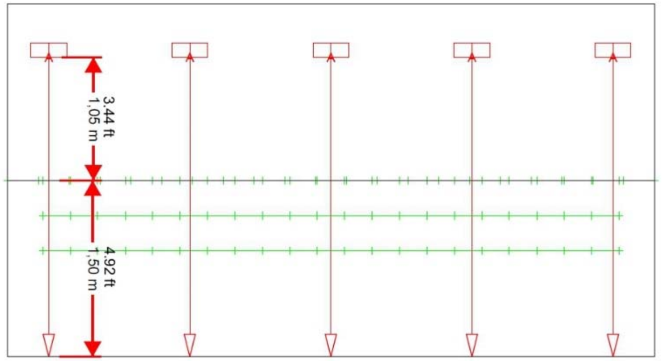


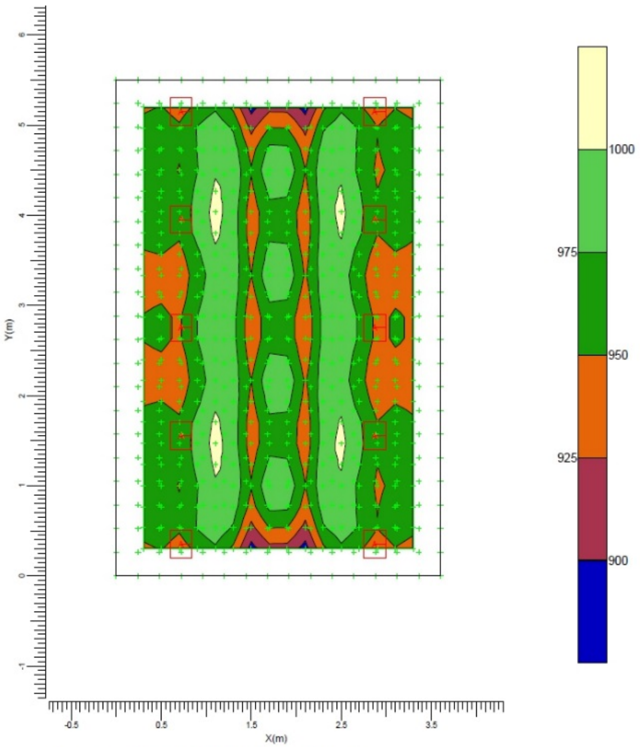


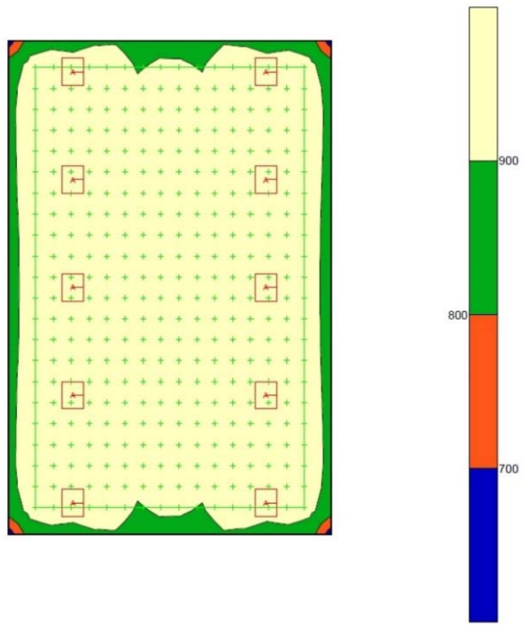
A — Gavita Pro 1000 DE HortiStar HR 96

Average	Minimum	Maximum	Min/Ave	Min/Max	Project maintenance factor	Scale
923	864	962	0.94	0.90	1.00	1:20









A Gavita Pro 1000 DE HortiStar HR 96