Introduction

With the development of urban cities, the room for agriculture is decreasing significantly. Thus, plant growing is gradually shifting from outdoors to indoors. Such changes lead to a new idea of agriculture called hydroponics.

Hydroponics is a method for growing plants using mineral nutrient solutions in water, without soil. It eliminates a majority of destructive effects on plants such as flooding and typhoons. Since hydroponics is usually carried indoor, an artificial light source, growth lamp with the Light-Emitting Diode (LED) technology, is used to provide the light energy to support plant growth.

Overall structure of the lamp

The project aims to design and construct an LED growth lamp for hydroponics. The sufficient and uniform intensity of light with specific wavelengths are the key factors to enhance the growth of every plant and increase the productivity of the hydroponics system. The ultimate goal of the project is to prove that LED growth lamp owns more advantages than the fluorescent lamp in hydroponics.

Implementation Stages

The first stage is LED pattern design stage, in which we use the software “TracePro” design a suitable LED pattern that can emit a uniform light intensity on the plant. This can ensure all the plants receive the same growing condition.

The second design stage is circuit design stage, in which we design a circuit that can connect all the 72 LEDs without exceeding the current limit and able to operate for a long time. The 72 LEDs are divided into six strings, each consists of 12 LEDs. Every two strings of LEDs are connected parallel and controlled by one LED driver.

The third design stage is programming stage, in which we control system including a microcontroller program and an android app to allow Smartphone to control through Bluetooth. The app can control the red and blue light intensity individually. Time function is also included in the control system that the light will automatically switch on and off according to the user setting.

Measurement

The efficient of LED light board was compared with fluorescent lamp in three aspects.

Light intensity

The light intensity is tuned by lux meter, the light intensities of both light source were measured and shown as below.

For LED light board, Mean = 374.42 lux, Standard deviation = 13.14443
For fluorescent lamp, Mean = 374.63 lux, Standard deviation = 10.96259

Energy consumption

For LED light board:
Power used on Red LED = 2.14 × 25.69 = 53.76 W
Power used on Blue LED = 2.14 × 37.69 = 78.94 W
Total Power used = 132.70 W

For fluorescent lamp:
Total Power used = 260 W (lamp) × 8 (lamps)
Energy reduce by LED = 224 W = 52.7% = 40.7%%

Plant mass

12 pairs of plants were chosen with symmetric location from each rank and measured.

Lettuce from LED light source Average of mass : 60.17 g
Average percentage of LED mass of LED over fluorescent light: 

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\text{For LED, the power per average mass} = \frac{224}{60.17} = 3.72 \text{ W/g}
\]

Lettuce from fluorescent lamp Average of mass : 55.57 g

For fluorescent lamp, the power per average mass: 

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\text{For fluorescent, the power per average mass} = \frac{260}{55.57} = 4.59 \text{ W/g}
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Conclusion

This project aims to design and assemble a LED growth lamp with sufficient and uniform light intensity and to prove that LED lamp owns more advantages than the fluorescent lamp in hydroponics system. Although the mass of plant growing under LED is 27.9% lighter, the energy consumed is only 59.2% of fluorescent light and have a 116% light intensity. Also the power required to produce 1 g of plant is less for LED than fluorescent lamp. To conclude, the LED lamp is more effective than fluorescent lamp in the hydroponics system.