# **UCD Lamp for Plant Cultivation**

### Kaixen Co., Ltd.

ecoucdusa

V1505-K

SINCE



V1410

2.0



### 1. Background of Study and Experiment

#### Request from well reputed Bio company

- \* To check UCD Lamp application for overseas vegetable factory project
  - $\rightarrow$  Vinyl house operation for vegetable cultivation
  - $\rightarrow$  To provide extra lighting after sunset during winter
  - → To provide extra lighting during continuous cloudy days
- \* Looking for a lamp having suitable spectrum and energy-saving feature

#### To check the possibility of contribution to vegetable cultivation industry

- \* Near sunlight feature of UCD Lamp
- \* Economical merit of energy-saving with UCD Lamp

#### To prove an opinion in the industry by short-term experiment

(Opinion; Near sunlight, white colored lighting is the best for plant cultivation.)

- \* Start experiment by transplanting lettuce seedlings on nutrient culture beds
- \* Provide 100% artificial lightings in dark space
- \* Compare UCD Lamp and Hi-pressure Sodium Lamp (HPS)

(HPS has been the most popular for greenhouse lighting in the world.)

# 2. Lighting Requirement for Vegetable Factory

#### Technical Viewpoint;

- \* Suitable light spectrum for Photosynthesis and Growth Stages
- \* Optimized light intensity (Lux, µMol/m²/sec)

#### Economical Viewpoint;

- \* Minimize initial investment for depreciation cost
- \* Minimize running energy cost

#### Operational Viewpoint;

- \* 100% Artificial lighting (Urban Vegetable Factory)
- \* Sunlight & Artificial light for extra lighting

(Greenhouse Vegetable Production)

ullet Cost Factors for Vegetable Factory arrow



# 3. Lighting Methods for Plant Cultivation

#### Urban Vegetable Factory with mixed Discharge Lamps



Urban Vegetable Factory with HEFL

![](_page_3_Picture_4.jpeg)

#### Greenhouse with Discharge Lamp

![](_page_3_Figure_6.jpeg)

#### Urban Vegetable Factory with LED Lamps

![](_page_3_Picture_8.jpeg)

### 4. Lighting Principles for Plant Cultivation

- Basically plants require whole visible light spectrum.
- Depending on the color of light, the effect of plant growth differs.
- Photosynthesis requires mainly Orange-red ray, 640~690 nm.
- Proper growth and formation of leaves require Indigo-blue ray, 420~470 nm.
- In case of 100% artificial light application, in order to save energy cost, Red and Blue parts of light spectrum are used by mixing with specific ration.

![](_page_4_Figure_6.jpeg)

#### \* Light Spectrum Overview

![](_page_4_Figure_8.jpeg)

#### \* Major Spectrum for Plant Growth

### 5. Lamp selection Guide-line for Vegetable Cultivation

For both vegetable factory (100% artificial lighting) and greenhouse (extra lighting), it is necessary to check characteristics and performances of lamp to be installed. Basic points to be checked are as follows.

#### • Spectrum Characteristic of Lamp

No plant grows properly only with one type of wave-length. For example, if you cultivate vegetable only with red light, the vegetable still grows but it never grows properly as a commercially acceptable vegetable. It is same with blue light only.

Even though it looks growing well but it is a succulent growth resulting in straggly, weak and thinstemmed status.

As a result of various experiments, it becomes obvious that the light spectrum for plant cultivation must be wide enough having all the visible light wavelengths.

The most suitable light for plant cultivation must be sunlight-like white ray which contains all visible colors evenly.

#### • Light Intensity

In case of 100% artificial light for plant cultivation, the light intensity must be 30~150 µmol/m²/sec. In case of extra lighting after sun-set, the light intensity should be 2~15µmol/m²/sec. But for the purpose of growing leaves only by delaying flower stalk, lower intensity of light can be effective.

### 6.Required Illuminance for Photosynthesis

![](_page_6_Picture_1.jpeg)

#### \* Reference; Sunlight on sunny day is 20,000 ~ 100,000 Lux, Sunlight on cloudy day is 10,000 Lux

Plant	Light Saturation Point	Light Compensation Point			
Tomato, Water melon	70,000 Lux (847 µmol/m²/sec)	3,000 Lux (36 µmol/m²/sec)			
Cucumber	55,000 Lux (665 µmol/m²/sec)	2,000 Lux (24 µmol/m²/sec)			
Lettuce, Paprika	25,000 Lux (302 µmol/m²/sec)	1,500 Lux (18 µmol/m²/sec)			
Ginseng	12,000 Lux (145 µmol/m²/sec)	500 Lux (6 µmol/m²/sec)			

#### \* Light Saturation Point;

As light intensity continues to rise, the rate of photosynthesis rises until a plateau is reached. Any further increase in light intensity has no effect on the rate of photosynthesis. The light intensity at which the plateau is reached is called the light saturation point.

#### \* Light compensation point;

The point is the amount of light intensity on the light curve where the rate of photosynthesis exactly matches the rate of respiration of the plant. At this point, we can say that the plant can not grow further by photosynthesis.

![](_page_6_Figure_8.jpeg)

재배작물	광포화점Ix(PPFD)	광보상점Ix(PPFD)
토마토, 수박	70,000 lx (847)	3,000 lx (36)
오이	55,000 Ix (665)	2,000 lx (24)
완두콩	40,000 Ix (484)	2,000 lx (24)
양상추, 피망	25,000 lx (302)	1,500 lx (18)
포도	40,000 lx (484)	400 lx (5)
귤	40,000 Ix (484)	200 Ix (2.5)
ың	40,000 Ix (484)	300 Ix (3.6)
복숭아	40,000 Ix (484)	400 Ix (5)
무화과	40,000 Ix (484)	1,000 lx (12)
세인트폴리어	5,000 lx(60)	500 Ix (6)
난종류	10,000 lx (121)	300 Ix (3.6)
시클라멘	15,000 lx (181)	300 Ix (3.6)
인삼	12,000lx (145)	500 lx (6)

### 7. UCD-XENON – FUTURS, ULTRA POWER-SAVING

- Reference from Sesame Industry Association
- Required illuminance to extend daylight;
  - \* 10 ~ 100 Lux; Effective range
  - \* 10 ~ 50 Lux; Starting range
  - \* Higher than 100 Lux; Completely effective
- \* Equating with natural sunlight (Color Rendering Index; 94 Ra)
- \* Wider light spectrum to cover whole visible light wavelength; 360 ~ 700 nm  $\frac{1}{2}$
- \* Supreme Energy-saving (Efficiency 120 Lm/W)
  - \*  $\rightarrow$  Doubled efficiency comparing to LED Lamp
  - \*  $\rightarrow$  Metal-halide Lamp 250W can be retrofit with UCD Lamp 150W.
- \* Instant ON and instant re-strike for easy management
  - \* → Hi-pressure Sodium Lamp takes 7 minutes to get stabilized and needs 10 minutes for re-strike.
- \* Best light source in cold weather conditions (Instant ON at -50° C)

### 7. UCD-XENON – FUTURS, ULTRA POWER-SAVING

ecoucd

- 1 UCD -Xenon, Ultra Constant Discharge
- 2 Excellent Instant Energy Saving = 60% 87%.
- 3 94 +RA Color-Index Near Natural Sunlight.
- 4 Enhances Visual Appel & Security 8 colors of rainbow are 94% near Sunlight.
- 5 Dual-Lamps Bulbs for maximum redundant operation number one on the world..
- 6 Smart Sensor correction on the entry of the ballast.
- 7 World's FIRST intelligent digital AC ballast only for UCD-ECL-Xenon lamp..
- 8 Voltazh operation European standard = 180 Volt 265 Volt.
- 9 After 14 years or 50,000 hors work, the lamp lose 25% the power of shining, and recommended to be replaced.
- 10 UCD-Xenon is retrofit on existing fixtures if the existing the IP = 65.
- 11 UCD is 100% Green Energy.
- 12 GREEN & Eco-friendly with fraction of mercury < 0.01 mg, much lower the standard World requirements.
- 13 UV blocking lamp for protection from bad UV rays.
- 14 Wider operating temperature range -35 Grade through +65 Grade Celsius.
- 15 Lower generation of Heat, minimal Insect attraction.
- 16 Highest World leader efficiency on the green energy revolution next 100 years = 91%.
- 17 Kaixen-Xenon-Kaiser is the ONLY primary lamp on World Cars Industries.
- 18 Columns UCD Lamps distance = 40 m, height of columns = 11 ~ 12 meter.
- 19– Lighting loss between columns is < 0.05 Count/meter, insignificant = ~ 700 n/m (nano/meter)

![](_page_8_Figure_21.jpeg)

#### The World's Best Lifetime & Luminous Flux

- 20 UCD have 120 Luminum/watt
- 21 Lifetime hours work = 50,000
- 22 Instant-ON and HOT re-strike = 1-20 sec
- 23 Lower Maintenance & Replacement Cost = Zero.
- 24 UCD is 4,500 5000 Kelvin.

### 8. Features of UCD for Plant Cultivation

- Equating with natural sunlight (Color Rendering Index; 94 Ra)
- Wider light spectrum to cover whole visible light wavelength; 360 ~ 700 nm
- Supreme Energy-saving (Efficiency 120 Lm/W)
  - $\rightarrow$  Doubled efficiency comparing to LED Lamp
  - $\rightarrow$  Metal-halide Lamp 250W can be retrofit with UCD Lamp 150W.
- Instant ON and instant re-strike for easy management
  - $\rightarrow$  Hi-pressure Sodium Lamp takes 7 minutes to get stabilized and needs
    - 10 minutes for re-strike.
- Best light source in cold weather conditions (Instant ON at -50° C)

### 9. Available Light Sources Comparison

![](_page_10_Picture_1.jpeg)

Light Source	Incandescent Fluorescent Bulb Lamp		Hi-pressure Sodium Lamp	LED Lamp	UCD Lamp	
Efficiency (Lumen/W)	15	15 37		70	120	
Lifetime (Hrs)	1,000	3,000	8,000	20,000	50,000	
Color Rendering (Ra)	100	60	65	70	94	
Merit	• Low cost	• Easy     • Low cost     procurement     • Low cost		•Various Color	<ul><li>High efficiency</li><li>Near Sunlight effect</li></ul>	
Demerit	rit • Extremely low efficiency •Extremely short lifetime		<ul> <li>Low efficiency</li> <li>No instant On</li> <li>No instant re-strike</li> </ul>	<ul> <li>High cost</li> <li>Weak against moisture</li> <li>Whole module replacement for service</li> </ul>	• No reference for plant cultivation	

### 10. Applicable Luminaires for Greenhouse & Warehouse

![](_page_11_Picture_1.jpeg)

![](_page_11_Picture_2.jpeg)

# 11. Applicable Street Light & Security Light

#### Replacement with UCD street lights on a bridge road with 11 lanes (72% saved)

![](_page_12_Picture_2.jpeg)

Before : Natrium 250W(Road)+150W(Sidewalk)=400W

After replaced with UCD 120W

# 12. Installation cases with UCD for plant cultivation

#### Comparison of light in a greenhouse (3 wavelength lamps vs. UCD)

![](_page_13_Picture_2.jpeg)

Model	W	Q'ty	Power Consumption	Remarks		Remarks		Model	W	Q′ty	Power Consumption	Remarks
3 Wavelength Lamp	18W	50EA	900W	<ol> <li>Waste of electric power</li> <li>Lack of amount of light</li> <li>Decrease of yield</li> </ol>		Xen-8 Wavelength Lamp	65W	10EA	650W	<ol> <li>High efficiency</li> <li>Twice the brightness</li> <li>8 wavelength with solar light</li> <li>Increase of yield</li> </ol>		

### 13. Installation cases with UCD for plant cultivation

#### Comparison of lights in a strawberry greenhouse (Incandescent lamps vs. Xen-8 lamps)

![](_page_14_Picture_2.jpeg)

Model	W	Q′ty	Power Consumption	Remarks	Model	W	Q′ty	Power Consumption	Remarks
Incandescent Lamp	60W	40EA	2,400W	<ol> <li>Waste of electric power</li> <li>Suspension of use</li> <li>Low efficiency</li> <li>Decrease of yield</li> </ol>	Xen-8 Wavelength Lamp	65W	6EA	390W	<ol> <li>High efficiency</li> <li>Twice the brightness</li> <li>8 wavelength with solar light</li> <li>Increase of yield</li> </ol>

### 14. Cultivation Experiment

![](_page_15_Picture_1.jpeg)

- Technical support from Jeonju Biomaterial Institute who is running Vegetable Factory
  - \* Support to advise cultivation procedures
  - \* To provide further supports in the future
- Experiment Method
  - \* Vegetable; Lettuce
  - \* Starting; Seedlings transplanted
  - \* Farming beds; Hydroponics
  - \* Location; Dark space in a warehouse
  - \* Lighting type; 100% Artificial lighting
  - \* Method; Comparison between UCD 120W and Hi-pressure Sodium (HPS) 150W
- Comparison Conditions; 2 Beds for same distance and 2 beds for same light intensity
- \* Daily checking made for the growing status monitoring.

Condition	Same	Distance		ensity
Lamp	UCD 120W	HPS (Natrium) 150W	UCD 120W	HPS (Natrium) 150W
PPF	191µmol/m²/sec	337µmol/m²/sec	524µmol/m²/sec	560µmol/m²/sec
Lux	872 Lux	1124 Lux	1925 Lux	1655 Lux
Bed No.	1	2	3	4

### **15. Lamp Spectrum Measurement for Experiment Application**

- Test Lab; Jeonbuk Techno-park
- Test Result Comparison; Spectrum and Color Coordinate

\* UCD Lamp 120W

![](_page_16_Figure_4.jpeg)

#### Same Distance (1m)

UCD 120W, 191µmol/m<sup>2</sup>/sec

![](_page_17_Picture_2.jpeg)

HPS 150W, 337µmol/m<sup>2</sup>/sec

![](_page_17_Picture_4.jpeg)

#### Same Light Intensity

#### UCD 120W, 524µmol/m²/sec

![](_page_17_Picture_7.jpeg)

#### HPS 150W, 560µmol/m²/sec

![](_page_17_Picture_9.jpeg)

# 2nd Day (Aug. 7, 2010 / PM 10:10, 28 Hrs after transplant)

![](_page_18_Picture_1.jpeg)

![](_page_18_Picture_2.jpeg)

![](_page_18_Picture_3.jpeg)

![](_page_18_Picture_4.jpeg)

![](_page_18_Picture_5.jpeg)

![](_page_18_Picture_6.jpeg)

![](_page_18_Picture_7.jpeg)

![](_page_18_Picture_8.jpeg)

![](_page_18_Picture_9.jpeg)

![](_page_18_Picture_10.jpeg)

![](_page_18_Picture_11.jpeg)

![](_page_18_Picture_12.jpeg)

![](_page_18_Picture_13.jpeg)

![](_page_18_Picture_14.jpeg)

Enlarged Photos on following pages  $\rightarrow$ 

### 2nd Day (Aug. 7, 2010 / PM 10:10, 28 Hrs after transplant)

Same Distance (1m)

#### UCD 120W, 191µmol/m²/sec

![](_page_19_Picture_4.jpeg)

![](_page_19_Picture_5.jpeg)

![](_page_19_Picture_6.jpeg)

### 2nd Day (Aug. 7, 2010 / PM 10:10, 28 Hrs after transplant)

#### Same Light Intensity

#### UCD 120W, 524µmol/m²/sec

![](_page_20_Picture_4.jpeg)

![](_page_20_Picture_5.jpeg)

![](_page_20_Picture_6.jpeg)

![](_page_21_Picture_0.jpeg)

![](_page_21_Picture_1.jpeg)

Enlarged Photos on following pages  $\rightarrow$ 

### 3rd Day Morning (Aug. 8, 2010 / AM 08:20, 38 Hrs after transplant)

#### Same Distance (1m)

#### UCD 120W, 191µmol/m<sup>2</sup>/sec

![](_page_22_Picture_3.jpeg)

![](_page_22_Picture_4.jpeg)

HPS 150W, 337µmol/m<sup>2</sup>/sec

![](_page_22_Picture_6.jpeg)

![](_page_22_Picture_7.jpeg)

### 3rd Day Morning (Aug. 8, 2010 / AM 08:20, 38 Hrs after transplant)

#### Same Light Intensity

#### UCD 120W, 524µmol/m²/sec

![](_page_23_Picture_3.jpeg)

![](_page_23_Picture_4.jpeg)

HPS 150W, 560µmol/m<sup>2</sup>/sec

![](_page_23_Picture_6.jpeg)

![](_page_23_Picture_7.jpeg)

![](_page_24_Picture_0.jpeg)

![](_page_24_Picture_1.jpeg)

![](_page_24_Picture_2.jpeg)

Enlarged Photos on following pages  $\rightarrow$ 

### 3rd Day Evening (Aug. 8, 2010 / PM 10:00, 52 Hrs after transplant)

![](_page_25_Picture_1.jpeg)

#### UCD 120W, 191µmol/m<sup>2</sup>/sec

![](_page_25_Picture_3.jpeg)

![](_page_25_Picture_4.jpeg)

HPS 150W, 337µmol/m<sup>2</sup>/sec

![](_page_25_Picture_6.jpeg)

![](_page_25_Picture_7.jpeg)

### 3rd Day Evening (Aug. 8, 2010 / PM 10:00, 52 Hrs after transplant)

#### Same Light Intensity

#### UCD 120W, 524µmol/m²/sec

![](_page_26_Picture_3.jpeg)

![](_page_26_Picture_4.jpeg)

HPS 150W, 560µmol/m<sup>2</sup>/sec

![](_page_26_Picture_6.jpeg)

![](_page_26_Picture_7.jpeg)

![](_page_27_Picture_0.jpeg)

#### UCD and HPS turned off and photos taken under Fluorescent Lamp

![](_page_27_Picture_2.jpeg)

![](_page_27_Picture_3.jpeg)

![](_page_27_Picture_4.jpeg)

![](_page_27_Picture_5.jpeg)

Enlarged Photos on following pages  $\rightarrow$ 

### 4th Day (Aug. 9, 2010 / PM 04:00, 70 Hrs after transplant)

#### Same Distance (1m)

#### UCD 120W, 191µmol/m²/sec

![](_page_28_Picture_3.jpeg)

![](_page_28_Picture_4.jpeg)

HPS 150W, 337µmol/m²/sec

![](_page_28_Picture_6.jpeg)

![](_page_28_Picture_7.jpeg)

### 4th Day (Aug. 9, 2010 / PM 04:00, 70 Hrs after transplant)

![](_page_29_Picture_1.jpeg)

Same Light Intensity

#### UCD 120W, 524µmol/m²/sec

![](_page_29_Picture_4.jpeg)

![](_page_29_Picture_5.jpeg)

HPS 150W, 560µmol/m<sup>2</sup>/sec

![](_page_29_Picture_7.jpeg)

![](_page_29_Picture_8.jpeg)

### 5th Day (Aug. 10, 2010 / PM 10:30, 100 Hrs after transplant)

![](_page_30_Picture_1.jpeg)

![](_page_30_Picture_2.jpeg)

UCD and HPS turned off and photos taken under Fluorescent Lamp

![](_page_30_Picture_4.jpeg)

![](_page_30_Picture_5.jpeg)

![](_page_30_Picture_6.jpeg)

![](_page_30_Picture_7.jpeg)

Enlarged Photos on following pages  $\rightarrow$ 

### 5th Day (Aug. 10, 2010 / PM 10:30, 100 Hrs after transplant)

![](_page_31_Picture_1.jpeg)

Same Distance (1m)

#### UCD 120W, 191µmol/m<sup>2</sup>/sec

![](_page_31_Picture_4.jpeg)

![](_page_31_Picture_5.jpeg)

HPS 150W, 337µmol/m²/sec

![](_page_31_Picture_7.jpeg)

![](_page_31_Picture_8.jpeg)

### 5th Day (Aug. 10, 2010 / PM 10:30, 100 Hrs after transplant)

![](_page_32_Picture_1.jpeg)

Same Light Intensity

#### UCD 120W, 524µmol/m²/sec

![](_page_32_Picture_4.jpeg)

Due to high humidity and no ventilation, fungal infection occurred.

![](_page_32_Picture_6.jpeg)

HPS 150W, 560µmol/m<sup>2</sup>/sec

![](_page_32_Picture_8.jpeg)

![](_page_32_Picture_9.jpeg)

### 6th Day (Aug. 11, 2010 / PM 10:30, 124 Hrs after transplant)

![](_page_33_Picture_1.jpeg)

![](_page_33_Picture_2.jpeg)

One lettuce removed due to fungal infection.

### 7th Day (Aug. 12, 2010 / PM 10:30, 148 Hrs after transplant)

![](_page_34_Picture_1.jpeg)

![](_page_34_Picture_2.jpeg)

![](_page_34_Picture_3.jpeg)

![](_page_34_Picture_4.jpeg)

![](_page_34_Picture_5.jpeg)

### 8th Day (Aug. 13, 2010 / PM 9:00, 171 Hrs after transplant)

![](_page_35_Picture_1.jpeg)

![](_page_35_Picture_2.jpeg)

![](_page_35_Picture_3.jpeg)

![](_page_35_Picture_4.jpeg)

![](_page_35_Picture_5.jpeg)

![](_page_35_Picture_6.jpeg)

![](_page_35_Picture_7.jpeg)

![](_page_35_Picture_8.jpeg)

![](_page_35_Picture_9.jpeg)

![](_page_35_Picture_10.jpeg)

![](_page_35_Picture_11.jpeg)

![](_page_35_Picture_12.jpeg)

![](_page_35_Picture_13.jpeg)

### 9th Day (Aug. 14, 2010 / PM 9:00, 195 Hrs after transplant)

#### \* UCD Lamp down-graded from 120W to 60W to reduce the heat.

![](_page_36_Picture_2.jpeg)

![](_page_36_Picture_3.jpeg)

![](_page_36_Picture_4.jpeg)

![](_page_36_Picture_5.jpeg)

![](_page_36_Picture_6.jpeg)

![](_page_36_Picture_7.jpeg)

![](_page_36_Picture_8.jpeg)

![](_page_36_Picture_9.jpeg)

![](_page_36_Picture_10.jpeg)

![](_page_37_Picture_0.jpeg)

![](_page_37_Picture_1.jpeg)

![](_page_37_Picture_2.jpeg)

![](_page_37_Picture_3.jpeg)

![](_page_37_Picture_4.jpeg)

## 11th Day (Aug. 16, 2010 / PM 11:00, 245 Hrs after transplant)

![](_page_38_Picture_1.jpeg)

![](_page_38_Picture_2.jpeg)

![](_page_38_Picture_3.jpeg)

![](_page_38_Picture_4.jpeg)

![](_page_38_Picture_5.jpeg)

![](_page_38_Picture_6.jpeg)

![](_page_38_Picture_7.jpeg)

![](_page_38_Picture_8.jpeg)

![](_page_38_Picture_9.jpeg)

![](_page_38_Picture_10.jpeg)

![](_page_38_Picture_11.jpeg)

![](_page_38_Picture_12.jpeg)

# 15th Day (Aug. 20, 2010 / PM 7:00, 337 Hrs after transplant)

![](_page_39_Picture_1.jpeg)

![](_page_39_Picture_2.jpeg)

![](_page_39_Picture_3.jpeg)

![](_page_39_Picture_4.jpeg)

![](_page_39_Picture_5.jpeg)

![](_page_39_Picture_6.jpeg)

![](_page_39_Picture_7.jpeg)

![](_page_39_Picture_8.jpeg)

### Daily checking History

![](_page_40_Picture_1.jpeg)

Date	Time	Temp. (°C)	Humi. (%)	Event	Remark
Aug. 6 (Fri)	PM 06:20	28~27	85	Transplanted seedlings	After 12 hours lighting in the night, lettuces under UCD lamp start to lead in the growth.
Aug. 7 (Sat)	PM 10:10	34~28	75	Leaves withered due to extremely high temperature.	Turned off all the lamps to cool down.
Aug. 8 (Sun)	PM 10:00	32~29	55	Gets OK after Lamp turn-off. During day time, temperature rises too high.	Due to high temperature, turned off all the lamps during day time, from PM 12:00 till PM 7:00. (31°C)
Aug. 9 (Mon)	PM 10:00	33~30	67	Temperature rises too high.	Due to high temperature, turned off all the lamps during day time, from AM 7:00 till PM 9:00. (31°C)
Aug. 10 (Tue)	PM 10:30	32~29	85	Temperature rises too high.	One lettuce on bed No. 3 withered due to water shortage.
Aug. 11 (Wed)	PM 11:30	31~29	68	Additional water supplied.	One lettuce on bed No. 3 was removed due to fungal infection
Aug. 12 (Thu)	PM 10:10	32~29	79	Growth becomes slow.	Experiment continued.
Aug. 13 (Fri)	PM 09:00	32~30	79	UCD Lamp for bed No3 down-graded from 120W to 60W to reduce heat.	Due to high temperature, turned off all the lamps during day time, from AM 8:00 till PM 9:00. (32°C)
Aug. 14 (Sat)	PM 08:30	32~31	80	Growth becomes slow.	Found moss on some roots.
Aug. 15 (Sun)	AM 10:00	30~28	94	Found water temperature reaches 32°C .	Replaced all the water and supplied nutrient.
Aug. 16 (Mon)	PM 10:30	28~26	95	Lettuces under UCD grows faster.	Low temperature helps to make growth faster.
Aug. 17 (Tue)	PM 10:00	31~30	80	Make air circulation for the space.	Experiment continued.
Aug. 18 (Wed)	PM 11:00	32~30	87	Leaves withered under HPS lamp.	Withered leaves under HPS lamp became yellowish.
Aug. 19 (Thu)	PM 10:00	33~32	73	Leaves under UCD lamp are OK.	Leaves under UCD are OK in high temperature condition.
Aug. 20 (Fri)	PM 07:00	34~33	68	Completed experiment and checked crops.	Crops under UCD are weighed double of the ones under HPS.

### Photos for Quick-view

![](_page_41_Picture_1.jpeg)

UCD 120W, 1M distance

![](_page_41_Picture_3.jpeg)

![](_page_41_Picture_4.jpeg)

UCD 60W, Same intensity

![](_page_41_Picture_6.jpeg)

HPS 150W, Same intensity

![](_page_41_Picture_8.jpeg)

![](_page_41_Picture_9.jpeg)

![](_page_41_Picture_10.jpeg)

![](_page_41_Picture_11.jpeg)

![](_page_41_Picture_12.jpeg)

On the final day of experiment

![](_page_41_Picture_14.jpeg)

![](_page_41_Picture_15.jpeg)

![](_page_41_Picture_16.jpeg)

![](_page_41_Picture_17.jpeg)

### Final Check & Crop Measurement

![](_page_42_Picture_1.jpeg)

#### **Roots status**

![](_page_42_Picture_3.jpeg)

![](_page_42_Picture_4.jpeg)

![](_page_42_Picture_5.jpeg)

![](_page_42_Picture_6.jpeg)

#### **Crops measurement**

![](_page_42_Picture_8.jpeg)

Biggest under UCD; 53g

![](_page_42_Picture_10.jpeg)

**Biggest under HPS; 25g** 

![](_page_42_Picture_12.jpeg)

Biggest under UCD; 34g

![](_page_42_Picture_14.jpeg)

Biggest under HPS; 23g

![](_page_42_Picture_16.jpeg)

![](_page_42_Picture_17.jpeg)

![](_page_42_Picture_18.jpeg)

![](_page_42_Picture_19.jpeg)

### 16. Crops Data Comparison

#### Weight measurement after completion of 14 days experiment.

Unit; Gram

Conditions	Bed Number		lead Nun	Total	No of	Average				
Contailione		1	2	3	4	5	6	Weight	Head	Weight
Same Distance (1M)	1 (UCD 120W)	53	34	44	39	33	47	250	6	41.7
	2 (HPS 150W)	22	20	19	25	22	17	125	6	20.8
Same Light	3 (UCD 60W)	Fungal infection	28	26	25	23	34	136	5	27.2
Intensity (500µmol/m²/sec)	4 (HPS 150W)	24	23	16	19	21	18	121	6	20.2

![](_page_43_Picture_4.jpeg)

![](_page_43_Picture_5.jpeg)

### 17. Greenhouse Lighting; 665 M<sup>2</sup> Type

- Greenhouse Dimension; Width 7m x Height 3.3m x Length 95m (665 M<sup>2</sup>)
- Illuminance Design;
  - \* Case 1) 100~200 Lux on the ground  $\rightarrow$  For extra lighting after sun-set
  - \* Case 2) Evenly 200 Lux on the ground  $\rightarrow$  For extra lighting after sun-set
  - \* Case 3) Up to 500 Lux on the ground  $\rightarrow$  Additional lighting during cloudy days

![](_page_44_Figure_6.jpeg)

### Greenhouse Lighting Design; Case 1

- Expected illuminance 120~250 Lux on the ground  $\rightarrow$  For extra lighting after sun-set
  - \* Lamp requirement; FDA 60W 20 sets

![](_page_45_Figure_3.jpeg)

# Greenhouse Lighting Design; Case 2

Subscript Expected illuminance 200~250 Lux on the ground  $\rightarrow$  For extra lighting after sun-set

\* Lamp requirement; FDA 60W 40 sets

![](_page_46_Figure_3.jpeg)

# Greenhouse Lighting Design; Case 3

- UD
- Expected illuminance 250~430 Lux on the ground  $\rightarrow$  For additional lighting during cloudy days
  - \* Lamp requirement; TNB 120W 40 sets

![](_page_47_Figure_4.jpeg)

## Greenhouse Lighting; 1235 M<sup>2</sup> Type

- Greenhouse Dimension; Width 13m x Height 4.7m x Length 95m (665 M<sup>2</sup>)
- Illuminance Design; 100~200 Lux on the ground  $\rightarrow$  For extra lighting after sun-set

![](_page_48_Figure_3.jpeg)

### **Greenhouse Lighting Design**

![](_page_49_Picture_1.jpeg)

- Expected illuminance 90 ~ 248 Lux on the ground  $\rightarrow$  For additional lighting during cloudy days
  - \* Lamp requirement; FDA 60W 32 sets

![](_page_49_Figure_4.jpeg)

## Warehouse Lighting; 1000 M<sup>2</sup> Type

- Warehouse Dimension; Width 20m x Height 9m x Length 50m (1000 M<sup>2</sup>)
- Illuminance Design; More than 90 Lux on the floor  $\rightarrow$  For storage management and inspection

![](_page_50_Figure_3.jpeg)

### Warehouse Lighting Design

![](_page_51_Picture_1.jpeg)

- Lamp Installation Height; 4.5m
- Expected illuminance 90 ~ 130 Lux on the ground
  - \* Lamp requirement; FDA 60W 16 sets

![](_page_51_Figure_5.jpeg)

## Roadway Lighting Design

![](_page_52_Picture_1.jpeg)

- Main Entrance Road; Width 6m x Length 60m
- In-site Road; Width 6m x Length 1,600m
- Illuminance Design;
  - \* Main Entrance; Height 9m, Max 80 Lux
    - → Street Light Type; STB 120W 6 sets
  - \* In-site Road; 40m span, Height 6m, Max 16 Lux
    - → Security Light Type; SCB 60W 40 sets

![](_page_52_Figure_9.jpeg)

#### 53

# 18. Application: UCD Solution for Urban Vegetable Factory Layout & Features Multiple Shelf Type → Suitable for Urban Vegetable Factory with minimum space Inclined Farming Bed → Easy management on visible site / Labor-saving bed structure Side lighting UCD Lamp → Energy-saving with minimum number of lamp System Concept

![](_page_53_Picture_2.jpeg)

![](_page_54_Picture_0.jpeg)

### Ultra Power-saving Green Growth with CO<sup>2</sup> Reduction Eco-friendly Product

![](_page_54_Picture_2.jpeg)

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![](_page_54_Picture_4.jpeg)