



LEDStormTM

Advanced LED Technology • Customer-Driven Solutions



LEDStorm™

LEDStorm™ EMS Technologies

LEDStorm™ Introduction **0.0**

Grow Spectrum Light w/ EMS Technology **1.0**

EMS Light Energy Theory **1.1**

Grow Spectrum Light **1.2**

Light Comparison Testing **1.8**

Test Results **1.12**



The story of **LEDStorm**'s revolutionary LED lighting systems has its roots in the entertainment industry.

The company was founded in 2007 in Cambridge, Massachusetts, by the partnership of Scott Gordon (CEO and Founder/Inventor), a graduate of Boston University with 20 years of lighting experience from the film and video industry (IATSE 477) and Michael Short (Co-founder/Inventor), a nuclear engineer from MIT who brought an innovative approach to electrical engineering. With the assistance of MIT's media lab, "hobby shop" facilities and mentoring program,

LEDStorm produced its first entertainment industry lighting instrument in 2008 and soon commercially deployed an array of cutting-edge lighting devices for the film, television and music industries to wide professional acclaim.



LEDStorm™

EMS Technologies Division
Grow Spectrum Lighting
w/ EMS Technology

EMS Light Energy Theory

(Scott L Gordon, 2010)

Electromagnetic Spectrum (EMS) energy is created by wavelengths generated by the invisible light spectrum. Visible light also has electromagnetic properties, however its shorter wavelengths are weaker and less penetrative. The stronger energy of these invisible spectrums, interacting with the visible spectrum, alter the characteristics of the waves of their visible counterparts, and when coupled with the different colors of the visible spectrum, creates a delivery system that increases the penetrative values of the lesser wavelengths.

Electromagnetic Spectrum (EMS) energy reacts with the physiology of humans, animals, and plants. These deep penetrating wavelengths, generated by the invisible spectrum, that in nature are relevant during the day and night, actually excite molecular activity...

The LEDStorm lighting system is a more efficient and natural approach to lighting; different from HID lighting, and different from other LED lighting systems. In the **LEDStorm** system we are utilizing a unique blend of invisible spectra on the Infrared range. This blend of higher nanometer ranges actually interacts with the visible spectra present in the fixture, and alters the characteristic of their wavelengths. The EMS wavelength energy emitted from the **LEDStorm** system is penetrating through the entire plant, right through the soil, and into the root system. When utilizing EMS technology, micro-moles (photons of light passing through a given area) and Photosynthetically Active Radiation (PAR) analysis are not enough alone. It is actually the coupling of these different energy sources that are relevant to a more efficient means of affecting the growth performance of any given plant.

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”



▲ **LEDStorm Grow Spectrum Light**
▼ w/EMS Technology



Plug-n-Grow:

- 12"x12"x1 1/2" Panel
- Removable front acrylic high transmittance shield.
- Conformal Coated PCB is resistant to water and high humidity.
- Performs well in hot and cold conditions
- Producing no significant heat, allows for closer proximity to plants with less de-hydration resulting in more efficient water usage. Generally better for C3 Plants.
- Suitable for all growth phases
- Covers up to a 5'x5' (25 square foot) area
- 60watts
- Plug in Power supply
- Line-in Voltage: 100-240vac (higher voltages available upon request, additional cost applies)
- Line-out Voltage: 24/48vdc (12vdc upon request)
- 40kHz-will not interfere with other electronic equipment

Visit our website for complete performance and technical data: www.LEDStorm.com

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”



Pipe Mounting Clamp



Bail Block



Adjustable Hanger Yo-Yo's

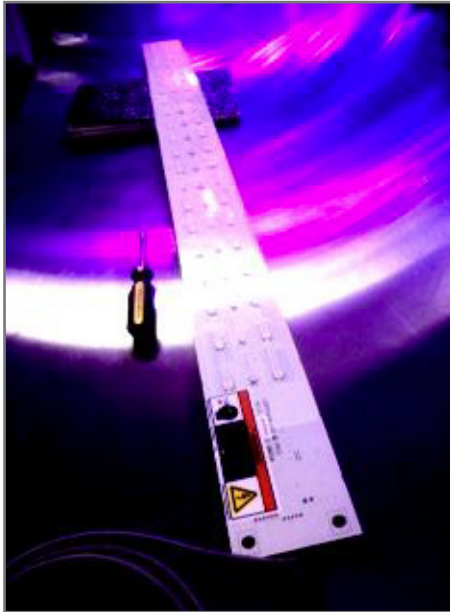
Plug-n-Grow (cont):

- 60 Diode Array: Full Spectrum White (Daylight source), Red, and EMS (Electromagnetic Spectrum) blended Invisible spectrum. The LEDStorm Grow Spectrum emits a unique wavelength energy field that penetrates through the entire plant, through the soil, right into the root system, interacting with the plant's physiology in ways other lights cannot. The visible spectrum also produces a natural looking source that will not distort the appearance of your plants and creates a more pleasant working environment.
- Fixture comes with your choice of: Bail Block, Pipe Clamp, or Adjustable Hangers (Yo-Yo's).
- Fixture Weight (with rigging): 3Lbs 2 ounces

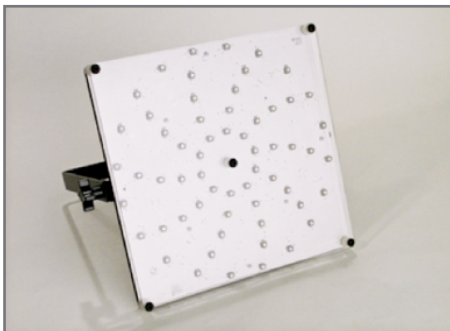
Visit our website for complete performance and technical data: www.LEDStorm.com

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”



Custom Arrays of Growing LED Panels Are User-Optimized for Plants & Algae.



LEDStorm can also provide complete turn key solutions to any grow operation, no matter what the size. **LEDStorm's** first grow system was developed, in 2011, at the request of algae producers seeking a practical, low-energy solution for very challenging grow lighting applications under water, **LEDStorm Grow Solutions** represent the most versatile, energy efficient, plant growth promotion system available.

Our commercially proven, user-friendly control system, and multi-frequency, user-tunable LED fixtures, allow indoor growers to adjust outputs to optimize production conditions and biomass increase for any plant species.

LEDStorm can meet all the lighting demands of any greenhouse, indoor grow, hydroponics, or algae production system (including 100% submerged applications). Energy savings are enormous compared to conventional greenhouse, or indoor grow operations, lighting using HID lamps.

Visit our website for complete performance and technical data: www.LEDStorm.com

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”



Multi Channel Power/Controller

LEDStorm Multi Channel Power/Controller System. The multi-control ballast system, 10 channel model, can be plugged into any household (110vac-264vac) power outlets. The 30 and 50 channel models, for large industrial applications operate on a Line-in AC voltage of 110vac-530vac. All three, 19" rack mountable, controllers can accommodate Line-out DC voltages of 12vdc, 24vdc, and 48vdc. LEDStorm's versatile control system can be operated locally or by remote, and it can control all fixtures simultaneously, individually, or in any combination the operator desires.

- Can handle up to 350 foot cable runs
- The shielded cable is available in 25', 50', and 100' lengths



Back of Controller System

The easy to move control system can be integrated into any environment, including the warm temperatures and high humidity of greenhouse environments. The control system will not interfere with the frequencies of any other present operating systems.

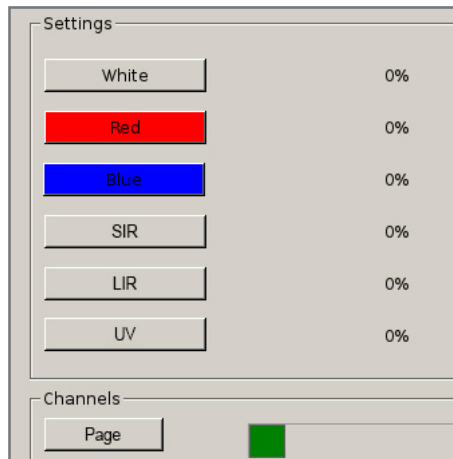
- Operating temperatures range from minus 20°C (-4°F) to plus 43°C (110°F).

The multi channel controllers are designed to be daisy-chained so the grow system can be configured for any size installation. The graphic user interface (GUI) for the control system, comes with a LCD, touch screen, color monitor (7" Wide (16:9)), but can be integrated into most any control system desired. The system will control any of our available grow light fixtures.

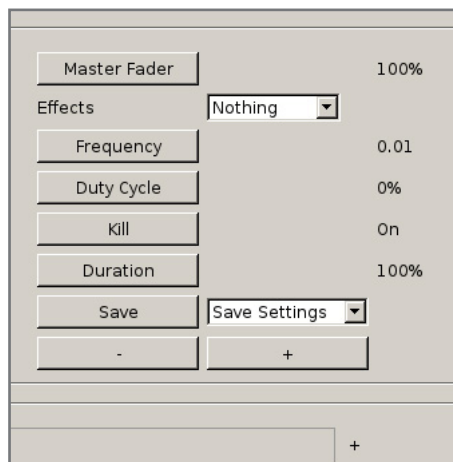
Visit our website for complete performance and technical data: www.LEDStorm.com

LEDStorm™ Grow Spectrum Light (with EMS Technology)

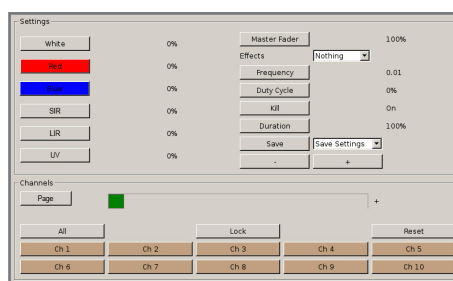
“A New Natural Approach to Lighting”



Touchscreen Controller Settings UI



Touchscreen Controller Effects UI



LEDStorm Touchscreen LCD Monitor

The control box's touch screen control monitor displays a menu of all functions and the following settings:

- Colors: red, green, blue, daylight (5,600K)
- Short infrared
- Long infrared
- Ultraviolet (upon request)
- % of light Intensity (via the dimmer)
- Frequency and Duty Cycle (associated with the pattern and frequency)
- Preset Effects (strobe, chase sequences, timed intervals)
- Manual
- Master Fader (allows any combination of colors or effects to be manually dimmed simultaneously)
- Kill Switch
- 10 Open Custom Presets (so the operator can save their own desired settings) – more if desired
- If the unit is powered down, or loses power unexpectedly, an internal memory chip maintains all the current settings.

Visit our website for complete performance and technical data: **www.LEDStorm.com**

LEDStorm™ Grow Spectrum Light (with EMS Technology)

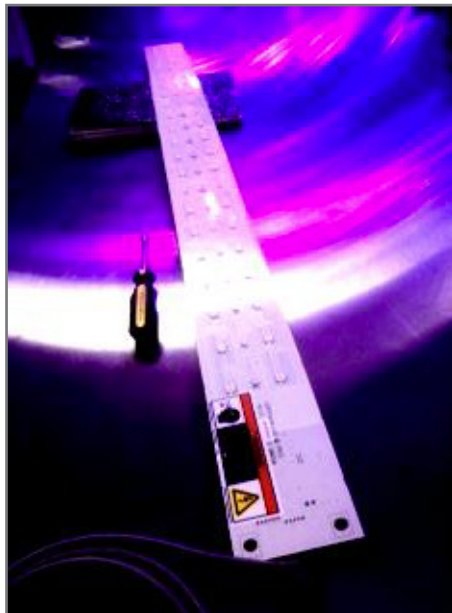
“A New Natural Approach to Lighting”



PL11GR LEDStorm Grow Panel

PL11GR LEDSTORM GROW PANEL is a 12" by 12" (30.5 cm x 30.5 cm) square grow panel that incorporates LEDs with a 130° angle (red, green, blue, short infrared, long infrared, and daylight (5,700K). UV is available upon request.

PL12 PANEL GROW LIGHT measures (3" x 43" (7.6 cm x 109.2 cm) and is also available in 6" x 22" (15.2 cm x 55.9 cm). It has the same features as the PL11GR but a more slender profile making it ideal for tube enclosures for underwater applications. It also has a larger footprint than the **PL11GR** that allows for the addition of ultraviolet LED sources if desired.



PL12 Panel Grow Light

Custom design and installation for any grow application, including an adjustable grid system that allows height and directional adjustments, are part of the **LEDStorm** customer commitment. All of our growth products and components are fully warranted for 5 years. Every system is 100% end-user tunable to optimize growing settings for any species of plant or algae. **LEDStorm** continues to conduct research to establish optimized settings for more and more commercially grown species of plant crops and algae.

*Visit our website for complete performance and technical data: **www.LEDStorm.com***

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Light Comparison Testing

Spokane, WA

Conducted by:

Jill Clapperton, PhD

April 12-15th 2016

This was a test to show that the **LEDStorm PL11**, 60w (Grow Spectrum Light w/EMS Technology), with its special array, can be used in a growth room to promote plant growth - similar to, or better than, conventional lighting (Gavita Pro 1000 DE, 1000w).

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

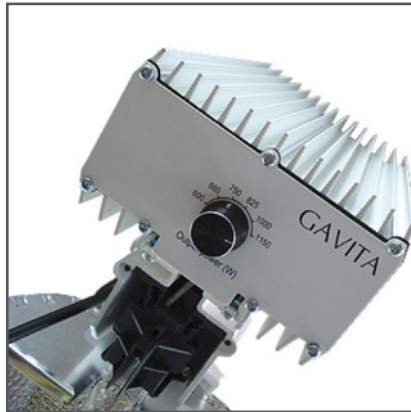
Experimental Materials and Conditions

- We chose to use vegetative plants, C3 (GG4), in matching 5 gal soil medium. Plants were watered the same.
- One variety where both plants were of similar size, age, and condition. Both plants were grown, previously, under a HID light source, Gavita Pro 1000 DE (850w)
- 2 treatments: 1. **control** – conventional, HID Light (Gavita Pro 1000 DE, 1000w), and 2. **LED-** Light (LEDStorm PL11, 60w)
- Proximity to the lights: control-36”, LED 18” from tallest point of each plant, and kept in separate rooms (8’x6’) to avoid light bleed from either source. The positions of each light allow for their respective optimal performance.

LEDStorm™ Grow Spectrum Light (with EMS Technology) “A New Natural Approach to Lighting”

Experimental Materials and Conditions (cont)

Control: *(Gavita Pro 1000 DE) 1000w*



LED: *LEDStorm PL11, 60w*
(Grow Spectrum Light w/ EMS Technology) w/EMS Technology

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Procedure (Measurements)

After 24 hours of exposure:

A plant leaf from the top whorl, mid whorl, and bottom whorl of leaves from the control and LED plant were sampled. The leaves, and the leaves petioles (small stem directly attached to the leaf), were analyzed by a portable X ray fluorescent spectrometry (PXRF) using a Bruker Tracer SD III for both Macro and Trace elements. The Tracer demonstrates immediate results in real time. The spectra were compared, and are shown in the following slides. Ca and Zn (particularly Zn) are critical elements in plants for the synthesis of chlorophyll, promoting photosynthesis.

- To analyze sugar content, the same leaves were extracted and the dissolved solids measured by Refractometer (Brix).
- C3 or cool season plants accumulate sugars in their leaves while they are photosynthesizing and then dump them to the roots to keep actively photosynthesizing.

NOTE: This perhaps makes conditions more advantageous to have a light source with less heat. Let temperatures be regulated entirely by climate control.

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Hypothesis

By measuring the difference between the elements in the petiole (small stem directly attached to the leaf) and leaf of each plant we can effectively demonstrate how the EMS energy created by the LEDStorm light promotes better distribution of essential elements through the entire plant as compared to traditional HID lighting. Plants with high differentials are limited and will slow down the movement of food and water through the leaf. If the leaf is actively growing it will be moving food and water into the leaf and there will be very little in the petiole and most of the essential elements will be in the leaf. This is vital to the overall health and growth rate of the plant.

Results

Refractometer (Brix Readings)

Date	Treatment	Leaf Whorl	Brix Reading
April 14th 2016	Control	Top, Mid, Bottom	t: 6.1 m: 8.1 b: 6.0
	LED	Top, Mid, Bottom	t: 5.9 m: 6.6 b: 5.0
April 15th 2016	Control	Top, Mid, Bottom	t: 8.2 m: 5.3 b: 8.2
	LED	Top, Mid, Bottom	t: 6.6 m: 7.6 b: 6.4

Refractometer (Brix) is a measure of the amount of dissolved solids in a solution and is often associated with the amount of sucrose, or sugar, in the leaf. The Brix clearly indicated that the plant under the LEDStorm light responds quite differently, and the LEDStorm exposed plant continued to increase more rapidly as it adjusted to the unique array of light energy. In conjunction with the following results of the Spectrometry reading from the Tracer, the leaves had greater density in the LEDStorm plant than the control which would account for the difference in the Brix readings. However, it also indicated that the dissolved solids and sugars were more evenly distributed through the whole plant under the LEDStorm light as compared to the control plant. In addition, there was far less differential between the petioles and the leaves in the LEDStorm plant as compared to the control.

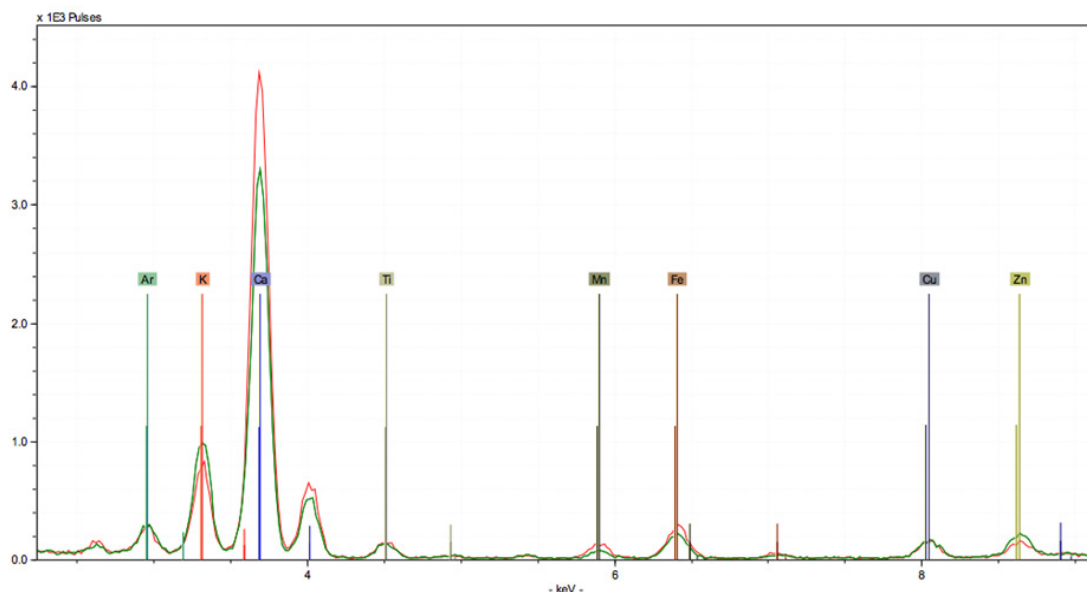
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



Bottom Leaf

Green represents LED and **Red** control- April 15

The bottom control leaves were yellowing or beginning to decline, and it was very likely that the plant in the control environment was dehydrated and showing signs of water stress, which is why we see an increase in manganese (Mn) and iron (Fe) in the bottom leaves of the control plants – these elements cannot be moved easily and accumulate. The LED leaves seemed to be healthy and moving elements.

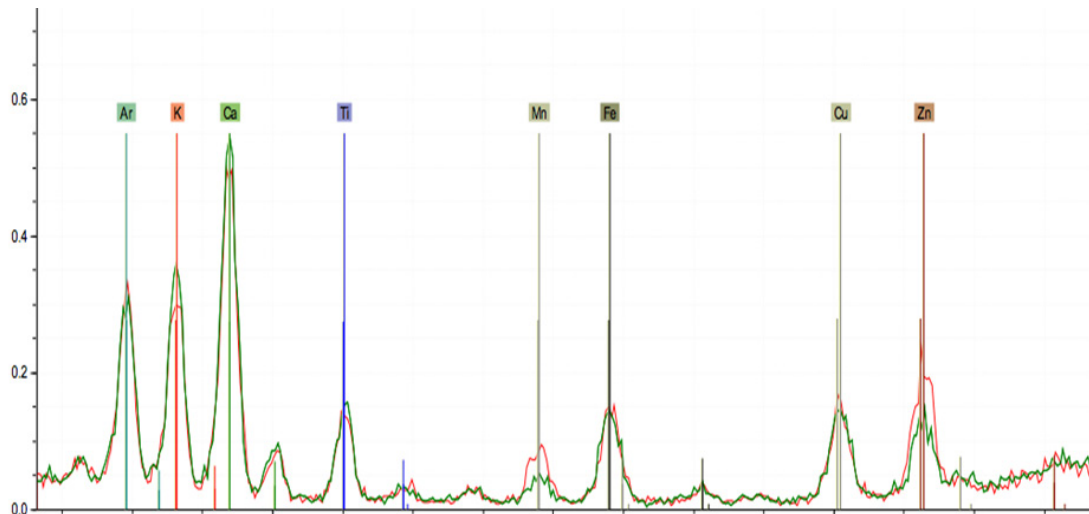
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



Bottom Leaf Petiole

Green represents LED and **Red** control- April 15

The analysis of the bottom leaf petioles showed that the control leaves were definitely senescing and the LED bottom petioles were still moving K and Ca- or actively growing- suggesting that the LED light was penetrating the canopy.

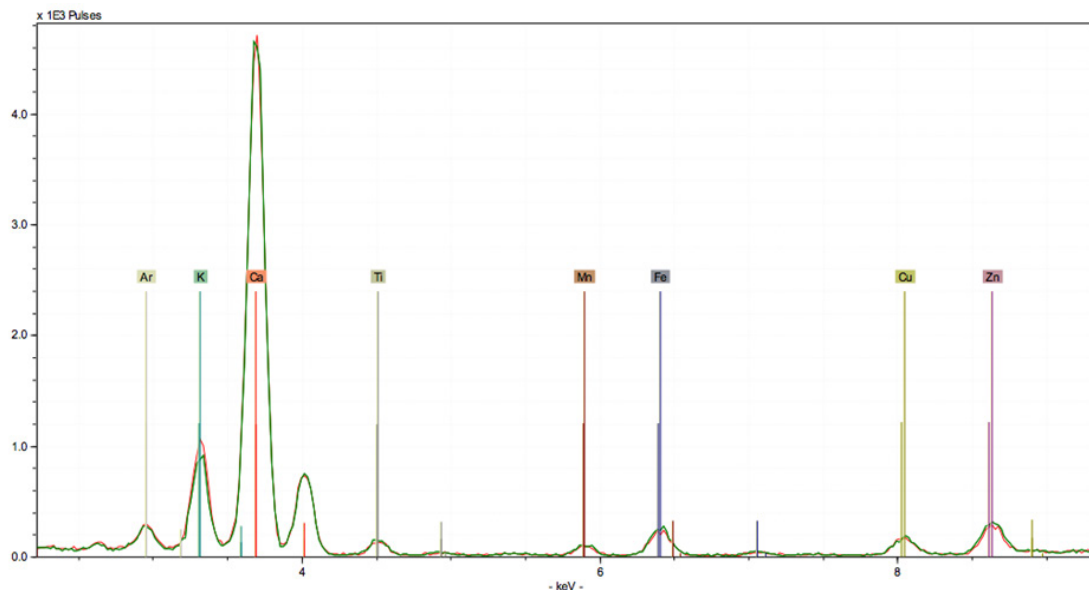
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



Middle Leaf

Green represents LED and **Red** control- April 15

The mid plant whorl of leaves are considered the most actively photosynthetic. As the plant grows, the next upper whorl of leaves will take over, and the lower leaves will eventually start to feed the reproductive growth. The plant can generate more power if all the leaves have access to photosynthetic energy. There is no difference between treatments for the middle leaves.

This is the total elemental content for the control leaf that had the highest Brix. Clearly, elementally, there is no difference despite the Brix readings. The LEDStorm leaves were denser than the control – despite being watered the same, which also affects the Brix. This accounts for the slight differences of the Brix readings. This slide shows that elementally the middle whorl leaves from the control and LEDStorm plants were the same.

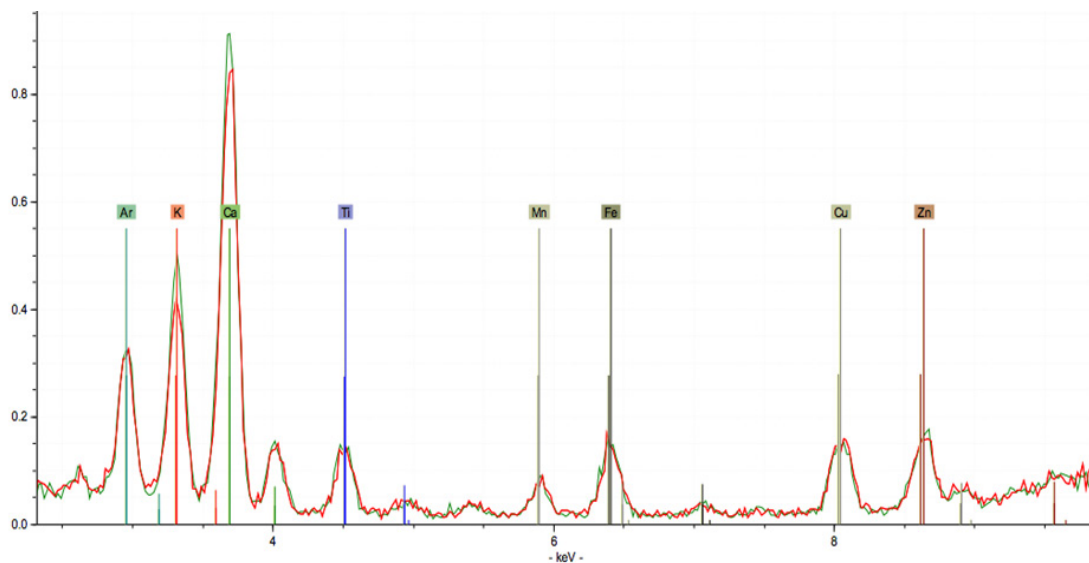
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



Middle Leaf Petiole

Green represents LED and **Red** control- April 15

Middle leaf petiole - this slide shows that the middle leaf whorl petioles were very similar in content but that the LED plant was moving more K and Ca to and/or from leaves. This suggests more active growth for the LED plant.

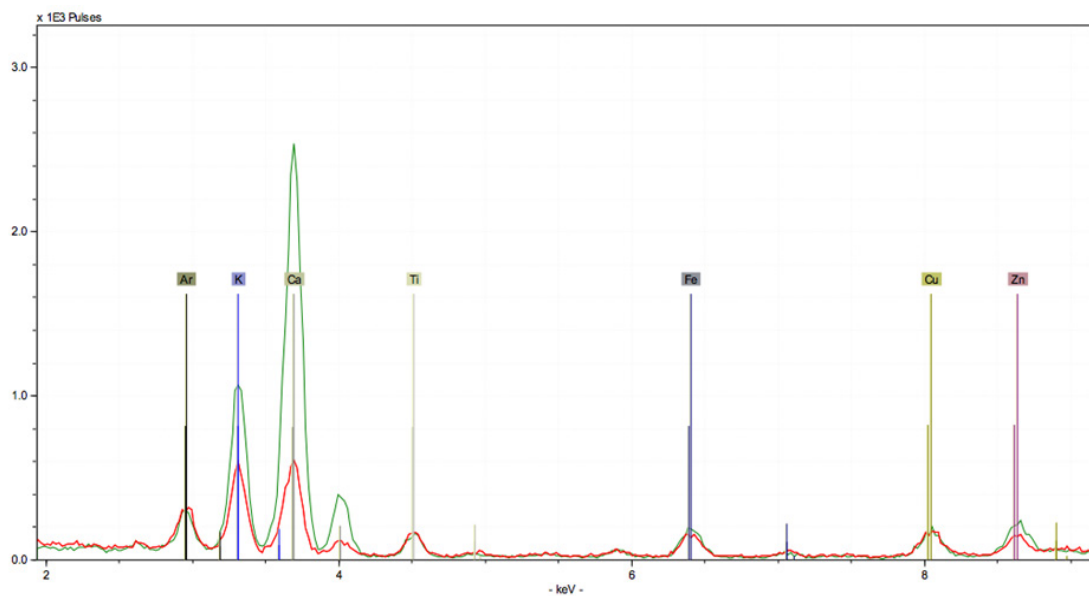
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



Top Leaf

Green represents LED and **Red** control- April 15

Comparing the PXRf spectrum between the LED and control leaves, shows how much more potassium (K), calcium (Ca) and zinc is in the LED leaf compared with the control.

This comparison of spectra clearly shows that the LED top leaves were more mature (more K, Ca, and Zn) than the control leaves. Zn is a required element for making chlorophyll, as is K and Ca – this means that the LEDStorm treated plant also had more chlorophyll in the leaves. The top leaves of the LEDStorm plants are more mature compared with the control plants, and therefore contributing to the overall energy of the plant.

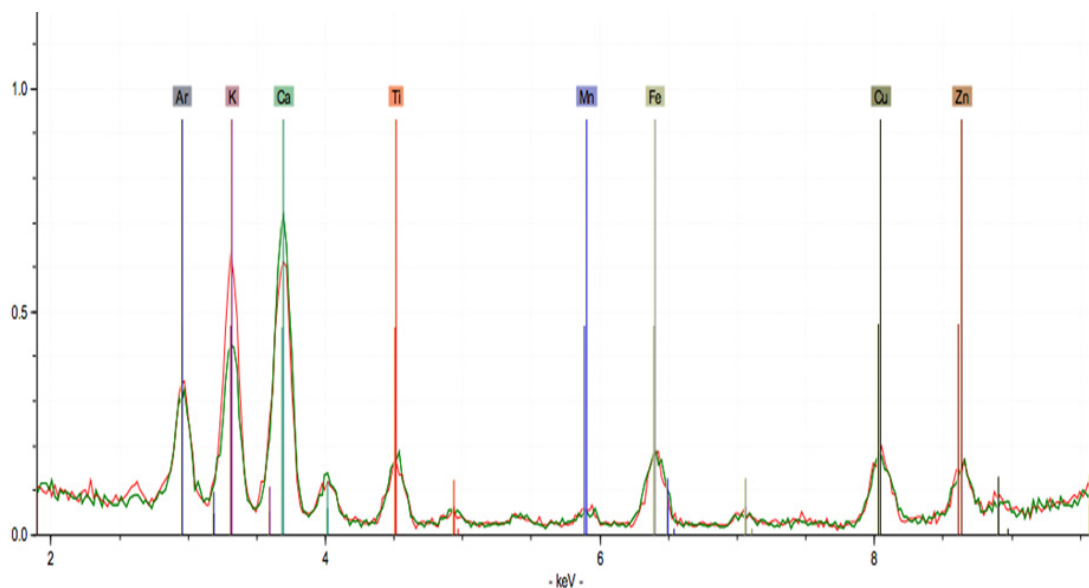
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



Top Leaf Petiole

Green represents LED and **Red** control - April 15

This slide compares the amount of key elements in the petiole (stem immediately attached to the leaf) showing that the control leaf is moving more potassium (K) whereas the LED leaf is moving calcium (Ca). Ca as an element regulates water uptake, and growth in length.

The top fully expanded leaf petioles- were similar between both plants- the differences are related to the level of maturity. When we compare (first slide), the amount of these elements in the leaf compared with the petioles for each treatment, we see that the top leaves of the LED plant are more actively growing- given the amount of K and Ca that is in motion between the leaf and petiole compared with the control plant.

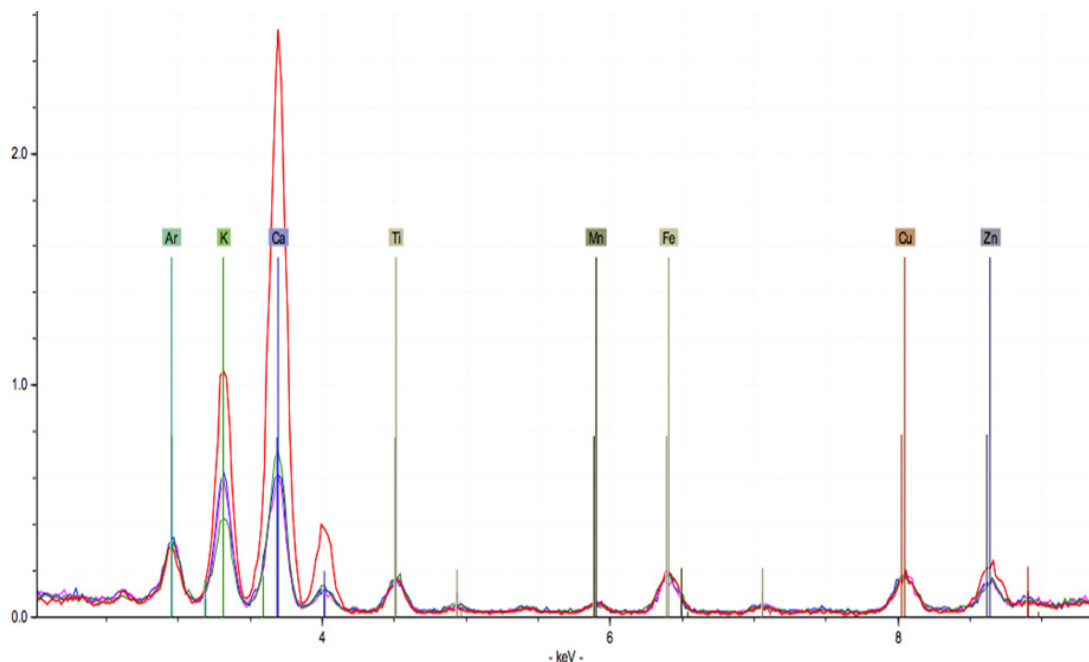
LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Results

(Spectrometry- Bruker Tracer SD III)

April 15th



LED and control top leaves and petioles

Green represents LED and **Red** control- April 15

This slide shows the PXRf spectra from the LED and Control leaf and petiole in an overlay. The elements shown are Argon (Ar), potassium (K), calcium (Ca), titanium (Ti), manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn). LED top leaf (red), petiole (green); Control top leaf (pink), petiole (blue). The spectrum for the LED top leaf also shows that the leaf was more dense- These results clearly display significantly less differential in the LEDStorm plant as compared to the control. The graph clearly shows the LEDStorm leaves have more K, Ca, and Zn compared to the petioles, whereas the control plants have similar amounts of elements in both leaves and petioles. This demonstrated that the upper leaves of the LEDStorm plants were functioning (moving solutes) compared with the control leaves. The large difference in total elemental content between the petiole and leaf from the LED compared with the control leaves also confirms increased maturity.

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Discussion

This was a preliminary test to show that the LED lights (LEDStorm PL11, 60w), with its special array can be used in a growth room to promote plant growth – similar or better than the conventional lighting (Gavita Pro 1000 DE, 1000w).

The LEDStorm PL11 exposed plant responded with increased growth and maturity compared with the control. The LEDStorm plant also had far less of a differential, than the control plant, between the petioles and the leaves throughout the entire plant.

It is recommended to expand testing with more replicates and plants in both reproductive and vegetative states.

LEDStorm™ Grow Spectrum Light (with EMS Technology)

“A New Natural Approach to Lighting”

Conclusion

- Based on this preliminary test- the **LEDStorm** lighting (PL11, 60w) increased the rate of plant growth compared with conventional HID lighting (Gavita Pro 1000 DE, 1000w).
- The opportunity for manipulating spectra to affect plant secondary metabolism is also possible with the **LEDStorm** PL11 lighting system.
- This experiment suggests that **LEDStorm** lighting can be used in growth rooms instead of conventional lighting.
- **LEDStorm** lighting also appeared to increase the rate of maturity in vegetative phase.
- Plants exposed to the EMS (Electromagnetic Spectrum) wavelengths produced from the **LEDStorm** fixture appear to grow faster, more efficiently, and are exposed to less temperature extremes which is also more conducive to the growth pattern for a cool season C3 plant species.
- Increased growth rates
- More photosynthetic capacity
- Less drought stress