Functional Structural Plant Models for Optimal Red:Blue Lighting Ratio as Assimilation Light Source Using Light-Emitting Diode in Indoor Horticulture Application

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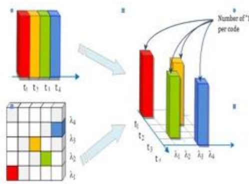
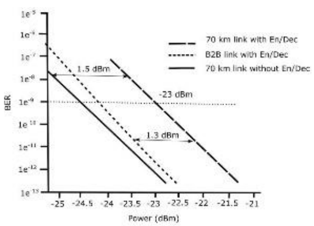
Member (UTB, Brunei): Associate Professor Dr Mohammad Rakib Uddin

Current Research on Photonics

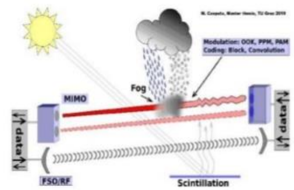
Optical CDMA/ Detection Techniques

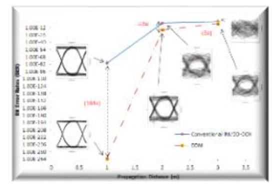




C.B.M. Rashidi,JOC, (2018)
S.A.Aljunid, PTL, (2004)
Anuar, M. S, Optical Communication, (2010)
C.B.M. Rashidi, Optik, (2014)

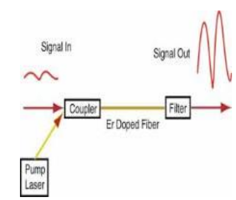
FiWi/FSO/RoF





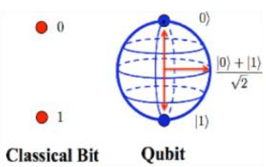
Junita,M.N, Optik, (2013)
A.K.Rahman, JATIT, (2014)
A.A. Anis, MATEC, (2017)

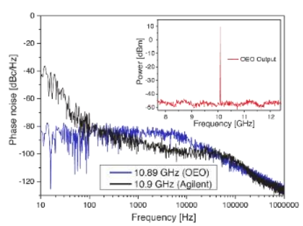
Amplifier/Spectroscopy



R.Endut, ICED, (2018)

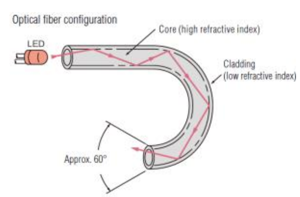
Quantum Computing

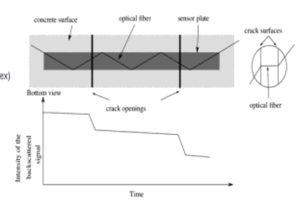




N.Ali, EPJ, (2017)

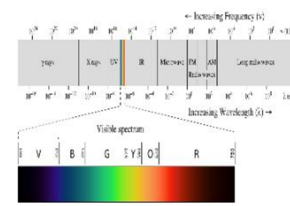
Optical Fiber Sensor

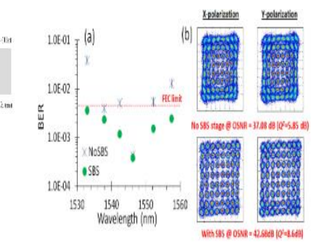




F.Harun, MUCET, (2009)
Imanuddin, ICED (2018)

VLC/OFDM





M.N. Nawawi, Optik, (2018)
A.O.A. Aldhaibani, OFT, (2015)

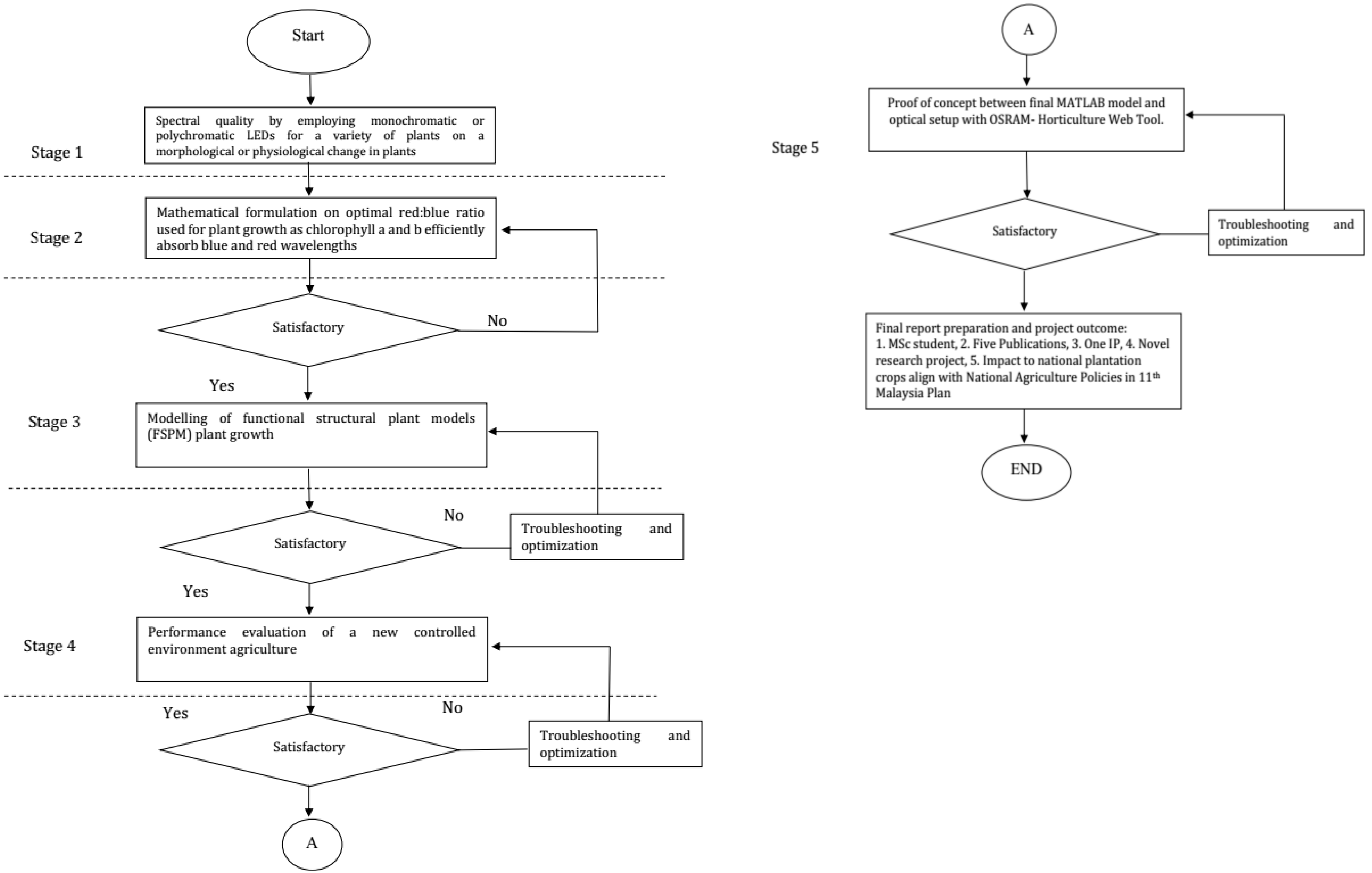
Problem Statement

- Artificial lighting employing conventional broad-spectrum sources such as HID. These light sources are inefficient because of their light-to-heat output and the suboptimal light qualities for plant growth
- Current fluorescent lights also incur high energy cost that may include cooling to offset the high heat, radiant output and this makes these lighting unsuitable for cost-effective in large-scale plant production
- Light illumination emissions based on traditional artificial lighting is neither spectrally optimal nor energetically efficient for several photoperiodic plant species especially when lamps are placed near the plants, tissue damage from photo stress is induced

The objectives to solve the problem:

1. To identify an effect of spectral quality by employing monochromatic or polychromatic LEDs for a variety of plants on a morphological or physiological change in plants.
2. To formulate an optimal red:blue ratio used for plant growth as chlorophyll a and b efficiently absorb blue and red wavelengths
3. To analyze and validate the modelling of functional structural plant models (FSPM) performance of a new controlled environment agriculture with artificial lighting for indoor horticulture.

Flow Chart of Research Activities



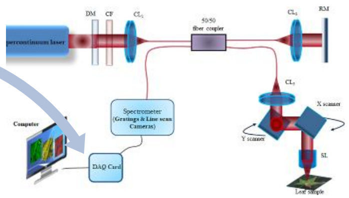
Proposed Method:

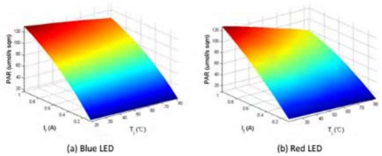
This methodology is described in FIVE stages as follows:

$$PAR_{blue} = 1.141 + 0.0071 \cdot T_j + 192.7 \cdot I_f - 0.4178 \cdot T_j \cdot I_f - 54.82 \cdot I_f^2 \quad ....(2)$$

$$PAR_{red} = -2.585 + 0.0173 \cdot T_j + 180.7 \cdot I_f - 0.7728 \cdot T_j \cdot I_f - 33.8 \cdot I_f^2 \quad ....(3)$$

$$0.05\text{A} \le I_f \le 1\text{A}, 20℃ \le T_j \le 90℃$$





Stage 1: Literature review

- The study is conducted to acquire knowledge on technology and science, agriculture to understand the relationship and to identify limitation

Stage 2: Mathematical formulation on new chemical reaction-based photon for photosynthesis approach using MATLAB tool

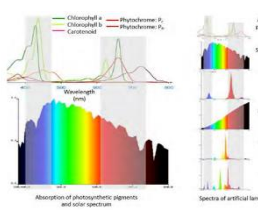
- The characteristics of LED, the forward current and junction temperature (Tj) are two key parameters to get accurate (PAR). The optimal ratio between blue and red light is of great relevance in determining the yield of plant growth and crop.

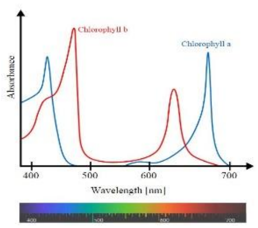
Stage 3: To design an optical model using visible light spectrum for artificial lighting ratio for optimal plant growth.

- Design and modelling of optical model which determines the other radiometric or photometric quantity such as photon intensity, irradiance, radiance, luminous flux, luminous intensity, illuminance, luminance

Stage 4: To analyze performance of a new controlled environment agriculture

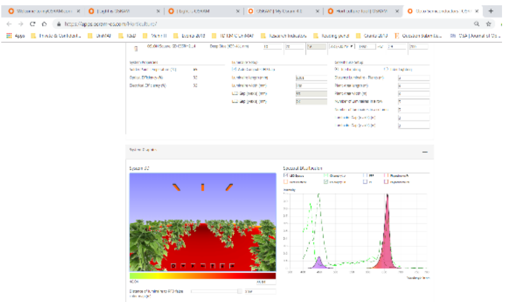
- In order to optimize the spectrum for plant growth or algae, light regime should be considered. Light quality, quantity and photoperiod are three key parameters need to be considered for performance analysis based artificial lighting



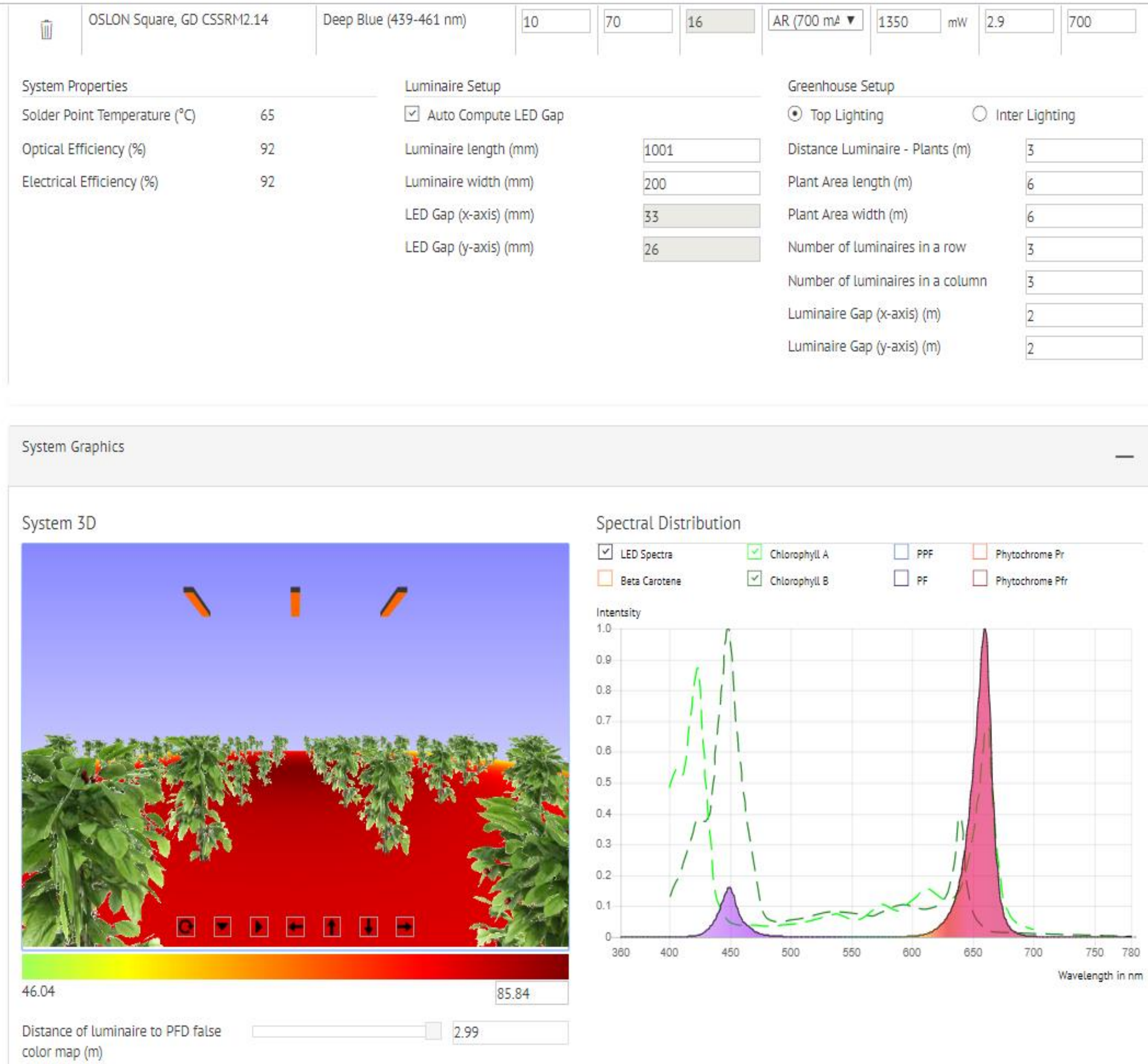


Stage 5: Validation process

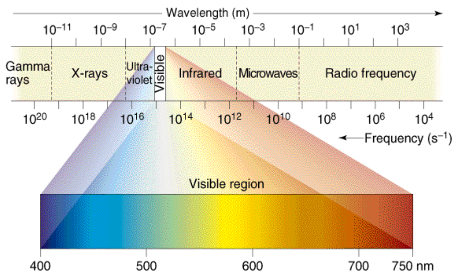
- This validation process is important to ensure that all parameters, characteristics, light setting, and result obtain align with industry specification for plant growth well in horticulture industry.

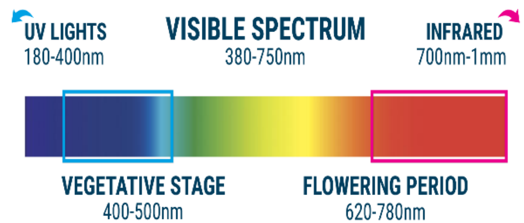


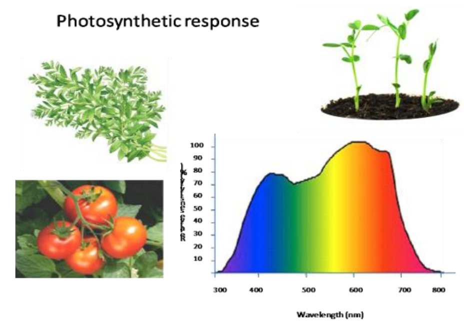
Horticulture Web Tool as Graphical User Interface (GUI):

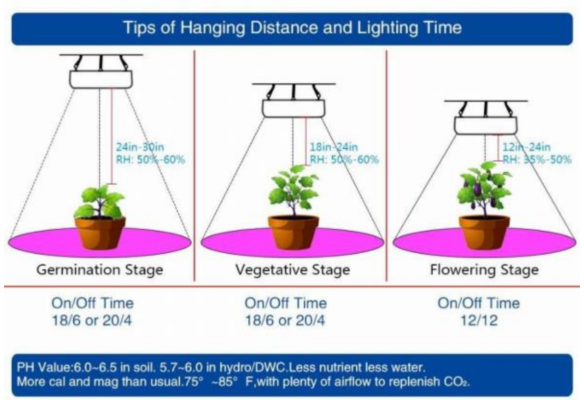


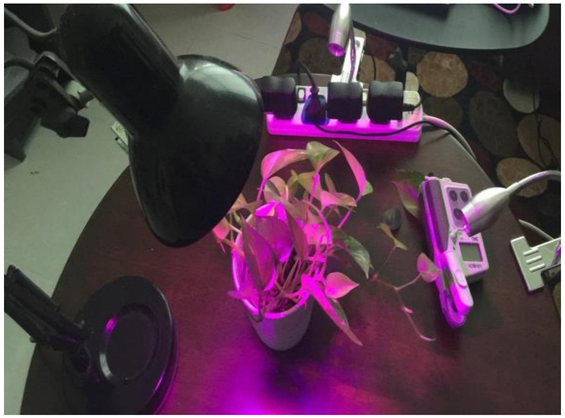
Indoor Horticulture (from idea to real implementation)



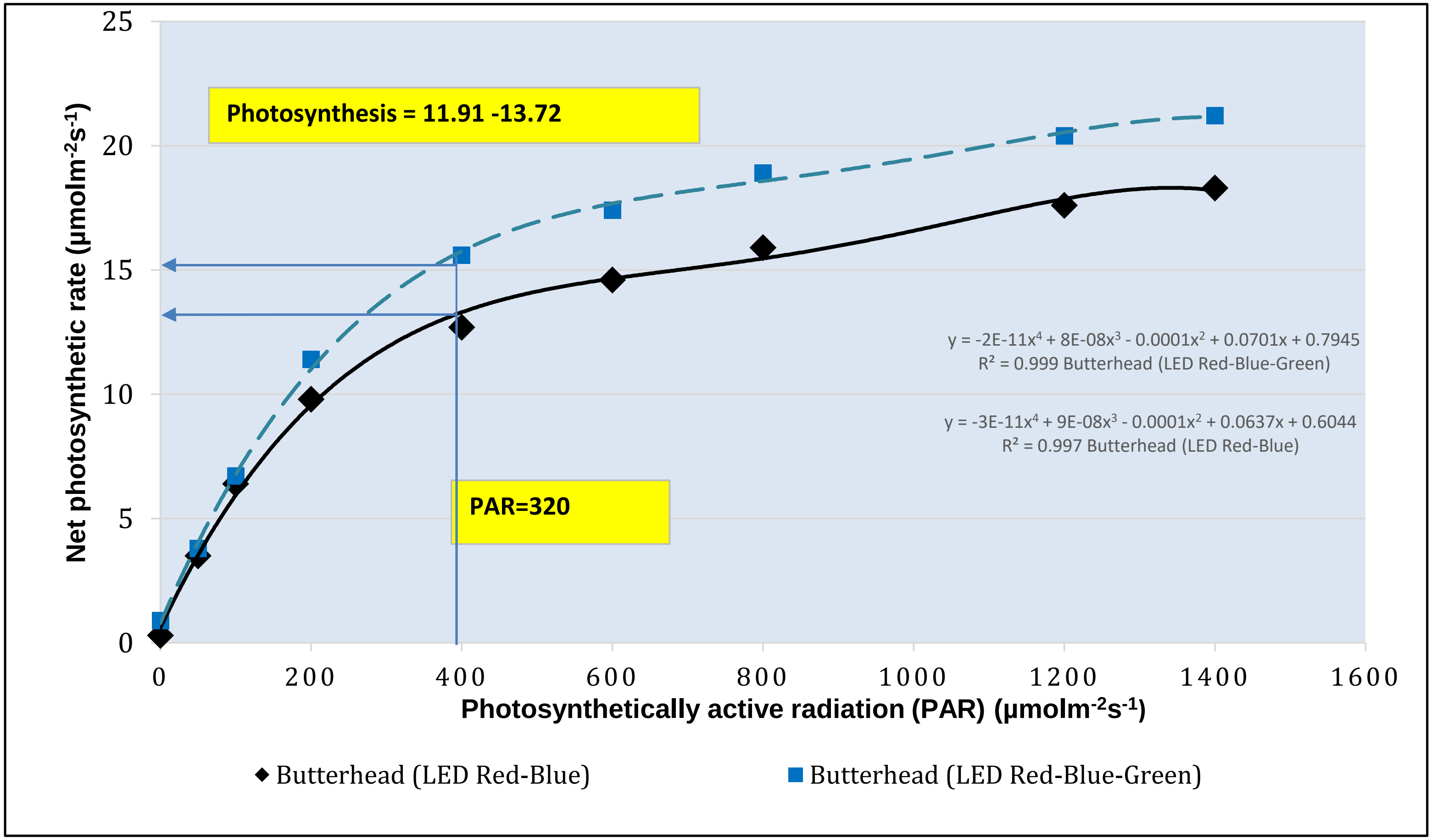








Light Response Curve of Butterhead Lettuce Planted Under Combination of 2 Spectrums (R:B & R:B:G)



"Green light is transmitted through a plant's organs and is utilized in deeper layers of cells. It is also used in the intra-canopy leaves and is more efficient than either blue or red light at driving CO2 fixation for photosynthesis at the abaxial (lower) sides" (Terashima,, at al.,2009).

Non-invasive IOT based Mango Sweetness Prediction using NIRS

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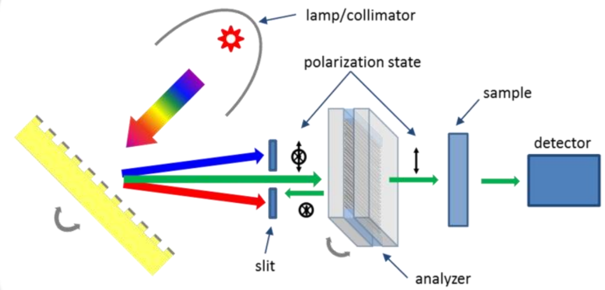
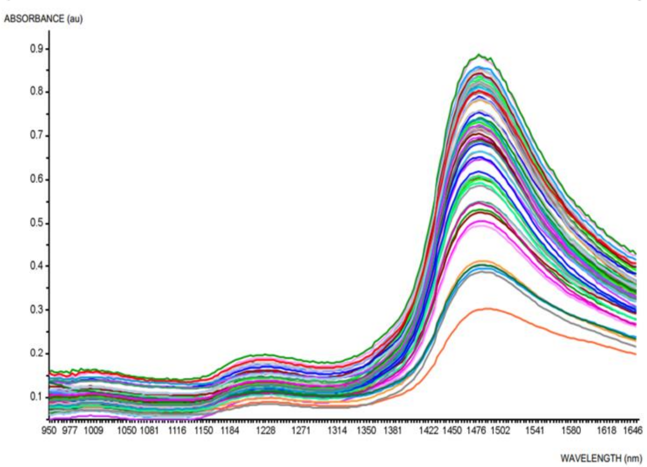
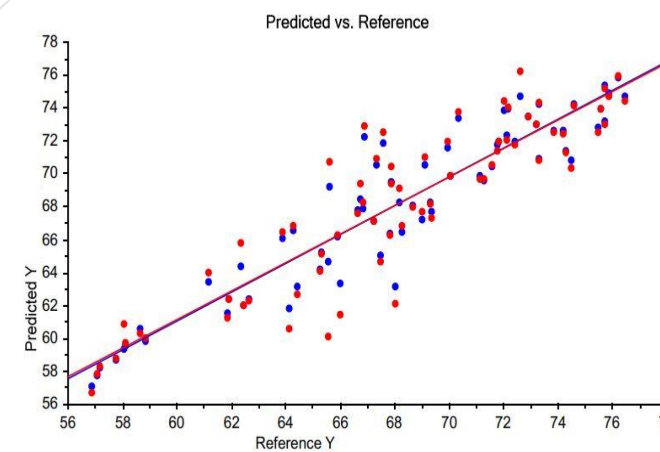
Description:

- Non-invasive/Non-destructive sampling
- Rapid & time saving for large sample
- Improve accuracy in term of sweetness detection
- Skip conventional chemical analysis







Impact:

1. <u>Impact on Economy and Nation</u>

Economy: Agriculture remains an important sector of Malaysia's economy, contributing 12 percent (12%) to the national GDP and providing employment for 16 percent (16%) of the Malaysia population.

Nation: Aim to produce Horticulture Based on Photonics Expertise in Agricultural Application for the nation

Impact area: Horticulture in Malaysia

Priorities: Horticulture farm in Peninsular Malaysia

Testing site:

- Institute of Sustainable Agrotechnology (INSAT), Padang Besar, Malaysia
- Persiaran MARDI-UPM, 43400, Serdang, Selangor DE, Malaysia

Output/Outcome:

2. Scientifically:-

- The novel of formulation of spectral quality by employing monochromatic or polychromatic LEDs for a variety of plants on a morphological or physiological change in plants.
- Modelling of functional structural plant models (FSPM) with different wavelengths can assist in identifying an optimal spectrum by reducing the number of experimental treatments to a feasible extent.

3. Potential Commercialization Industries

1. Agricultural commodity plantation (Vertical farming) – Bernas, Malaysia
2. Green house industry – Mardi, Malaysia
3. Raw material fertilization warehouse screening – SME Industry
4. Food Security – Jakim, Malaysia

Collaborators

RS TECH
ROCKSOLID TECHNOLOGY

Soul Communication
Malaysia Fiber Specialist

TM

SigTech

KESUMA BARAKAH

ABEX

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- MyIPO Copyright Title: "Light Source Based on Artificial Light Spectrum for Indoor Horticulture Application“ Total Number of IP: 1

Conclusion:

- It is very significant in Malaysia as now country are moving towards vertical farming and broad field of plant growth research, with many diverse topics, e.g. How to improve colouration and how to affect biomass production for the use of green plant near future.

- A new modelling of optical design based on spectro spectrum for artificial lighting ratio for identifying optimal ratio of plant growth.

- As our nation is entering the last mile to Vision 2020, agriculture has become one of the component sectors that requires improvement to produce wealth to the nation. In order to realize this vision, the government has put emphasis to the development of agriculture technology via high-impact technology implementation related to IR 4.0 technology.