

UNIVERSITI PUTRA MALAYSIA

INDOOR PRODUCTION OF BRASSICACEAE MICROGREENS USING LED LIGHT AND DIFFERENT LIGHT INTENSITIES

NURSYAFIQAH BINTI IBRAHIM

FP 2022 10



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By

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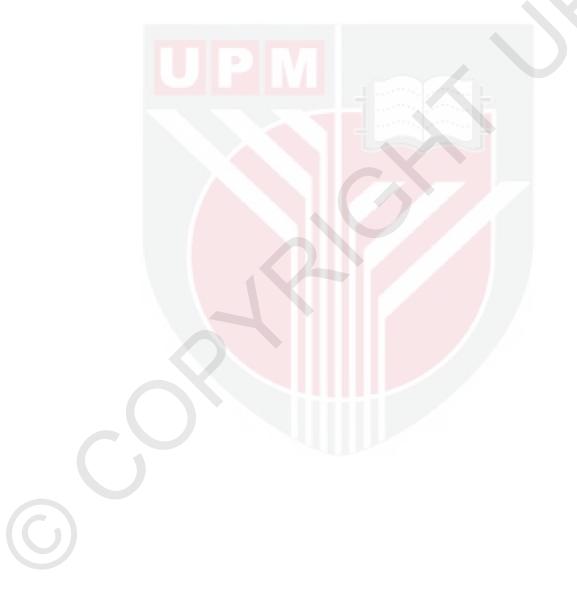
Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

November 2020

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DEDICATION

This thesis is dedicated to myself, my beloved parents and siblings, my thoughtful supervisor and colleagues for giving and offering me with so much kindness, knowledge, love and affection.



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

INDOOR PRODUCTION OF BRASSICACEAE MICROGREENS USING LED LIGHT AND DIFFERENT LIGHT INTENSITIES

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NURSYAFIQAH BINTI IBRAHIM

November 2020

Chairman : Associate Professor Yahya Awang, PhD Faculty : Agriculture

A study was conducted to assess the effect of different regimes of irradiance generated by LEDs with cool white fluorescent (CWF) on the growth and nutritional contents of four species of Brassica microgreens (Chinese kale, Pak Choy, mustard and radish). The objective of this study was to determine the effects of different combination of light quality (red and blue LED with CWF) and intensity (120, 150, 180 and 210 µmol m⁻² s⁻¹), sowing density and nutrient concentration in influencing growth and phytochemical compound of Brassica microgreens. Light regime had insignificant effect on yield, however, vegetative features such as hypocotyl elongation, cotyledon area and stem thickness varied significantly under different light treatment. While yield was insignificant, combination of red, blue LEDs with CWF (150 µmol m⁻² s⁻¹) produced visually pleasing microgreens. Radish produced higher yield and higher concentration of phenolic and flavonoid compound than the other species. In second experiment, effects of light regime and sowing density (3.5 and 7.0 g seeds per container) on radish microgreens were determined. Higher sowing density, produced higher fresh weight due to increase in number of emerging shoots per area in response to higher seeds number, however, individual shoot weight decreased by 15%. Lower sowing density promoted higher individual fresh weight, nutrients, phenolic and DPPH activity. Five levels of nutrients concentration was used (1.0, 1.5, 2.0, 2.5 and 3.0 mS cm⁻¹) in the subsequent study. Results indicated that microgreens fresh weight increased gradually by 6%, 17%, 27% and 31% with increasing concentration (1.5, 2.0, 2.5 and 3.0 mS cm⁻¹) compared to microgreens grown with EC1.0. Total phenolic gradually increase by 28%, 47%, 65% and 81% as nutrient concentrations increased. Flavonoid content was highest when grown using EC2.5 but decreased by 57% when treated with EC 3.0. Nitrate accumulation in microgreens under EC2.5 was lower with 16% reduction compared to EC3.0. In conclusion, light regime did not affect final yield of microgreens, but the distribution of vegetative part of microgreens was largely affected by the combination of light spectrum and intensity. Increased in nutrients concentration with proper sowing rate help to enhance microgreens growth and increased yield.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGELUARAN MIKROGREEN BRASSICACEAE DI DALAM BANGUNAN MENGGUNAKAN CAHAYA LED DAN INTENSITI CAHAYA BERBEZA

Oleh

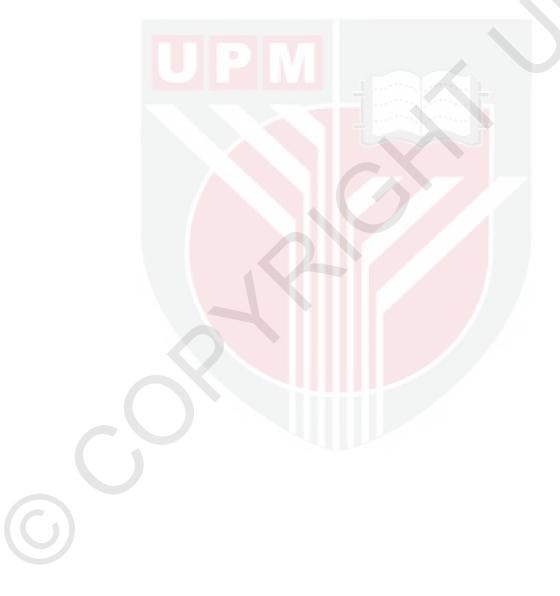
NURSYAFIQAH BINTI IBRAHIM

November 2020

Pengerusi Fakulti

Profesor Madya Yahya Awang, PhDPertanian

Satu kajian dilakukan untuk menilai kesan pelbagai jenis pancaran cahaya yang dihasilkan oleh LED dengan pendarfluor putih sejuk (CWF) pada pertumbuhan dan kandungan nutrien dari empat spesies Brassica microgreens (Kailan, Pak Choy, sawi dan lobak putih). Matlamat kajian ini adalah untuk mengetahui kesan kombinasi kualiti cahaya yang berbeza (LED merah dan biru dengan CWF) dan keamatan (120, 150, 180 dan 210 µmol m⁻² s⁻¹), kadar penyemaian dan kepekatan nutrien dalam mempengaruhi pertumbuhan dan sebatian fitokimia mikro hijau Brassica. Rejim cahaya mempunyai kesan yang tidak ketara terhadap hasil, namun, ciri vegetatif seperti pemanjangan hipokotil, luas kotiledon dan ketebalan batang berbeza dengan ketara disebabkan oleh rawatan yang digunakan. Walaupun hasilnya tidak ketara, gabungan LED merah dan biru dengan CWF (150 µmol m-² s-1) menghasilkan microgeens yang menarik dari segi rupa bentuk. Lobak putih menghasilkan hasil tinggi dan kepekatan kandungan fenolik dan flavonoid yang lebih tinggi daripada spesies lain. Dalam kajian berikut, kesan rejim cahaya dan kadar penyemaian (3. 5 dan 7.0 g biji setiap bekas) pada microgreens lobak putih ditentukan. Kadar penyemaian yang lebih tinggi, menghasilkan berat basah yang lebih tinggi kerana peningkatan jumlah pucuk yang muncul di setiap kawasan sebagai tindak balas kepada jumlah biji yang lebih tinggi, namun, berat pucuk individu menurun sebanyak 15%. Kadar penyemaian yang lebih rendah mendorong peningkatan berat badan, nutrien, fenolik dan aktiviti DPPH individu yang lebih tinggi. Lima tahap kepekatan nutrien digunakan (1.0, 1.5, 2.0, 2.5 dan 3.0 mS cm-1) dalam kajian seterusnya. Hasil kajian menunjukkan bahawa berat microgreens meningkat secara beransur-ansur sebanyak 6%, 17%, 27% dan 31% dengan peningkatan kepekatan (1.5, 2.0, 2.5 dan 3.0 mS cm-1) berbanding dengan microgreens yang tumbuh dengan EC1.0. Jumlah fenolik secara beransur-ansur meningkat sebanyak 28%, 47%, 65% dan 81% apabila kepekatan nutrien meningkat. Kandungan flavonoid adalah tertinggi ketika ditanam menggunakan EC2.5 tetapi menurun sebanyak 57% apabila dirawat dengan EC 3.0. Pengumpulan nitrat dalam microgreens di bawah EC2.5 adalah lebih rendah dengan pengurangan sebanyak 16% berbandingkan dengan EC3.0. Sebagai kesimpulan, rejim cahaya tidak mempengaruhi hasil akhir microgreens, tetapi pengagihan bahagian vegetatif microgreens banyak dipengaruhi oleh gabungan spektrum cahaya dan keamatan. Peningkatan kepekatan nutrien dengan kadar penyemaian biji benih yang sewajarnya membantu meningkatkan pertumbuhan microgreens dan peningkatan hasil.



ACKNOWLEDGEMENTS

Alhamdullilah, I offer my sincerest gratitude to ALLAH S.W.T. for the blessing and guidance He had granted me throughout my thesis study. First and foremost, I offer my sincerest gratitude to my supervisor, Assoc. Prof. Dr. Yahya Bin Awang, who has supported me throughout my thesis with his patience and knowledge whilst allowing me the room to work in my own way.

I would like to express my gratitude to my supervisor committee, Dr. Mohd. Hakiman Mansor for the valuable guidance and encouragement. I would also like extend my thanks to Mr. Mazlan Bin Bangi for helping me in the various laboratories works and equipment handling.

My sincere thanks also goes to my fellow colleagues, Zurafni Binti Mat Daud and Fatin Izzati Binti Mislani for their helps and motivation. Without their precious support it would not be possible to conduct this research. Last but not least, I would like to thank my family: my parents and to my brothers and sister for supporting me spiritually throughout writing this thesis and my life in general.

Sincerely,

NURSYAFIQAH IBRAHIM

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date: 9 June 2022

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

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LIST OF ABBREVIATIONS

μmol	micromole
AA	Ascorbic acid
ADI	Acceptable daily intake
ANOVA	Analysis of variance
ARS	Agricultural Research Service
cm	Centimetre
cm ²	Square centimeter
DRV	Dietary reference values
DW	Dry weight
EFSA	European Food Safety Authority
FW	Fresh weight
FP	Fresh products
g	Gram
GA	Gibberellic acid
GAE	Gallic acid equivalent
GLDH	L-galactono-1,4-lactone dehydrogenase
H ₂ O ₂	Hydrogen peroxide
H ₂ SO ₄	Sulphuric acid
HPSL	High pressure sodium lamp
LED	Light emitting diodes
LHC	Light harvesting complex
MH	Metal halide
mg/L	Milligram per litre

mS	millisiemen
NFT	Nutrient film technique
PAR	Photosynthetically active radiation
PET	Polyethylene terephthalate
PPFD	Photosynthetic photon flux
RDA	Recommended dietary allowance
ROS	Reactive oxygen species
SCF	The Scientific Committee on Food

C

CHAPTER 1

INTRODUCTION

Microgreens are young, tiny versions of vegetables or herbs, loaded with phytonutrients and antioxidants. Microgreens can be grown by a combination of hydroponics and sole-source (SS) lighting in multilayer vertical growing system by using light-emitting diodes (LEDs) or conventional lighting. LEDs are known for its advantage of producing specific light wavelengths to influence plant morphology and phytochemical contents. LEDs has become an important device in many areas and applications including horticultural lighting. LED is defined as a solid-state semiconductor that emits light when a current is applied through the device. They are discovered for its functionality around the year 1897, however the development of LED technology and industry did not begin until the late year of 1960 (Shubert, 2003).

The primary role of LED in horticultural sector is to provide supplemental light source for the plant that are grown inside laboratory, greenhouse and structure house. LED is a type of semiconductor diode that can produce specific wavelength and able to control the spectral composition, thus allowing the adaption of light to be matched with the plant requirement. It is also high in energy efficiency. Most of the power supplied to LED is converted into radiation in the desired form. Efficiency of LEDs is not affected by the shape and size of the bulbs or tubes (Gupta et al, 2013). LEDs are also known for their long operational lifetime which ranged from 30,000 to 50,000 h and even beyond that. Heat generation of LEDs is relatively low compare to fluorescence light.

Plant or any culture can be placed close to the light source without damaging the plant or causing photo-stress. It has been reported that different lights are widely used to study the effects of spectral quality on plant growth and it has been proven to induce excellent growth of plants by adjusting the spectral quality. Previous study had showed that by combining the spectra of both conventional lighting sources with LED wavelengths, it is possible to not only optimize the spectral quality for various plant and different physiological processes (growth, flowering, photosynthetic efficiency), but also to create economically efficient lighting system (Li & Kubota, 2009; Lin et al., 2013).

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As stated before, the blue and red zone of the visible light spectrum are the most beneficial for plant growth. The absence of one of the two (red or blue) light wavelengths creates photosynthetic inefficiencies that affect plant growth and development. It has also been reported that red light is important for shoot/stem elongation, phytochrome responses and changes in plant anatomy (Schuerger et al., 1997). In contrast, blue light is important in chlorophyll biosynthesis, stomatal opening, enzyme synthesis, maturation of chloroplast and photosynthesis (Tibbitts et al., 1983). Sowing density and nutrient concentration are among the important factor that generally affect plant growth. Optimal sowing rate is crop-specific, based on average seed weight, germinability and desired shoot population density.

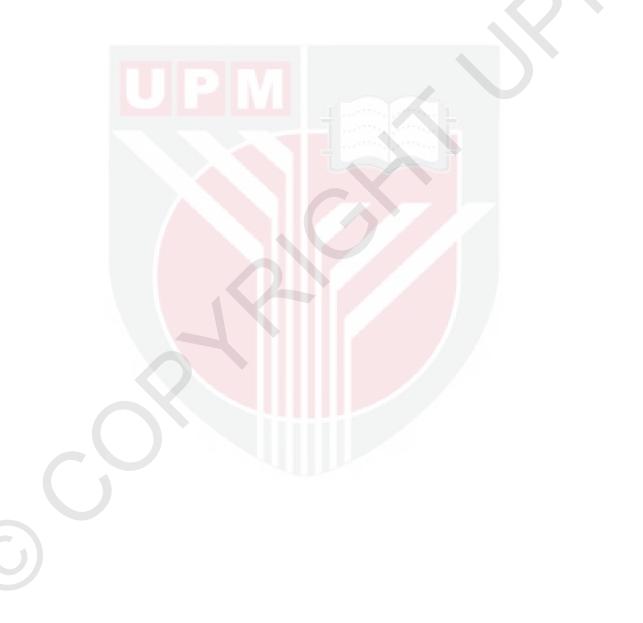
Currently, there are no standardize sowing rate for specific species. Growers usually measure the sowing rate based on their field trial by using their own seeds. This is because the size of the seeds can differ among varieties of the same species or due to different methods of seed production. However, Di Gioia & Santamaria, (2015) recommended general sowing density for microgreens ranging from 1 seed per cm² in large-seeded species such as pea, chickpea and sunflower, up to 4 seeds per cm² in small-seeded species like arugula, watercress, mustard. Murphy & Pill (2010) observed a linear increase in fresh yield per unit area with increasing sowing rate, but also a decrease in mean shoot weight in arugula microgreens. Increasing sowing rate to maximize yield will reflect on the cost of production, while excessive stand density may produce undesirably elongated shoots and limited air circulation which can promotes development of fungal diseases.

Microgreens can be grown in conventional bench-top production or hydroponically. Plastic flats with drainage holes at the bottom are generally used for microgreen production. The trays are either lined with a sterile fiber-like seeding mat or partially filled with a peat-based soilless germinating media. Hydroponic producers may utilize aggregate culture with rockwool as the inert growing medium (Yildiz & Wiley, 2017). As microgreens are usually grown with soil or other soilless media (peat and peat-based media) containing nutrients, not much information was obtained regarding nutrient solution concentration that is suitable for microgreens production. Abad et al. (2001) recommended that growing media should have a pH of 5.5-6.5, low electrical conductivity (<500 mS/cm) and optimal water holding capacity (55-70% v/v) and aeration (20-30% v/v). Information regarding possible interaction between light treatment with sowing rate and nutrient concentration in microgreens is too little.

Microgreens have been claimed as nutritionally beneficial crop and various type of studies were carried out to enhance the nutritional value and increase the production yield of microgreens. It was known that each spectral band of light can induce certain responses in plants from various past studies. LEDs offers an advantage of producing specific light wavelengths to influence plant morphology and phytochemical contents. Thus, by manipulating the spectra and intensity and other factors such as sowing rate and nutrient concentration, it is possible to manipulate plant growth and improve phytochemical contents. In justification, this study will examine the interaction between LED lightings on different mirogreens growth performance, beneficial nutrition and yield. Thus, the objectives of this study are:

i) To measure the effects of intensity levels and spectra produced by LEDs on growth and phytochemical content in different Brassicaceae microgreens.

- ii) To determine the interactive effect between different LED light regime and sowing density on growth and phytochemical contents of selected microgreens.
- iii) To determine the interactive effect between different LED light regimes and different EC nutrient solutions on growth and phytochemical content of microgreens.



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