

NOTICE: There are currently some performance issues with IOPscience, which may also cause error messages to appear. Apologies for the inconvenience..

IOP Conference Series: Earth and Environmental Science



The open access *IOP Conference Series: Earth and Environmental Science (EES)* provides a fast, versatile and cost-effective proceedings publication service.

Sign up for new issue notifications

Latest published conferences

Vol 1031

Conference archive

2022

[View forthcoming volumes](#) accepted for publication.

JOURNAL LINKS

[Journal home](#)
[Journal scope](#)
[Information for organizers](#)
[Information for authors](#)
[Contact us](#)
[Reprint services from Curran Associates](#)

If you would like more information regarding *IOP Conference Series: Earth and Environmental Science* please visit conferenceseries.iop.org, and if you are interested in publishing a proceedings with IOP Conference Series please visit our page for [conference organizers](#).

Conference organizers can use our [online form](#) and we will get in touch with a quote and further details.



PAPER • OPEN ACCESS

Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

Ardiansyah¹, A Hardanto¹ and E Sumarni¹

Published under licence by IOP Publishing Ltd

IOP Conference Series: Earth and Environmental Science, Volume 653, The 2nd International Conference on Sustainable Agriculture for Rural Development 2020 20 October 2020, Purwokerto, Indonesia

Citation Ardiansyah *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **653** 012100

ard@unsoed.ac.id

¹ Department of Agricultural Engineering, Jendral Soedirman University, Purwokerto, Indonesia<https://doi.org/10.1088/1755-1315/653/1/012100>

Buy this article in print

[Sign up for new issue notifications](#)[Create citation alert](#)

Abstract

The research is trying to observe the effect of different light sources on red spinach (*Amaranthus Tricolor L*) plant. Plant-factories were installed and divided into three compartments. Each compartment was given three light sources: Red-Blue LED (R-B), Multi-Color LED (M-C), and White LED (W). The energy of each light sources R-B, M-C, and W were 192 Watt, 92 Watt, and 8 Watt, respectively. The research took place on March 2018 in the Agriculture Technology Laboratory, Jenderal Soedirman University, Indonesia. The growth parameters measured were plant height, biomass, and number of leaves. Results showed that there was significant difference of growth parameters of treatment R-B compared to treatment M-C, and W. Shierary Model were used to study the mechanism of growth parameter difference. The model used the input of radiation energy of light sources that were affected by leaves development, that called the intercepted radiation. The result of the model showed that the intercepted radiation influenced the growth parameters. Treatment R-B, which generates commonly used light wave for photosynthetic, caused better plant growth. The influence of the heat emerged from the light sources were seemed to create better micro-climate for photosynthesis.

Export citation and abstract

[BibTeX](#)[RIS](#)[◀ Previous article in issue](#)[Next article in issue ▶](#)

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

You may also like

JOURNAL ARTICLES

[Special issue on applied neurodynamics: from neural dynamics to neural engineering](#)[Electrochemical Upgrading of Wastes to Products- Fundamental Studies Using a Combined Experimental and Computational Approach](#)[Workshop on Intakes of Radionuclides: Occupational and Public Exposure, Avignon, 15-18 September 1997](#)

EDITORIAL

[Impedance-Resolved Beginning-of-Life Electrochemical Performance and Durability of Treated Carbon Felt Electrodes in Vanadium Redox Flow Batteries](#)[SRP Annual General Meeting: Health Physics Instrumentation and Analytical Techniques Edinburgh, 24-26 April 2001](#)



Who do you want to contact

Conference Series ▼



David McDade



SENIOR PUBLISHER - CONFERENCE SERIES

Anete Ashton



CONFERENCE SERIES OPERATIONS MANAGER

Rosalind Barrett





COMMISSIONING EDITOR - CONFERENCE SERIES

Lorna Wroe



COMMISSIONING EDITOR - CONFERENCE SERIES

Feichi Gao



CONFERENCE SERIES COORDINATOR

Kayleigh Parsons



CONFERENCE SERIES COORDINATOR

Reyes Velazquez





RESEARCHERS

[Publishing Support](#)

[Author guidelines](#)

[Submit your paper](#)

[Checking the proofs of your journal article](#)

[Article structure](#)

[Editing services](#)

LIBRARIANS

[Ordering](#)

[Continued Access Rights Policy](#)

PARTNERS

[Partners](#)

[Work with us](#)

OUR COMPANY

[About us](#)

[News](#)

[Jobs](#)

[Contacts](#)

[view all our sites](#) ▼

[IOP regional sites](#)

[China](#)

[Latinoamérica](#)

[About us](#)

[Publications](#) ▼

[Researchers](#)

[Librarians](#) ▼

[Partners](#) ▼

[Open Physics](#)

[News](#)

[Contacts](#)

[Jobs](#) ▼

[Bookstore](#)

[Sustainability](#)



[Modern Slavery Policy](#)

[Gender Pay Gap Report](#)

[Advertising policy](#)

[Federated access privacy statement](#)

[Journal policies](#)

SOCIAL



[BACK TO TOP](#)

Table of contents

Volume 653

2021

◀ Previous issue Next issue ▶

The 2nd International Conference on Sustainable Agriculture for Rural Development 2020 20 October 2020, Purwokerto, Indonesia

Accepted papers received: 19 January 2021

Published online: 09 February 2021

Open all abstracts

Preface

OPEN ACCESS 011001

Preface

+ Open abstract  View article  PDF

OPEN ACCESS 011002

Committee of the 2nd ICSARD 2020

+ Open abstract  View article  PDF

OPEN ACCESS 011003

Peer review declaration

+ Open abstract  View article  PDF

Papers

OPEN ACCESS 012001

Village development program: The view of "askesiros" in social construction, a development reality of Local Papuan Residents in Manokwari Regency

T Tapi, G Kurnia, I Setiawan and A Sumule

+ Open abstract  View article  PDF

OPEN ACCESS 012002

Analysis of comparative and competitive advantages of maize, rice and cocoa commodities in Gorontalo, Indonesia

J Sumarno, F S I Hiola and N M Muhammad

+ Open abstract  View article  PDF

OPEN ACCESS 012003

Sweet potato agribusiness development strategy to improve farmers' income

S K Dermoredjo, M Azis, Y H Saputra, G Susilowati and B Sayaka

+ Open abstract  View article  PDF

OPEN ACCESS 012004

Characteristics and farmer's response to climate variability to support sustainable agriculture: case study in Tasikmalaya, West Java

W Suringtyas, Sucarni and S K Dermoredjo
This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012005

Livelihood impacts of the cattle management practices in mixed crop-livestock farming systems in South Sulawesi, Indonesia

S Bahar, L J Williams, C M Grünbühel and M van Wensveen

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012006

Enhancing red onion agribusiness development: e-planting calendar and production allocation

S Wahyuni, J Hestina, I A Setiajie and E Suryani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012007

Analysis of income and expenditure of farmers' household in the rain-fed area of Boyolali district

B Hartoyo, Komalawati and D Sahara

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012008

Indonesian sugarcane seed system performance: an assessment from the perspective of institutional and technological innovation support

I K Ardana, R S Hartati, S Wulandari, Saefudin and S Suhesti

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012009

Predicting the impacts of climate change on Indonesia's five main horticulture commodities

A Setiyanto and S M Pasaribu

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012010

Competitiveness effect of the UPSUS Program on rice production in West Java Province, Indonesia

A Setiyanto, I M Pabuayon, C B Quicoy, J V Camacho Jr. and D P T Depositario

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012011

Food security in the disaster-prone area: an empirical study from the rural area of Indonesia

A R T Hidayat, T A Rachmawati and L Wahyuningtyas

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012012

The papaya selection based on fruit characters: a way to assembly new preferred variety

T Budiyaniti, Noflindawati, R Prihatini, D Fatria and Sunyoto

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012013

The addition of biosilica and coconut oil to improve the characteristic of starch-based biofoam packaging

K Wahyuningsih, E S Iriani and B Amalia

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012014

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.

The development potential of multipurpose trees in northern Bandung special area as alternative for sustainable land use in upstream area



B Susanto, H Supriyadi and Y Argo

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012015

Soil moisture distribution analysis of subsurface flow constructed wetland using capacitive soil moisture sensor and its relation with *Ipomoea reptans* Poir growth

D Setiawan, F Rohman, Y D Prasetyatama, L Soetiarso and Radi

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012016

The effect of types and moisture contents of soybeans (*Glycine max*) on terminal velocity

A S Safira and N Bintoro

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012017

The influence of types and moisture contents of coffee beans (*Coffea sp*) on sphericity and geometric means diameter

A P Khansa and N Bintoro

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012018

Modelling the respiration rate of mango (*cv. Manalagi*) during storage under various temperatures and gas compositions

D Rahayu, N Bintoro and A D Saputro

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012019

Physiological activity of banana coated with sago starch and cellulose nanofiber edible coating

R Kasim, N Bintoro, S Rahayoe and Y Pranoto

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012020

Evaluation of watermelon ripeness using self-developed ripening detector

W A Pamungkas and N Bintoro

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012021

The effect of concentrations and exposure durations of ethylene gas on the respiration rate of tomato fruit (*Solanum lycopersicum*)

S Aprianti and N Bintoro

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012022

Content and potential of rice straw as a mineral source of zinc in ruminant feed

N D Suretno, F Y Adriyani and R Hevrizen

[+ Open abstract](#)
[View article](#)
[PDF](#)
OPEN ACCESS

012023

Optimization of irrigation water allocation by using linear programming: case study on Belitang irrigation system

F Imron and Murtiningrum

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.



OPEN ACCESS	012024
The relationship between soil nitrate distribution and growth rate of <i>Capsicum frutescens</i> in subsurface flow constructed wetland integrated with household septic tank	
Y D Prasetyatama, Ngadisih, R Maftukhah, R E Masithoh, J N W Karyadi and L Soetiarso	
+ Open abstract View article PDF	
OPEN ACCESS	012025
Kinetics analysis of the effect of types and concentrations of ripening agents on the physical quality changes of banana fruit (<i>Musa acuminata</i> Colla)	
A Khairuddin and N Bintoro	
+ Open abstract View article PDF	
OPEN ACCESS	012026
Equilibrium and kinetic studies of methylene blue biosorption by sugar palm dregs	
H M A Hakim and W Supartono	
+ Open abstract View article PDF	
OPEN ACCESS	012027
Effect of various drying methods on the physical characteristics of arrowroot powder	
Y P Indrasari, J N W Karyadi, N F Nugraheni, S N Tarwaca, R Albyan, I Setiyadi and D Ayuni	
+ Open abstract View article PDF	
OPEN ACCESS	012028
Estimating of soil moisture using shetran model at Cisanggarung catchment area	
Suroso, R P Wahyuni and Ardiansyah	
+ Open abstract View article PDF	
OPEN ACCESS	012029
Groundwater depth prediction using Shetran model in Citarum River basin	
Suroso, F P Rahmat and Ardiansyah	
+ Open abstract View article PDF	
OPEN ACCESS	012030
Insects identification with convolutional neural network technique in the sweet corn field	
A P Naufal, C Kanjanaphachoat, A Wijaya, N A Setiawan and R E Masithoh	
+ Open abstract View article PDF	
OPEN ACCESS	012031
Impact of land use changes on the water availability in Ciwulan watershed, West Java	
Suroso, A Putudewi and Ardiansyah	
+ Open abstract View article PDF	
OPEN ACCESS	012032
Trend analysis of extreme precipitation indices in the southern part of Java	
W P Abdila and B D A Nugroho	
+ Open abstract View article PDF	
OPEN ACCESS	012033
Vegetation cover modelling for soil erosion control in agricultural watershed	
A Prasetyo, C Setyawan, Ngadisih and R Tirtalistyani	
+ Open abstract View article PDF	

Asis, L E Pakpahan and F Ferayanti

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012092

The family welfare of horticulture farmers: case in Pegalengan District, Bandung Regency, West Java

H Hapsari, E Wulandari, E Suminartika and T Karyani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012093

Development of Boyolali local peanut and composite corn planting patterns on rainfed rice fields

M N Setiapermas and R Nurlaily

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012094

Determinants of livelihood vulnerability of smallholder tea farmers in Lam Dong province, Vietnam

N N Thuy and H H Anh

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012095

Analysis of consumers preferences of rambutan as a leading commodity in Langsa City

F Alham and F H Saragih

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012096

The effect of attractant production factors on the income of curly red chili (*Capsicum annum L.*) farming (case in Pasirwangi District, Garut Regency)

T Karyani, A Susanto, S Tedy and H Hapsari

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012097

Determination of thermal diffusivity of bulk corn kernel and bulk milled corn kernel using numerical method

S Waluyo, A Ardiyanto and M Telaumbanua

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012098

Evaluation of flushing efficiency at a sand trap: A case study of Pengasih Weir, Special Region of Yogyakarta

A G Pradipta, G I Nafisa, Murtiningrum, C Setyawan and S S Arif

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012099

Analysis and Projections of Rainfall using representative concentration pathways (RCPs) Scenarios in Sleman Yogyakarta

H N Annisa and B D A Nugroho

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012100

Biomass growth of red spinach in plant-factory system under three kinds of LED light sources


Ardiansyah, A Hardanto and E Sumarni

[+ Open abstract](#) [View article](#) [PDF](#)

This site uses cookies. By continuing to use this site you agree to our use of cookies. To find out more, see our Privacy and Cookies policy.

012100

IOP Conference Series: Earth and Environmental Science

COUNTRY	SUBJECT AREA AND CATEGORY	PUBLISHER	H-INDEX
United Kingdom	Earth and Planetary Sciences Earth and Planetary Sciences (miscellaneous)	IOP Publishing Ltd.	34
 Universities and research institutions in United Kingdom	Environmental Science Environmental Science (miscellaneous)		
	Physics and Astronomy Physics and Astronomy (miscellaneous)		
PUBLICATION TYPE	ISSN	COVERAGE	INFORMATION
Conferences and Proceedings	17551307, 17551315	2010-2021	Homepage How to publish in this journal ees@ioppublishing.org



SCOPE

The open access IOP Conference Series: Earth and Environmental Science (EES) provides a fast, versatile and cost-effective proceedings publication service.




 Join the conversation about this journal

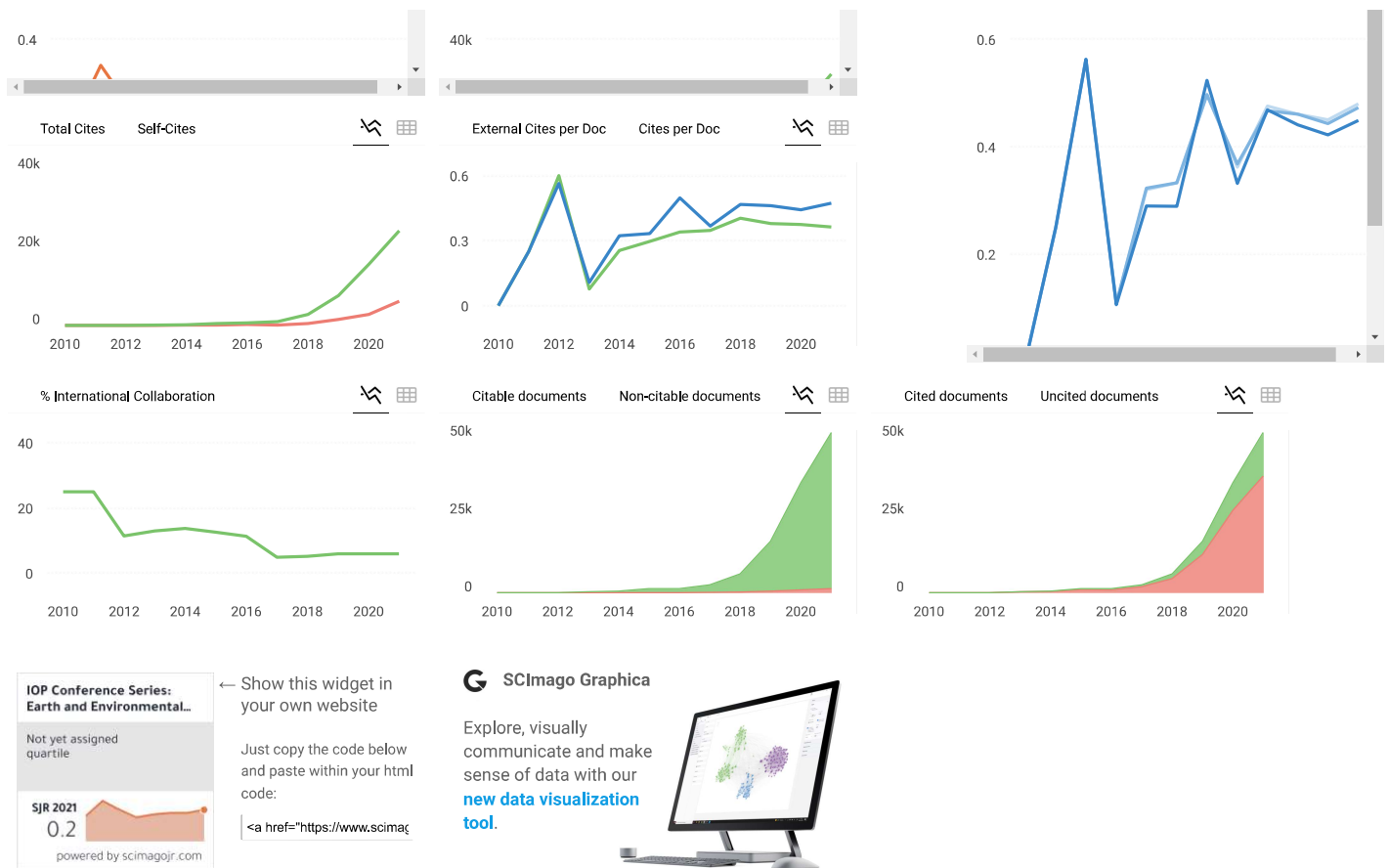
Solve Math & Earn Money

Can you help struggling students learn math? Start your side hustle t

portal.photomath.net

Sigr

SJR	Total Documents	Citations per document
		



Solve Math & Earn Money

Can you help struggling students learn math? Start your side hustle today!

portal.photomath.net

[Sign Up](https://portal.photomath.net)

Metrics based on Scopus® data as of April 2022

N **NAJI** 1 month ago

Hello Dear

I participated as a corresponding author in IOP conf .series: Earth and Environment Science
877(2021)012046

I want do this IOP still in Scopus ???

kind regards

reply



SCImago Team

Melanie Ortiz 1 month ago

Dear Naji, thank you very much for your comment. We suggest you consult the Scopus database directly. Keep in mind that the SJR is a static image (the update is made one time per year) of a database (Scopus) which is changing every day.
The Scopus' update list can also be consulted here:
<https://www.elsevier.com/solutions/scopus/how-scopus-works/content>
Best Regards, SCImago Team

A

Alharia Dinata 1 year ago

IOP Conference Series: Earth and Environmental Science - Volume 708 is not available in Scopus.

reply



SCImago Team

Melanie Ortiz 1 year ago

Dear Alharia,
thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you contact Scopus support:
https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/
Best Regards, SCImago Team

V

Vani 1 year ago

good evening, whether this journal is Q4 or Q2 ?

reply



SCImago Team

Melanie Ortiz 1 year ago

Dear Vani,
Thank you for contacting us.
As said below, we calculate the SJR data for all the publication's types, but the Quartile's data are only calculated for Journals and Book Series.
Best regards, SCImago Team

F

FEROSKHAN M 2 years ago

IOP Conference Series: Earth and Environmental Science - Volume 573 is not available in Scopus.
But later volumes are available. May I know when will they publish in Scopus?

reply



SCImago Team

Melanie Ortiz 2 years ago

Dear Sir/Madam,
thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you contact Scopus support:
https://service.elsevier.com/app/answers/detail/a_id/14883/kw/scimago/supporthub/scopus/
Best Regards, SCImago Team

N

Natt 2 years ago

I would like to know the quartile of this journal. Why isn't it showing on the website?

reply



SCImago Team

Melanie Ortiz 2 years ago

Dear Natt,
Thank you for contacting us. We calculate the SJR data for all the publication's types, but the Quartile's data are only calculated for Journals and Book Series.
Best regards, SCImago Team

N **Nurgustaana** 2 years ago

Dear SCImago Team!
I want to know previous quartiles of journal (for 2018 and 2019 years). I have tried find information about a quartile, but discovered just SJR for 2018. Could you please provide information about it?
Yours sincerely, Nurgustaana

reply



Melanie Ortiz 2 years ago

SCImago Team

Dear Nurgustaana,
Thank you for contacting us. We calculate the SJR data for all the publication types, but the Quartile data are only calculated for Journal type's publications. Best regards,
SCImago Team

M **Mora** 2 years ago

hello, how to search one of journal who publised by IOP, because when i find it by the title, they are not able in scimagojr but the publisher is available in here, thank you for the respond it means a lot

reply



Melanie Ortiz 2 years ago

SCImago Team

Dear Mora,

thank you for contacting us. Could you provide us the Title of the journal? We remember that SCImago Journal & Country Rank shows all the information have been provided by Scopus. If you didn't localize the journal in the search engine, it means that Scopus / Elsevier has not provided us the corresponding data.

Best Regards, SCImago Team

D **Dr. Yousif** 2 years ago

Dear Sir,

I have published a paper in Earth and Environmental Science Journal (only myself, single author) I am trying to withdraw it after 28 days of publishing online, is it possible? Could you please tell me the procedure of withdrawing a paper?
Thank you,

reply



Melanie Ortiz 2 years ago

SCImago Team

Dear Yousif,
thank you for contacting us.
We are sorry to tell you that SCImago Journal & Country Rank is not a journal. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus. Unfortunately, we cannot help you with your request, we suggest you to contact the journal's editorial staff , so they could inform you more deeply. Best Regards, SCImago Team

A **Agustinus Kastanya** 2 years ago

need information about renking of the Journal on Scopus

reply



Melanie Ortiz 2 years ago

SCImago Team

Dear Agustinus, thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you to consult the Scopus database directly. Remember that the SJR is a static image of a database (Scopus) which is changing every day. Best regards, SCImago Team

M

Mahipal 2 years ago

Dear Admin,

How could our journal include in your IOP?

reply



Melanie Ortiz 2 years ago

SCImago Team

Dear Mahipal,
thank you for contacting us.
We suggest you to contact the IOP's editorial staff , so they could inform you more deeply.
If you would like to make an application to Scopus, please contact them to help you with this issue here: <https://www.elsevier.com/solutions/scopus/content/content-policy-and-selection>
<http://suggestor.step.scopus.com/suggestTitle/step1.cfm>
Best Regards, SCImago Team

M

Mursalin 3 years ago

Dear SCImago Team

My name is mursalin from Jambi City, Indonesia. I have published my article titled The Effect of Temperature on MDAG Purification Using Creaming Demulsification Technique at the IOP Conference Series: Earth and Environmental Science, Volume 309, conference 1 and could be accessed at: <https://iopscience.iop.org/article/10.1088/1755-1315/309/1/012068>. But why until now it does not appear into Google Scholar and my account.

Please help me to resolve the issue. Thank you for your kindness. I am waiting for good news from you.

Sincerely,
Mursalin

reply



Melanie Ortiz 3 years ago

SCImago Team

Dear Mursalin,

Thank you for contacting us. Unfortunately, we can not help you with your request. Maybe other users can help you. Best Regards, SCImago Team

N

Танзиля Созаева 3 years ago

Доброго времени суток! Интересует информация по квартилю журнала (издания)

reply



Melanie Ortiz 3 years ago

SCImago Team

Dear user, thank you very much for your request. You can consult that information in SJR website. Best Regards, SCImago Team

S **syaiful** 4 years ago

I am very interested to send my paper to this conference

best regards

syaiful

reply



Elena Corera 4 years ago

SCImago Team

Dear user, in the link below you will find the information corresponding to the author's instructions of this journal. Best regards, SCImago Team
<https://publishingsupport.iopscience.iop.org/author-guidelines-for-conference-proceedings/>

Leave a comment

Name

Email

(will not be published)



I'm not a robot

reCAPTCHA
[Privacy](#) - [Terms](#)

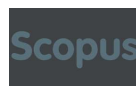
Submit

The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.

Developed by:



Powered by:



Follow us on @ScimagoJR

Scimago Lab, Copyright 2007-2022. Data Source: Scopus®

EST MODUS IN REBUS
Horatio (Satire 1.1.106)



Source details

IOP Conference Series: Earth and Environmental Science

Scopus coverage years: from 2010 to Present

Publisher: Institute of Physics Publishing

ISSN: 1755-1307 E-ISSN: 1755-1315

Subject area: Earth and Planetary Sciences: General Earth and Planetary Sciences

Environmental Science: General Environmental Science

Source type: Conference Proceeding

CiteScore 2021

0.6



SJR 2021

0.202



SNIP 2021

0.409



[View all documents >](#)

[Set document alert](#)

[Save to source list](#) [Source Homepage](#)

[CiteScore](#) [CiteScore rank & trend](#) [Scopus content coverage](#)

i Improved CiteScore methodology



CiteScore 2021 counts the citations received in 2018-2021 to articles, reviews, conference papers, book chapters and data papers published in 2018-2021, and divides this by the number of publications published in 2018-2021. [Learn more >](#)

CiteScore 2021

$$0.6 = \frac{45,063 \text{ Citations 2018 - 2021}}{74,324 \text{ Documents 2018 - 2021}}$$

CiteScoreTracker 2022

$$0.6 = \frac{40,750 \text{ Citations to date}}{69,023 \text{ Documents to date}}$$

CiteScore rank 2021 ⓘ

Category	Rank	Percentile
Earth and Planetary Sciences	#153/191	20th
General Earth and Planetary Sciences		
Environmental Science	#191/228	16th
General Environmental		

[View CiteScore methodology >](#) [CiteScore FAQ >](#) [Add CiteScore to your site 🔗](#)

About Scopus

[What is Scopus](#)

[Content coverage](#)

[Scopus blog](#)

[Scopus API](#)

[Privacy matters](#)

Language

[日本語版を表示する](#)

[查看简体中文版本](#)

[查看繁體中文版本](#)

[Просмотр версии на русском языке](#)

Customer Service

[Help](#)

[Tutorials](#)

[Contact us](#)

ELSEVIER

[Terms and conditions](#) ↗ [Privacy policy](#) ↗

Copyright © [Elsevier B.V](#) ↗. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

We use cookies to help provide and enhance our service and tailor content. By continuing, you agree to the [use of cookies](#) ↗.



PAPER • OPEN ACCESS

Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

To cite this article: Ardiansyah *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **653** 012100

View the [article online](#) for updates and enhancements.

You may also like

- [Watt and joule balances](#)
Ian A Robinson
- [Gravitational water vortex pico hydro power modeling for aquaculture implementation](#)
D W Maulana, F M Rizwan, C Mulyana et al.
- [The Influence of Light Wavelengths Toward the Growth of *Brassica rapa* L.](#)
Rizky Maiza and Daniel Kurnia



ECS Membership = Connection

ECS membership connects you to the electrochemical community:

- Facilitate your research and discovery through ECS meetings which convene scientists from around the world;
- Access professional support through your lifetime career;
- Open up mentorship opportunities across the stages of your career;
- Build relationships that nurture partnership, teamwork—and success!

Join ECS!

Visit electrochem.org/join



Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

Ardiansyah*, A Hardanto and E Sumarni

Department of Agricultural Engineering, Jendral Soedirman University, Purwokerto, Indonesia

Corresponding author: ard@unsoed.ac.id

Abstract. The research is trying to observe the effect of different light sources on red spinach (*Amaranthus Tricolor L*) plant. Plant-factories were installed and divided into three compartments. Each compartment was given three light sources: Red-Blue LED (R-B), Multi-Color LED (M-C), and White LED (W). The energy of each light sources R-B, M-C, and W were 192 Watt, 92 Watt, and 8 Watt, respectively. The research took place on March 2018 in the Agriculture Technology Laboratory, Jendral Soedirman University, Indonesia. The growth parameters measured were plant height, biomass, and number of leaves. Results showed that there was significant difference of growth parameters of treatment R-B compared to treatment M-C, and W. Shierary Model were used to study the mechanism of growth parameter difference. The model used the input of radiation energy of light sources that were affected by leaves development, that called the intercepted radiation. The result of the model showed that the intercepted radiation influenced the growth parameters. Treatment R-B, which generates commonly used light wave for photosynthetic, caused better plant growth. The influence of the heat emerged from the light sources were seemed to create better micro-climate for photosynthesis.

1. Introduction

Several studies showed the relationships between climatic factors and plant growth. These factors, for example, influence plant physiology [1], canopy resistance [2] or water stress [3]. *Plant-factory* or controlled crop chamber are intensive cultivation methods carried out in chamber, in which all climate factors can be adjusted and managed. It can improve yields and be efficient in land use [4-6]. Research shows that there is an acceleration of growth and an increase in biomass if light, temperature, humidity, and CO_2 concentrations are controlled at a certain level [7].

Plant's micro-climate arrangement is possible to manage; because it relates to parameters that can be controlled technically using mechanical or electrical devices. Information about good growth conditions can be obtained by experiments using various controlled parameters. Automatic control is the keyword to get the optimum parameters (in experiments), also to control the plant environment at optimum conditions (in production). Biomass production is affected by photosynthetic activity, which is influenced by various factors. Automatic control of these optimum factors allows maximum biomass growth. Thus, the micro-climate arrangement can be optimized to grow optimum biomass in production scale.



The need to predict biomass growth based on micro-climate condition is the key for optimizing micro-climate parameter in *Plant-factory*. The biomass predictors, such as canopy resistance, water stress, carbon dioxide assimilation can be used to estimate biomass. However, to measure or calculate those predictors are difficult to do. It needs complex measurement and sophisticated instrument. Consequently, the requirement to use simple parameter to predict biomass growth is urgent. Light or radiation can be used as predictor. The measurement is simple, and the instrument is easy to buy or to assemble. This research will use different kind of LED light sources (treatments) and observe the biomass growth under the treatments.

The purposes of this research are firstly, observing radiation intercepted by the plant canopy under three types of artificial light, secondly, measuring changes in growth parameters and biomass under three types of artificial light, and thirdly, applying biomass modeling to predict biomass growth and development, by incorporating intercepted light as input variable.

2. Materials and methods

2.1. Experiment setting

The type of plant-factory used in this research is a complete-control type [6], where all the factor such as light, temperature, and humidity is electrically controlled. Measurement variables include measurement of a) external production factors (input: light, humidity, temperature) and b) plant growth response (plant height, number of leaves, and biomass development). Figure 1 shows the experiment setting.

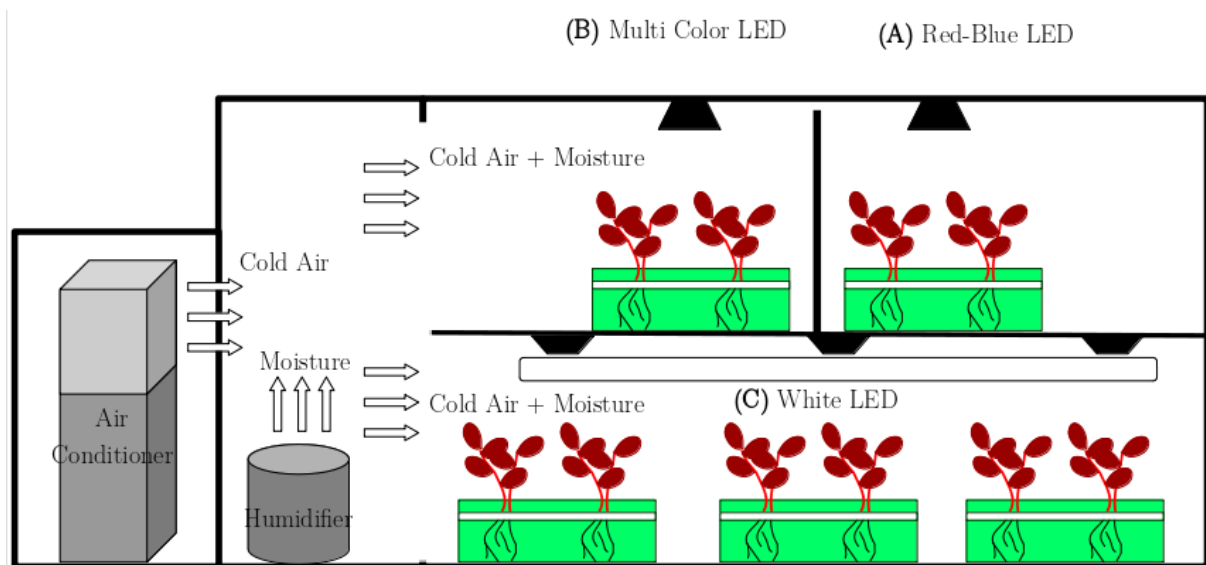


Figure 1. Experiment Setting

2.2. Biomass modelling

Concept applied for biomass modelling is microclimate condition that stated by Thermal Unit (TU). The main concept is that the growth phase is moving from existing phase to next phase after the TU is fulfilled [8–10]. After the concept of TU, the biomass growth described by the conversion of photosynthetic radiation into biomass. The model called Shierary Rice Model [11]. Conversion from radiation into biomass controlled by coefficient called radiation efficiency (ϵ). The equation is appeared in Equation (1).

$$dW = \epsilon \cdot Q_{intercept} \quad (1)$$

where dW is total biomass production (g), $\epsilon = 1.65 \text{ gMJ}^{-1}$ is radiation efficiency of converting light into biomass.

Intercepted radiation ($Q_{intercept}$, $\text{MJ} \cdot \text{m}^{-2}$) is calculated using equation (2) :

$$Q_{interception} = (1 - \tau) \cdot Q_s \quad (2)$$

where τ ($\tau = e^{-k \cdot LAI}$ or $\tau = \frac{Q_{trans}}{Q_s}$) is fraction of light transmitted below the canopy. Q_s is daily incoming radiation ($\text{MJ} \cdot \text{m}^{-2}$).

Partition of whole biomass growth (1) into their plant-organs (root, stem, leaves) is using equation (3)

$$dW_x = \eta_x dW - R_g - R_m \quad (3)$$

dW_x is biomass development in plant-organs (x) (gm^{-2}), η_x = allocation of biomass for certain organs (root, straw, leaves, or grains). Growth respiration (R_g , gm^{-2}) and maintenance respiration (R_m , gm^{-2}) [12] is the energy used by the plant. They're using result of photosynthesis. They were calculated using Equation (4) and Equation (5):

$$R_g = k_g \cdot \eta_x \cdot dW. \quad (4)$$

$$R_m = k_m \cdot W_x \cdot Q_{10} \quad (5)$$

where k_g is growth respiration coefficient = 0.0108, dan k_m = maintenance respiration coefficient = 0.13. W_x = biomass of plant-organ (g), Q_{10} [13] were calculated as $Q_{10} = \left(\frac{K_2}{K_1}\right)^{\frac{10}{(T_2 - T_1)}}$ which accordingly can be stated as:

$$Q_{10} = 2^{\frac{10}{(T - 20)}} \quad (6)$$

Graphically, the concept of modeling plant biomass growth is shown in the Figure 2. The variables calculated in equations (1) to (6) are listed in the nodes in the chart. The lines connecting one node to another node show the transformation of the calculation to the variable shown in the arrow.

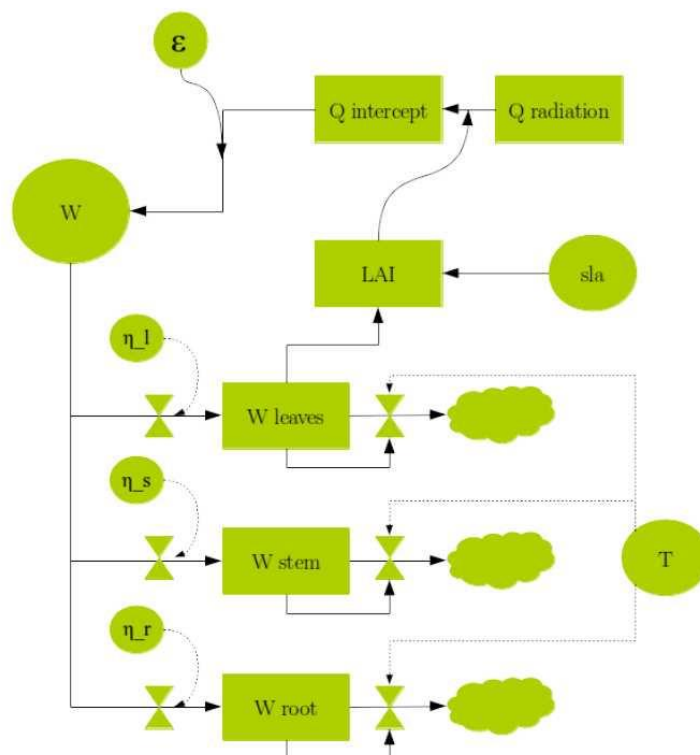


Figure 2. Model Calculation in Graphical Form

3. Results and discussion

3.1. Plant growth and development

Acceptance of radiation intercepted by leaves becomes material for photosynthesis. Energy will be converted into biomass and allocated to organs in the plant. The growth of organs can be used as an indicator of biomass growth. The concept of biomass growth can be seen in Figure 3.

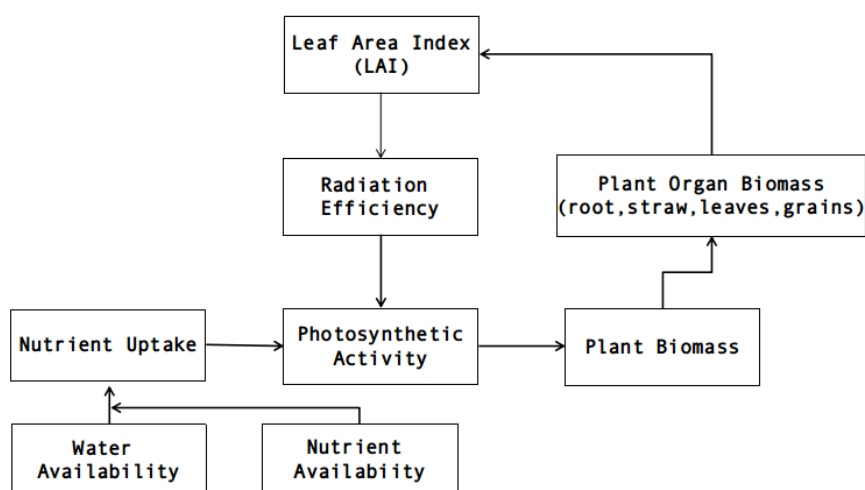


Figure 3. Biomass Growth Concept [19]

Time series data on plant height, number of leaves, root length, wet weight and dry weight are presented in graphical form. The data includes measurements on day 0 (after planting) until day 27. The use of photosynthetic lamps to replace sunlight needs to consider the spectrum of light used.

Figure 4 shows the growth of spinach plants with Red-Blue LED lighting (192 Watts) and Multi-Color LED (92 Watts). The best growth is seen in plants with Red-Blue LED. When compared with White LED (8 Watts) with color temperatures of 6500 K, then both types of Red-Blue and Multi-Color LED show much better results.

The development of leaf number and plant height during the planting period also indicates that Red-Blue LEDs provide better growth than Multi-Color LED. White LEDs provide significantly less yield than Red-Blue LED and Multi-Color LED (Figure 5 and Figure 6).

The highest growth of leaf numbers is shown in the order of Red-Blue light, followed by Multi-Color light, and White light. This growth pattern is exponential as any other growth pattern [14–16]. On the 15th day, plants with Blue-Red LED lighting showed a rapid increase compared to plants with Multi-Color LED lighting.

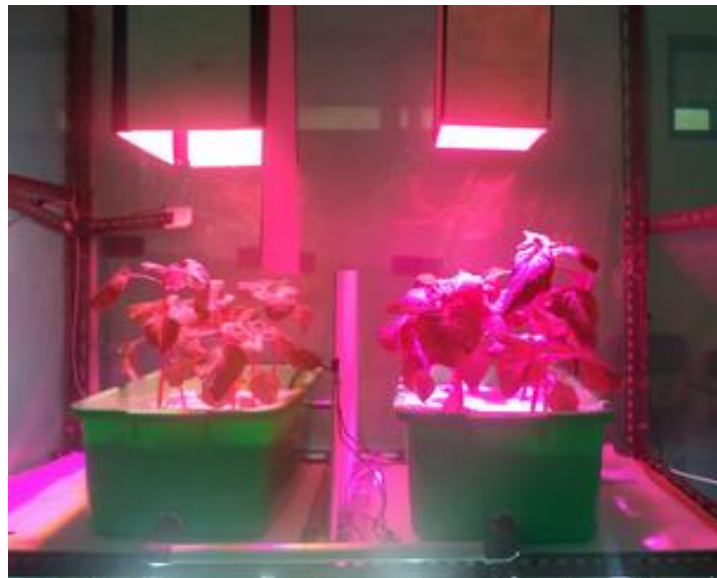


Figure 4. Growth of Spinach on Multi-Color LED Lights (92 Watts) and Red-Blue LEDs (192 Watts)

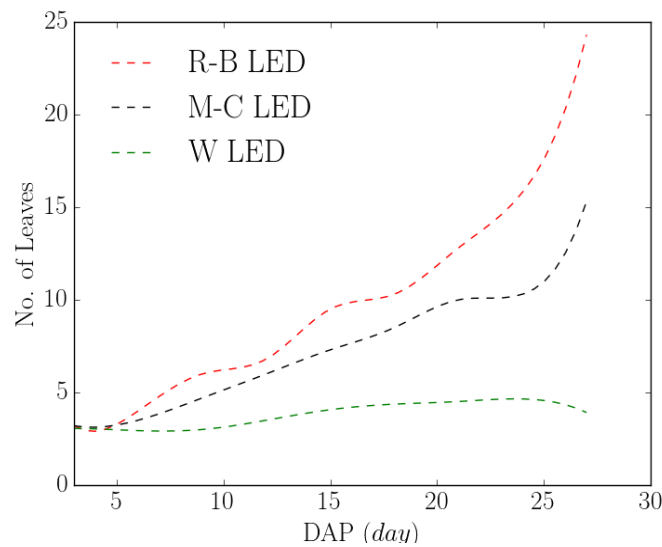


Figure 5. Development of Amounts of Spinach Leaves on 3 Types of Lighting

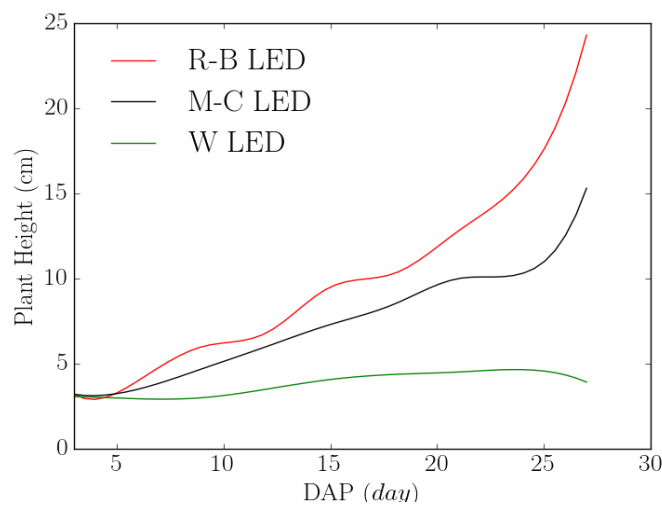


Figure 6. High Development of Spinach Plants in 3 Types of Lighting

3.2. Biomass development

Root length is the implication of biomass growth. The flow of photosynthesis results, one of which will be used to increase root mass. The Red-Blue LED treatment gave the best results, with a root length of 38.42 cm, followed by Multi-Color LEDs (30.83 cm) and White LEDs (3.10 cm) (Figure 7)

Wet and dry weight in the Red-Blue LED treatment was higher (29.08 grams and 1.09 grams) compared to Multi-Color LEDs (14.90 grams and 0.55 grams) and White LEDs (0.13 grams and nearly 0 gram). This parameter still shows that the Red-Blue LED gives the best results (Figure 8). Of the various growth parameters used, it is known that Red-Blue LEDs provide the best results compared to Multi-Color LEDs and White LEDs. The R-B LED said to increase the ratio of a/b chlorophyll [17]

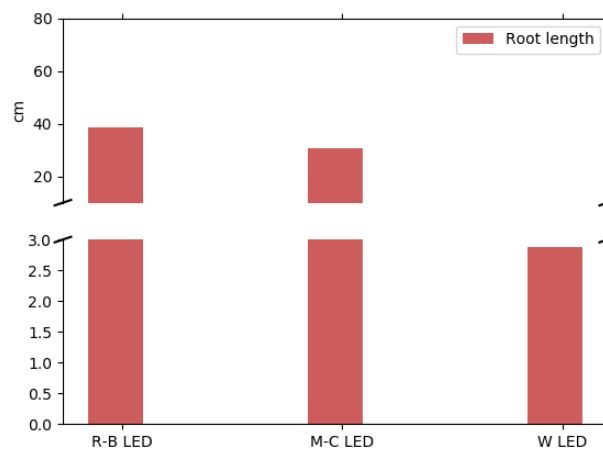


Figure 7. Development of Spinach Root Length in 3 Types of Lighting

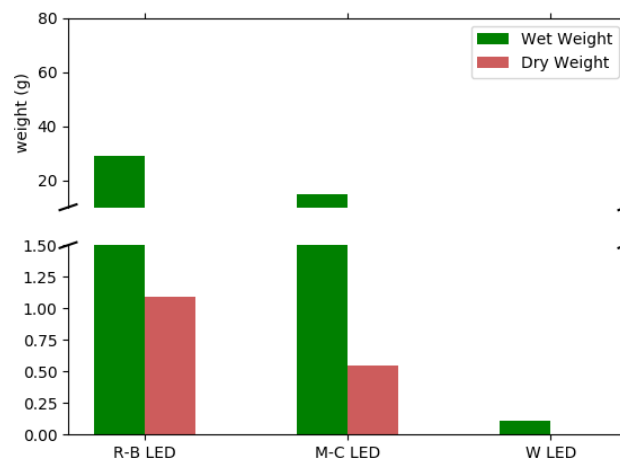


Figure 8. Wet weight and dry weight in 3 types of lighting

The experimental results show that the difference in growth is strongly influenced by the artificial light used. The growth and development of biomass depends not only on the type of light, but also on the interception of light by plant canopy [18]. This is illustrated in Figure 3, where there is an interdependence between LAI and radiation absorption efficiency. The greater the intercepted light in the plant canopy, the greater the photosynthetic activity which results in an increase in plant biomass.

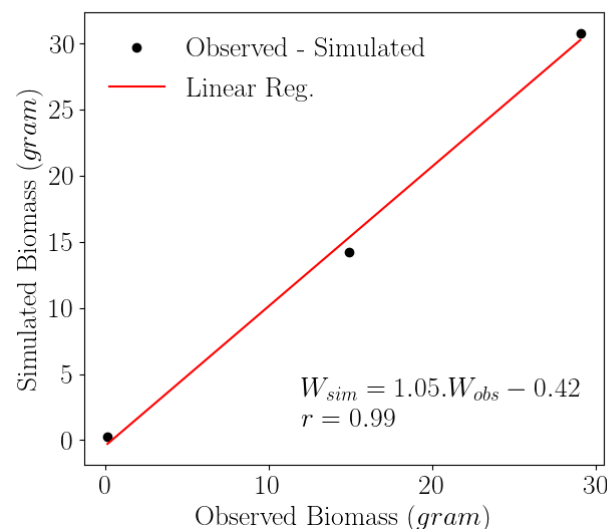


Figure 9. Observed and Simulated Biomass

The simulation using the biomass growth model shows the correspondence between the observed results and the simulation results with a correlation coefficient of 0.99 (Figure 9). These results indicate that the use of a biomass model with the main parameters of radiation or artificial lighting is sufficient to describe the actual growth process. The conversion factor from light to biomass is an important factor that must be calibrated for other crops. In micro-climatic conditions that meet the requirements for plant growth, photosynthesis will occur optimally depending on the amount of lighting provided. When the micro-climate does not support, for example, in terms of air temperature, then growth is stunted, providing light suitable for growth will not increase the biomass produced by growth. In the Thermal Unit (TU) concept, the plant will not move to the next growth phase when TU is not achieved.

Much higher light intensity causes more energy use for photosynthesis. The temperature in the Red-Blue LED is relatively higher than the other two treatments. Temperature will stimulate metabolism and stomatal opening. Another influential factor is humidity. At higher air temperatures, air humidity tends to be low in conditions without a source of evaporation. The plants use hydroponic nutrient planting media covered by Styrofoam, so there is no additional evaporation into the micro air. As a low RH will increase the Vapor Pressure Deficit (D) and drive an increase in transpiration. The nutrients carried to the leaves by the transpiration process will meet with sufficient light intensity from the Red-Blue LED.

4. Conclusion

The biomass model used could predict the biomass growth of the experiment because the simulated biomass matched the observed biomass. Both biomass model result and experiment result showed the 3 artificial lighting has difference in radiation absorption efficiency (ϵ). R-B LED provided highest treatment in all parameter (plant height, number of leaves, root length, and biomass). It means that the intercepted radiation was used for photosynthesis effectively.

The radiation of R-B LED was used the wavelength of red and blue light which is enable for leaves to absorb and use it for photosynthetic. The energy of the LED is also play role to provide enough micro-climate factor for photosynthesis to occur.

Overall, the approach used by the model which is using light interception as main parameter for biomass growth is appropriate. As long as the micro-climate is favorable, light interception greatly determines the increase in plant biomass. In a plant-factory system, proper radiation is required using R-B LED for optimal growth.

Acknowledgments

Authors wishing to acknowledge Indonesian Government which provided financial support that enable this research to happen

References

- [1] Restrepo-Díaz H, Melgar J C and Lombardini L 2010 *Agron. Colomb.* **28** 71–79
- [2] Amer K H and Hatfield J L 2004 *Agron J* **96** 978–85
- [3] Jackson R D 1982 *Irrigation* **1** 43–85
- [4] McAvoy R J, Janes H W and Giacomelli G A 1988 Development of a Plant Factory Model: I. the Organizational and Operational Model Ii. a Plant Growth Model: The Single Truss Tomato Crop *International Symposium on Models for Plant Growth, Environmental Control and Farm Management in Protected Cultivation* 248 pp 85–94
- [5] Ijaz F, Siddiqui A A, Im B K and Lee C 2012 Remote Management and Control System for Led Based Plant Factory Using Zigbee and Internet *2012 14th International Conference on Advanced Communication Technology (ICACT)* pp 942–6
- [6] Wakahara T and Mikami S 2011 *JACIII* **15** 831–7
- [7] Ikeda A, Tanimura Y, Ezaki K, Kawai Y, Nakayama S, Iwao K and Kageyama H 1991 *International Workshop on Sensors in Horticulture* 304 pp 151–8
- [8] Marques B S, Silva A P P, Lima R S O, Machado E C R, Gonçalves M F and Carvalho S J P 2014 *Planta Daninha* **32** 483–90
- [9] Murakami T 1973 *Jpn. Agric. Res. Q.* **7** 1
- [10] Parthasarathi T, Velu G and Jeyakumar P 2013 *J. Crop Sci. Technol.* **2** 2319–3395
- [11] Yuliawan T and Handoko I 2016 *Procedia Environ. Sci.* **33** 214–20
- [12] Lötscher M, Klumpp K and Schnyder H 2004 *New Phytol.* **164** 305–16
- [13] Adu-Bredu S, Yokota T and Hagihara A 1997 *Ecol. Res.* **12** 357–62
- [14] Paine C E T, Marthews T R, Vogt D R, Purves D, Rees M, Hector A and Turnbull L A 2012 *Methods Ecol. Evol.* **3** 245–56
- [15] Gregorczyk A 1991 *Acta Soc. Bot. Pol.* **60** 67–76
- [16] Kawano T, Wallbridge N and Plummer C 2020 *Plant Signal. Behav.* **15** 1709718
- [17] Wang S, Wang X, Shi X, Wang B, Zheng X, Wang H and Liu F 2016 *Hortic. Plant J.* **2** 82–90
- [18] Ardiansyah A, Sumarni E S and Sahirman S 2018 *J. Keteknik Pertanian.* **6** 295–302
- [19] Ardiansyah, Chusnul A, Krissandi W and Asna M 2018 *IOP Conf. Ser. Earth Environ. Sci.* **147** 012041

Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

by Ardiansyah Ardiansyah

Submission date: 09-Jul-2022 08:06PM (UTC+0700)

Submission ID: 1868308899

File name: diansyah_2021_IOP_Conf._Ser._Earth_Environ._Sci._653_012100.pdf (822.2K)

Word count: 2675

Character count: 13988

PAPER • OPEN ACCESS

Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

To cite this article: Ardiansyah *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **653** 012100

View the [article online](#) for updates and enhancements.

You may also like

- 5 [Watt and Joule balances](#)
Jan A Robinson
- 5 [Gravitational water vortex pico hydro power modeling for aquaculture](#)
D W Maulana, F M Rizwan, C Mulyana et al.
- 7 [Implementation](#)
D W Maulana, F M Rizwan, C Mulyana et al.
- 3 [The Influence of Light Wavelengths Toward the Growth of *Brassica rapa* L.](#)
Rizky Maiza and Daniel Kurnia



*Benefit from connecting
with your community*

ECS Membership = Connection

ECS membership connects you to the electrochemical community:

- Facilitate your research and discovery through ECS meetings which convene scientists from around the world;
- Access professional support through your lifetime career;
- Open up mentorship opportunities across the stages of your career;
- Build relationships that nurture partnership, teamwork—and success!

Join ECS!

Visit electrochem.org/join



Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

Ardiansyah*, A Hardanto and E Sumarni

Department of Agricultural Engineering, Jendral Soedirman University, Purwokerto, Indonesia

Corresponding author: ard@unsoed.ac.id

Abstract. The research is trying to observe the effect of different light sources on red spinach (*Amaranthus Tricolor L*) plant. Plant-factories were installed and divided into three compartments. Each compartment was given three light sources: Red-Blue LED (R-B), Multi-Color LED (M-C), and White LED (W). The energy of each light sources R-B, M-C, and W were 192 Watt, 92 Watt, and 8 Watt, respectively. The research took place on March 2018 in the Agriculture Technology Laboratory, Jendral Soedirman University, Indonesia. The growth parameters measured were plant height, biomass, and number of leaves. Results showed that there was significant difference of growth parameters of treatment R-B compared to treatment M-C, and W. Shierary Model were used to study the mechanism of growth parameter difference. The model used the input of radiation energy of light sources that were affected by leaves development, that called the intercepted radiation. The result of the model showed that the intercepted radiation influenced the growth parameters. Treatment R-B, which generates commonly used light wave for photosynthetic, caused better plant growth. The influence of the heat emerged from the light sources were seemed to create better micro-climate for photosynthesis.

1. Introduction

Several studies showed the relationships between climatic factors and plant growth. These factors, for example, influence plant physiology [1], canopy resistance [2] or water stress [3]. *Plant-factory* or controlled crop chamber are intensive cultivation methods carried out in chamber, in which all climate factors can be adjusted and managed. It can improve yields and be efficient in land use [4-6]. Research shows that there is an acceleration of growth and an increase in biomass if light, temperature, humidity, and CO_2 concentrations are controlled at a certain level [7].

Plant's micro-climate arrangement is possible to manage; because it relates to parameters that can be controlled technically using mechanical or electrical devices. Information about good growth conditions can be obtained by experiments using various controlled parameters. Automatic control is the keyword to get the optimum parameters (in experiments), also to control the plant environment at optimum conditions (in production). Biomass production is affected by photosynthetic activity, which is influenced by various factors. Automatic control of these optimum factors allows maximum biomass growth. Thus, the micro-climate arrangement can be optimized to grow optimum biomass in production scale.



Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd

The need to predict biomass growth based on micro-climate condition is the key for optimizing micro-climate parameter in *Plant-factory*. The biomass predictors, such as canopy resistance, water stress, carbon dioxide assimilation can be used to estimate biomass. However, to measure or calculate those predictors are difficult to do. It needs complex measurement and sophisticated instrument. Consequently, the requirement to use simple parameter to predict biomass growth is urgent. Light or radiation can be used as predictor. The measurement is simple, and the instrument is easy to buy or to assemble. This research will use different kind of LED light sources (treatments) and observe the biomass growth under the treatments.

The purposes of this research are firstly, observing radiation intercepted by the plant canopy under three types of artificial light, secondly, measuring changes in growth parameters and biomass under three types of artificial light, and thirdly, applying biomass modeling to predict biomass growth and development, by incorporating intercepted light as input variable.

2. Materials and methods

2.1. Experiment setting

The type of plant-factory used in this research is a complete-control type [6], where all the factor such as light, temperature, and humidity is electrically controlled. Measurement variables include measurement of a) external production factors (input: light, humidity, temperature) and b) plant growth response (plant height, number of leaves, and biomass development). Figure 1 shows the experiment setting.

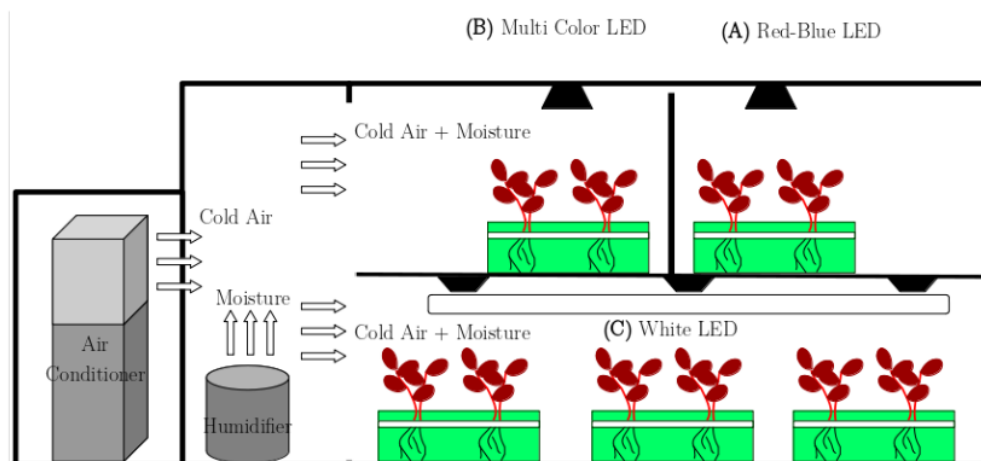


Figure 1. Experiment Setting

2.2. Biomass modelling

Concept applied for biomass modelling is microclimate condition that stated by Thermal Unit (TU). The main concept is that the growth phase is moving from existing phase to next phase after the TU is fulfilled [8–10]. After the concept of TU, the biomass growth described by the conversion of photosynthetic radiation into biomass. The model called Shierary Rice Model [11]. Conversion from radiation into biomass controlled by coefficient called radiation efficiency (ϵ). The equation is appeared in Equation (1).

$$dW = \epsilon \cdot Q_{intercept} \quad (1)$$

where dW is total biomass production (g), $\epsilon = 1.65 \text{ g MJ}^{-1}$ is radiation efficiency of converting light into biomass.

Intercepted radiation ($Q_{intercept}$, $\text{MJ} \cdot \text{m}^{-2}$) is calculated using equation (2) :

$$Q_{interception} = (1 - \tau) \cdot Q_s \quad (2)$$

where τ ($\tau = e^{-k \cdot LAI}$ or $\tau = \frac{Q_{trans}}{Q_s}$) is fraction of light transmitted below the canopy. Q_s is daily incoming radiation ($\text{MJ} \cdot \text{m}^{-2}$).

Partition of whole biomass growth (1) into their plant-organs (root, stem, leaves) is using equation (3)

$$dW_x = \eta_x dW - R_g - R_m \quad (3)$$

dW_x is biomass development in plant-organs (x) (gm^{-2}), η_x = allocation of biomass for certain organs (root, straw, leaves, or grains). Growth respiration (R_g , gm^{-2}) and maintenance respiration (R_m , gm^{-2}) [12] is the energy used by the plant. They're using result of photosynthesis. They were calculated using Equation (4) and Equation (5):

$$R_g = k_g \cdot \eta_x \cdot dW. \quad (4)$$

$$R_m = k_m \cdot W_x \cdot Q_{10} \quad (5)$$

where k_g is growth respiration coefficient = 0.0108, dan k_m = maintenance respiration coefficient = 0.13. W_x = biomass of plant-organ (g), Q_{10} [13] were calculated as $Q_{10} = \left(\frac{K_2}{K_1}\right)^{\frac{10}{(T_2 - T_1)}}$ which accordingly can be stated as:

$$Q_{10} = 2^{\frac{10}{(T - 20)}} \quad (6)$$

Graphically, the concept of modeling plant biomass growth is shown in the Figure 2. The variables calculated in equations (1) to (6) are listed in the nodes in the chart. The lines connecting one node to another node show the transformation of the calculation to the variable shown in the arrow.

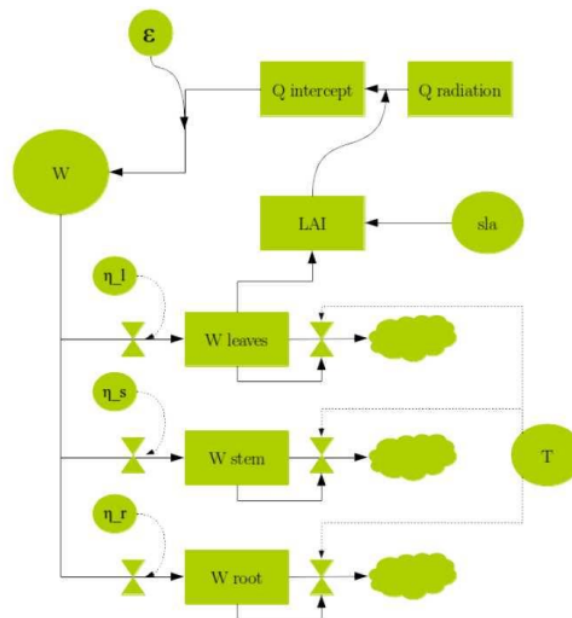


Figure 2. Model Calculation in Graphical Form

8

3. Results and discussion

3.1. Plant growth and development

Acceptance of radiation intercepted by leaves becomes material for photosynthesis. Energy will be converted into biomass and allocated to organs in the plant. The growth of organs can be used as an indicator of biomass growth. The concept of biomass growth can be seen in Figure 3.

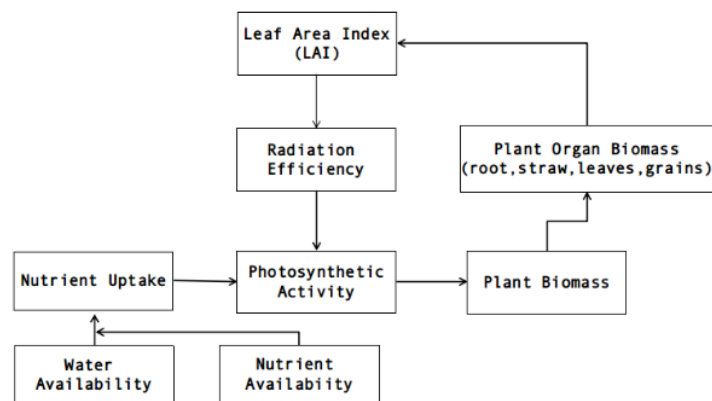


Figure 3. Biomass Growth Concept [19]

6

Time series data on plant height, number of leaves, root length, wet weight and dry weight are presented in graphical form. The data includes measurements on day 0 (after planting) until day 27. The use of photosynthetic lamps to replace sunlight needs to consider the spectrum of light used.

Figure 4 shows the growth of spinach plants with Red-Blue LED lighting (192 Watts) and Multi-Color LED (92 Watts). The best growth is seen in plants with Red-Blue LED. When compared with White LED (8 Watts) with color temperatures of 6500 K, then both types of Red-Blue and Multi-Color LED show much better results.

The development of leaf number and plant height during the planting period also indicates that Red-Blue LEDs provide better growth than Multi-Color LED. White LEDs provide significantly less yield than Red-Blue LED and Multi-Color LED (Figure 5 and Figure 6).

The highest growth of leaf numbers is shown in the order of Red-Blue light, followed by Multi-Color light, and White light. This growth pattern is exponential as any other growth pattern [14–16]. On the 15th day, plants with Blue-Red LED lighting showed a rapid increase compared to plants with Multi-Color LED lighting.

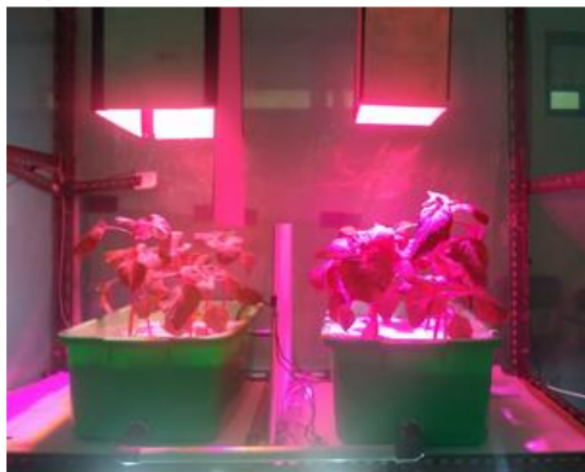


Figure 4. Growth of Spinach on Multi-Color LED Lights (92 Watts) and Red-Blue LEDs (192 Watts)

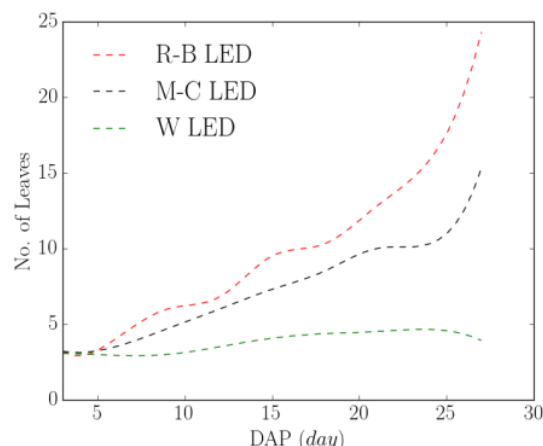


Figure 5. Development of Amounts of Spinach Leaves on 3 Types of Lighting

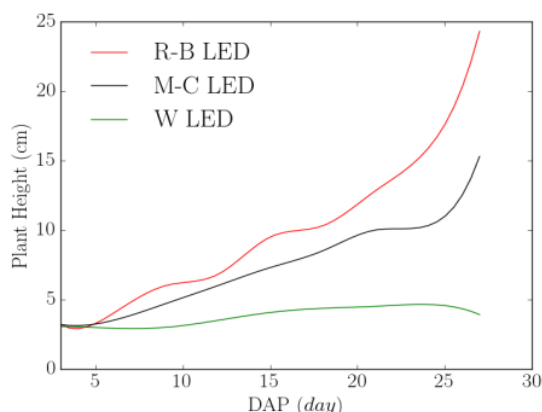


Figure 6. High Development of Spinach Plants in 3 Types of Lighting

3.2. Biomass development

Root length is the implication of biomass growth. The flow of photosynthesis results, one of which will be used to increase root mass. The Red-Blue LED treatment gave the best results, with a root length of 38.42 cm, followed by Multi-Color LEDs (30.83 cm) and White LEDs (3.10 cm) (Figure 7)

Wet and dry weight in the Red-Blue LED treatment was higher (29.08 grams and 1.09 grams) compared to Multi-Color LEDs (14.90 grams and 0.55 grams) and White LEDs (0.13 grams and nearly 0 gram). This parameter still shows that the Red-Blue LED gives the best results (Figure 8). Of the various growth parameters used, it is known that Red-Blue LEDs provide the best results compared to Multi-Color LEDs and White LEDs. The R-B LED said to increase the ratio of a/b chlorophyll [17]

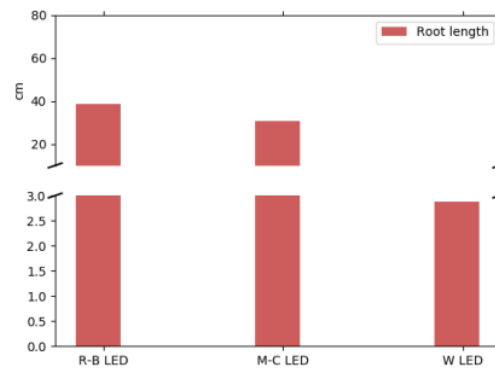


Figure 7. Development of Spinach Root Length in 3 Types of Lighting

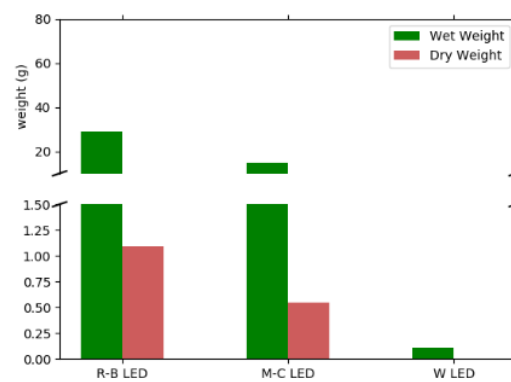


Figure 8. Wet weight and dry weight in 3 types of lighting

The experimental results show that the difference in growth is strongly influenced by the artificial light used. The growth and development of biomass depends not only on the type of light, but also on the interception of light by plant canopy [18]. This is illustrated in Figure 3, where there is an interdependence between LAI and radiation absorption efficiency. The greater the intercepted light in the plant canopy, the greater the photosynthetic activity which results in an increase in plant biomass.

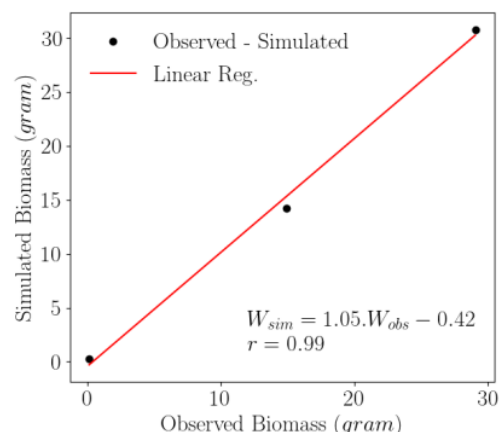


Figure 9. Observed and Simulated Biomass

The simulation using the biomass growth model shows the correspondence between the observed results and the simulation results with a correlation coefficient of 0.99 (Figure 9). These results indicate that the use of a biomass model with the main parameters of radiation or artificial lighting is sufficient to describe the actual growth process. The conversion factor from light to biomass is an important factor that must be calibrated for other crops. In micro-climatic conditions that meet the requirements for plant growth, photosynthesis will occur optimally depending on the amount of lighting provided. When the micro-climate does not support, for example, in terms of air temperature, then growth is stunted, providing light suitable for growth will not increase the biomass produced by growth. In the Thermal Unit (TU) concept, the plant will not move to the next growth phase when TU is not achieved.

Much higher light intensity causes more energy use for photosynthesis. The temperature in the Red-Blue LED is relatively higher than the other two treatments. Temperature will stimulate metabolism and stomatal opening. Another influential factor is humidity. At higher air temperatures, air humidity tends to be low in conditions without a source of evaporation. The plants use hydroponic nutrient planting media covered by Styrofoam, so there is no additional evaporation into the micro air. As a low RH will increase the Vapor Pressure Deficit (D) and drive an increase in transpiration. The nutrients carried to the leaves by the transpiration process will meet with sufficient light intensity from the Red-Blue LED.

4. Conclusion

The biomass model used could predict the biomass growth of the experiment because the simulated biomass matched the observed biomass. Both biomass model result and experiment result showed the 3 artificial lighting has difference in radiation absorption efficiency (ϵ). R-B LED provided highest treatment in all parameter (plant height, number of leaves, root length, and biomass). It means that the intercepted radiation was used for photosynthesis effectively.

The radiation of R-B LED was used the wavelength of red and blue light which is enable for leaves to absorb and use it for photosynthetic. The energy of the LED is also play role to provide enough micro-climate factor for photosynthesis to occur.

Overall, the approach used by the model which is using light interception as main parameter for biomass growth is appropriate. As long as the micro-climate is favorable, light interception greatly determines the increase in plant biomass. In a plant-factory system, proper radiation is required using R-B LED for optimal growth.

Acknowledgments

Authors wishing to acknowledge Indonesian Government which provided financial support that enable this research to happen

References

- [1] Restrepo-Díaz H, Melgar J C and Lombardini L 2010 *Agron. Colomb.* **28** 71–79
- [2] Amer K H and Hatfield J L 2004 *Agron J* **96** 978–85
- [3] Jackson R D 1982 *Irrigation* **1** 43–85
- [4] McAvoy R J, Janes H W and Giacomelli G A 1988 Development of a Plant Factory Model: I. the Organizational and Operational Model II. a Plant Growth Model: The Single Truss Tomato Crop *International Symposium on Models for Plant Growth, Environmental Control and Farm Management in Protected Cultivation* 248 pp 85–94
- [5] Ijaz F, Siddiqui A A, Im B K and Lee C 2012 Remote Management and Control System for Led Based Plant Factory Using Zigbee and Internet 2012 *14th International Conference on Advanced Communication Technology (ICACT)* pp 942–6
- [6] Wakahara T and Mikami S 2011 *JACH* **15** 831–7
- [7] Ikeda A, Tanimura Y, Ezaki K, Kawai Y, Nakayama S, Iwao K and Kageyama H 1991 *International Workshop on Sensors in Horticulture* 304 pp 151–8
- [8] Marques B S, Silva A P P, Lima R S O, Machado E C R, Gonçalves M F and Carvalho S J P 2014 *Planta Daninha* **32** 483–90
- [9] Murakami T 1973 *Jpn. Agric. Res. Q.* **7** 1
- [10] Parthasarathi T, Velu G and Jeyakumar P 2013 *J. Crop Sci. Technol.* **2** 2319–3395
- [11] Yuliawan T and Handoko I 2016 *Procedia Environ. Sci.* **33** 214–20
- [12] Lötscher M, Klumpp K and Schnyder H 2004 *New Phytol.* **164** 305–16
- [13] Adu-Bredu S, Yokota T and Hagihara A 1997 *Ecol. Res.* **12** 357–62
- [14] Paine C E T, Marthews T R, Vogt D R, Purves D, Rees M, Hector A and Turnbull L A 2012 *Methods Ecol. Evol.* **3** 245–56
- [15] Gregorczyk A 1991 *Acta Soc. Bot. Pol.* **60** 67–76
- [16] Kawano T, Wallbridge N and Plummer C 2020 *Plant Signal. Behav.* **15** 1709718
- [17] Wang S, Wang X, Shi X, Wang B, Zheng X, Wang H and Liu F 2016 *Hortic. Plant J.* **2** 82–90
- [18] Ardiansyah A, Sumarni E S and Sahirman S 2018 *J. Keteknik Pertanian.* **6** 295–302
- [19] Ardiansyah, Chusnul A, Krissandi W and Asna M 2018 *IOP Conf. Ser. Earth Environ. Sci.* **147** 012041

Biomass growth of red spinach in plant-factory system under three kinds of LED light sources

ORIGINALITY REPORT

13%
SIMILARITY INDEX

13%
INTERNET SOURCES

11%
PUBLICATIONS

11%
STUDENT PAPERS

PRIMARY SOURCES

1 Submitted to Aberystwyth University 6%
Student Paper

2 eprints.untirta.ac.id 2%
Internet Source

3 D A Filatov, A A Vetchinnikov, S I Olonina, I Yu Olonin. "Intermittent LED lighting helps reduce energy costs when growing microgreens on vertical controlled environment farms", IOP Conference Series: Earth and Environmental Science, 2022 1%
Publication

4 Submitted to Universitas Negeri Semarang 1%
Student Paper

5 D W Maulana, F M Rizwan, C Mulyana, F Faizal, C Panatarani, I M Joni. "Gravitational water vortex pico hydro power modeling for aquaculture implementation", Journal of Physics: Conference Series, 2020 1%
Publication

6

www.ojs.uma.ac.id

Internet Source

1 %

7

M N Hidayat, F Ronilaya, I H Eryk, A Setiawan, E Rohadi. "Application of the cascade system to increase the capacity of a pico-hydro power generation", IOP Conference Series: Materials Science and Engineering, 2021

Publication

<1 %

8

dergiler.ankara.edu.tr

Internet Source

<1 %

Exclude quotes On

Exclude matches Off

Exclude bibliography On



Certificate

Awarded to

Ardiansyah, S.TP., M.Si., Ph.D.

for participation in

**The 2nd International Conference on
Sustainable Agriculture for Rural Development
(2nd ICSARD)**

as

Presenter

Faculty of Agriculture | Universitas Jenderal Soedirman

Purwokerto, October 20th 2020

Dean of
The Faculty of Agriculture



Dr. Ir. Anisur Rosyad, M.S.

Chairman of
The 2nd ICSARD 2020



Susanto B. Sulistyo, Ph.D.



Organizing Committee
The 2nd International Conference on Sustainable Agriculture
for Rural Development 2020 (2nd ICSARD 2020)
Faculty of Agriculture - Jenderal Soedirman University
Jl. Dr. Soeparno, Karangwangkal, Purwokerto, Indonesia 53123
Web: bit.ly/icsard2020unsoed; Email: icsard@unsoed.ac.id



LETTER OF ACCEPTANCE

October 5, 2020

Dear Ardiansyah

The organizing committee of the 2nd International Conference on Sustainable Agriculture for Rural Development (2nd ICSARD) 2020 is pleased to inform you that the submitted abstract entitled:

Biomass Growth of Red Spinach in Plant-Factory System under Three Kinds of LED Light Sources

has been accepted for Oral Presentation based on the peer-review by the scientific committee of 2nd ICSARD, which will be held virtually on October 20, 2020. The abstract will be appeared in the book of program and will be available for all participants of the conference. We would like to thank for your contribution in the 2nd ICSARD 2020 and look forward to your participation in this event.

Best regards,

Susanto Budi Sulistyo, PhD.

Chairman of 2nd ICSARD Committee

Book of Program



OCTOBER 20th
2020

The 2nd International Conference on Sustainable Agriculture for Rural Development (ICSARD)

Organized by :

Faculty of Agriculture
Universitas Jenderal Soedirman

Supported by :





Organizer

The 2nd International Conference on Sustainable Agriculture for Rural Development 2020 is organized by the Faculty of Agriculture, Jenderal Soedirman University.

Secretariat Address

Faculty of Agriculture
Jenderal Soedirman University
Jl dr. Soeparno Telp (0281) 638791 Purwokerto 53123
Indonesia



Conference Report by the Chairman

Assalamu'alaikum warahmatullahi wabarakatuh
Good morning

The honorable Rector of Jenderal Soedirman University or his representative,
The honorable deans of all faculties in Jenderal Soedirman University,
The honorable invited speakers,
And all distinguished participants,

Ladies and gentlemen,

On behalf of the Organizing Committee, I am honored and delighted to welcome you to the official opening of the 2nd International Conference on Sustainable Agriculture for Rural Development 2020 which is held virtually due to the pandemic of COVID-19.

This conference is organized by the Faculty of Agriculture, Jenderal Soedirman University and is a part of the event series to celebrate the 58th Anniversary of the Faculty of Agriculture, Jenderal Soedirman University. This one-day seminar comprises both plenary and parallel session. In the plenary session there are three invited speakers who will give presentations and share their knowledge and expertise. I would like to express my sincere gratitude to all invited speakers, Prof. Ting-ting Wu, Ph.D. from National Yunlin University of Science and Technology, Taiwan, Prof. Tatsuo Sato, Ph.D. from Ibaraki University, Japan, and Suprayogi, Ph.D. from Jenderal Soedirman University, Indonesia, who have accepted our invitation.

Ladies and gentlemen,

We have accepted 207 abstracts from researchers who will present their most recent research in the parallel session. Participants are mostly from Indonesia and also from abroad, i.e. Japan, Vietnam, Sudan, Oman, Iraq, and New Zealand. We hope that this virtual conference will provide a perfect forum for participants to interact and possibly discuss future collaborations.

As a general chair of this conference, I realize that the success of the conference depends ultimately on many people who have worked with us in planning and organizing both the technical program and supporting social arrangements. I would like to thank all committee members who have worked extremely hard for the details of important aspects of the conference programs.

We hope that you will experience a fruitful and inspiring meeting and leave this virtual conference with enlarged horizons for research and education perspectives.

Thank you.
Wassalamu'alaikum warahmatullahi wabarakatuh

Susanto B. Sulistyono, Ph.D.
Chairman of the 2nd ICSARD 2020



2nd ICSARD 2020

International Conference on Sustainable Agriculture
for Rural Development

Purwokerto, Indonesia - October 20, 2020



Session 2 (15.00 – 17.00)

Moderator		Dr. Afik Hardanto, S.TP., M.Sc.			
Notulen		Dian Novitasari, S.TP., M.Si.			
No	Time	Paper ID	Title	Authors	Affiliation
1.	15.00-15.10	1157	Prediction of the velocity of air flow by dimensional analysis for drying application	Siswantoro, Agus Margiwiyatno, and Joko Maryanto	Study Program of Agricultural Engineering, Department of Agricultural Technology, Faculty of Agriculture, Jenderal Soedirman University, Indonesia
2.	15.10-15.20	1167	Anomaly Weather and Its Impact on The Growth of Maize (Zea mays)	Wini Prayogi Abdila A, and Bayu Dwi Apri Nugroho	Master Program, Departement of Agricultural and Biosystems Engineering, Universitas Gadjah Mada, Indonesia
3.	15.20-15.30	1175	The effect of Extreme Weather on Rice Growth and Productivity	Hertiyana Nur Annisaa, and Bayu Dwi Apri Nugroho	Master Program Departement of Agriculture and Biosystem Engineering
4.	15.30-15.40	1229	Development of Short-Term Evapotranspiration Forecasting Model using Time Series Method for Supporting the Precision Agriculture Management in Tropics	Andri Prima Nugroho, Dita Endah Rahayu, Lilik Sutiarso, Murtiningrum, Mohammad Affan Fajar Falah and Takashi Okayasu	Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada, Indonesia
5.	15.40-15.50	1247	Physical Characteristics of Heat Resistant Dark Chocolate Made with The Addition of Cocoa Butter Replacer at Several Durations of Crystal Maturation	Nafisa Shinta Syafira, Arifin Dwi Saputro, Annisa Nur Khasanah, Theresia Oetama1, Sri Rahayoe1, and Nursigit Bintoro	Department of Agricultural and Biosystems Engineering Faculty of Agricultural Technology Universitas Gadjah Mada, Indonesia
6.	15.50-16.00	1248	Physical Characteristics of Chocolate Made with Cocoa Butter Replacer (CBR) and Coffee Powder	Annisa Nur Khasanah, Arifin Dwi Saputro, Nafisa Shinta Syafira, Theresia Oetama1, and Joko Nugroho Wahyu Karyadi, and Yudha Dwi Prasetyatama	Department of Agricultural and Biosystems Engineering Faculty of Agricultural Technology Universitas Gadjah Mada, Indonesia



2nd ICSARD 2020

International Conference on Sustainable Agriculture
for Rural Development

Purwokerto, Indonesia - October 20, 2020



No	Time	Paper ID	Title	Authors	Affiliation
7.	16.00-16.10	1272	Physical and Mechanical Properties of Paper Pulp Packaging made from Banana Stalk and Rice Husk	Rifah Ediaty, Ulumul Nur Aina, Agus Margiwiyatno and Riana Listanti	University of Jenderal Soedirman, Indonesia
8.	16.10-16.20	1274	Rice fields Classification among Google Earth Sattelite Images using Convolutional Neural Network	Imron Rosyadi, Fendy Prayogi, Farida Asriani, and Rifah Ediaty	Electrical Engineering, Jenderal Soedirman University, Indonesia
9.	16.20-16.30	1193	Biomass Growth of Red Spinach in Plant-Factory System under Three Kinds of LED Light Sources	Ardiansyah, Afik Hardanto, and Eni Sumarni	Lab. of Bio-Environmental Management and Control Engineering, Dept. of Agricultural Engineering, Jenderal Soedirman University, Indonesia