Mahidol University

CHIBA UNIVERSITY

MU-CU Joint Symposium 2019
“Integrated Horticulture for Better Quality of Life”

10 May 2019
Stang Mongkolsuk Conference Room
Faculty of Science, Mahidol University
Bangkok, the Kingdom of Thailand

Index

MU-CU Joint Symposium 2019
Integrated Horticulture for Better Quality of Life

Background

The Faculty of Science, Mahidol University (MUSC) is strongly committed to promote its research findings and academic services among national and international communities, through a variety of public communications. Knowledge sharing is one of the most effective activities that has long been driving and put MUSC into the forefront, also considered as a crucial factor responding to social responsibility to be an international learning organization in this 21st century.

MUSC strengthens knowledge sharing capability, utilizing its existing national and international academic networks, in order to affiliate scientists, researchers, lecturers and students to meet, discuss and share their own experiences through the specific student exchange programs, joint seminars, meetings, conferences and symposiums. These special academic events will not only be used to enhance MUSC's international collaboration mechanism but also to create student network, encourage and prepare those students for further internationalization exposure.

The Faculty of Science has a very great pleasure to invite delegates to join the "MU-CU Joint Symposium 2019" with the theme "Integrated Horticulture for Better Quality of Life", which will be held on 10th May 2019.

Date

10th May 2019

Venue

The symposium will take place at the Conference Room, Stang Mongkolsuk Building, Faculty of Science, Mahidol University, Phayathai Campus.
Postal Address: 272 Rama VI Road, Ratchathewi, Bangkok 10400, Thailand.
Tel: +66 2201 5070

Language

All presentations are required to prepare in an electronic file format and must be presented in English. Abstract submission and other related documents will also be required to submit in English.

Topic

Topic 1: "Plant environmental control for production of plant-derived pharmaceuticals in a plant factory"

Topic 2: "Study of LED wavelength on ABA metabolism, anthocyanin synthesis, and sugar translocation in grapes"

Topic 3: "Microclimate technology and physiological information for fruit orchard management"

Topic 4: "Smart farm – ICT&AI agriculture based on monitoring and modeling of plants"

Topic 5: "Study of Light and Amino Acid Applications on Growth and Nitrate Uptake in Hydroponically-grown Lettuce."

Topic 6: "Medicinal and aromatic plants production in plant factory"

Topic 7: "Inflorescent xylem development as a key to cope with suboptimal water availability in tropical fruit production"

Expected Attendant

The Symposium expects approximately 100 staff members/researcher/lecturers and students from local universities and co-organizers.

Food and Beverage

The symposium will provide complementary food and beverages, 2 times, including lunches and refreshments

Facility and Transportation

Invited oral speakers will be provided an airport pick-up and needed local transportations including technical assistance, accommodation information, computing and internet connectivity and presentation file test.

Organizing Committee

Dr. Kanyaratt Suphibunwatana	kanyaratt.sup@mahidol.ac.th
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Program for the MU-CU Joint Symposium 2019
"Integrated Horticulture for Better Quality of Life"
10 May 2019, at Stang Mongkolsuk Conference Room
Faculty of Science, Mahidol University
Bangkok, the Kingdom of Thailand

9.00	- Multimedia presentation :MC, Ms.Rungrat Suriyin
9.15	- Opening session & Group photo Opening remark by Assoc. Prof. Kanyaratt Supaibulwatana, Vice Dean
9.30-10.10	(30 minutes of presentation and 10 minutes of Q&A) - Topic 1 "Plant environmental control for production of plant-derived harmaceuticals in a plant factory" by Prof. E. Goto (Chiba University)
10.10-10.50	- Topic 2 "Study of LED wavelength on ABA metabolism, anthocyanin synthesis, and sugar translocation in grapes" by Prof. S. Kondo (Chiba University
10.50-11.05	- Refreshment (coffee/tea break)
11.05-11.45	- Topic 3 "Microclimate technology and physiological information for fruit orchard management" by Assist. Prof. Watcharra Chintakovid (Mahidol University)
11.45-13.00	- Lunch hosted by MUSC
13.00-13.40	- Topic 4 "Smart farm – ICT&AI agriculture based on monitoring and modeling of plants" by Prof. E. Goto (Chiba University)
13.40-14.20	- Topic 5 "Study of Light and Amino Acid Applications on Growth and Nitrate Uptake in Hydroponically-grown Lettuce." by Dr. Napassorn Punyasuk (Mahidol University)
14.20-14.35	- Refreshment (coffee/tea break)
14.35-15.15	- Topic 6 "Medicinal and aromatic plants production in plant factory" by Dr. Lu Na (Chiba University)
15.15-15.55	- Topic 7 "Inflorescent xylem development as a key to cope with suboptimal water availability in tropical fruit production" by Dr.Tatpong Tulyananda (Mahidol University)

Abstract
Oral Presentation

Topic: 1

Plant environmental control for production of plant-derived pharmaceuticals in a plant factory

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Abstract

Plant factories where leafy vegetables are cultivated until harvest in closed systems with artificial lighting were proposed, developed, and implemented in Japan during the 1980s. During the 1990s, the products from these factories received high evaluations by the food service industry, to which they primarily catered. During the 2000s, commercial production of nursery plants of fruits and vegetables was initiated in plant factories. Since the late 2000s, plant factory technology has been introduced worldwide, particularly to Asian countries. Plant factories also provide good cultivation systems for the production of medicinal plants and genetically modified crops for pharmaceutical use. In late 2000s, light-emitting diodes (LEDs) were introduced to plant factories as a more efficient light source. LEDs are expected to reduce the electricity costs of lighting and cooling because they have a higher efficiency of converting electric power to light power and exert lower cooling loads than conventional light sources. To achieve plant production in plant factories, more achievement of plant research is required taking engineering and plant physiological approaches, in areas such as the creation of optimal LED lighting systems, promotion of photosynthesis, control of gene expression, photomorphogenesis, and synthesis of secondary metabolites. This study reviews recent research status and achievements regarding plant production in plant factories with artificial lighting and introduces plant research topics related to plant environment control for production of plant-derived pharmaceuticals.

Keywords

Functional protein, GM plant, light quality, medicinal plant, secondary metabolites

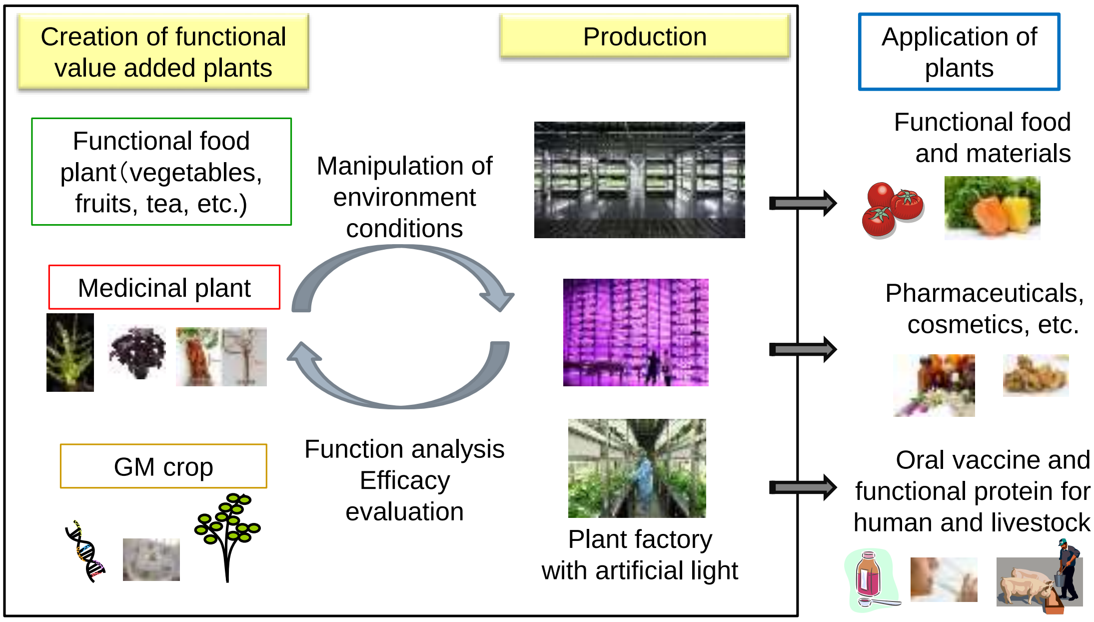

Fig. Creation of high-value added plants and development of production systems. Cited from Science Council of Japan, Academic research plan 2017, proposed by Chiba University.

Topic: 2

Study of LED wavelength on ABA metabolism, anthocyanin synthesis, and sugar translocation in grapes

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Abstract

The interaction between abscisic acid (ABA) and blue or red light irradiation on anthocyanin and sugar syntheses in 'Kyoho' (V*itis labrusca*╳*V. vinifera*) grape berries was examined. The following two experiment groups were created. In the first group, ABA antagonist of PYL-PP2C receptor (AS-6) was treated to the cluster at 38 days after full bloom (DAFB) (one week before veraison) and 48 DAFB (veraison). The second group was the untreated control group. The anthocyanin and sugar concentrations, ABA metabolism, and their related gene expressions were analyzed at 38, 48, 58, and 68 DAFB. The anthocyanin, glucose, fructose, sucrose concentrations, and the *VlMybA2* and *VvUFGT* expression levels were inhibited in AS-6 treated berries. In contrast, the expression levels of *VvPC2C9* in AS-6 treated berries were increased at 48 DAFB. These results suggest that endogenous ABA is associated with anthocyanin and sugar syntheses in grape skin.

To consider the effects of light on ABA metabolism and anthocyanin formation, three experiment groups were created. In the first group, blue (clusters)/blue (leaves) LED was irradiated for six hours at night from full bloom to harvest. In the second group, blue (clusters)/red (leaves) LED was similarly irradiated. The third group was the untreated control. The *VvNCED1* expression levels were increased in the first and second groups compared to the untreated control. The *CYP707A1* expression levels in the second group was decreased at 62 DAFB. The *VvPP2C9* expression levels in the first and second groups were inhibited. These expression levels influenced ABA concentrations in the skin. The anthocyanin concentrations were increased in the first and second groups. These results suggest that light quality influences ABA metabolism, resulting in anthocyanin formation in the grape skin.

Keywords: Light quality, Anthocyanin, Abscisic acid, ABA receptor, Grapes, Fruit

References

1. Effects of IPT or NDGA application on ABA metabolism and maturation in grape berries. Hong, L. S. Wang,

T Saito, K Okawa, H Ohara, A Kongsuwan, J Haifeng, G Yinshan, H Tomiyama and S. Kondo. (Corresponding

author). Journal of Plant Growth Regulation 37:1210-1221. 2018.

2. Exogenous ABA and endogenous ABA affects ‘Kyoho’ grape berry coloration in different pathway. Saito T. S. Thunyamada S. Wang, K. Ohkawa H. Ohara, S. Kondo. (Corresponding author). Plant Gene 14:74-82. 2018.
3. Effects of light emitting diode irradiation at night on abscisic acid metabolism and anthocyanin synthesis in grapes in different growing seasons. Rodyoung A, Masuda Y, Tomiyama H, Saito T, Okawa K, Ohara H, Kondo S. (Corresponding author). Plant Growth Regulation 79:39-46. 2016.
4. α-Ketol linolenic acid (KODA) application affects endogenous abscisic acid, jasmonic acid and aromatic volatiles in grapes infected by a pathogen (*Glomerella cingulata*). Wan, S., Saito, T., Okawa, K., Oghara, H., Shishido, M., Ikeura, H., Kondo, S. (Corresponding author). Journal of Plant Physiology 192:90-97. 2016.
5. Jasmonate application influences endogenous abscisic acid, jasmonic acid and aroma volatiles in grapes infected by a pathogen (Glomerella cingulate). Wan S., Shishido, M., Ikeura, H., Kondo, S. (Corresponding author). Scientia Horticulturae 192: 166-172. 2015.
6. Abscisic acid metabolism and anthocyanin synthesis in grape skin are affected by blue and red light irradiation at night. S Kondo, H Tomiyama, A Rodyoung, K Okawa, H Ohara, S Sugaya, N Terahara, N Hirai. (Corresponding author). Journal of Plant Physiology 171:823-829. 2014.

Microclimate technology and physiological information for fruit orchard management

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Global climate change did not affect only on human being, but also on agricultural activities especially on plant growth and development. Effective management of fruit orchards is required for improving their productivity and efficient use of production factors under uncertainty. Microclimate is environmental parameters surrounding crop canopy including aerial (*e.g*. light, temperature, humidity, wind and gas composition and soil (*e.g.* moisture, temperature, nutrient, organic matter) environments. Experience in solving problems in Longan orchard by using microclimate technology and physiological information will be presented.

Acknowledgement:

This project was granted by TRF (RDG6020040 and RDG6120031).

Topic: 4

Smart farm – ICT&AI agriculture based on monitoring and modeling of plants

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Abstract

Conventional research and technology of cultivation management and environment control have already become matured and saturated. At present the most important issues in greenhouse horticulture are succession of farm expert technology and reduction of labor management. As for large-scale commercial greenhouses, development of labor management to reduce labor cost, mechanization and installation of robots receive more attention. Application of information and communication technology (ICT) and artificial intelligence (AI) is one of possible methods for documentation and quantifying of the technology. Variety of noteworthy research and development using image-sensing based on AI technology are in progress in Japan. In this study, technologies for ICT/AI-based monitoring and modeling of plants are reviewed.

Keywords

Computer simulation, fruit, growth and development, growth model, image analysis, plant canopy

Categor	Measured item	Instrument	ICT/AI based method	M[2)]	Automatio
Plant canopy and leaf	Canopy structure	3D Camera,	Image analysis	N	○
	Leaf area index	3D Camera,	Image analysis	N	○
	Leaf color	VIS camera		N	△
	Chlorophyll conc.	SPAD meter		N	△
	Leaf thermal	IR camera		N	○
	Spectral	VIS/IR		D/N	△
Growth	Growth rate	VIS camera	Image analysis, Weather	N	○
	Predicted growth rate	VIS camera	Image analysis, Weather data, Computer	N	○
	Leaf area	VIS camera	Image analysis	N	○
	Fruit, Seed	VIS camera	Image analysis	N	○
	Leaf photosynthesis	LI-6400/ I-		D	×
	Whole plant photosynthesis	3D camera	Image analysis, Computer simulation, Ray tracing	N	○
	Leaf transpiration	LI-6400/I-		D	×
	Whole plant	Electric		D/N	×
	SPAC[1)]	Sap flow		D/N	×
		Stem diameter		D/N	△
	Chlorophyll	VIS camera	Image analysis	N	○

Fruit	Number of fruits,	VIS camera	Image analysis	N	○
	Maturity, Quality	VIS camera	Image analysis, Machine	N	○
	Predicted maturity and quality	VIS camera	Image analysis, Machine learning, Growth data,	N	○
Disease	Species	VIS camera	Image analysis, Weather data, Machine learning	N	○
	Damage	VIS camera	Image analysis, Machine learning	N	○

[1)]SPAC: Soil-Plant -Atmospheric continuum. [2)]M column: D is destructive. N is nondestructive.

Topic: 5

Study of Light and Amino Acid Applications on Growth and Nitrate Uptake in Hydroponically-grown Lettuce

Napassorn Punyasuk, PhD
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Nowadays, the hydroponic system is a popular method for plant production. Oversupply of nitrogen fertilizer might affect too much nitrogen absorption in plants and leads to accumulation of nitrate in plant tissues. This situation could reduce plant quality in term of heathy food perspective. Therefore, it is reasonable to develop a practical method to control over-accumulation of nitrate in hydroponics system. It was previously found that the reduction of nitrogen fertilizer could reduce the accumulation of nitrate in lettuce *(Lactuca sativa)*. Unfortunately, decreased nitrate accumulation in plant tissues also reduced growth and yield of lettuce since nitrogen is a macro-nutrient for plant growth & development. Regarding this problem, the study about methods that can improve plant growth while maintain low nitrate level in plant tissues is very important. Previously, application of some amino acids could improve plant growth and development. In addition, light is also considered to be crucial factor for plant growth and development. Light-emitting Diode (LED) lights at specific wavelengths can promote growth of many plants including lettuce. Therefore, the objectives of these studies are to improve the production of red oak lettuces by treated with two levels of nutrient strengths, 1x and 1/4x, and grown with 4 types of LED light treatments and green oak lettuce was also treated with amino acids by foliar applications. In summary, it was found that Red oak lettuce treated with combination of red light (620 and 660 nm), blue light (460 nm) with 1/4x nitrate in nutrient solution has the best overall growth and appearance. Meanwhile, glycine-treated green oak lettuce grown in 1/4x nitrate in nutrient solution showed the highest growth by monitoring growth parameters when compared to controlled planted treated with distilled water. In addition, foliar application of glycine-treated green oak lettuce caused the lowest nitrate accumulation in root and shoot of lettuce in 1/4x nitrate treatment. Therefore, these results provided the applications of growing lettuce in low-nitrate treatment while maintaining growth in hydroponic systems by foliar application of amino acids and specific LED light treatments.

Topic: 6

Medicinal and Aromatic Plants Production in Plant Factory

NA LU, PhD
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Abstract
Bioactive compounds in plants have been intensively studied to evaluate their effects on human health and many of them are proved to be clinically active against various types of diseases (e.g. anti-cancer effects). In recent years, consumers prefer to take health product derived from natural plants for disease prevention. The demand on functional plants that contain high concentration of bioactive compounds is increasing rapidly. However, due to fast climate variations, overuse of pesticides, air pollutions, farm land reduction, and restraint on import of medicinal plants, solutions to realize sustainable production of high-quality functional/medicinal plants become extraordinarily important and urgent.

A plant factory with artificial light is an effective system to produce functional plants to satisfy specific demands on growth and bioactive compound accumulation in plants. Because all environmental factors inside a plant factory can be controlled without climate and location limitation. Especially by regulating LED light and root zone environments, the production of bioactive compounds in plants can be largely enhanced.

In our research, aromatic herbs such as coriander and mint; medicinal plants such as perilla and water spinach are subjected to different light and root zone environments in a plant factory. Some bioactive compounds eg. perillaldehyde and rosmarinic acid in perilla leaves; phenolic compounds and flavonoids, especially rutin and chlorogenic acid in coriander were investigated. These compounds are reported having strong antioxidant, anti-mutagen, anti-cancer properties or anti-allergic, anti-inflammatory and antidepressant effects. Different plant species would need different light and EC levels for maximizing their growth and specific bioactive compound accumulation. The responses of the plants to light intensity, light spectra, and interactions among light and root zone environments and their bioactive compound accumulation in plants are revealed.

Keywords: perilla, water spinach, coriander, secondary metabolites, light, root zone

References

1. M. Kitayama, N. Lu, D. T.P. Nguyen, M. Takagaki. 2019. Effect of light quality on physiological disorder, growth and secondary metabolite content of water spinach (Ipomoea

aquatica Forsk) cultivated in closed-type plant production system. Korean Journal of Horticultural Science & Technology.

2. N. Lu, M. Takagaki, W. Yamori, N. Kagawa. 2018. Flavonoid productivity optimized for green and red forms of perilla frutescens via environmental control technologies in plant factory. Journal of Food Quality, https://doi.org/10.1155/2018/4270279.

3. J. Khwankaew, D.T. Nguyen, N. Kagawa, M. Takagaki, G. Maharjan, N. Lu. 2018. Growth and Nutrient Level of Water Spinach (Ipomoea aquatica Forsk) in Response to LED Light Quality in Plant Factory. Acta Horticulturae 1227: 653-660.

4. N. Lu, Bernardo E. L., Tippayadarapanich C., Takagaki M., Kagawa N., Yamori W. 2017. Growth and Accumulation of Secondary Metabolites in Perilla as Affected by Photosynthetic Photon Flux Density and Electrical Conductivity of the Nutrient Solution, Frontiers in Plant Science. doi:10.3389/fpls.2017.00708

Topic: 7

Inflorescence xylem development as a key to cope with heat issue in tropical fruit production

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Abstract

Longan (*Dimocarpus longan*) is a well-acclaimed tropical fruit tree which suffer from irreversible flower abortion caused by seasonal hot wind, even in well-irrigated area. Inflorescence of the plant elongates along with the blooming of earlier developed flowers; thus, produce a mixture of flower states in each flowering stem. However, only a specific state suffers from the heat. Here, we proposed a possible answer to the problem from anatomical study of xylem tissue of the inflorescence. The vessel element development correlated to the sensitive flower state are limited as the whole inflorescence expanding. The number of vessel and total water transportation area per stem at the heat-sensitive flower state is 25% of other insensitive states. Without proper development of xylem tissue to transport water, unlimited water availability would not overcome the damage. Xylem tissue is, along with other important factors, might be a key to cope with water-related issue in the tropical fruit production.

Keywords: longan, flower, hot wind, inflorescent, anatomy, xylem, development

Acknowledgments
The Thailand Research Fund (TRF) grant # RDG6120031, project title “Impact study of climate change on longan production at Banpaew District, Samutsakhon Province”

Phanchita Vejchasarn, Ph.D., High-throughput Rice Genomic and Phenomic (HRGP) lab. Ubon Ratchathani Rice Research Center (URRC)

References

Apiratikorn S, Sayan Sdoodee and Atsamon Limsakul. 2014. Climate-related Changes in Tropical-fruit flowering Phases in Songkhla Province, Southern Thailand. Research Journal of Applied Sciences, Engineering and Technology. 7(15): 3150-3158.

Tulyananda Tatpong, Nilsen Erik T. (2017) (a) A comparison of xylem vessel metrics between tropical and temperate Rhododendron species across elevation ranges. Australian Journal of Botany 65, 389-399.

Speaker profile

Eiji Goto (Professor, PhD)

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Academic Career

- PhD: November 1992	Received Ph. D. from Graduate School of Agriculture/ The University of Tokyo
- MS: March 1985	Agricultural Engineering/ Graduate School of Agriculture/ The University of Tokyo
- BS: March 1983	Faculty of Agriculture/ The University of Tokyo

Professional Career

April 2007 - present	Professor Graduate School of Horticulture, Chiba University, Japan
April 2005 - March 2007	Professor Faculty of Horticulture, Chiba University, Japan
March 2004 - March 2005	Associate Professor Faculty of Horticulture, Chiba University, Japan
April 1997 - Feb. 2004	Associate Professor Graduate School of Agriculture and Life Sciences, The University of Tokyo, Japan
June 1986 - March 1997	Assistant Professor Graduate School of Agriculture and Life Sciences, The University of Tokyo, Japan

Awards

Best Journal Paper Award of The Society of the Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists (2014)
Distinguished Scientist Award of The Society of the Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists (2012)
Best Journal Paper Award of The Society of Agricultural Meteorology of Japan (2005)
Distinguished Scientist Award of Japanese Society of High Technology in Agriculture (2004)
Distinguished Scientist Award of The Society of Agricultural Meteorology of Japan (2001)
Best Journal Paper Award of The Society of Eco-Engineering (1999)

Major thesis

- Manipulation of light environment for plant production
- Production of value-added functional plants in plant factories
- Development of environment controls for greenhouses
- Development of nondestructive plant monitoring system in greenhouses

Satoru Kondo (Professor, PhD)

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- 2012-2014: Editor-In-Chief (Journal of the Japanese Society for Horticultural Science)
- 2013-2017: A chief in symposium (International Horticultural Society, Plant Growth Regulators in Fruit Production)
- 2014 -: A council person (Japanese Society for Horticultural Science)
- 2016 -: Editor-In-Chief (Scientia Horticulturae) (Elsevier)

Research theme

1. Roles of physiological active substances in fruit growth (Cell wall metabolism, anthocyanin biosynthesis, and aroma volatile production and so on).
2. Metabolism of abscisic acid, jasmonates and ethylene on fruit ripening. The analysis is performed using GC/MS and gene expressions.
3. Effects of environmental stress (low temperature, water stress and so on) on antioxidant activity and physiological active substances in fruit trees or fruit.
4. Relationship between flower bud formation and physiological active substances. The analysis is performed using LC/MS and gene expression.
5. Fruit tree growing and fruit production in plant factory with LED lighting

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B.Sc. Agriculture (Horticulture), Kasetsart University, Thailand
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Ph.D. Bioenergy science, Chiba University, Japan

Selected publication

1. Bunteang S, Chanakul W, Hongthong S, Kuhakarn C, **Chintakovid W**, Sungchawek N, Akkarawongsapat R, Limthongkul J, Nantasaen N, Reutrakul V, Jaipetch T. 2018. Anti-HIV activity of alkaloids from *Dasymaschalon echinatum*. Nat Prod Commun.13(1):29-32.
2. Pichakum A, **Chintakovid W**, Chanseetis C and Supaibulwatana K. 2014. Role of temperature and altitude on flowering performances of macadamia nut. Acta Hort. (ISHS): 1024:127-132.
3. Cha-um S, Chanseetis C, Chintakovid W, Pichakum A, Supaibulwatana K, 2011, Promoting root induction and growth of in vitro macadamia (*Macadamia tetraphylla* L. 'Keaau') plantlets using CO_2-enriched photoautotrophic conditions. Plant Cell, Tissue and Organ Culture. 106(3): 435-444 pp DOI: 10.1007/s11240-011-9940-8.
4. **Chintakovid W**, Visoottiviseth P, Khokiattiwong S, and S. Lauengsuchonkul, 2008, Potential of the hybrid marigolds for arsenic phytoremediation and income generation of remediators in Ron Phibun District, Thailand. Chemosphere.70(8):1532-7

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Professional Position
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Education
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B.S. Biology, second class honors.

CONFERENCE PRESENTATIONS

Punyasuk, N., Meetam, M. and Goldsbrough P.B. Functional Analysis of Seed-Expressed Metallothioneins in Arabidopsis. Poster session in the Botany and Plant Biology Joint Congress, Chicago, IL, 2007

Punyasuk, N. and Goldsbrough P.B. Functional Characterization of Seed-Expressed Metallothioneins in *Arabidopsis thaliana*. Poster session in ASPB Plant Biology, Montreal, Canada, 2010.

PUBLICATIONS

Benatti, M.R., Yookongkaew, N., Meetam, M., Guo W.J., Punyasuk, N., AbuQamar, S. and Goldsbrough, P. 2014. Metallothionein deficiency impacts copper accumulation and redistribution in leaves and seeds of Arabidopsis. New Phytologist. 202(3). 940–951.

Patanun, O., Viboonjun, U., Punyasuk, N., Thitamadee, S., Seki, M. and Narangajavana. J. 2019. Cassava MicroRNAs and Storage Root Development. *Biologia Plantarum*. 63: 193-199.

PROCEEDING

Buasong, A., Narangajavana, J., Thitamadee and Punyasuk, N. 2014. Correlation of Fertilizer Application, Growth and Nutrient Transporter Gene Expressions in Thai Cassava. The 26th Annual Meeting of the Thai Society for Biotechnology and International Conference. Mae Fah Lunag University, Chiang Rai, Thailand. 203-209.

Pinkaew, S., Narangajavana, J., Kongsawadworakul, P. and Punyasuk, N. 2015. Expression of phosphate transporter 1 (*PHT1*) in Thai cassava under drought condition. The 27th Annual Meeting of the Thai Society for Biotechnology and International Conference. Mandarin Hotel Bangkok by Center Point. Bangkok, Thailand.

Siphai ,K., Yoktongwattana, K. and Punyasuk, N. 2019. Effect of Nitrogen Sources on Lettuce Root Growth and Development in Physiological and Molecular Levels. The 20th National Graduate Research Conference. Khon Kaen, Thailand. 597-605.

Na Lu (PhD)

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Work experience
2015- present
Chiba University, Assistant Professor
Research on environmental control technologies for promoting plant growth and quality on leafy vegetables and medicinal plants grown in plant factory. Especially about LED lighting applications in artificial lighting plant factories.
2012-2015
Philips Horticulture LED Solutions, Plant Specialist Asia
Responsible for LED light recipe development and research on various crops in Asia Pacific Region. Focused on LED light applications for various crops cultivated in plant factory, greenhouse, and tissue culture labs, to improve plant growth, production, flowering control, and energy saving.
2009-2012
Chiba University, PhD Research Project
Application of supplemental lighting with LEDs to improve the tomato yield and quality of single-truss tomato plants grown at high planting density

Recent publications
1. T. Hang, N. Lu, M. Takagaki, H.P. Mao. 2019. Leaf area model based on thermal effectiveness and photosynthetically active radiation in lettuce grown in mini-plant factories under different light cycles. Scientia Horticulturae, 252: 113-120. https://doi.org/10.1016/j.scienta.2019.03.057
2. M. Kitayama, N. Lu, D. T.P. Nguyen, M. Takagaki. 2019. Effect of light quality on physiological disorder, growth and secondary metabolite content of water spinach (Ipomoea aquatica Forsk) cultivated in closed-type plant production system. Korean Journal of Horticultural Science & Technology.
3. N. Lu, M. Takagaki, W. Yamori, N. Kagawa. 2018. Flavonoid productivity optimized for green and red forms of perilla frutescens via environmental control technologies in plant factory. Journal of Food Quality, https://doi.org/10.1155/2018/4270279.
4. J. Khwankaew, D.T. Nguyen, N. Kagawa, M. Takagaki, G. Maharjan, N. Lu. 2018. Growth and Nutrient Level of Water Spinach (Ipomoea aquatica Forsk) in Response to LED Light Quality in Plant Factory. Acta Horticulturae 1227: 653-660.
5. S. Saengtharatip, N. Lu, M. Takagaki. 2018. Supplemental upward LED lighting for growing romaine lettuce (Lactuca sativa) in plant factory: Cost performance by light intensity and different light spectra. Acta Horticulturae 1227: 623-630.
6. Q. Yang, N. Lu, L. Wang, XQ. Huang, DQ. Yang, J. Sun. 2018. Exogenous spermidine

promoted Ca2+ absorption in lettuce roots and reduced incidence of tipburn. Korean Journal of Horticultural Science & Technology, 36(5), 702-712. https://doi.org/10.12972/kjhst.20180070

7. S. Saengtharatip, N. Lu, M. Takagaki, M. Kikuchi. 2018. Productivity and cost performance of lettuce production in a plant factory using various light-emitting-diodes of different spectra. Journal of ISSAAS (International Society for Southeast Asian Agricultural Sciences), 24(1), 1-9
8. Wang LW., Zhou H., Guo S., An Y., Shu S., Lu N., Sun J. 2018. Exogenous spermidine maintains the chloroplast structure of cucumber seedlings and inhibits the degradation of photosynthetic protein complexes under high temperature stress. Acta Physiologiae Plantarum, 40: 47.
9. Wang Y., Guo S., Wang L., Wang LW., He XY., Shu S., Sun J., Lu N. 2018. Identification of microRNAs associated with the the regulation of exogenous spermidine-mediated improvement of high temperature tolerance in cucumber seedlings (Cucumis sativus L.). BMC Genomics, 19: 285.
10. Yang Q., Lu N., Wang L., Huang XQ., Yang DQ., Sun J. 2018. Exogenous spermidine promoted Ca^{2+} absorption in lettuce roots and reduced incidence of tipburn. Korean Journal of Horticultural Science & Technology.
11. Saengtharatip S., Lu N., Takagaki M., Kikuchi M. 2018. Productivity and cost performance of lettuce production in a plant factory using various light-emitting-diodes of different spectra. International Society for Southeast Asian Agricultural Sciences.
12. Lu N., Bernardo E. L., Tippayadarapanich C., Takagaki M., Kagawa N., Yamori W. 2017. Growth and Accumulation of Secondary Metabolites in Perilla as Affected by Photosynthetic Photon Flux Density and Electrical Conductivity of the Nutrient Solution, Frontiers in Plant Science. doi:10.3389/fpls.2017.00708
13. Xu Y., Guo S., Li H., Sun H., Lu N., Shu S., Sun J. 2017. Resistance of Cucumber Grafting Rootstock Pumpkin Cultivars to Chilling and Salinity Stresses. Korean Journal of Horticultural Science & Technology, 35(2): 220-231.
14. Sun J., Lu N., Xu H., Maruo T., Guo S. 2016. Root zone cooling and exogenous Spermidine root-pretreatment promoting *Lactuca sativa* L. growth and photosynthesis in the high-temperature season. Frontiers in Plant Science, 7: Article 368. doi: 10.3389/fpls.2016.00368
15. Tewolde F. T., Lu N., Shiina K., Maruo T., Takagaki M., Kozai T., Yamori W. 2016. Nighttime supplemental LED inter-lighting improves growth and yield of single-truss tomatoes by enhancing photosynthesis in both winter and summer. Frontiers in Plant Science, 7: Article 448. doi: 10.3389/fpls.2016.00448
16. Lu N., Nukaya T., Kamimura T., Zhang D., Kurimoto I., Takagaki M., Maruo T., Kozai T., Yamori W. 2015. Control of vapor pressure deficit (VPD) in greenhouse enhanced tomato growth and productivity during the winter season. Scientia Horticulturae.197, 17-23.

Books

1. Na Lu and S. Shimamura. 2018. Next Generation Plant Factory. Chapter 3: Protocols, issues and potential improvements of current cultivation systems. Springer (USA).
2. Na Lu and Cary A. Mitchell. 2016. LED Lighting for Urban Agriculture. Chapter 16. Supplemental lighting for greenhouse-grown fruiting vegetables. p. 219-232. Springer (USA).
3. Merrill F. Brandon, Na Lu, ToshitakaYamaguchi, Michiko Takagaki, Toru Maruo, Toyoki Kozai, etc. 2016. Handbook of Photosynthesis, 3rd Edition. Chapter 40. The Next Evolution of Agriculture: A review of innovations in Plant Factories. P. 723-740. CRC Press.

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EDUCATION:
Ph.D. (Biological Science), Virginia Polytechnic Institute & State University, Blacksburg VA, USA
B.Sc. (Plant Science), Mahidol University, Thailand

PRESENTATION and WORKSHOP:

2018 **Tropical Rhododendron and Their Survival Tactics**. Seminar speaker, Department of Biotechnology, Faculty of Science, Mahidol University
JENESYS program: Exchange for Manufacturing and Technology, Japan International Cooperation Center, Japan

2017 **Rhododendron Adaptation to warmer climate and microclimate Restriction: A Research Approach.** Department of Botany, Faculty of Science, Kasetsart University, Thailand

2016 **Vegetative Anatomy of *Rhododendron* with a Focus on a Comparison between Temperate and Tropical Species.** Defense seminar, Department of Biological Science, Virginia Tech, USA.

2016 **Evolution of Tropical *Rhododendrons*.** Guest speaker, Virginia Native Plant Society, Virginia, USA.

2015 **A Comparison of Leaf Anatomical Traits Between Temperate and Tropical members of *Rhododendron*.** Oral presentation, Graduate Research Symposium 2015, College of William and Mary, USA.

2015 **Comparison of Idioblast Expression in Temperate and Tropical *Rhododendrons*.** Poster presentation with Rose Peterson. Research Day, Virginia Tech, USA.

RESEARCH AND PUBLICATION:

Tulyananda, T., Nilsen, E.T. (2017) **A comparison of xylem vessel metrics between tropical and temperate *Rhododendron* species across elevation ranges.** *Australian Journal of Botany*, 65(4): 389-399.

Tulyananda, T., Nilsen, E.T. (2017) **The role of idioblasts in leaf water relations of tropical *Rhododendron*.** *American Journal of Botany*, 104(6): 828-839.

Tulyananda, T. (2016) **Vegetative Anatomy of Rhododendron with a Focus on a Comparison between Temperate and Tropical Species** (doctoral dissertation). Virginia Polytechnic Institute & State University.

Nilsen, E.T., Tulyanon, T. (2015) **An update on the diversity and function of foliar scales using data from *Rhododendron* in section *Schistanthe* (Ericaceae)**. *Journal American Rhododendron Society*, 69: 187-193.

RESEARCH GRANT (2014-2019):

- **Effect of seasonal hot wind to longan (*Dimocarpus longan* Lour.) flower bud development in physiology, molecular, morphology and anatomy aspect.** The Thailand Research Fund (Agriculture Division), Thailand
- **Sustainable Life-supporting Bioreactor from Watermeal for Future Space Exploration.** Geo-Informatics and Space Technology Development Agency, Thailand
- **Differences in functional traits between tropical and temperate groups of *Rhododendron***. Graduate Research Development Program (GRDP), Virginia Tech, USA.