

The 1st International Conference on Sustainable Agriculture and Aquaculture For Well Being and Food Security



Book of Abstracts



Participatory and Integrative Support
for Agricultural Initiative



Date : 11-12 January 2021

Venue : The 8th floor, LRC Building, Prince of Songkla University
Organized by : Faculty of Natural Resources

Prince of Songkla University
THAILAND

Aquatic Science Alummni Association

**Joint Symposium-Thai & Japan Universities
on Basic and Applied Studies on Plant Natural Products**



Co-funded by the
Erasmus+ Programme
of the European Union



“All rights reserved. Reproduction and dissemination of material in this information product for institutional or other non-commercial uses are authorized without any prior written permission from the copyright holders provided the source is fully acknowledged. Reproduction of material in this information product for resale or other commercial purposes is prohibited without written permission.”

Published by the PISAI Project
Prince of Songkla University, THAILAND
e-mail: chutima.t@psu.ac.th

Online-version: <http://natres.psu.ac.th/pisai/document/result-and-outputs/WP4.1/Bookofabstract-icsaa.pdf>

Completed in January 2021

Acknowledgment:

Production of this document was funded by the project entitled “Participatory and Integrative Support for Agricultural Initiative” within the Erasmus+ Programme: Capacity-Building projects in the field of Higher Education (E+CBHE), project number: 586157-EPP-1-2017-1-TH-EPPKA2-CBHE-JP.

The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Message from President

Dear Participants,

It is my great pleasure to welcome all distinguished guests, prominent scholars, academics and participants to “The First International Conference on Sustainable Agriculture and Aquaculture (ICSAA): For Well Being and Food Security”, organized by the Faculty of Natural Resources, Prince of Songkla University. This event is a significant activity of the PISAI project (Participation and Integrative Support for Agricultural Initiative) under the Erasmus+ programme of the European Union. The project’s objective is to improve the Agricultural Education in Thailand as an efficient channel for agricultural production that contributes to the food security and high-quality food for global consumption.

In addition, this event aims to be a platform for researchers, scientists and students from both PSU and other Higher Education Institutions to present their beneficial research works related to Sustainable Agriculture and Aquaculture.

On behalf of Prince of Songkla University, I would like to express my heartfelt appreciation to the organizers and to various institutions both locally and internationally for their great contribution and collaboration to make this conference a success. My sincere thanks also go to the presenters and participants who are an important part of this conference. I truly believe that this conference will bring valuable benefits and practical applications for sustainable development in Agriculture and Aquaculture. Furthermore, all participants will be able to apply the knowledge gained from this event to further develop the agricultural production and its social and environmental sustainability.

Lastly, I would like to take this opportunity to make a sincere wish for a successful and memorable conference for everyone. I hope you will enjoy the conference, enjoy spending time in Hat Yai, and enjoy the pleasant hospitality of our organizing committee.



Asst. Prof. Dr. Niwat Keawpradub
President
Prince of Songkla University

Message from Chairman of Organizing Committee and Coordinator of PISAI Project

(Participatory and Integrative Support for Agricultural Initiative- the Erasmus+ Capacity Building in Higher Education Project under the European Union)

The First International Conference on Sustainable Agriculture and Aquaculture materialized due to four main factors. The first factor is the PISAI project commitment to organise the conference as an arena for students to present their work to a wide audience, get feedback from professors, and exchange with friends. The second factor is the PISAI project consortium, which have been working together since 2017 on a collaborative Double Degree Master's Programme, whose students are presenting their theses at this event. The third factor is the Discipline of Excellence in Sustainable Aquaculture, the collaboration of three PSU faculties offering aquaculture programmes, with strong support from Aquatic Science Alumni Association and commitment to furthering their contribution to sustainable aquaculture by having their students present up-to-date research finds, as well as organise a special seminar on sustainable aquaculture. The last important factor is the professors, researchers and students from different institutions nationally and internationally who participated in the conference. Without their participation, the meeting would have been incomplete.

For these reasons, I would like to thank PISAI consortium members for their input and continuous contributions to the PISAI project and this conference. Appreciation is extended to scientific committees who donated valuable time reviewing the papers, and to the invited speakers for their precious time providing excellent presentations. I would lastly like to take this opportunity to express my sincere gratitude to our colleagues and friends, both in Thailand and overseas, for their contributions to the event, either in-person or on-line, especially considering the obstacles posed by the COVID19 pandemic.



Asst. Prof. Dr. Chutima Tantikitti
Faculty of Natural Resources
Prince of Songkla University

Opening Speech

Ministry of Higher Education Representative

THE FIRST INTERNATIONAL CONFERENCE ON SUSTAINABLE AGRICULTURE AND AQUACULTURE
Disseminating Activity of E+-CBHE Project Entitled
“Participatory and Integrative Support for Agricultural Initiative (PISAI)”

It is a great pleasure to be here and take part in the opening ceremony of the **First International Conference on Sustainable Agriculture and Aquaculture**.

First of all, I would like to express my gratitude to Prince of Songkla University for inviting me to this important event, which gives me the great opportunity to meet His Excellency the EU Ambassador, project’s commission team, and PSU administrators and faculty members.

Furthermore, on behalf of the Ministry of Higher Education, Science, Research and Innovation, I would like to thank PSU for organizing this very important conference which is in line with Thailand’s national development plan. The sustainable agriculture is the prime priority that we are promoting in order to be self-sustained from the grass-root community impacting the nation-wide achievement as foreseen by our King Rama 9.

I have learned that the conference is the final academic and disseminating activity of the PISAI project funded by Erasmus Plus – Capacity Building in Higher Education Programme of the European Union. The project aims at the double degree master program development among the four Thai leading universities in agriculture, namely Kasetsart University, Chiang Mai University, Khon Kaen University and Prince of Songkla University. This is a spearhead in the higher education development direction in our country that we are very happy to see happening. This initiation is very challenging, but the PISAI consortium has made it possible and successfully materialized it. I would also like to thank to the Erasmus Plus programme of the European Union and to the European partners, SupAgro in France, Czech University of Life Science Prague in Czech Republic, University of Copenhagen in Denmark, University of Helsinki in Finland and Agrinatura, for taking an important part in the project, and making the development of modules and double degree master program in sustainable agriculture happen. The Ministry highly values the partnership with international Higher Education institutions, and this conference shows that our higher education has strong ties with outstanding partners not only in our Asian region, but also with those in European countries. We really appreciate this close relationship and support.

Moreover, having professors and students from different institutes and countries to meet at this conference is truly a challenge during this COVID-19 pandemic. We highly appreciate the participation of a high number of international professors from Europe, Japan and ASEAN countries, who could not make their trip to Thailand.

I would like to mention that one of our main tasks at the Ministry of Higher Education is to support initiatives of all universities that bring Thailand to the forefront of internationally recognized education society. The concerted efforts in bringing the leading institutions in Thailand to create a Double Degree Master Program, to showcase students’ performances not only of those under the project but also of others from around Thailand, as well as to disseminate the outputs of students to the scholastic community, are fully recognized and supported.

Apart from the scientific conference, I have been informed that there will also be a Thai partner consortium meeting to discuss about the continuity of the Double Degree Master Program in the field of agriculture within these two intensive days. Since the educational programs need to serve the future dynamic world, I strongly support this endurance for the benefit of students who need an educational program that suit their needs and is based not only on one single discipline.

Finally, I would like to stress that amid the pandemic that has made the organization of this conference so complicated, I am confident that Prince of Songkla University has put their best effort to make this meaningful event a huge success. Thus, I do wish for this conference to bring continuous and strong cooperation among all partners and for the double degree master program to continue for the benefits of all parties within Thailand and overseas.

Thank you very much for your kind attention.

**Dr. Sumet Tantivejkul,
Secretary-General, the Chaipattana Foundation**

**An Opening Remark Delivered at International Conference on
Sustainable Agriculture and Aquaculture**

Since ‘sustainable agriculture’ is described as the ability of a crop production system to produce food by creating minimal damage to the environment in a continuous manner, a healthy soil is, therefore, closely associated with the term. In other words, the goal of agricultural sustainability cannot be reached if soil is not healthy.

Although most of the agricultural products and food that we consume everyday grow out of soil, most local people still take soil for granted. Today, we are now facing the problems of soil desertification, erosion and contamination. If we continue degrading our soil, our food security will surely be disturbed. Regarding this urgent matter, His Majesty King Bhumibol Adulyadej The Great of Thailand, thus, devoted himself tirelessly to find solutions. His Late Majesty’s methods for tackling soil problems are mostly simple, but at the same time they need to be affordable and practical. They are simple for the local people to easily understand, affordable to reach out to the poor, and practical for the local people to effectively apply as well as for the country to develop in a sustainable manner.

The United Nations recognized His Late Majesty’s determined effort in the field of soil and agriculture development. In 2013, the United Nations General Assembly in New York adopted a resolution to declare 5 December of every year as the World Soil Day because the 5th of December corresponds with the birthday of His Majesty King Bhumibol Adulyadej The Great. It is hoped to promote and raise awareness, particularly to the future generations in the areas of agricultural development, nutrition and food security with the intention to tackle the challenges of growing number of the world population.

EU Ambassador to Thailand

"European Cooperation with Thailand on Education and Sustainable Agriculture"

Contents

Overall Schedule		Page
Presentation Program		1
Keynote Speakers		4
	Asst. Prof. Dr. Budsara Limmirankul	37
	Enhancing Sustainable Agriculture Development and Food System for Rural Livelihood in Northern Thailand	
	Assoc. Prof. Dr. Hanna Tuomisto	38
	Towards Sustainable Food Systems	

Abstracts

Oral Presentation		
Agriculture Session		
Agriculture – Plant Science		
Invited Speaker	Sustainable Uses of Local Vegetables and Pomology of Southern Thailand under Her Royal Highness Maha Chakri Sirindhorn Project: Biotechnological Propagation and Conservation	41
AG-PS-O1	Gene Expression of Ethylene Biosynthesis and Ethylene Signaling Involved in Chilling Injury of Hom Thong Banana	42
AG-PS-O2	Genetic Diversity of Native Pumpkin Accessions in Nan Province with Genotyping-by-Sequencing Technology	43
AG-PS-O3	Xylem Sap Flow and Tree Transpiration of Pummelo (<i>Citrus grandis</i> L. Osbeck) ‘Thong Dee’ in Harvesting Stage under Varied Environmental Conditions	44
AG-PS-O4	Effect of Pruning on the Transpiration of Mango Cultivar ‘Nam Dok Mai Si Thong’	45
AG-PS-O5	Evaluation of Seed Germination and Flowering of Edible Flowers for Greenhouse Production under Southern Thailand Condition	46
AG-PS-O6	Effects of Water-Cooling Temperature on Growth, Development and Carbohydrate Contents in Sacred Lotus	47
AG-PS-O7	Physiological and Biochemical Responses in Two Rubber Rootstocks Submitted to Drought Stress	48
AG-PS-O8	Effect of Rubber Rootstocks on Morphological and Reactive Oxygen Species Changes of RRIT 251 Scion during Drought Condition	49
AG-PS-O9	Possibility of Unbalance Nutrients in Plant Parts Cause on the Gummosis Symptom of Immature Rubber Tree Clone RRIT251	50
AG-PS-O10	Preliminary Evaluation on Development of Nutrient Standard for the Rubber Tree by Bark and Rubber Yield Compare with Leaves	51
AG-PS-O11	Development of the Leaf Nutrient Standard of Mature Rubber Tree Clone RRIM600 in Northeast Thailand	52
AG-PS-O12	Preliminary Study on the Physiological Status of <i>Hevea</i> rubber and its Relationships under Different Rubber-based Intercropping Practices	53
AG-PS-O13	Effects of Intercropping on Growth and Biomass in Oil Palm Seedlings	54
Agriculture – Animal Science		
Invited Speaker	An Opportunity for Dairy Goat Farming in Thailand	56
AG-AS-O1	Effect of Perilla Seed Meal for Replacement Soybean Meal in Diets on Carcass Characteristic of Crossbred Pig	57
AG-AS-O2	Screening and Selection of Lactic Acid Bacteria from Ensiled Total Mixed Ration at Different Ensiling Time	58
AG-AS-O3	Effects of Dietary Protein Levels in Concentrate on Growth Performance and Nutrient Utilization of Post Weaning Thai Indigenous Male Goat	59
AG-AS-O4	Chemical Composition and Kinetics of Gas Production of Partially Defatted Moringa Seed Meal	60
AG-AS-O5	Production of Nutrient Enrichment Cassava Pulp by Ruminant Microbes Inoculation	61
Agriculture – Pest Management		
Invited Speaker	Insect Gall Formation Requires Switching from Source to Sink Organs	63
Invited Speaker	Application of Geographic Information Systems and Remote Sensing for Sugarcane Pest Management in Kamphaeng Phet, Thailand	64
Invited Speaker	Sustainable Control of Blood-sucking Flies for Livestock Keeping	65
AG-PM-O1	Control Potential of Entomopathogenic Nematodes and Entomopathogenic Fungi Against Melon Fruit Fly <i>Zeugodacus cucurbitae</i> (Coquillett)	66

		Page
AG-PM-02	Efficacy of Entomopathogenic Nematodes Against Stable Fly Larvae under Laboratory Condition	67
AG-PM-03	Preliminary Screening of the Resistance of Rice Cultivars (<i>Oryza sativa</i> L.) and their mechanisms against <i>Meloidogyne graminicola</i>	68
AG-PM-04	Screening of the Antagonistic <i>Bacillus</i> spp. Isolated from Banana Rhizosphere Soil for the Control of Banana Blood Disease	69
AG-PM-05	Laboratory Rearing of <i>Musca domestica</i> L. (Diptera: Muscidae) from Fishery Waste (<i>Lates calcarifer</i>) for Alternative Protein Source in Aquatic Feeds	70
AG-PM-06	Race Identification and Aggressiveness of <i>Fusarium oxysporum</i> f.sp. <i>cubense</i> Isolates in Northeast Thailand	71
AG-PM-07	Optimizing the Sex Ratio and Oviposition Material for Mass Production of Assassin Bug, <i>Sycanus collaris</i> (F.) (Hemiptera: Reduviidae)	72

Agriculture - Technology

Invited Speaker	Development of the Suitable Water and Nutrient Managements for Economic Trees in Northeast Thailand	74
AG-TE-01	Impact of Land Use Change from Forest to Rubber on Soil Phosphorus and Microbial Biomass Phosphorus in Tropical Sandy Soils	75
AG-TE-02	Reuse of Swine Wastewater for <i>Azolla</i> Production for Sustainable Agriculture and Environment	76

Agricultural System Session

Agricultural System

Invited Speaker	Local Organic Foods and Consumer's Purchase Intention	78
AgS-O1	Beef Cattle Situation among Farmers in Rattaphum District Songkhla Province	79
AgS-O2	Alternative Farming on the Highland and Livelihood Assets of Small Scale Farmer in Na Noi District, Nan Province	80
AgS-O3	Assessing the Livelihood Strategies on the Sustainability of the Natural Resource Utilizations in Peat Swamp Ecosystems. Lessons Learned from the Khreng Peat Swamp Ecosystem, South Thailand.	81
AgS-O4	Development of Chinese Cabbage Production Processes for Distribution in “The Green Market” of Songkhla Province: The Agri-Market, Faculty of Natural Resources, Prince of Songkla University	82
AgS-O5	Sustainability is Dynamic: Assessing Processes of Change and Innovation in Smallholders Agriculture around Tonle Sap Lake, Cambodia	83
AgS-O6	Understanding Decision Drivers that Threaten Conservation Efforts amongst Hmong Communities Adjoining a National Park in Lao PDR	84
AgS-O7	Individual Social and Economic Position Versus the Impact of Collective Services: The Contribution to Small-Scale Farmers' Adoption on Single Origin (SO) Coffee Processing Scheme	85
AgS-O8	Impact of Climate Change on Farmer Adaptation and Tobacco Productivity in Temanggung Regency	86
AgS-O9	Multidimensional Database for Assessment of Novel Foods in Future Diets to Improve the Sustainability of Food Systems	87
AgS-O10	In a Developing Economy, Cooperation and Contract Farming Operate as Complements or Alternatives for Each Other	88
AgS-O11	Carbon Sequestration in Coffee Agroforestry Systems of Southwestern Ethiopia	89
AgS-O12	Consumer's Attitudes Toward Insect Consumption in Cambodia	90

Aquaculture Session

Aquatic Animal Nutrition

AQ-Nutrition-01	Palm Oil and Myo-inositol Increase Survival Rate of Seawater Nile Tilapia	92
AQ-Nutrition-02	Effects on Growth Performance and Body Composition of Tilapia (<i>Oreochromis sp.</i>) Fed with Fish Waste Product in Practical Diet	93
AQ-Nutrition-03	Ontogeny of Digestive System in Spotted Scat (<i>Scatophagus argus</i> Linnaeus, 1766)	94
AQ-Nutrition-04	Effects of Fish Oil Replacement by a Combination of Soybean and Palm Oil in Asian seabass (<i>Lates calcarifer</i>) Diet on Growth, Fatty Acid Profile, Digestive Enzyme Activity, Immune Parameters and Salinity Challenge	95
AQ-Nutrition-05	Effects of Crude Anthocyanins from Three Plants on Lipid Contents in White leg shrimp (<i>Penaeus vannamei</i>)	96
AQ-Nutrition-06	The Possibility of Using Zero Fishmeal Diets and Effect on Growth Performance, Immune Response of Pacific White Shrimp (<i>Litopenaeus vannamei</i>)	97

		Page
AQ-Nutrition-07	Effect of <i>Ulva intestinalis</i> Linnaeus to Optimum Dietary Inclusion on Growth Performance and Cooked Shrimp Color of <i>Litopenaeus vannamei</i> Boone, 1931	98
AQ-Nutrition-08	Role of Pom-nang Seaweed, <i>Gracilaria</i> spp. on Growth and Survival of Juvenile Mud Crab, <i>Scylla paramamosain</i>	99
AQ-Nutrition-09	Optimal Feeding Frequency for Bigfin Reef Squid (<i>Sepioteuthis lessoniana</i>)	100
Aquatic Animal Breeding		
AQ-Breeding-01	Germ Cell Transplantation Techniques in Aquaculture-targeted Marine Fishes	102
AQ-Breeding-02	Exploring Various Cryoprotectants for Cryopreservation of Spermatozoa of Tropical Oysters <i>Magallana bilineata</i> (Röding, 1798)	103
AQ-Breeding-03	Oogenesis, Spermatogenesis and Hatching Rate of Seawater-acclimated Nile Tilapia	104
AQ-Breeding-04	Reproductive Biology of <i>Rastrelliger brachysoma</i> of Pattani Bay, the Lower Gulf of Thailand	105
AQ-Breeding-05	Reproductive Biology of <i>Rastrelliger brachysoma</i> of Pattani Bay, the Lower Gulf of Thailand	106
AQ-Breeding-06	Some Biological Aspects of Mature Female Sepat Siam, <i>Trichogaster pectoralis</i> (Regan,1910) for Breeding	107
Aquaculture System		
AQ-Aquaculture System-01	Development of DHS-USB Reactors for Longtooth Grouper Closed Recirculating Aquaculture System	109
AQ-Aquaculture System-02	The Development of a Prospective Zero-water Exchange System for Aquaria Using the Ozone-DHS-USB System	110
AQ-Aquaculture System-03	Sustainability of Recirculating Aquaculture Systems – The Aqualis Experience	111
AQ-Aquaculture System-04	Isolation and Characterization of Heterotrophic Nitrifying Bacteria <i>Alcaligenes faecalis</i> and Efficiency on Shrimp Wastewater Treatment	112
AQ-Aquaculture System-05	Optimum Stocking Density of Hybrid Catfish (<i>Pangasianodon gigas</i> x <i>P. hypophthalmus</i>) in Giant Freshwater Prawn Polyculture	113
Aquatic Animal Health and Disease		
AQ-Health-01	Image Technology Based Detection of Infected Shrimp in Adverse Environments	115
AQ-Health-02	Isolation of Beneficial Bacteria from Nile Tilapia (<i>Oreochromis niloticus</i>) for Their Activity to Inhibit Fish Pathogens	116
AQ-Health-03	Test for the Ability to Inhibit Pathogenic Bacteria, <i>Vibrio parahaemolyticus</i> , by Using Algae and Photosynthetic Bacteria	117
AQ-Health-04	Types of Cells in the Hepatopancreas of the Pacific Whiteleg Shrimp <i>Litopenaeus vannamei</i> Being Infected by <i>Enterocytozoon hepatopenaei</i>	118
AQ-Health-05	Isolation and Screening of Lactic Acid Bacteria (LAB) for Antagonizing <i>Vibrio parahaemolyticus</i> (AHPND strains) in White Shrimp (<i>Litopenaeus vannamei</i>)	119
AQ-Health-06	The Use of <i>Zooshikella</i> sp. as a Probiotic Against Vibriosis in Asian seabass (<i>Lates calcarifer</i>)	120
Aquaculture-Eco-Management		
AQ-Eco-Management-01	Composition of Nutrients in the Sediment in Relation to the Abundance and Size of Blood cockle (<i>Tegillarca granosa</i>) at Kuala Juru, Penang, Malaysia	122
AQ-Eco-Management-02	Species Diversity and Seasonal Variation of Coastal Crab in Pattani bay of Southern Thailand	123
AQ-Eco-Management-03	GIS Application for Green Mussel (<i>Perna viridis</i>) Pole Culture for Natural Production Enhancement in Pattani Bay, Thailand	124
AQ-Eco-Management-04	Diversity of Caddisflies (Trichoptera) Species and Their Importance to Sustainable Aquaculture Production in Surat Thani Province, Southern Thailand	125
AQ-Eco-Management-05	Pollution Assessment Through Macrobenthic Fauna Communities as Bio-Indicator in Human Activities Area at Koh Yo, Songkhla Lagoon	126

Poster Presentation

Agriculture Session

Agriculture – Plant Science

AG-PS-P1	Appropriate Postharvest Handling for Extending the Shelf Life of Ready-to-Cook Leaves of Melinjo (<i>Gnetum gnemon</i> L.) Vegetable	129
AG-PS-P2	Comparison of Mono-papaya and Papaya-banana Intercropping Systems on Growth, Fruit Quality, and Nutrients	130
AG-PS-P3	Alleviation of Postharvest Fruit Dehiscence of ‘Chanthaburi II’ Durian Using Gibberellic Acid and Chitosan Coating	131
AG-PS-P4	Phytochemical Components and Antioxidant Activities Changes in Fresh and Dried of Tropical Water Lily (<i>Nymphaea lotus</i> L.) Flower	132
AG-PS-P5	Effect of Coating and Temperature on Quality and Manage the Rot Disease of the Nam Dok Mai Si Thong	133
AG-PS-P6	Chitosan and Sodium Alginate - Double Coatings Integrated with Sweet-Flag Extract Affecting the Postharvest Quality of ‘Nam Dok Mai’ Mango	134
AG-PS-P7	Tolerant Evaluation of 10 Tian Corn Inbred Lines Under Temporary Waterlogging Condition	135
AG-PS-P8	Yield and Quality Evaluation Trials of Purple Sweet Waxy Corn Hybrids	136
AG-PS-P9	Yield and Nutritional Composition of Sweet Potato Tips Genotypes with Varying Fleshed Colors and Various Application Fertilizer	137
AG-PS-P10	Promoted Early Flowering and Sweetness of Edible Curcuma Inflorescence by Nutrient Management	138
AG-PS-P11	Application of Gibberellic Acid to Improve the Seed Germination of Commercial Cactus Varieties	139
AG-PS-P12	Stability Study of Select Mulberry Lines Based on Growth, Antioxidant and Chemical Compounds	140
AG-PS-P13	Effect of Coating and Temperature during Storage on Phenolic, Lycopene and β -Carotene Content of ‘Nam Dok Mai Si Thong’ Mango	141
AG-PS-P14	Chemical Composition, Antioxidant and Antibacterial Activities of Ultrasound-Assisted Extract of <i>Annona squamosa</i> L. Leaves	142
AG-PS-P15	Effect of Coating and Temperature on the Quality, Extend the Shelf life of ‘Nomsod’ Indian Jujube Produced in the Phon Sub-district, Kalasin Province, Thailand	143

Agriculture – Pest Management

AG-PM-P1	Surveys and Characterization of Plant-parasitic Nematodes Associated with Medicinal Plants	145
AG-PM-P2	Trichoderma Species Associated with Green Mold Disease of <i>Ganoderma lingzhi</i> in Thailand	146
AG-PM-P3	Potential of Edible Mushroom <i>Pleurotus</i> spp. for the Biocontrol of Root-knot Nematode (<i>Meloidogyne incognita</i>) and Their Cuticle Degrading Enzyme Production	147
AG-PM-P4	Prey Preference and Predation Efficacy of <i>Sycanus collaris</i> (F.) (Hemiptera: Reduviidae) on <i>Tenebrio molitor</i> (L.) (Coleoptera: Tenebrionidae)	148

Agriculture - Technology

AG-TE-P1	Research and Development on Water Onion’s Micropropagation by Temporary Immersion Bioreactor (TIB) for Protection and Sustainable use	150
AG-TE-P2	Effects of Media, BA, and LEDs Lights on the Growth of <i>Rhynchosyilis coelestis</i> in vitro Culture	151

Agricultural System Session

Agriculture – Agricultural System

AgS-P1	Assessment of Farm Level Dynamics and Sustainability of Incorporating Cacao Production in Farm Systems in San Fernando, Camarines Sur, Philippines	153
AgS-P2	Study on Supply Chain Model of Coconut Production in Prachuap Khiri Khan, Chumphon and Surat Thani Provinces	154
AgS-P3	The Competitiveness of Aromatic Coconut Product in Case of Thailand Food Valley 1 st Year Agroindustry Networking	155
AgS-P4	An Analysis of Factors Affecting Revealed Symmetric Comparative Advantage of Crude Palm Oil Exports of Indonesia, Malaysia and Thailand in the World Markets	156

		Page
AgS-P5	A Comparative Analysis of Maize-Based Smallholder Farming Systems (MSFS) Towards Household Food and Nutrition Security Improvement in Senqu River Valley (SRV) Agroecological Zone, Lesotho	157
AgS-P6	Supply Chain Management of Golden Dried Longan in Lamphun Province	158
AgS-P7	Supply Chain Management of Rice Cultivars in Chiang Mai and Phatthalung Province	159
AgS-P8	Technical Efficiency of Soybean Production, Chiang Mai Province.	160
AgS-P9	Production Management and Technical Efficiency of Tilapia Production, Chiang Rai and Nakhon Si Thammarat Province	161

Aquaculture Session

Aquatic Animal Nutrition

AQ-Nutrition-P1	Physical Pretreatments of Food Waste and Its Possible Potential as Diet for Juvenile Striped Catfish (<i>Pangasianodon hypophthalmus</i>)	163
AQ-Nutrition-P2	Effect of Lecithin-Enriched Diet on the Reproductive Performance of Eeltail Catfish (<i>Protosus canius</i>)	164
AQ-Nutrition-P3	Effect of Dietary Supplementation of Sea Lettuce (<i>Ulva</i> sp.) on Growth Performance and Survival Rate of Mud Crab (<i>Scylla serrata</i>)	165
AQ-Nutrition-P4	Effects of Climate Change on Spiny Lobster Aquaculture in Koh Yao District, Phang-Nga Province	166
AQ-Nutrition-P5	Preliminary Study on the Culture of Seagrapes (<i>Caulerpa lentillifera</i>) in Semi-enclosed and Enclosed Area in Pulau Pinang, Malaysia	167
AQ-Nutrition-P6	Uses of Para-rubber Seed Kernel Protein in Feed on Growth Performance and Feed Utilization in Red Claw Crayfish (<i>Cherax quadricarinatus</i>)	168
AQ-Nutrition-P7	Effect of Inversion of Cultured Frames on Growth and Characteristic of Green Caviar Seaweed, <i>Caulerpa lentillifera</i> (Chlorophyceae)	169

Aquatic Animal Health and Disease

AQ-Health-P1	Effects of Ground Pepper and Piperine on Growth Performance and Bacteria Disease Resistance in White Shrimp, <i>Penaeus vannamei</i>	171
AQ-Health-P2	Effect of Bioproducts from <i>Zooshikella</i> sp. on Growth Performance and Immune Responses in Nile Tilapia (<i>Oreochromis niloticus</i>)	172
AQ-Health-P3	Factors Related to the Use and Production of Vaccine Against Motile <i>Aeromonas</i> Septicemia in Tilapia (<i>Oreochromis</i> spp.)	173
AQ-Health-P4	Characterization of Cyanobacteria strain Osci-TK01	174
AQ-Health-P5	Species Diversity and Tetracycline Resistance of Pathogenic <i>Aeromonas</i> spp. in Nile Tilapia Seed Farms in Southern Thailand over a 5-Year Period (2016-2020)	175
AQ-Health-P6	Cytokine Homologue Genes in Kuruma Shrimp, <i>Marsupenaeus japonicus</i>	176

Aquaculture-Eco-Management

AQ-Eco-Management-P1	Environmental Factors Influencing the Distribution of Coastal Molluscs in Pattani Bay of Gulf of Thailand	178
AQ-Eco-Management-P2	Accumulation of Microplastics in Water Column at Koh Yo, Songkhla Lagoon, Thailand.	179
AQ-Eco-Management-P3	Fecundity, Hatching Rate and Growth of Gravid Female Blue Swimming Crab (<i>Portunus pelagicus</i>) and Guidelines for the Management of Crab Bank: Case Study of Crab Bank Sub-Anan Local Fisheries Group, Singhanakhon District, Songkhla Province	180

Special Exhibition

AG-SE-P1	Willingness to Study Abroad: Case Study of Thai Agricultural Students	182
AG-SE-P2	Challenges and Opportunities of Double Degree Master: Case Study in Thailand	183

List of Scientific Committees	184
List of Local Organizing Committees	185
List of Participants	186

Overall Schedule

Program for International Conference on Sustainable Agriculture and Aquaculture – BCG for Well Being and Food Security (cont.)

10 – 12 Jan 2021

Venue: Learning Resource Center, Prince of Songkla University

Date	Activity	
Sunday 10 January 2021		
14.30 – 17.30	Registration of participants - Arrival of participants and check-in at the hotels in Hat Yai City - Registration/Fee payment/Setting-up Posters	
Monday 11 January 2021		
Morning		
08.30 – 12.00	Registration of participants - Registration/Fee payment - Conference document - Setting-up Posters	Aquaculture Session
		08.30 – 09.30 Registration
08.30 – 11.30	EU – Roadshow for Erasmus Programme (LRC 1)	10.15 – 11.45 Scientific Sessions Oral Presentations - Aquatic Animal Nutrition (LRC2) - Aquatic Animal Breeding (Training Room) - Aquatic Animal Health and Disease (Meeting Room)
12.00 – 13.30	Lunch	
Afternoon		
13.30 – 14.00	Opening sessions (LRC 1) - Welcome Address by PSU President - Opening Speech by Permanent Secretary, Ministry of Higher Education, Science, Research and Innovation	
14.00 – 14.30	Keynote speech (LRC 1) - Dr. Sumet Tantivejkul, Secretary General of the Chaipattana Foundation <i>The Chaipattana Foundation, established for His Majesty the King's principle of sustainable development, aims for promoting and supporting sustainable development and self-reliance of farmers and their livelihoods.</i> <i>“Chaipattana” the name bestowed upon the Foundation by His Majesty the King, suitably means “Victory of Development.”</i> - EU Ambassador to Thailand	
14.30 – 15.00	Coffee break	14.30-14.40 Coffee break
15.00 – 15.30	Keynote speakers (LRC 1) - Dr. Budsara Limnirankul <i>Chiang Mai University</i> <i>“Enhancing sustainable agriculture and food system for rural livelihood in Northern Thailand”</i> - EU partner representative Dr. Hanna Tuomisto <i>University of Helsinki, Finland</i> <i>“Towards Sustainable Food Systems”</i>	Aquaculture Session
		14.40-15.55 Scientific Sessions - Oral Presentations - Aquatic Animal Nutrition (LRC2) - Aquaculture System (Training Room) - Eco-Management (Meeting Room)
15.30 – 17.00	Scientific Sessions - Poster Presentations 1) Agriculture 2) Agricultural System	15.55-17.00 Scientific Sessions - Poster Presentations
Evening 18.00 – 20.30	Conference Dinner at the Centara Hotel	

Program for International Conference on Sustainable Agriculture and Aquaculture – BCG for Well Being and Food Security (cont.)

10 – 12 Jan 2021

Date	Activity		
Tuesday 12 January 2021			
Morning			
08.00-08.30	Pick up at the hotel		
09.00-10.30	Agriculture Session		Aquaculture Special Seminar (LRC 1)
	Scientific Sessions - Oral Presentations 1) Agriculture - Plant Science (LRC 2) - Animal Science (Training Room) 2) Agricultural System (Meeting Room)		09.00-09.45 The role of the Department of Fisheries: Support for the future development of aquaculture 09.45-10.30 Aquaculture business management guidance for Covid-19 era
10.30-10.45	Coffee break		
10.45-12.00	Scientific Sessions - Oral Presentations 1) Agriculture - Plant Science (LRC 2) - Pest Management (Training Room) 2) Agricultural System (Meeting Room)	10.00-12.00 Thai Partners Consortium Meeting for DDMP in the Future (Lertphat Meeting Room) (12nd floor)	10.45-11.15 Aquaponics system 11.30-12.00 Current breeding technique and culture development of mud crab (<i>Scylla paramamosain</i> Estampador, 1949)
12.00–13.00	Lunch		
Afternoon			
13.00–14.45	Scientific Sessions - Oral Presentations 1) Agriculture - Plant Science (LRC 2) - Pest Management (Training Room)	14.00-14.45 Scientific Sessions - Oral Presentations - Agricultural System (Meeting Room)	Aquaculture Special Seminar (LRC 1)
			13.00-13.25 Sea cucumber culture 13.25-13.50 Seaweed 13.50-14.15 Streptococcosis of cultured fish in Thailand
14.45–15.00	Coffee break		
15.00-15.45	Scientific Sessions - Oral Presentations 1) Agriculture - Technology (Training Room)	15.00-15.45 Special Seminar (Meeting Room)	14.15-15.15 Panel Discussion-Sea bass Mr. Suthi Mahalao Thai Marine Finfish Farmers Association Mr. Chonlachat Keawwan Somsakplakapong Limited partnership Mr. Arkrit Sasiangkul Arkrit's Farm Moderator: Lt. Sakrapee Hirunchat
16.00–16.30	Student Presentation Award Session		
16.30–17.00	Closing Ceremony		

Remark: Taking down posters at the end of the conference in the evening of January 12, 2021

Oral Presentation Schedule

Aquaculture Session

January 11, 2021

Oral Presentation

January 11, 2021

Aquatic Animal Nutrition (Room - LRC 2)			
Morning Session (10.15-11.30)			
Chairman: Assoc. Prof. Dr. Karun Thongprajukaew / Co-Chairman: Dr. Nutt Nuntapong			
Presentation No.	Time	Title	Presenter
AQ-Nutrition-O1	10.15-10.30	Palm Oil and Myo-inositol Increase Survival Rate of Seawater Nile Tilapia	Mr. Behnam Foroutan
AQ-Nutrition-O2	10.30-10.45	Effects on Growth Performance and Body Composition of Tilapia (<i>Oreochromis sp.</i>) Fed with Fish Waste Product in Practical Diet	Ms. Dg Siti Rahayu Zaihurin
AQ-Nutrition-O3	10.45-11.00	Ontogeny of Digestive System in Spotted Scat (<i>Scatophagus argus</i> Linneaus, 1766)	Dr. Laddawan Krongpong
AQ-Nutrition-O4	11.00-11.15	Effects of Fish Oil Replacement by a Combination of Soybean and Palm Oil in Asian seabass (<i>Lates calcarifer</i>) Diet on Growth, Fatty Acid Profile, Digestive Enzyme Activity, Immune Parameters and Salinity Challenge	Mr. Md Arefin Rahman
AQ-Nutrition-O5	11.15-11.30	Effects of Crude Anthocyanins from Three Plants on Lipid Contents in White leg shrimp (<i>Penaeus vannamei</i>)	Mr. Pongsakorn Limlek
Lunch (12.00 - 13.00)			
Opening Session: Room - LRC 1 (13.30 - 14.00)			

Afternoon Session (14.40-15.40)			
Chairman: Asst. Prof. Dr. Suphada Kiriratnikom / Co-Chairman: Dr. Teeyaporn Keawtawee			
Presentation No.	Time	Title	Presenter
AQ-Nutrition-O6	14.40-14.55	The Possibility of Using Zero Fishmeal Diets and Effect on Growth Performance, Immune Response of Pacific White Shrimp (<i>Litopenaeus vannamei</i>)	Mr. Kanin Patrachotpakinkul
AQ-Nutrition-O7	14.55-15.10	Effect of <i>Ulva intestinalis</i> Linnaeus to Optimum Dietary Inclusion on Growth Performance and Cooked Shrimp Color of <i>Litopenaeus vannamei</i> Boone, 1931	Ms. Pawinee Kleebthong
AQ-Nutrition-O8	15.10-15.25	Role of Pom-nang Seaweed, <i>Gracilaria</i> spp. on Growth and Survival of Juvenile Mud Crab, <i>Scylla paramamosain</i>	Mr. Wasina Rungruang
AQ-Nutrition-O9	15.25-15.40	Optimal Feeding Frequency for Bigfin Reef Squid (<i>Sepioteuthis lessoniana</i>)	Ms. Jirapan Satjarak

**Oral Presentation
January 11, 2021**

Aquatic Animal Breeding (Training Room)			
Morning Session (10.15-11.45)			
Chairman: Assoc. Prof. Dr. Thumronk Amornsakun / Co-Chairman: Asst. Prof. Dr. Jareeporn Ruangsri			
Presentation No.	Time	Title	Presenter
AQ-Breeding-O1	10.15-10.30	Germ Cell Transplantation Techniques in Aquaculture-targeted Marine Fishes	Prof. Dr. Yutaka Takeuchi (On-line)
AQ-Breeding-O2	10.30-10.45	Exploring Various Cryoprotectants for Cryopreservation of Spermatozoa of Tropical Oysters <i>Magallana bilineata</i> (Röding, 1798)	Prof. Dr. Shau Hwai (Aileen) Tan (On-line)
AQ-Breeding-O3	10.45-11.00	Oogenesis, Spermatogenesis and Hatching Rate of Seawater-acclimated Nile Tilapia	Mr. Biboon Withyachumnarnkul
AQ-Breeding-O4	11.00-11.15	Reproductive Biology of <i>Rastrelliger brachysoma</i> of Pattani Bay, the Lower Gulf of Thailand	Ms. Kay Khine Soe
AQ-Breeding-O5	11.15-11.30	Reproductive Features of Sultan Fish, <i>Leptobarbus hoevenii</i> (Bleeker, 1851)	Ms. Sajeenuth Srithongthum
AQ-Breeding-O6	11.30-11.45	Some Biological Aspects of Mature Female Sepat Siam, <i>Trichogaster pectoralis</i> (Regan, 1910) for Breeding	Ms. On-anong Siprasert
Lunch (12.00 - 13.00)			
Opening Session: Room - LRC 1 (13.30 - 14.00)			

Oral Presentation

January 11, 2021

Aquaculture System (Training Room)

Afternoon Session (14.40-15.55)

Chairman: Asst. Prof. Dr. Yutthapong Sangnoi / Co-Chairman: Asst. Prof. Dr. Sompong O-Thong

Presentation No.	Time	Title	Presenter
AQ-Aquaculture System-O1	14.40-14.55	Development of DHS-USB Reactors for Longtooth Grouper Closed Recirculating Aquaculture System	Asst. Prof. Dr. Takahiro Watari (On-line)
AQ-Aquaculture System-O2	14.55-15.10	The Development of a Prospective Zero-water Exchange System for Aquaria Using the Ozone-DHS-USB System	Dr. Nur Adlin (On-line)
AQ-Aquaculture System-O3	15.10-15.25	Sustainability of Recirculating Aquaculture Systems – The Aqualis Experience	Dr. Fabio Soller
AQ-Aquaculture System-O4	15.25-15.40	Isolation and Characterization of Heterotrophic Nitrifying Bacteria <i>Alcaligenes faecalis</i> and Efficiency on Shrimp Wastewater Treatment	Ms. Sunipa Chankaew
AQ-Aquaculture System-O5	15.40-15.55	Optimum Stocking Density of Hybrid Catfish (<i>Pangasianodon gigas</i> x <i>P. hypophthalmus</i>) in Giant Freshwater Prawn Polyculture	Ms. Nongnaphat Jongkrajak

**Oral Presentation
January 11, 2021**

**Aquatic Animal Health and Disease
(Meeting Room)**

Morning Session (10.15-11.45)

Chairman: Dr. Jumroensri Thawonsuwan / Co-Chairman: Dr. Sunee Wanlem

Presentation No.	Time	Title	Presenter
AQ-Health-O1	10.15-10.30	Image Technology Based Detection of Infected Shrimp in Adverse Environments	Prof. Dr. Thi Thi Zin (On-line)
AQ-Health-O2	10.30-10.45	Isolation of Beneficial Bacteria from Nile Tilapia (<i>Oreochromis niloticus</i>) for Their Activity to Inhibit Fish Pathogens	Mr. Kantakan Thepnarong
AQ-Health-O3	10.45-11.00	Test for the Ability to Inhibit Pathogenic Bacteria, <i>Vibrio parahaemolyticus</i> , by Using Algae and Photosynthetic Bacteria	Ms. Wannisa Saengkaew
AQ-Health-O4	11.00-11.15	Types of Cells in the Hepatopancreas of the Pacific Whiteleg Shrimp <i>Litopenaeus vannamei</i> Being Infected by <i>Enterocytozoon hepatopenaei</i>	Ms. Niroyhannah Nima
AQ-Health-O5	11.15-11.30	Isolation and Screening of Lactic Acid Bacteria (LAB) for Antagonizing <i>Vibrio parahaemolyticus</i> (AHPND strains) in White Shrimp (<i>Litopenaeus vannamei</i>)	Mr. Apisit Kimtun
AQ-Health-O6	11.30-11.45	The Use of <i>Zooshikella</i> sp. as a Probiotic Against Vibriosis in Asian seabass (<i>Lates calcarifer</i>)	Ms. Sumesa Puangpee

Lunch (12.00 - 13.00)

Opening Session: Room - LRC 1 (13.30 - 14.00)

**Oral Presentation
January 11, 2021**

Aquaculture-Eco-Management (Meeting Room)			
Afternoon Session (14.40-15.55)			
Chairman: Prof. Dr. Boonsirm Withayachamnarnkul / Co-Chairman: Mr. Arnon Uppabullung			
Presentation No.	Time	Title	Presenter
AQ-Eco-Management-O1	14.40-14.55	Composition of Nutrients in the Sediment in Relation to the Abundance and Size of Blood cockle (<i>Tegillarca granosa</i>) at Kuala Juru, Penang, Malaysia	Ms. Nuramira Syahira Saffian (On-line)
AQ-Eco-Management-O2	14.55-15.10	Species Diversity and Seasonal Variation of Coastal Crab in Pattani bay of Southern Thailand	Dr. Sarawuth Chesoh
AQ-Eco-Management-O3	15.10-15.25	GIS Application for Green Mussel (<i>Perna viridis</i>) Pole Culture for Natural Production Enhancement in Pattani Bay, Thailand	Dr. Supat Khongpuang
AQ-Eco-Management-O4	15.25-15.40	Diversity of Caddisflies (Trichoptera) Species and Their Importance to Sustainable Aquaculture Production in Surat Thani Province, Southern Thailand	Mr. Solomon Valdon
AQ-Eco-Management-O5	15.40-15.55	Pollution Assessment Through Macrobenthic Fauna Communities as Bio-Indicator in Human Activities Area at Koh Yo, Songkhla Lagoon	Ms. Thanaphan Jombodin

Oral Presentation Schedule

Agriculture Session

January 12, 2021

Oral Presentation

January 12, 2021

Agriculture - Plant Science (Room - LRC 2)			
Morning Session I (09.00-10.15)			
Chairman: Dr. Thitima Wongsheree / Co-Chairman: Dr. Sureerat Yenchon			
Presentation No.	Time	Title	Presenter
Invited Speaker	09.00-09.15	Sustainable Uses of Local Vegetables and Pomology of Southern Thailand under Her Royal Highness Maha Chakri Sirindhorn Project: Biotechnological Propagation and Conservation	Prof. Dr. Sompong Te-chato
AG-PS-O1	09.15-09.30	Gene Expression of Ethylene Biosynthesis and Ethylene Signaling Involved in Chilling Injury of Hom Thong Banana	Ms. Pattamawan Anusornpornpong
AG-PS-O2	09.30-09.45	Genetic Diversity of Native Pumpkin Accessions in Nan Province with Genotyping-by-Sequencing Technology	Dr. Nongnat Phoka
AG-PS-O3	09.45-10.00	Xylem Sap Flow and Tree Transpiration of Pummelo (<i>Citrus grandis</i> L. Osbeck) 'Thong Dee' in Harvesting Stage under Varied Environmental Conditions	Mr. Somyot Meetha
AG-PS-O4	10.00-10.15	Effect of Pruning on the Transpiration of Mango Cultivar 'Nam Dok Mai Si Thong'	Mr. Tanapon Adultithipat
Coffee Break (10.30-10.45)			

Morning Session II (10.45-12.00)			
Chairman: Dr. Jessada Sopharat / Co-Chairman: Asst. Prof. Dr. Ladawan Lerslerwong			
Presentation No.	Time	Title	Presenter
AG-PS-O5	10.45-11.00	Evaluation of Seed Germination and Flowering of Edible Flowers for Greenhouse Production under Southern Thailand Condition	Ms. Chattamas Promdach
AG-PS-O6	11.00-11.15	Effects of Water-Cooling Temperature on Growth, Development and Carbohydrate Contents in Sacred Lotus	Mr. Sornnarin Suangto
AG-PS-O7	11.15-11.30	Physiological and Biochemical Responses in Two Rubber Rootstocks Submitted to Drought Stress	Mr. Poramet Kaewprasert
AG-PS-O8	11.30-11.45	Effect of Rubber Rootstocks on Morphological and Reactive Oxygen Species Changes of RRIT 251 Scion during Drought Condition	Ms. Laksanaporn Sriyapunt
AG-PS-O9	11.45-12.00	Possibility of Unbalance Nutrients in Plant Parts Cause on the Gummosis Symptom of Immature Rubber Tree Clone RRIT251	Ms. Sujitra Sri-ubon
<i>Lunch (12.00 - 13.00)</i>			

Afternoon Session (13.00-14.00)			
Chairman: Assoc. Prof. Dr. Supat Isarangkool na Ayuthaya / Co-Chairman: Asst. Prof. Dr. Ladawan Lerslerwong			
Presentation No.	Time	Title	Presenter
AG-PS-O10	13.00-13.15	Preliminary Evaluation on Development of Nutrient Standard for the Rubber Tree by Bark and Rubber Yield Compare with Leaves	Ms. Bhonbubcha Kayaphad
AG-PS-O11	13.15-13.30	Development of the Leaf Nutrient Standard of Mature Rubber Tree Clone RRIM600 in Northeast Thailand	Ms. Wantanee Meeloon
AG-PS-O12	13.30-13.45	Preliminary study on the physiological status of <i>Hevea</i> rubber and its relationships under different rubber-based intercropping practices	Mr. Zar Ni Zaw
AG-PS-O13	13.45-14.00	Effects of Intercropping on Growth and Biomass in Oil Palm Seedlings	Mr. Thanet Khomphet

Oral Presentation

January 12, 2021

Agriculture – Animal Science (Training Room)			
Morning Session (09.00-10.30)			
Chairman: Asst. Prof. Dr. Saowaluck Yammuen-Art / Co-Chairman: Assoc. Prof. Dr. Wanwisa Ngampongsai			
Presentation No.	Time	Title	Presenter
Invited Speaker	09.00-09.15	An Opportunity for Dairy Goat Farming in Thailand	Asst. Prof. Dr. Chaiyawan Wattanachant
AG-AS-O1	09.15-09.30	Effect of Perilla Seed Meal for Replacement Soybean Meal in Diets on Carcass Characteristic of Crossbred Pig	Ms. Chanmany Souphannavong
AG-AS-O2	09.30-09.45	Screening and Selection of Lactic Acid Bacteria from Ensiled Total Mixed Ration at Different Ensiling Time	Mr. Natcha Ketpanich
AG-AS-O3	09.45-10.00	Effects of Dietary Protein Levels in Concentrate on Growth Performance and Nutrient Utilization of Post Weaning Thai Indigenous Male Goat	Ms. Kanokwan Sangthong
AG-AS-O4	10.00-10.15	Chemical Composition and Kinetics of Gas Production of Partially Defatted Moringa Seed Meal	Ms. Katalee Nulong
AG-AS-O5	10.15-10.30	Production of Nutrient Enrichment Cassava Pulp by Ruminal Microbes Inoculation	Mr. Saeree Engsatittanawan
<i>Coffee Break (10.30-10.45)</i>			

Oral Presentation

January 12, 2021

Agriculture - Pest Management (Training Room)			
Morning Session (10.45-11.45)			
Chairman: Asst. Prof. Dr. Supot Kasem / Co-Chairman: Assoc. Prof. Dr. Anurag Sanpapao			
Presentation No.	Time	Title	Presenter
Invited Speaker	10.45-11.00	Insect Gall Formation Requires Switching from Source to Sink Organs	Prof. Seiji Takeda (On-line)
AG-PM-O1	11.00-11.15	Control Potential of Entomopathogenic Nematodes and Entomopathogenic Fungi Against Melon Fruit Fly <i>Zeugodacus cucurbitae</i> (Coquillett)	Ms. Jureeporn Sukhatiphum
AG-PM-O2	11.15-11.30	Efficacy of Entomopathogenic Nematodes Against Stable Fly Larvae under Laboratory Condition	Ms. Niyaporn Khwanket
AG-PM-O3	11.30-11.45	Preliminary Screening of the Resistance of Rice Cultivars (<i>Oryza sativa</i> L.) and their mechanisms against <i>Meloidogyne graminicola</i>	Mr. Natthidech Beesa
Lunch (12.00 - 13.00)			

Afternoon Session (13.00-14.45)			
Chairman: Asst. Prof. Dr. Buncha Chinnasri / Co-Chairman: Asst. Prof. Dr. Atirach Noosidum			
Presentation No.	Time	Title	Presenter
Invited Speaker	13.00-13.15	Application of Geographic Information Systems and Remote Sensing for Sugarcane Pest Management in Kamphaeng Phet, Thailand	Asst. Prof. Dr. Ratchadawan Ngoen-Klan
Invited Speaker	13.15-13.30	Sustainable Control of Blood-sucking Flies for Livestock Keeping	Prof. Dr. Gerard Duvallet (On-line)
AG-PM-O4	13.30-13.45	Screening of the Antagonistic <i>Bacillus</i> spp. Isolated from Banana Rhizosphere Soil for the Control of Banana Blood Disease	Mr. Akkachai Laopha
AG-PM-O5	13.45-14.00	Laboratory Rearing of <i>Musca domestica</i> L. (Diptera: Muscidae) from Fishery Waste (<i>Lates calcarifer</i>) for Alternative Protein Source in Aquatic Feeds	Ms. Warin Klakankhai
AG-PM-O6	14.15-14.30	Race Identification and Aggressiveness of <i>Fusarium oxysporum</i> f.sp. <i>cubense</i> Isolates in Northeast Thailand	Ms. Wanarat Natino
AG-PM-O7	14.30-14.45	Optimizing the Sex Ratio and Oviposition Material for Mass Production of Assassin Bug, <i>Sycanus collaris</i> (F.) (Hemiptera: Reduviidae)	Dr. Tewee Maneerat
<i>Coffee Break (14.45-15.00)</i>			

Oral Presentation

January 12, 2021

Agriculture – Technology Session (Training Room)			
Afternoon Session (15.00-15.45)			
Chairman: Asst. Prof. Dr. Panupon Hongpakdee / Co-Chairman: Assoc. Prof. Dr. Surassawadee Promyou			
Presentation No.	Time	Title	Presenter
Invited Speaker	15.00-15.15	Development of the Suitable Water and Nutrient Managements for Economic Trees in Northeast Thailand	Assoc. Prof. Dr. Supat Isarangkool Na Ayutthaya
AG-TE-O1	15.15-15.30	Impact of Land Use Change from Forest to Rubber on Soil Phosphorus and Microbial Biomass Phosphorus in Tropical Sandy Soils	Ms. Apinya Saentho
AG-TE-O2	15.30-15.45	Reuse of Swine Wastewater for <i>Azolla</i> Production for Sustainable Agriculture and Environment	Mr. Phearun Lay (On-line)

Oral Presentation Schedule
Agricultural System Session
January 12, 2021

Oral Presentation

January 12, 2021

Agricultural System (Meeting Room)

Morning Session I (09.00-10.15)

Chairman: Dr. Budsara Limmirankul / Co-Chairman: Dr. Kobchai Worrapiumphong

Presentation No.	Time	Title	Presenter
Invited Speaker	09.00-09.15	Local Organic Foods and Consumer's Purchase Intention	Prof. Dr. Mei-Fang, Chen (On-line)
AgS-O1	09.15-09.30	Beef Cattle Situation among Farmers in Rattaphum District Songkhla Province	Mr. Seksan Duangsingtham
AgS-O2	09.30-09.45	Alternative Farming on the Highland and Livelihood Assets of Small Scale Farmer in Na Noi District, Nan Province	Ms. Priyanud Chuensin
AgS-O3	09.45-10.00	Assessing the Livelihood Strategies on the Sustainability of the Natural Resource Utilizations in Peat Swamp Ecosystems. Lessons Learned from the Khreng Peat Swamp Ecosystem, South Thailand.	Ms. Rosawadee Sukkum
AgS-O4	10.00-10.15	Development of Chinese Cabbage Production Processes for Distribution in “The Green Market” of Songkhla Province: The Agri-Market, Faculty of Natural Resources, Prince of Songkla University	Ms. Keminee Tongma

<i>Coffee Break (10.30 – 10.45)</i>			
Morning Session II (10.45-11.45)			
Chairman: Prof. Dr. Buncha Somboonsuke / Co-Chairman: Dr. Kobchai Worrapimphong			
Presentation No.	Time	Title	Presenter
AgS-O5	10.45-11.00	Sustainability is Dynamic: Assessing Processes of Change and Innovation in Smallholders Agriculture around Tonle Sap Lake, Cambodia	Mr. Donira Khan (On-line)
AgS-O6	11.00-11.15	Understanding Decision Drivers that Threaten Conservation Efforts amongst Hmong Communities Adjoining a National Park in Lao PDR	Ms. Maiyer Xiong (On-line)
AgS-O7	11.15-11.30	Individual Social and Economic Position Versus the Impact of Collective Services: The Contribution to Small-Scale Farmers' Adoption on Single Origin (SO) Coffee Processing Scheme	Mr. Bayu Rizky Pratama (On-line)
AgS-O8	11.30-11.45	Impact of Climate Change on Farmer Adaptation and Tobacco Productivity in Temanggung Regency	Mr. Bayu Rizky Pratama (On-line)
<i>Lunch (12.00-13.00)</i>			
Afternoon Session (14.00-15.00)			
Chairman: Miss Rungrat Saeyang / Co-Chairman: Dr. Kobchai Worrapimphong			
AgS-O9	14.00-14.15	Multidimensional Database for Assessment of Novel Foods in Future Diets to Improve the Sustainability of Food Systems	Ms. Rachel Mazac (On-line)
AgS-O10	14.15-14.30	In a Developing Economy, Cooperation and Contract Farming Operate as Complements or Alternatives for Each Other	Ms. Olta Sokoli (On-line)

AgS-O11	14.30-14.45	Carbon Sequestration in Coffee Agroforestry Systems of Southwestern Ethiopia	Mr. Sebastian Peczek (On-line)
AgS-O12	14.45-15.00	Consumer's Attitudes Toward Insect Consumption in Cambodia	Mr. Techhong Lim (On-line)

Special Seminar (15.00-15.45)			
	Time	Title	Speaker
Invited Speaker	15.00-15.15	Looking for the Proof: The Challenge of Measuring Sustainability and Resilience	Dr. Didier Pillot Montpellier SupAgro (On-line)
Invited Speaker	15.15-15.30	Sustainability Challenges in Agriculture	Dr. Thilde Bech Bruun University of Copenhagen (On-line)
Invited Speaker	15.30-15.45	To Work or Not to Work in Agriculture? Perspectives and Expectations of Students and Employers in Thailand	Dr. Petra Chaloupková Czech University of Life Sciences Prague (On-line)

Aquaculture Special Seminar

January 12, 2021

January 12, 2021

Aquaculture Special Seminar

(Room - LRC 1)

Morning Session (09.00-12.00)

Presentation No.	Time	Title	Presenter
1	09.00-09.45	The Role of the Department of Fisheries: Support for the Future Development of Aquaculture	Mr. Tanawut Kunchittichanok
2	09.45-10.30	Aquaculture Business Management Guidance for Covid-19 Era	Mr. Pairoj Apiraknosit
<i>Coffee Break (10.30 - 10.45)</i>			
3	10.45-11.15	Aquaponics System	Mr. Weerapong Thapuksorn
4	11.30-12.00	Current Breeding Technique and Culture Development of Mud Crab (<i>Scylla paramamosain</i> Estampador, 1949)	Mrs. Siriwan Nooseng
<i>Lunch (12.15 - 13.00)</i>			
Afternoon Session 13.00-16.00			
5	13.00-13.25	Sea Cucumber Culture	Mr. Issama-el Bensaard
6	13.25-13.50	Seaweed	Assoc. Prof. Dr. Rapeeporn Ruangchuay
7	13.50-14.15	Streptococcosis of Cultured Fish in Thailand	Asst. Prof. Dr. Naraid Suanyuk
8	14.15-15.15	Panel Discussion - Sea bass Moderator: Lt.Sakrapee Hirunchat	Mr. Suthi Mahalao
			Mr. Chonlachat Keawwan
			Mr. Arkrit Sasiangkul

Poster Presentation
Agriculture Session
January 11, 2021

Poster Presentation

January 11-12, 2021

Agriculture - Plant Science		
Presentation No.	Title	Presenter
AG-PS-P1	Appropriate Postharvest Handling for Extending the Shelf Life of Ready-to-Cook Leaves of Melinjo (<i>Gnetum gnemon</i> L.) Vegetable	Asst. Prof. Dr. Kanokpon Bunya-atichart
AG-PS-P2	Comparison of Mono-papaya and Papaya-banana Intercropping Systems on Growth, Fruit Quality, and Nutrients	Mr. Chutisorn Deemak
AG-PS-P3	Alleviation of Postharvest Fruit Dehiscence of 'Chanthaburi II' Durian Using Gibberellic Acid and Chitosan Coating	Assoc. Prof. Dr. Chalermchai Wongs-Aree
AG-PS-P4	Phytochemical Components and Antioxidant Activities Changes in Fresh and Dried of Tropical Water Lily (<i>Nymphaea lotus</i> L.) Flower	Assoc. Prof. Dr. Surassawadee Promyou
AG-PS-P5	Effect of Coating and Temperature on Quality and Manage the Rot Disease of the Nam Dok Mai Si Thong	Dr. Supatchaya Nampila
AG-PS-P6	Chitosan and Sodium Alginate - Double Coatings Integrated with Sweet-Flag Extract Affecting the Postharvest Quality of 'Nam Dok Mai' Mango	Assoc. Prof. Dr. Chalermchai Wongs-Aree
AG-PS-P7	Tolerant Evaluation of 10 Tian Corn Inbred Lines Under Temporary Waterlogging Condition	Assoc. Prof. Dr. Suchada Boonlertnirun

AG-PS-P8	Yield and Quality Evaluation Trials of Purple Sweet Waxy Corn Hybrids	Assoc. Prof. Dr. Kitt Boonlertnirun
AG-PS-P9	Yield and Nutritional Composition of Sweet Potato Tips Genotypes with Varying Fleshed Colors and Various Application Fertilizer	Asst. Prof. Dr. Laongsri Sirikesorn
AG-PS-P10	Promoted Early Flowering and Sweetness of Edible Curcuma Inflorescence by Nutrient Management	Asst. Prof. Dr. Panupon Hongpakdee
Presentation No.	Title	Presenter
AG-PS-P11	Application of Gibberellic Acid to Improve the Seed Germination of Commercial Cactus Varieties	Ms. Timapon Artnafai
AG-PS-P12	Stability Study of Select Mulberry Lines Based on Growth, Antioxidant and Chemical Compounds	Mr. Wattawatit Chaisaentao
AG-PS-P13	Effect of Coating and Temperature during Storage on Phenolic, Lycopene and β -Carotene Content of 'Nam Dok Mai Si Thong' Mango	Dr. Supatchaya Nampila
AG-PS-P14	Chemical Composition, Antioxidant and Antibacterial Activities of Ultrasound-Assisted Extract of <i>Annona squamosa</i> L. Leaves	Asst. Prof. Dr. Pornpun Siramon
AG-PS-P15	Effect of Coating and Temperature on the Quality, Extend the Shelf life of 'Nomsod' Indian Jujube Produced in the Phon Sub-district, Kalasin Province, Thailand	Ms. Sasithorn Niyanut

Poster Presentation

January 11-12, 2021

Agriculture - Pest Management		
Presentation No.	Title	Presenter
AG-PM-P1	Surveys and Characterization of Plant-parasitic Nematodes Associated with Medicinal Plants	Ms. Phornthawon Phanbut
AG-PM-P2	Trichoderma Species Associated with Green Mold Disease of <i>Ganoderma lingzhi</i> in Thailand	Ms. Chosita Ubolsuk
AG-PM-P3	Potential of Edible Mushroom <i>Pleurotus</i> spp. for the Biocontrol of Root-knot Nematode (<i>Meloidogyne incognita</i>) and Their Cuticle Degrading Enzyme Production	Ms. Kanyani Chaiyadit
AG-PM-P4	Prey Preference and Predation Efficacy of <i>Sycanus collaris</i> (F.) (Hemiptera: Reduviidae) on <i>Tenebrio molitor</i> (L.) (Coleoptera: Tenebrionidae)	Ms. Pornsawan Poopat

Poster Presentation

January 11-12, 2021

Agriculture - Technology		
Presentation No.	Title	Presenter
AG-TE-P1	Research and Development on Water Onion's Micropropagation by Temporary Immersion Bioreactor (TIB) for Protection and Sustainable use	Ms. Supaporn Sachati
AG-TE-P2	Effects of Media, BA, and LEDs Lights on the Growth of <i>Rhynchosyilis coelestis</i> in vitro Culture	Dr. Supanath Kanjanawattanawong

Poster Presentation
Agricultural System Session
January 11, 2021

**Poster Presentation
January 11-12, 2021**

Agriculture - Agricultural System		
Presentation No.	Title	Presenter
AgS-P1	Assessment of Farm Level Dynamics and Sustainability of Incorporating Cacao Production in Farm Systems in San Fernando, Camarines Sur, Philippines.	Ms. Ciara Sophia Roxas
AgS-P2	Study on Supply Chain Model of Coconut Production in Prachuap Khiri Khan, Chumphon and Surat Thani provinces	Ms. Hathaikarn Sittha
AgS-P3	The Competitiveness of Aromatic Coconut Product in Case of Thailand Food Valley 1 st Year Agroindustry Networking	Asst. Prof. Dr.Thitima Wongsheree
AgS-P4	An Analysis of Factors Affecting Revealed Symmetric Comparative Advantage of Crude Palm Oil Exports of Indonesia, Malaysia and Thailand in the World Markets	Ms. Rungrat Saeyang
AgS-P5	A Comparative Analysis of Maize-Based Smallholder Farming Systems (MSFS) Towards Household Food and Nutrition Security Improvement in Senqu River Valley (SRV) Agroecological Zone, Lesotho	Ms. Qhithiwe Anna Seko
AgS-P6	Supply Chain Management of Golden Dried Longan in Lamphun Province	Ms. Ammarin Auparakat
AgS-P7	Supply Chain Management of Rice Cultivars in Chiang Mai and Phatthalung Province	Ms. Jirattikan Yontawong
AgS-P8	Technical Efficiency of Soybean Production, Chiang Mai Province.	Ms. Ploiphailin Tantiwit
AgS-P9	Production Management of Tilapia and Input-use Efficiency A comparative the Study between Phan District, Chiang Rai Province and Pak Phanang District, Nakhon Si Thammarat Province	Ms. Kawintip Kongina

Poster Presentation
Aquaculture Session
January 11, 2021

Poster Presentation

January 11-12, 2021

Aquatic Animal Nutrition		
Presentation No.	Title	Presenter
AQ-Nutrition-P1	Physical Pretreatments of Food Waste and Its Possible Potential as Diet for Juvenile Striped Catfish (<i>Pangasianodon hypophthalmus</i>)	Ms. Chotiga Khaudtong
AQ-Nutrition-P2	Effect of Lecithin-Enriched Diet on the Reproductive Performance of Eeltail Catfish (<i>Protosus canius</i>)	Mr. Poosana Keawkong
AQ-Nutrition-P3	Effect of Dietary Supplementation of Sea Lettuce (<i>Ulva</i> sp.) on Growth Performance and Survival Rate of Mud Crab (<i>Scylla serrata</i>)	Ms. Wanwisa Sangwong
AQ-Nutrition-P4	Effects of Climate Change on Spiny Lobster Aquaculture in Koh Yao District, Phang-Nga Province	Ms. Thanyapat Chamnina
AQ-Nutrition-P5	Preliminary Study on the Culture of Seagrapes (<i>Caulerpa lentillifera</i>) in Semi-enclosed and Enclosed Area in Pulau Pinang, Malaysia	Dr. Sau Pinn Woo
AQ-Nutrition-P6	Uses of Para-rubber Seed Kernel Protein in Feed on Growth Performance and Feed Utilization in Red Claw Crayfish (<i>Cherax quadricarinatus</i>)	Ms. Sudarat Chantakam
AQ-Nutrition-P7	Effect of Inversion of Cultured Frames on Growth and Characteristic of Green Caviar Seaweed, <i>Caulerpa lentillifera</i> (Chlorophyceae)	Ms. Manthana Donnoklai

Poster Presentation

January 11-12, 2021

Aquatic Animal Health and Disease		
Presentation No.	Title	Presenter
AQ-Health-P1	Effects of Ground Pepper and Piperine on Growth Performance and Bacteria Disease Resistance in White Shrimp, <i>Penaeus vannamei</i>	Asst. Prof. Dr. Jareeporn Ruangsri
AQ-Health-P2	Effect of Bioproducts from <i>Zooshikella</i> sp. on Growth Performance and Immune Responses in Nile Tilapia (<i>Oreochromis niloticus</i>)	Ms. Chalanda Kamnerddee
AQ-Health-P3	Factors Related to the Use and Production of Vaccine Against Motile <i>Aeromonas</i> Septicemia in Tilapia (<i>Oreochromis</i> spp.)	Mr. Suppanat Thaneerat
AQ-Health-P4	Characterization of Cyanobacteria strain Osci-TK01	Ms. Kanokwan Maaiad
AQ-Health-P5	Species Diversity and Tetracycline Resistance of Pathogenic <i>Aeromonas</i> spp. in Nile Tilapia Seed Farms in Southern Thailand over a 5-Year Period (2016-2020)	Asst. Prof. Dr. Raja Sudhakaran
AQ-Health-P6	Cytokine Homologue Genes in Kuruma Shrimp, <i>Marsupenaeus japonicus</i>	Prof. Dr. Toshiaki Itami

Poster Presentation

January 11-12, 2021

Aquaculture-Eco-Management		
Presentation No.	Title	Presenter
AQ-Eco-Management-P1	Environmental Factors Influencing the Distribution of Coastal Molluscs in Pattani Bay of Gulf of Thailand	Dr. Sarawuth Chesoh
AQ-Eco-Management-P2	Accumulation of Microplastics in Water Column at Koh Yo, Songkhla Lagoon, Thailand.	Mr. Sakarat Pat-iam
AQ-Eco-Management-P3	Fecundity, Hatching Rate and Growth of Gravid Female Blue Swimming Crab (<i>Portunus pelagicus</i>) and Guidelines for the Management of Crab Bank: Case Study of Crab Bank Sub-Anan Local Fisheries Group, Singhanakhon District, Songkhla Province	Ms. Wachiraporn Seubhorn

Poster Presentation
Special Exhibition
January 11, 2021

Poster Presentation

January 11-12, 2021

Special Exhibition		
Presentation No.	Title	Presenter
AG-SE-P1	Willingness to Study Abroad: Case Study of Thai Agricultural Students	Mr. David Zeman
AG-SE-P2	Challenges and Opportunities of Double Degree Master: Case Study in Thailand	Ms. Sreykhouch Ek

Enhancing Sustainable Agriculture Development and Food System for Rural Livelihood in Northern Thailand

Budsara Limmirankul

*Department of Agricultural Economy and Development, Chiang Mai University, Chiang Mai 50200, Thailand.
budsara.l@cmu.ac.th*

Abstract

North of Thailand has highly diversified and intensive agro-ecosystems. The smallholder farmers, in particular, are facing competing challenges for sustaining their farming livelihoods. The main objectives of the research were to explore existing agricultural systems and transformation of alternative farming systems, to assess key assets and success for sustainable agricultural development. The three cases studies highlighted, the elements for success are locally rooted, but certain common features emerged. These includes 1) community's own assets and resources as the basis for development; it empowers the farmers of the community by encouraging them to utilize and be able to transform in their farming base on the resource. 2) Farmers' strong will power to change. 3) Capacity building through effective design of social learning, 4) Team building of small-numbered, 5) System management in using information, collective planning, allocation of responsibility, communications, monitoring and evaluation, 6) Leadership strengthening for delivering technological and social innovations).

Keywords: Sustainable Agriculture, Food System, Rural Livelihood, Asset Base

Towards Sustainable Food Systems

Hanna Tuomisto

*Department of Agricultural Sciences, Helsinki Institute of Sustainability Science (HELSUS)
University of Helsinki, Finland.
hanna.tuomisto@helsinki.fi*

Oral Presentation

Agriculture– Plant Science

Sustainable Uses of Local Vegetables and Pomology of Southern Thailand under Her Royal Highness Maha Chakri Sirindhorn Project: Biotechnological Propagation and Conservation

Sompong Te-chato*, Sureerat Yenchon, Tassanee Khawnium and Waraporn Hidchim

Division of Agricultural Innovation and Management, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Thailand, 90110

*Corresponding author: sompong.t@psu.ac.th

Abstract

Many local or indigenous fruits and vegetables in southern Thailand provided small to moderate amounts of macronutrients and minerals. The highest content of β -carotene and phenolic compounds was found in ripe cashew apple (*Anacardium occidentale*) and Gnetum (*Gnetum gnemon*). Moreover, excellent sources of vitamin C was found in *Garcinia* spp. L., *Syzygium jambos* (Wight) S.N. Mitra., *Baccaurea* spp. Lour., Asam paya (*Eleiodoxa conferta* (Griff.) Burr.) and young cashew leaves. Downy murtle (*Rhodomyrtus tomentosa* (Aiton) Hassk.) and *Archidendron pauciflorum* (Benth.) I.C. Nielsen, *Parkia* spp. are rich in polyphenols. Those plants provide diverse natural bioactive compounds that contribute wealth benefits to southern Thailand people for long period of time. Recently, ecosystem of the plants was being destroyed due to deforestation, overexploitation and construction of resorts or human residents. Some of those species are being extinct and account as endangered species. To maintain and conserve of those valuable plants for sustainable uses in the future *in vitro* propagation is setting up under the supporting fund through Royal Project. Different explant, include seed segment, shoot tip, node, zygotic embryo and leaf were tried to maximize mass scale propagation through both organogenesis and embryogenesis and ready for returning to their ecosystem. By the way, the suitable explants such as shoot tip, node, zygotic and somatic embryos were conserved *in vitro* by means of slow growth or cryopreservation for long term utilization. By this technique economically important indigenous fruit and vegetable crops of southern Thailand will be sustainable used for multi-purposes in future generation.

Keywords: Local fruit, vegetable, propagation, conservation, biotechnology, sustainable use

Gene Expression of Ethylene Biosynthesis and Ethylene Signaling Involved in Chilling Injury of Hom Thong Banana

Pattamawan Anusornpornpong^a and Wachiraya Imsabai^{a,b,*}

^a Department of Horticulture, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, 73140 Thailand.

^b Postharvest Technology Innovation Center, Ministry of Higher Education, Science, Research and Innovation, Bangkok, 10400, Thailand.

*Corresponding author: wachiraya.i@ku.th

Introduction

Hom Thong banana reveals chilling injury (CI) when stored at low temperatures. The CI symptoms are peel browning and abnormal fruit ripening. This research aimed to study the expression of ethylene-related genes on the chilling injury of Hom Thong banana.

Methods

Bananas were separated into three groups before storage at 7 ± 1 °C for four days consist of control (C), 1-methylcyclopropene (M) fumigation, and ethylene (ET) treatment; then banana was transferred to 25 ± 1 °C for three days.

Results

The browning and ripening score indicates that ET was tolerant of CI and had normal ripening. The browning score of the control banana was similar to ET, but the ripening was delayed. In contrast, the banana fumigated with M susceptible to CI and did not ripe. The ripening index (peel color change, firmness, and TSS) is related to *MaACS1* and *MaACO1* genes' expression levels. These banana genes treated with ET showed high expression level after storage and transfer to 25 ± 1 °C, while these genes in banana fumigated with M did not found. Control banana found low expression levels of these genes. The expression level of *MaERS3* of banana treated with ET did not differ from control and fumigated with M at 7 ± 1 °C. The *MaERS3* gene in banana treated with ET was up-regulated while the expression level of *MaCTR1* and *MaEIL2* had a significant down-regulated at 7 ± 1 °C and these genes were up-regulated after transfer to 25 ± 1 °C.

Conclusion

Ethylene treatment up-regulated *MaACS1*, *MaACO1*, and *MaERS3* genes and down-regulated *MaCTR1* and *MaEIL2* genes during storage at low temperature resulting in Hom Thong banana tolerant to CI and had normal ripening after transferring to room temperature.

Keywords: low temperature, ripening, ethylene signaling

Selected References:

1. Saiyawan, K. *Master Thesis, Horticulture, Kasetsart University, Thailand, 2012* Retrieved from <https://www-lib-ku-ac-th.portal.lib.ku.ac.th/KUthesis/2555/kitti-sai/index.htm>.
2. Hong, K.; Xie J.; Zou, R.; Zhang, E.; Xin, M.; Huang, M.; He, Q. *Acta Physiol Plant*, **2015**, 37:252, 1-11.

Genetic Diversity of Native Pumpkin Accessions in Nan Province with Genotyping-by-Sequencing Technology

Nongnat Phoka^a, Monchai Neesang^b, Siwaret Arikit^c

^aKing Mongkut's University of Technology Thonburi, Ratchaburi Campus, Ratchaburi 70150, Thailand.

^bPilot Plant Development and Training Institute, King Mongkut's University of Technology Thonburi, Bangkuntien, Bangkok 10150, Thailand.

^cRice Science Center and Department of Agronomy at Kamphaeng Saen, Faculty of Agriculture, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140.

*Corresponding author: nongene@gmail.com

Introduction

Communities in many areas of Nan province commonly grow corns for livestock feed, which are the main source of their income. Chemical fertilizers are used and create a huge effect on the wellness of community members. Consequently, many communities are finding an alternative crop to solve this problem. Pumpkin is one of the important native vegetables in Nan Province. Some communities initiated the transformation of monoculture to the integrated farming system. They grow pumpkins for distributing to Bangkok markets. However, documented information of acclimated pumpkin landraces in Nan is deficient in identifying duplicates and deciding how many and which samples represent the most genetic diversity. These native pumpkins still have diverse morphological characteristics and have not been proven that the species are technically correct. In this study, we analyzed the genetic diversity of 31 pumpkin accessions with GBS technology, aiming at collecting useful information for further conservation and breeding of pumpkin accessions for the business benefits of local communities.

Methods

A total of 31 pumpkin accessions collected from three sampling areas in Nan province were used in this study. Pumpkin species were examined the genetic distinctions, repetitive regions of genomes in each species by constructing GBS library and genome maps of pumpkin species. Phylogenetic trees using the unweighted pair group method with arithmetic mean (UPGMA) and neighbor-joining (NJ) algorithms with the MEGA X program (Kumar et al., 2018).

Results

Clean reads of 31 pumpkin accessions were mapped to the pumpkin reference genome and SNP call. A total of 473,195 SNPs was generated with an average mapping rate of 83.95%. Phylogenetic analysis was performed to gain an insight into the genetic diversity of pumpkin accessions. The results showed that each pumpkin accession's genetic codes from the three sampling areas in Nan province are not duplicated, but they are related on some levels. Still, they are not in the same accessions.

Conclusion

The results of this study will benefit the conservation of pumpkin species. Moreover, it will help classify the species to serve consumer needs.

Keywords: Native Pumpkin, Nan Province, Genetic Diversity, Genotyping-By-Sequencing

Selected References:

1. Kumar, S.; Stecher, G.; Li, M.; Knyaz, C.; Tamura, K, I. *Mol. Biol. Evol.*, **2018**, *35*, 1547-1549.

Xylem Sap Flow and Tree Transpiration of Pummelo (*Citrus grandis* L. Osbeck) ‘Thong Dee’ in Harvesting Stage under Varied Environmental Conditions

Somyot Meetha^a, Tanapon Adultithipat^a, Rumpai Nampila^a and Supat Isarangkool Na Ayutthaya^{a*}

^a*Horticultural section, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.*

*Corresponding author:isupat@kku.ac.th

Introduction

Measurement of water requirement by sap flow probe is an instrument to understand whole-tree water use. The aim of this study was to evaluate the water use of a mature commercial ‘Thone Dee’ pummelo tree (*Citrus grandis* L. Osbeck) growing in sandy loam soil. The experiment was conducted in the farmer’s orchard at Kaset Sombun District, Chaiyaphum Province, Northeast Thailand.

Methods

Five of 5-years old pummelo were selected, with the trunk girth around 46.7-66.0 cm. Stem sap flow was measured during the rainy season from August to September 2020. Sap flow probe was inserted into a trunk at 20 cm above the soil in the north azimuthal position. The data was recorded through the transient thermal dissipation method (10 min of heating and 20 min of cooling in a half-hour period; TTD10) with a Granier-type probe. Data were calculated for both sap flux density (Js) and daily tree transpiration (ET). In addition to every 30 minutes data collection, the volumetric soil water content is measured by a CS616 Water Content Reflectometer probe; and, the climate data (temperature and relative humidity) recorded with a U23 Pro v2 Temperature/Relative Humidity Data Logger-U23-001 (Bourne, MA, USA). Then, each 30-minute vapor pressure deficit (VPD) was calculated from the climate data.

Results

The soil status was well-watered and maintained at field capacity moisture, the volumetric water content was around 26.29-29.94 m³ m⁻³. Four condition of climate were compared; extremely sunny day (VPD 5.0 kPa), typical sunny day (VPD 2.4 kPa), cloudy day (VPD 1.5 kPa) and rainy day (VPD 0.2 kPa). The results show that the daily sap flux density was dramatically reduced on a rainy day compared with a sunny day. On the extremely sunny day, the daily sap flux density was seemly stable, pummelo tree transpiration inhibited in extremely evaporative demand.

Conclusion

The tree transpiration rate of pummelo ‘Thong Dee’ ranged from 53 to 66 L day⁻¹ when the maximum VPD was around 2.4-5.0 kPa.

Keywords: water requirement, sap flux density, evaporative demand

Effect of Pruning on the Transpiration of Mango Cultivar 'Nam Dok Mai Si Thong'

Tanapon Adultithipat^a, Somyot Meetha^a and Rumpai Nampila^a, Supat Isarangkool Na Ayutthaya^{a*}

^a*Horticultural section, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.*

*Corresponding author: isupat@kku.ac.th

Introduction

Transpiration is a physiological process on the water loss from the plant. In both external and internal factors regulated this process. For example, in the internal factor, it is a leaf number in the canopy. Thus, this work evaluated the pruning management (reducing of leaves in the canopy) on the water loss of the exported mango.

Method

The experiment was conducted in a mango plantation, cv. Nam Dok Mai Si Thong, located in the Banhat District, Khon Kaen Province, Thailand. Seven eight-year-old mango trees in harvesting until the pruning stage were selected to investigate the transpiration rates from April to June 2020. The pruning process was done on 16th June 2020. The tree transpiration was measured through the transient thermal dissipation (TTD) method. The canopy's penetration of light was measured by Li-cor Li-1500 Light sensor at 1 meter above the soil in both sizes from the center of the canopy.

Results

Before and after pruning, the comparison of light penetration showed that the light intensity after pruning increased from 5.55-14.16 % to 41.78-67.55 %. The tree transpiration showed a 10% reduction of maximum sap flux density and daily tree transpiration after the pruning. Additionally, on a pruning day, the reduction of xylem sap flow and transpiration suddenly responded to the pruning.

Conclusion

The pruning reduces leaves in the canopy process and reduces the transpiration of 'Nam Dok Mai Si Thong' mango.

Keywords: pruning, light through the canopy, transpiration

Evaluation of Seed Germination and Flowering of Edible Flowers for Greenhouse Production under Southern Thailand Condition

Chattamas Promdach^a, and Ladawan Lerslerwong^{a,*}

^a*Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: ladawan.l@psu.ac.th

Introduction

In Thailand, the flowering plants are produced mostly in the Northern and Northeastern areas, with the weather suitable for commercial growing. The flowering plant's field production in the Southern area is limited by the weather condition, which has a lot of rain and high humidity. However, the trend to use the flower as edible flowers is increasing continuously. Therefore, this study aimed to evaluate the seed germination and flowering of thirteen edible flowers grown as potted plants. This information will select the edible flowers that have the potential for greenhouse production under Southern Thailand's condition.

Methods

Thirteen species of edible flowers were two of Vinca (*Catharanthus roseus*), 'Pacifica' and 'Vintesse', Impatiens (*Impatiens wallerana*), two of Dianthus (*Dianthus chinensis*), 'Diamond Series' and 'Diana Series', Dalia (*Dahlia* spp.), Pansy (*Viola tricolor*), Snapdragon (*Antirrhinum majus*), Celosia (*Celosia spicata*), Cosmos (*Cosmos sulphureus*), Gazania (*Gazania splendens*), Zinnia (*Zinnia elegans*), and Gloxinia (*Sinningia speciosa*). Seeds were sown and then seedlings were grown under a greenhouse with PE cover at the Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Thailand. Germination percentage and index, the first date of flower bud break and blooming were recorded. A data logger was used for greenhouse environment monitoring.

Results

The results based on germination percentage, these flower seeds could be divided into three groups as follows: 1) Dahlia and Gloxinia (low, $\leq 60\%$), 2) 'Pacifica' Vinca, Impatiens, Zinnia, and 'Diamond Series' Dianthus (moderate, 61-80%), and 3) 'Vintesse' Vinca, Pansy, 'Diana Series' Dianthus, Snapdragon, Celosia, Cosmos, and Gazania (high, $> 80\%$). The results showed the correlation between seed germination and greenhouse environmental, i.e., temperature, humidity, and daylength. While the results based on the days of flower bud break and blooming, it could be divided into five groups as follows: 1) Celosia (≤ 40 days), 2) Cosmos, Snapdragon, and 'Vintesse' Vinca ($> 40-50$ days), 3) Impatiens, Gazania, and 'Pacifica' Vinca, 'Diana Series' and 'Diamond Series' Dianthus ($> 50-60$ days), 4) Zinnia and Pansy ($> 60-100$ days), and 5) Dahlia and Gloxinia (> 100 days). It was found that the maximum temperature was the main factor that effects faster flowering.

Conclusion

Seed germination and flowering of edible flowers grown as potted plants respond differently to environmental factors, temperature and daylength. The interpreted results can be used to select and plan for greenhouse production in Southern Thailand.

Keywords: ornamental plants, greenhouse, germination, flowering, temperature, daylength

Selected References:

1. Ferranate, A.; Trivellini, A.; Scuderi, D.; and Romano, D. *Postharvest Biol. Technol.*, 2015, 100, 99-108.

Effects of Water-Cooling Temperature on Growth, Development and Carbohydrate Contents in Sacred Lotus

S. Suangto^{1,2,3}, S. Ruamrungsri² and P. Hongpakdee^{1*}

¹Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

²Department of Plant and Soil Science, Faculty of Agriculture, Chiang Mai University, Chiangmai, Thailand

³Graduate student under the Participatory and Integrative Support for Agricultural Initiative (PISAI) Project.

*Corresponding author: panupon@kku.ac.th

Introduction

Sacred lotus (*Nelumbo nucifera* Gaertn.) is an important flower crop in Thailand. When the temperature is lower, their natural dormancy leads to reducing vegetative growth, flowering, and change in carbohydrate metabolism. The cooling temperature mechanism on growth, development, and carbohydrate content is essential and required for a better understanding of some flowering control management in sacred lotus.

Methods

The experiment was conducted for one month under three ranges of artificial water-cooling temperature (WCT), i.e., 15, 20 at nighttime and ambient temperature (25 °C) as a control treatment. Growth parameters were collected every week. The leaf, stolon, and root were sampled to investigate reducing sugars (RS) and total non-structural carbohydrate (TNC) analysis.

Results

The growth of sacred lotus was showed a non-significantly different. Only plant fresh weight was significantly different. WCT at 15 and 20 °C increased leaf dry weight proportion but decreased the stolon dry weight proportion. The WCT yielded higher RS content in leaf and root but lower in stolon than control. The higher leaf RS proportion was found in WCT. TNC concentration after WCT was lower than the control in stolon but higher in the root. TNC distribution to the leaf of the WCT treated plant was higher than in control.

Conclusion

The 1-month WCT did not affect lotus growth except the fresh weight and leaf dry weight proportion. The cooling treatment increased RS and TNC concentration and the proportion of leaves. Nevertheless, carbohydrate metabolism had changed after 1-month WCT treatment. Neither vegetative growth nor flowering percentage in sacred lotus was affected by WCT.

Keywords: *Nelumbo nucifera* Gaertn., water cooling temperature, total non-structural carbohydrate, reducing sugar

Physiological and Biochemical Responses in Two Rubber Rootstocks Submitted to Drought Stress

Poramet Kaewprasert^a, Charassri Naulsri^a, Poonpipope Kasemsap^b, Natthakorn Woraathasin^a and Korakot nakkanong^{a,*}

^a*Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

^b*Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.*

*Corresponding author: korakot.n@psu.ac.th

Abstract

In rubber plantation, tolerance to drought can be improved by bud grafting high yield rubber clones onto drought tolerant rootstocks. The aim of this work was to investigate the responses to drought stress of two rubber rootstocks (RRIM 623 and PB 5/51) bud grafted with RRIT 251 scion. The effects of drought stress at the different time points of water deficit conditions (0, 5, 8, and 11 days after water withholding) were evaluated as changes in physiological and biochemical traits. The results showed that at the end of the experiment, RRIT 251 grafted on RRIM 623 (RRIT251/RRIM623) had a better relative water content (RWC) and Fv/Fm, which were decreased by 34.1% and 46.3%, respectively, supported by lower electrolyte leakage (EL) and proline content (11.5% and 11.7 $\mu\text{mol g}^{-1}$ FW respectively). According to our results, water stress severity was alleviated by using RRIM 623 rootstock.

Keyword: rubber, rootstock, drought, responses

Selected References:

1. Ahmad, B. *Journal of Rubber Research*, 1999, 2, 99-119.
2. Yao, X.; Chen, X.; Wang, J.; Zhou, J.; Cai, M.; Lin, W. *Journal of Rubber Research*, 2017, 20, 203-212.

Effect of Rubber Rootstocks on Morphological and Reactive Oxygen Species Changes of RRIT 251 Scion during Drought Condition

Laksanaporn Sriyapunt^a, Charassri Nualsri^a, Natthakorn Woraathasin^b, Poonpipope Kasemsap^c and Korakot Nakkanong^{a,*}

^aAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^bDepartment of Science, Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani 94000, Thailand.

^cDepartment of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

*Corresponding author: korakot.n@psu.ac.th

Abstract

The utilization of drought-tolerant rubber rootstock is one alternative solution to minimize the effect of drought stress. This study's objective was to investigate the effect of different rubber rootstocks on morphological and reactive oxygen species changes. RRIT 251 scions grafted on RRIM 623 (RRIT 251/RRIM 623) or PB 5/51 (RRIT 251/PB 5/51) rootstocks were observed at different time points of water-deficit conditions (0, 5, 8, and 11 days of withholding water). During water deficit, the leaf greenness decreased while the malondialdehyde (MDA) and ROS [superoxide anion (O_2^-) and hydrogen peroxide (H_2O_2)] accumulation increased. At 11 days after withholding water, MDA, O_2^- and H_2O_2 accumulation were increased in RRIT 251 scions grafted on both rootstocks. The result showed that RRIT 251/RRIM 623 exhibited greater leaf greenness (34.90 SPAD unit) than RRIT 251/PB 5/51 (28.15 SPAD unit). In addition, RRIT 251/PB 5/51 had higher accumulated in MDA, O_2^- and H_2O_2 than RRIT 251/RRIM 623 after 11 days of withholding water. Our results indicate that RRIT 251 bud grafted with RRIM 623 alleviated the oxidative damage caused by drought stress.

Keywords: Drought stress, water-deficit, leaf greenness, reactive oxygen species (ROS)

Selected References:

1. Choudhury, S.; Panda, P.; Sahoo, L. and Panda, S. K. *Plant signaling & behavior*, **2013**, *84*, e23681.
Wang, L. F. *Plant Physiology and Biochemistry*, **2014**, *83*, 243-249.

Possibility of Unbalance Nutrients in Plant Parts Cause on the Gummosis Symptom of Immature Rubber Tree Clone RRIT251

Sujitra Sri-ubon^{a,*}, Anan Wongcharoen^b and Supat Isarangkool Na Ayutthaya^a

^a *Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.*

^b *Department of Plant Pathology, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.*

*Corresponding author: sujitra.s@kkumail.com

Introduction

Gummosis symptom, a bark cracking with latex flow out on the trunk, is a critical problem of the immature stage of rubber tree planted in northeast Thailand. The cause may occur from the unbalancing of plant nutrient status. This investigation aimed to evaluate some nutrients, e.g., nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and boron (B) in leaves, top shoot, and bark at 3 m above the soil of rubber tree clone RRIT251 (the immature stage before tapping).

Methods

The experimental design was a completely randomized design (CRD) with three treatments; healthy tree (no symptom), mild gummosis (small cracking bark length <5 cm and a black latex flowing out), severe gummosis (considerable cracking bark length > 5 cm and a highly black latex flowing out). In each treatment, the five replicated trees were selected. The soil and plant samples were collected in May 2020 in 7 years old farmer's plantation located at Pakkhat district, BuengKan province.

Results

The result showed that the soil in both mild and severe gummosis symptom trees had lower K concentration in the soil than the healthy trees, but other nutrients were not a significantly different. The plant investigation showed that the bark of 2 levels of gummosis symptom tended to thicker than healthy trees. Additionally, in the bark nutrient analysis, the two gummosis symptom trees were higher in N concentration and lower in K concentration than the healthy tree. Other plant parts, top shoot and leaves, the K concentration in the top shoot, and the Ca concentration in the leaves exhibited lower gummosis symptom trees than a healthy tree. However, the B in both the bark and leaves surprisingly showed higher concentration in the gummosis symptom trees than the healthy tree.

Conclusion

The possible cause of the gummosis symptom should be the higher N and K ratio in the bark and top shoot; also, the possible cause could be the lower Ca in the leaves.

Keywords: rubber tree, bark cracking, nutrient analysis

Preliminary Evaluation on Development of the Nutrient Standard for the Rubber Tree by Bark and Rubber Yield Compare with Leaves

B. Kayaphad^{a,*}, C. Siriwong^b, P. Hongpakdee^a and S. Isarangkool Na Ayutthaya^a

^a Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand; ^bDepartment of Chemistry, Faculty of Science, Khon Kaen University, Khon Kaen, Thailand.

*Corresponding Author: sauce203kps@gmail.com

Introduction

For several trees, the optimum fertilizer supply uses the analysis of nutrients in leaves compared with the leaf nutrient standard method. However, the the rubber tree leaf sampling, which is a tall tree, is not easy for the collection for nutrient analysis. This preliminary study aimed to evaluate the bark and dry latex for developing these parts nutrient standards to replace the leaves' nutrient standard guideline. This study focused on the mobile nutrients; nitrogen (N), phosphorus (P), and potassium (K), as well as immobile nutrients; calcium (Ca) and, boron (B).

Methods

The study was conducted in ten farmer's rubber plantations (RRIM 600 and RRIT 251 clone) located in Pak Khat District, Bueng Kan Province. The age of trees was around 10-15 years old. Ten sampled rubber trees in each replicated plantation were selected to sample leaves, bark, and latex in May 2020. Then nutrients in each plant part were analyzed in the laboratory of the Faculty of Agriculture, Khon Kaen University. The dry rubber yield in the unit of gram per length of tapping was calculated from the fresh latex weight, total solid weight, and length of tapping scar. The relationship between dry rubber yield and nutrients in each plant parts were analyzed.

Results

Results showed that the relationship between dry rubber yield and all nutrients in leaves and bark was a nonlinear relation (bell curve) according to the envelope curve concept. It meant that these relations could express the optimum range of nutrients in leaves and bark. The relationship between dry rubber yield and P in yield exhibited a positive linear relation, while the dry rubber yield and B in yield were a negative relation. Additionally, the Ca in the dry rubber was too small content (no detection). This evidence showed that the dry yield could not evaluate the optimum range of some nutrients.

Conclusion

Our preliminary work concluded that the bark nutrient standard possibly replaced the rubber tree's leaf nutrient standard. The bark sample is suitable for collection than the leaves.

Keywords: *Hevea brasiliensis*, nutrients, plant tissues analysis

Development of the Leaf Nutrient Standard of Mature Rubber Tree Clone RRIM600 in Northeast Thailand

Wantanee Meeloon^{a,b}, Suput Isarangkool Na Ayutthaya^{b,*}, Panupon Hongpakdee^b and Buncha Somboonsuke^a

^aAgricultural development, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^bDepartment of Horticulture, Faculty of Agriculture, Khon Kaen University 40002, Thailand

*Corresponding isupat@kku.ac.th

Introduction

Nowadays, several plants' fertilizer recommendation is advised according to the soil and plant nutrient analysis guidelines. The Rubber Research Institute of Thailand already developed the leaf nutrient standard for rubber trees, but it can vary from the clone, soil properties, and environments. The rubber tree planting in the northeast region had differed from the traditional area in the south of Thailand. This study's objective was to develop the leaf nutrient standard for rubber tree clone RRIM 600 planted in northeast region.

Methods

This work was done in the 30 farmer's rubber tree plantations in northeast Thailand, which separated located in 6 provinces, including Buriram, Khon Kaen, Sakon Nakhon, Udon Thani, Nong Khai, and Loei. Each province had five represented plantations. The leaf samples and yield (dry rubber) from 10 replication trees were collected in each represented plantation during July 2016. The nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and boron (B) in leaves were analyzed. Then, the relationship between yield and each nutrient concentration was established by the upper envelope curve concept. The potential yield for estimated the optimum nutrient content was 40 g tree⁻¹ tapping⁻¹.

Results

The survey of yield founded that the dry rubber ranged from 29.9 to 46.5 g tree⁻¹. The non-linear relationship between yield and all nutrients under the upper envelope curve concept expressed that the optimum ranges of N, P, K, Ca, and B in leaves of rubber tree clone RRIM600 were 1.40-3.30%, 0.19-0.38%, 1.07-1.71%, 0.42-0.93%, and 17.10-40.00 mg/kg, respectively.

Conclusion

The leaf nutrient standards of rubber tree clone RRIM600 developed by the potential yield at 40 g tree⁻¹ tapping⁻¹ were 1.40-3.30% for N, 0.19-0.38% for P, 1.07-1.71% for K, 0.42-0.93% for Ca, and 17.10-40.00 mg/kg for B.

Keywords: nutrient standard, rubber tree, upper envelope curve

Preliminary Study on the Physiological Status of *Hevea* Rubber and Its Relationships under Different Rubber-based Intercropping Practices

Zar Ni Zaw* and Rawee Chiarawipa

Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: 6110630008@psu.ac.th

Abstract

The study aimed to preliminarily explore the relationship of the rubber tree's physiological status and processable properties with response to different agroecosystem components especially leaf area index (LAI) and soil moisture contents (SMC) under three types of rubber-based intercropping notably rubber-bamboo (RB), rubber-coffee (RC) and rubber-melinjo (RM) compared to a rubber monocrop (R). RB and RM significantly showed the highest LAI values of around 1.4 while that of R had the smallest value (40% lesser than the highest values). Soil moisture contents (SMC) of R and RC were higher than that of the others in the soil depth of 0-20 cm. However, in the 21-40 cm soil depth, the higher SMCs were observed in RM and RB plots. Significant positive relationships were observed between the LAI and molecular weight of rubber, and between the SMC and the processable properties. The physiological status of the rubber tree was also positively correlated to both LAI and SMC.

Keywords: rubber-based intercropping, leaf area index, soil moisture content, physiological status, processable properties

Effects of Intercropping on Growth and Biomass in Oil Palm Seedlings

Thanet Khomphet^{a,*}, Theera Eksomtramage^a and Jakarat Anothai^a,

^a*Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: tanetkie@gmail.com

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is one of the world's most important oil crops in the world. 2018, Thailand had planted 0.94 million hectares (OAE, 2018). Because of Thailand's increasing population, new palm plantations have increased rapidly to produce more palm oil and their products (Phitthayaphinant *et al.*, 2012). The empty space in oil palm farms is used for many purposes to earn extra income. Intercropping, the system of simultaneously growing two or more crops on the same land (Mousavi and Eskandary, 2011), is widely practiced on oil palm farms in Southern Thailand. Several plants are successfully intercropped with oil palm, on many farms. However, research on the effects of intercropped plants on oil palm is lacking. In this study, intercropped plants on oil palm farms were surveyed and selected. The selected plants have edible leaves and are successfully planted on many oil palm farms. The plants were cashew, sweet leaf bush, cha-om, melinjo and melientha. The purposes of this study were to evaluate the effects of five intercropped plants on growth and biomass in oil palm seedlings, and to select the most suitable intercrop plants, for growth and biomass performance, and inhibition of oil palm seedling growth.

Methods

This experiment used a completely randomized design with six treatments, including sole cropped oil palm seedling (T1), oil palm seedling cropped with cashew (T2), sweet leaf bush (T3), cha-om (T4), melinjo (T5), and melientha (T6). Each treatment consisted of 3 replications. A 3-month-old oil palm seedling was planted with an intercropped plant in a plastic plot (30 cm in diameter, 50 cm in height). The experiment was conducted from October 2019 to April 2020 at the Faculty of Natural Resources, Prince of Songkla University. The growth parameters of oil palm seedlings were plant height, plant diameter, leaf length and width, number of bifurcate and pinnate leaves. The growth parameters of intercropped plants were plant height and diameter, branch length, and diameter. The growth parameters of those seedlings and plants were recorded every month from November 2019 to April 2020. The biomass of oil palm seedlings was fresh and dry weights of the stem, leaf, roots at 0-25 cm, 25-50 cm, and >50 cm. The biomass of intercropped plants was fresh and dry weights of the stem, branch, leaf, roots at 0-25 cm, 25-50 cm, and >50 cm. Those seedlings and plants' biomass were weighted every two months (December 2019, February 2020, and April 2020).

Results

Plant height, plant diameter, leaf length, leaf width, number of bifurcate and pinnate leaves were not significantly different among the treatments throughout the experiment, except for the number of bifurcate leaves in January and the number of pinnate leaves in April 2020. Fresh and dry weights of the stem, leaf, roots at 0-25 cm, 25-50 cm, and > 50 cm were not significantly different among the treatments in all observed months, except root fresh weights at 0-25 cm and 25-50 cm in December 2019. For intercropped plants, cashew, sweet leaf bush, and cha-om produced the most remarkable growth and biomass parameters in all observed months.

Conclusion

Most growth and biomass parameters of oil palm seedlings were not significantly different among the treatments in all observed months. It can be concluded that intercropped plants did not inhibit the growth and development of oil palm seedlings. In terms of growth performance and biomass accumulation, cashew, sweet leaf bush, and cha-om were the most suitable for intercropping with oil palms. However, long-term study under different conditions is required to determine the specific effects.

Keywords: biomass, growth, intercropped plant, oil palm seedling

Selected References:

1. Mousavi, S. R., Eskandary, H. *J. Appl. Environ. Biol. Sci.*, **2011**, 1(11), 482-486.
2. Phitthayaphinant, P.; Nissapa, A.; Somboonsuke, B., Eksomtramage, T. *KKU Res. J.*, **2012**, 11(1), 66-76.
3. Office of Agriculture Economics (OAE). <http://www.oae.go.th/view/1/Information/EN-US>, **2018**.

Agriculture– Animal Science

An Opportunity for Dairy Goat Farming in Thailand

Chaiyawan Wattanachant^{*1,2}

¹ *Division of Animal Production Innovation & Management, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand*

² *Small Ruminant Research & Development Center, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand*

*Corresponding author: chai_tum@yahoo.com

Abstract

The market for goat milk in Thailand was rather limited until the year 2015 when it started experiencing growth. This increase in the amount of milk consumption from 2015 to 2019 was probably related to the growth in middle-class consumers as well as the increasing awareness of the health benefits of goat milk. In addition, the growth of the goat milk market may also be related to growth in Thailand's senior population, who have a strong desire for good quality food. This resulted in a promoting future for dairy goat farming in Thailand. However, most Thai dairy goat farms are faced with a low quality and quantity of milk, a lack of GAP standard for farming, and a lack of GMP standard for milk processing. Furthermore, most farmers lack appropriate production and marketing knowledge, and are not innovative. Although raising dairy goats holds opportunity as Thai people's demand for goat milk increases, but it will become necessary for Thai dairy goat farmers to improve their production systems including breeding and genetics, milk processing, and marketing systems.

Effect of Perilla Seed Meal for Replacement Soybean Meal in Diets on Carcass Characteristic of Crossbred Pig

Chanmany Souphannavong^a, Chaiwat Arjin^a, Apinya Sartsook^a, Prapas Mahinchai^b, Korawan Sringarm^{a*}

^aDepartment of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand

^bChiang Mai Livestock Research and Breeding Center, Bureau of Animal Husbandry and Genetic Improvement, Department of Livestock Development

*Corresponding author: korawan.s@cmu.ac.th

Abstract

Perilla seed meal (PSM) is the high protein content, it could be used as an alternative protein source for soybean meal (SM) replacement. This study was to evaluate the effect of PSM replacement SM on carcass characteristics of crossbred pig. Twenty-one crossbred pigs (Thai native x Duroc x Meishan x Pietrian; 70 kg, approximately) were randomly divided into three treatments (7 pigs per treatment) receiving diets containing 0%, 25%, and 50% PSM replaced SM (T1: 0% PSM, T2: 25% PSM, and T3: 50% PSM, respectively) for 12 weeks. At the end of the experiment, all pigs were slaughtered for carcass characteristics measurement. The PSM replacement for SM in all treatments had no different impacts on slaughter weight, percentage of carcass, carcass length, hot carcass weight, and chill carcass weight ($p>0.05$). But *longissimus dorsi* from T2 and T3 were significantly higher than T1 ($p<0.05$). These results indicate that PSM replaced SM in crossbred pigs' diets can increase the pork loin.

Keywords: Soybean meal, Perilla seed meal, crossbred pig, carcass characteristic

Screening and Selection of Lactic Acid Bacteria from Ensiled Total Mixed Ration at Different Ensiling Time

Natcha Ketpanich^{a,b,*}, Saowaluck Yammuen-art^a and Phongthorn Kongmun^b

^aDepartment of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chaing Mai 50200, Thailand.

^bDepartment of Animal Husbandry, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand

*Corresponding author: saowaluck.y@cmu.ac.th

Introduction

Ensiled total mixed ration is the feed preservation. Lactic acid bacteria are a common species in silage and has an important role in ensiling process. (Muck, 2010). The accumulation of lactic acid leads to reduction of pH. The low pH condition inhibits the growth and nutrient utilization of desirable microorganism which results in reducing loss of nutrient. (McDonald *et al.*, 1991) Natural fermentation of silage can cause loss of nutrient by epiphytic bacteria. The quality of silage could be improved by lactic acid bacteria inoculants, consequently lactic acid production occurs more quickly and loss of nutrients during ensiled can be reduced. The period of ensiling process associates with species of lactic acid bacteria. Li *et al.* (2016) found different dominant species of lactic acid bacteria in silage which different ensiling period. Therefore, the objective of this study is to screen the best performance of lactic acid bacteria for inoculated in ensiled total mixed ration from different ensiling period.

Methods

Total mixed ration was prepared and collected at 3, 7, 14 and 21 days of ensiled. Thirty bacterial colony from each fermentation period were collected. The lactic acid bacteria were tested by pH measurement, thermotolerant test, lactic acid and acetic acid production and growth curve. The DNA of lactic acid bacteria were extracted by commercial kits (Biofact, Korea). The DNA were amplified by PCR. The PCR product were nucleotide sequenced. The nucleotide sequencing result were compared with Gen Bank data base using BLAST algorithm.

Results

From one hundred-twenty colony of lactic acid bacteria, eighty-four colony reduce pH value under 4.2. The thermotolerant test found that thirty-four colony can grow at 45°C. Thirty-three colony produced lactic acid and acetic acid. Fifteen lactic acid bacteria that produce highest lactic acid were identified and compared in NCBI database. The result showed that there were *Lactobacillus plantarum*, *Pediococcus acidilactici*, *Lactobacillus paracasei* and *Pediococcus pentosaceus*. *P. pentosaceus* has a rapidly growth rate compared with other species at 3, 6 and peak at 12 hr. of incubation.

Conclusion

The best performance of lactic acid bacteria in this study is *Pediococcus pentosaceus*. This strain rapidly reduces pH value lower than 4.2. It was thermotolerant and grow at high temperature condition while high lactic acid production and growth rate.

Keywords: lactic acid bacteria, dairy cows, total mixed ration

Selected References

1. Li, X., Xu, W., Yang, J., Zhao, H., Pan, C., Ding, X., & Zhang, Y., Anim Nutr., **2016**, 2(3), 229-233.
2. McDonald, P., Henderson, A. R., & Heron, S. J. E., The biochemistry of silage, **1991**, 340.
3. Muck R. E., Rev. Bras. de Zootec., **2010**, 39, 183-191.

Effects of Dietary Protein Levels in Concentrate on Growth Performance and Nutrient Utilization of Post Weaning Thai Indigenous Male Goat

Kanokwan Sangthong^{a,*}, Pitunart Noosen^a and Wanwisa Ngampongsai^a

^aAnimal Production Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90110, Thailand.

*Corresponding author: sangthong.bbums@gmail.com

Abstract

Effects of protein levels in concentrate on growth performance and nutrient utilization of post weaning male goat were studied. Sixteen Thai indigenous male goats, 3 months old, with average body weight of 8.2 ± 2.7 kg, were allocated into 4 treatments under a completely randomized design (CRD) for 100 days study period. Treatment diets consisted of pangola hay *ad libitum* supplemented with concentrate at 2% of body weight (BW) as dry matter (DM) basis. The crude protein (CP) levels in concentrate were 8, 10, 12 and 14% of DM, respectively. There was no effect of CP levels in concentrate on the amount of hay, concentrate and total feed intake, including digestibility coefficient of dry matter (DM), organic matter (OM) and CP ($P > 0.05$). Increasing CP content in the concentrate significantly ($P < 0.05$) increase amount of CP intake (3.10, 3.85, 4.47 and 5.39 g/kgBW^{0.75}/d, respectively), N balance (4.10, 4.57, 6.77 and 7.13 g/d, respectively) and blood urea nitrogen (3.71, 4.38, 6.07 and 8.81 mg%, respectively). Increasing CP content in the concentrate resulted in linearly ($P = 0.01$) increased average daily gain (ADG) of goats (20.83, 31.48, 30.56 and 40.28 g/d, respectively). In addition, the results of the regression of CPI on ADG showed that goat needed 3.13 (± 0.31) g/kgBW^{0.75}/d to maintain their BW. The estimation of CP requirement for goat BW gain (g/g) was 0.39 (± 0.05).

Keywords: dietary protein levels, Thai indigenous male goat, growth performance, nutrient utilization

Chemical Composition and Kinetics of Gas Production of Partially Defatted Moringa Seed Meal

Katalee Nulong^a, Chaiyawan Wattanachant^{a,*} and Chaermpon Yuangklang^b

^a Division of Animal Production Innovation and Management, Faculty of Natural Resources, Prince of Songkla University, Hat Yai District, Songkhla 90112, Thailand

^b Rajamangala University of Technology Isan, Nakornratchasima 30000, Thailand

*Corresponding author: chai_tum@yahoo.com

Abstract

This study aimed to determine chemical composition, *in vitro* organic matter digestibility (IVOMD) and metabolizable energy of partially Moringa seed meal (MSM) compared with soybean meal (SBM). From the study, MSM had higher organic matter (OM), crude fiber (CF), ether extract (EE) and gross energy (GE) contents, but MSM had lower crude protein content (CP) than SBM (34.59 vs. 49.43 %DM). However, higher content of linoleic acid was indicated in MSM than SBM (4,443.98 vs 22.51 mg/100g). Considering the kinetic of gas production, MSM had lower immediately soluble fraction (a) value than SBM (-2.9 vs. -1.88 ml). The gas production from the insoluble fraction (b) and the potential extent of gas production (|a|+ b) of MSM were 112.64 ml/0.5 gDM and 109.74 ml, while the amount of b and |a|+ b of SBM were 106.85 ml/0.5 gDM and 110.59 ml, respectively. Although both feedstuff had similar metabolizable energy (ME) (11.68 vs. 11.48 MJ/kg DM) and short chain fatty acid (1.46 vs. 1.42 mmol/0.5 gDM), but MSM had slightly lower IVOMD percentage than SBM (89.32 vs. 94.60 %DM). From the results, it could be concluded that MSM can substitute SBM in the ruminant feed.

Keywords: Moringa seed meal, soybean meal, chemical composition, *in vitro* gas production

Production of Nutrient Enrichment Cassava Pulp by Ruminal Microbes Inoculation

Saeree Engsatittanawan^a, Saowaluck Yammuen-art^{a, *}, Siwat Sangsritavong^b, Benjaphon Suraraksa^{c, d}, Peerada Prommeenate^d and Nimaradee Boonapatcharoen^c

^aDepartment of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand

^bNational Center for Genetic Engineering and Biotechnology, Thailand Science Park, Pathum Thani 12120, Thailand

^cExcellent Center of Waste Utilization and Management, King Mongkut's University of Technology Thonburi (KMUTT), Bangkok 10150, Thailand

^dBiochemical Engineering and Systems Biology Research Group, National Center for Genetic Engineering and Biotechnology, at KMUTT, Bangkok 10150, Thailand

*Corresponding author: saowaluck.y@cmu.ac.th

Introduction

Cassava pulp is the main by-product of the cassava starch industry that causes environmental pollution. On the other hand, they can be used as cattle feedstuff. However, the low protein content is the limit for utilization. Therefore, the nutrition of the cassava pulp must be improved. Fermentation is one of the techniques to enhance nutrients and improve protein content. Cassava pulp has great potential to use as a carbon source for microbes fermentation without any pretreatment (Ashok *et al.*, 2000). The use of ruminal microbial as inoculum might be one strategy to improve cassava pulp's nutrient because this consortium can ferment several carbohydrates to produce short-chain fatty acid (SCFA) and synthesis single-cell protein (Timothy and Jeffrey, 2015). Ammonium chloride (NH₄Cl) is an excellent nitrogen source for rumen microbial cell growth. This study aimed to evaluate the influence of the ruminal microbes and NH₄Cl levels on the chemical composition, lactic acid, and SCFA profiles of inoculated cassava pulp.

Methods

The cassava pulp was inoculated with rumen fluid (RF) and naturally inoculated without any inoculum (CON) with three levels of NH₄Cl added (0, 0.25, 0.5% DM) for 0, 7, and 14 days. The mixtures were analyzed chemical composition (AOAC, 2000), true protein, non-protein nitrogen (NPN) (Giuseppe *et al.*, 1996), fiber content (Van Soest *et al.*, 1991) and pH levels, Lactic acid, SCFA were determined.

Results

There was a significant increase ($P < 0.001$) in the true protein content of cassava pulp in RF treatment, while NPN and non-fiber carbohydrate (NFC) continuously decreased after 7 and 14 days of inoculation. The true protein content of cassava pulp in CON treatment was not influenced by inoculation. The lactic acid and SCFA concentration of cassava pulp in all treatments were significantly increased after inoculation. The effect of true protein and SCFA content improvement due to NH₄Cl supplementation was not observed in this experiment.

Conclusion

The ruminal microbes can be used as the inoculum to improve true protein content and enhance the short-chain fatty acid concentration of cassava pulp.

Keywords: cassava pulp, cattle, ruminal microbes

Selected References:

1. AOAC. *OMA*, **2000**, 17.
2. Ashok, P.; Carlos, S.; Poonam, N.; Vanete, T. *Bioresour. Technol.*, **2000**, 74, 81-87.
3. Giuseppe, L.; Tonia, H; Van soest J.P. *Anim. Feed Sci.*, **1996**, 57, 347-358.
4. Timothy, H.; Jeffrey, F. *Front. Microbiol.*, **2015**, 6, 465-471.
5. Van soest, J.P.; James B.R.; Lewis A.B. *J. Dairy Sci.*, **1991**, 74, 3583-3597.

Agriculture– Pest Management

Insect Gall Formation Requires Switching from Source to Sink Organs

Seiji Takeda^{a,b,*}, Makiko Yoza^a, Taisuke Amano^a, Issei Ohshima^a, Tomoko Hiarno^a, Masa H. Sato^a, Tomoaki Sakamoto^c, and Seisuke Kimura^c

^a Graduate School of Life and Environmental Sciences, Kyoto Prefectural University, Kyoto 606-8522, Japan.

^b Biotechnology Research Department, Kyoto Prefectural Agriculture Forestry and Fisheries Technology Center, Seika, Kyoto 619-0244, Japan.

^c Department of Bioresource and Environmental Sciences, Faculty of Life Sciences, Kyoto Sangyo University, Kyoto 603-8555, Japan.

*Corresponding author: seijitakeda@kpu.ac.jp

Introduction

Galls are plant structures generated by gall-inducing organisms including insects, nematodes, fungi, bacteria, and viruses. Those made by insects generally consist of inner callus-like cells surrounded by lignified hard cells, supplying both nutrients and protection to the gall insects living inside. This indicates that gall insects hijack developmental processes in host plants to generate tissues for their own use. Although galls are morphologically diverse, the molecular mechanism for their development remains poorly understood.

Methods

To identify genes involved in gall development, we performed RNA-sequencing-based transcriptome analysis for leaf galls. We examined the young and mature galls of *Glochidion obovatum* (Phyllanthaceae), induced by the micromoth *Caloptilia cecidophora* (Lepidoptera: Gracillariidae), the leaf gall from *Eurya japonica* (Pentaphylacaceae) induced by *Borboryctis euryae* (Lepidoptera: Gracillariidae), and the strawberry-shaped leaf gall from *Artemisia montana* (Asteraceae) induced by gall midge *Rhopalomyia yomogicola* (Oligotrophini: Cecidomyiidae).

Results

Gene ontology (GO) analyses suggested that genes related to developmental processes, including floral homeotic genes, are up-regulated, whereas ones related to photosynthesis are down-regulated in these three galls. Comparison of transcripts in these three galls together with the gall on leaves of *Rhus javanica* (Anacardiaceae), induced by the aphid *Schlechtendalia chinensis* (Hemiptera: Aphidoidea), suggested 38 genes commonly up-regulated in galls from different plant species. GO analysis showed that peptide biosynthesis and metabolism are commonly involved in the four different galls.

Conclusion

Our results suggest that gall development involves common processes across gall inducers and plant taxa. Especially, down-regulation of photosynthetic genes and up-regulation of floral genes indicate that switching from photosynthetic source organ to sink organ is a key process for gall formation.

Keywords: gall, transcriptome, photosynthesis, floral homeotic genes

Selected References:

1. Takeda, S.; Yoza, M.; Amano, T.; Ohshima, I.; Hirano, T.; Sato, H.M.; Sakamoto, T.; Kimura, S. *PLOS ONE*, **2019**, 14, e0223686.
2. Hirano, T.; Kimura, S.; Sakamoto, T.; Okamoto, A.; Nakayama, T.; Matsuura, T.; Ikeda, Y.; Takeda, S.; Suzuki, Y.; Ohshima, I.; Sato, M.H. *Front Plant Sci*, **2020**, 11, 471.

Application of Geographic Information Systems and Remote Sensing for Sugarcane Pest Management in Kamphaeng Phet, Thailand

Ratchadawan Ngoenklan^{a,*} and Prakai Rajchanuwong^a

^b*Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.*

*Corresponding author: fagrwn@ku.ac.th

Introduction

Sugarcane, *Saccharum officinarum*, is an important commercial crop worldwide. Over 1.91 million hectares of sugarcane plantations in Thailand, central region is one of the majorities of sugarcane production, especially for Kamphaeng Phet province. To date, sugarcane yield losses are threatened by two groups of economically important pests, vectors of a phytoplasma pathogen causing sugarcane white leaf (SCWL) disease and sugarcane stem borers. Beside sugarcane insect pest management using physical and chemical control techniques, the Geospatial technology has certainly playing a crucial role to decision makers in forming strategies for management of insect pests and diseases of agriculture crops. In this project, we applied geographic information systems and remote sensing data to assess the spatio-temporal risk maps for key pests of sugarcane in Kamphaeng Phet province.

Methods

In Kamphaeng Phet province, vectors for sugarcane white leaf (SCWL) and sugarcane stem borers were surveyed in 139 and 245 sugarcane plantations, respectively, from February to May 2019. The coordinates containing insect population data of surveyed sugarcane fields were imported into QGIS 3.16.0 and pest monitoring maps were produced by using Inverse Distance Weight (IDW). Climatic factors, soil physical properties, remote sensing data (Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature derived from Terra MODIS) and insect monitoring data were combined to predict the appropriate area for sugarcane planting against the outbreak of white leaf disease vectors and sugarcane stem borers in Kamphaeng Phet Province using GIS-Based Niche Modeling.

Results

Results from heat risk maps and maps of ecological niche modeling for outbreak of leafhopper insect Vectors in SCWL and sugarcane stem borers suggested that the eastern area of the province, especially the south of Sai Ngam district that connected to the north of Sai Thong Wattana district and the southeast of Sai Thong Wattana district that connected to the north of Bueng Samakkhi district were predicted as epidemic areas for those key insect pests. Physical factors influenced the spread of sugarcane pests were vegetation index at 0.55-0.60, 10 days of cumulative rainfall between 34.5-35.5 millimeters, average yearly wind speed less than 4.5 km/h and silt loam.

Conclusion

The potential geographical distribution of insect pests in sugarcane using GIS-Based Niche Modeling can provide the information in developing effective management strategies for these destructive pests of sugarcane.

Keywords: sugarcane white leaf, sugarcane stem borers, ecological niche model

Selected References:

1. Fand B. B.; Kumar, M.; Kamble, A. L. Predicting the potential geographic distribution of cotton mealybug *Phenacoccus solenopsis* in India based on MAXENT ecological niche model. *J Environ Biol*, **2014**, *35*, 973-982.
2. Palaniswami, C.; Gopaldasundaram, P.; Bhaskaran, A. Application of GPS and GIS in Sugarcane Agriculture *Sugar Tech*, **2011**, *13*, 360-365.

Sustainable Control of Blood-sucking Flies for Livestock Keeping

Duvallet Gerard*

Paul-Valery Montpellier University, Center for Functional and Evolutionary Ecology, route de Mende, 34000 Montpellier Cedex 5, France

*Corresponding author: gerard.duvallet@univ-montp3.fr

Introduction

Blood-sucking flies like Tabanids, Tsetse flies and Stable flies are responsible of huge blood spoliation, stress, loss of appetite and energy, and of immunosuppression. The annual productivity losses are estimated at around 130 Kg of milk/cow and 25 Kg of meat/ox (1). In addition to that, those flies can be biological or mechanical vectors of viruses (equine infection anemia, ovine catarrhal fever), bacteria (Q fever, anthrax) and parasites (*Besnoitia*, *Trypanosoma*) (2, 3). Control of those hematophagous flies is often performed with insecticide spraying on walls or animals. Those insecticides contaminate animal products and environment. And this strategy is expensive and of short-term efficacy, due to increase of chemo-resistance (4, 5). New sustainable and environmentally acceptable control methods must be developed.

Methods

Recent control methods proposed for tsetse flies on one side and for horseflies and stable flies on the other side will be reviewed. In Africa, *Glossina* sp. (tsetse flies) are low prolific and sensitive to insecticides. In all the world, Tabanids (more than 4400 species) and *Stomoxys* flies (18 different species, one of them cosmopolite *S. calcitrans*), but also other hematophagous flies like *Haematobia* sp., *Haematobosca* sp. and *Musca crassirostris* (6) are highly prolific and develop early chemoresistance to insecticides. Different projects in USA, in Europe, in Africa and in Thailand have developed and evaluated new control methods.

Results

For tsetse flies in Africa, the development of insecticide impregnated fabric targets proved to be very efficient and are used now in different countries (7). For stable flies, in the framework of an international project called *FlyScreen*, coordinated by Cirad, supported by the French Research Agency, carried out by teams from France, Thailand, Burkina Faso and Tanzania, a Multi Target Method has been developed. Low cost blue polyethylene screens have shown to be very attractant. The incorporation of insecticides with a slow release system was very efficient in areas where stable fly chemo-resistance was still low, like Thailand. For Tabanids, H-Traps were very efficient but insufficient to control horse fly populations on a relatively small area (8). All those results will be shortly presented.

Conclusion

Progresses have been done to promote low-cost, and low-polluting control methods against sucking flies to protect livestock. If insecticide impregnated mini-targets are efficient in Africa against tsetse flies, if slow-release insecticide impregnated blue polyethylene screens are very useful against stable flies in areas without chemo-resistance, research is still necessary to control horseflies and chemo-resistant stable flies. Release of specific parasitoids in complement to trapping systems could be a solution for an Integrated Pest Management program.

Keywords: stable flies, horse flies, tsetse flies, pest control, integrated pest management.

Selected References:

1. Taylor, D.B.; Moon, R.D.; Mark, D.R. *J Med Entomol*, 2012, 49, 198–209.
2. Baldacchino, F.; Muenwom, V.; Desquesnes, M.; Desoli, F.; Charoenviriyaphap, T.; Duvallet, G. *Parasite* **2013**, 20, 26.
3. Baldacchino, F.; Desquesnes, M.; Mihok, S.; Foil, L.D.; Duvallet, G.; Jittapalapong, S. *Genet Evol*, **2014**, 28, 596–615.
4. Olafson, P.; Kaufman, P.; Duvallet, G.; Solorzano, J.; Taylor, D.; Trout Fryxell, R. *J. Med. Entomol.* **2019**, 56, 1145–11.
5. Tainchum, K.; Shukri, S.; Duvallet, G.; Etienne, L.; Jacquiet, P. *Parasitol Res*, **2018**, 117, 4027–4032.
6. Desquesnes M.; Onju S.; Chalermwong, P.; Jittapalapong, S.; Masmeatathip, R. *Med Vet Entomol*, **2019**, 33, 16-30.
7. Rayaisse, J.B.; Kröber, T.; McMullin, A.; Solano, P.; Mihok, S.; Guerin, P.M. *PLoS Negl Trop Dis*, **2012**, 6:e1491.
8. Ferjani, A.; Lucas, E.; Duvallet, G. *Agr Nat Resour*, **2020**, 54, 158–164.

Control Potential of Entomopathogenic Nematodes and Entomopathogenic Fungi Against Melon Fruit Fly *Zeugodacus cucurbitae* (Coquillett)

Jureporn Sukhatiphum^{a,*}, Prakaijan Nimkingrat^a, Narit Thaochan^b

^a Department of Entomology Faculty of Agriculture, Khon Kaen University, Khon Kaen 40000, Thailand.

^b Department of Entomology Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: Jurephorn2303@gmail.com

Abstract

The melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae) is an economically important pest and can cause devastating damage to cucurbitaceae. The most common control method rely on the use of chemical, though, this method is difficult to control hidden larvae inside fruits and underground pupae. Entomopathogenic nematodes (EPNs) was the most reported bio-agents against many foliage and cryptic insect pests. The two native commercial EPNs, *Steinernema siamkayai* and *S. carpocapsae* and entomopathogenic fungi (EPF), *Metarhizium anisopliae* PSUM02 were assessed the virulence on last instar larvae and pupae of *Z. cucurbitae*. Completely Randomized Designs (CRD) was used in this experiment. Different doses of EPNs at 0, 4,000, 5,000, 12,000, 15,000, 20,000 and 25,000 IJ/host and different concentrations of EPF at 1×10^5 , 1×10^6 , 1×10^7 , 1×10^8 spore/ml. were tested. The LD₅₀ values of larvae and pupae after sprayed with *S. siamkayai* and *S. carpocapsae* were 11,275 11,453 and 6,284 9,599 IJs/host, respectively. The highest mortality rate of larvae and pupae was recorded after treated with *S. siamkayai* (90 and 90%), followed by *S. carpocapsae* (95 and 90%) and EPF (62 and 59%), respectively. Moreover, the combination of EPNs and EPF reached the maximum mortality rate at 100% for both larval and pupal stages.

Keywords: biological control, entomopathogenic nematodes, entomopathogenic fungi, *Zeugodacus cucurbitae*, cucumber

Selected References:

1. Cristhiane Rohde, Alcides Moino Junior, Fabiano D. Carvalho, Marco A. T. da Silva, 2012. Selection of entomopathogenic nematodes for the control of the fruit fly *Ceratitis capitata* (Diptera: Tephritidae). Scientific Journals from Latin America. vol. 7: 2012: pp. 797-802.
2. Mir S. H., S. A. Dar , G. M. Mir And S. B. Ahmad. 2014. Biology of *Bactrocera cucurbitae* (Diptera:Tephritidae) on cucumber. Florida Entomologist 97(2): 753-758.

Efficacy of Entomopathogenic Nematodes Against Larvae under Laboratory Conditions

Niyaporn Khwanket^{a*}, Atirach Noosidum^a and Krajana Tainchum^b

^a Department of Entomology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

^b Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: niyaporn3842@gmail.com

Introduction

Entomopathogenic nematodes (EPNs) are soil-dwelling obligate parasites of insects. EPNs are also reported with infection to instar larvae of various flies under laboratory conditions. Normally, the larvae of stable fly (*S. calcitrans*) spend their part of the life cycle within animal manure and organic matter. In Thailand, the control of stable fly by EPN applications under laboratory and field conditions has not been reported before. Therefore, this study aims to evaluate the efficacy of EPNs when applied to larvae of *S. calcitrans* under laboratory conditions.

Methods

Seven isolates of EPNs consist of *Steinernema carpocapsae*, *S. siamkayai*, *Steinernema* sp. EPNKU60, *Heterorhabditis bacteriophora*, *H. indica* EPNKU82, *Heterorhabditis* sp. EPNKU64 and *Heterorhabditis* sp. EPNKU67 were tested by filter paper bioassays at the rate of 0, 50, 100, 200 and 400 infective juveniles (IJs)/cm² against second and third instar larvae of *S. calcitrans*. Insect mortality was recorded every 24 hours and 30 replicates were conducted for each treatment.

Results

Results showed that all EPN isolates at the rate of 50, 100, 200 and 400 IJs/cm² were able to infect and kill second and third instar larvae of *S. calcitrans* from 3 days of exposure. *Heterorhabditis bacteriophora* at the rate of 50 IJs/cm² firstly killed the second instar larvae of *S. calcitrans* for 100% after 3 days of exposure. *Steinernema carpocapsae*, *H. bacteriophora*, *H. indica* EPNKU82, *Heterorhabditis* sp. EPNKU64, *Heterorhabditis* sp. EPNKU67 at the rate of 50 IJs/cm² and all EPN treatments at the rate of 100-400 IJs/cm² killed the second instar larvae over 80-100% insect mortality after 7 days of exposure. The lower pathogenicity of the seven EPN isolates was found when applied to the third instar larvae of *S. calcitrans*. Over 80% mortality of the third instar larvae was found in *H. indica* EPNKU82 treatments at the rate of 50 IJs/cm² after 4 days of exposure. The higher insect mortality (over 80%) was mostly found when applied *Heterorhabditis* sp. EPNKU64 (100%), *H. indica* EPNKU82 (83-93%), and *S. carpocapsae* (80-93%) at the rate of 200-400 IJs/cm² to the third instar larvae after 7 days of exposure.

Conclusion

The second instar larvae of *S. calcitrans* were more susceptible to the EPNs isolates than the third instar larvae. *Heterorhabditis* sp. EPNKU64, *H. indica* EPNKU82 and *S. carpocapsae* were effective against both second and third instar larvae of *S. calcitrans* under laboratory conditions.

Keywords: Entomopathogenic nematode, stable fly, biological control, *Steinernema*, *Heterorhabditis*

Selected References:

1. Moon, R. D.; Muscid Flies (Muscidae). *Med Vet Entomol*, **2002**, L. A. Durden and G. A. Mullen. San Diego, CA, Academic Press: 279-301.
2. Taylor, D. B.; Szalanski A. L.; Adams B. J.; Peterson R. D.; Susceptibility of house fly (Diptera: Muscidae) larvae to entomopathogenic nematodes (Rhabditida: Heterorhabditidae, Steinernematidae). *Environ. Entomol*, **1998**, 27(6), 1514-1519.

Preliminary Screening of the Resistance of Rice Cultivars (*Oryza sativa* L.) and their Mechanisms against *Meloidogyne graminicola*

Natthidech Beesa^{a,b}, Kansiree Jindapunnapat^c, Buncha Chinnasri^b and Thanunchanok Chairin^{a,*}

^a Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90110, Thailand.

^b Department of Plant Pathology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

^c Department of Entomology and Plant Pathology, Faculty of Agriculture, Khon Kaen University, Khon Kaen, 40002, Thailand.

*Corresponding author: Thanunchanok.c@psu.ac.th

Introduction

Root-knot nematodes (RKN), *Meloidogyne graminicola* have been reported damaging various rice cultivars and caused yield losses up to 11-80% of rice plantation (Dutta et al., 2012). Planting rice resistance cultivar is one of the best methods to manage the nematode due to being a low cost and sustainable option for controlling nematodes in the long-term period (Boerma and Hussey, 1992; Pandey et al., 2016). Therefore, the objectives of this study were to evaluate the resistance levels of rice against *M. graminicola* infestation and to determine the up-regulation of defense-related enzymes including phenylalanine ammonia lyase (PAL), peroxidase (POD), and polyphenol oxidase (PPO) in rice infected by *M. graminicola*.

Methods

Six rice cultivars including Khao Dawk Mali 105 (KDML105), Pathum Thani 1 (PT1), San-Pah-Tawng 1 (SPT1), Rice Department No. 6 (RD6), Rice Department No. 43 (RD43), and Rice Department 57 No. (RD57) were evaluated for their resistance levels to RKN. Firstly, 10-day-old rice plants were inoculated by 100 second-stage juveniles (J2s) of RKN (five replicates/cultivar) and then nematode gall numbers, gall index and reproduction factor were measured at 15th day post inoculation (DPI). At the same time, the number of nematodes successfully infecting into roots of each cultivar was counted at 2 DPI and 14 DPI by staining rice roots with acid fuchsin dye. Finally, rice cultivars with greatest and lowest levels of resistance were chosen to determine defense-related enzyme activities including PAL, PPO and POD at 1, 2, 3, 4 and 7 DPI.

Results

RD6 proved to be the most resistant among six rice cultivars, with significantly lowest number of galls, gall index and reproduction factor ($p \leq 0.05$). Moreover, the number of nematodes inside roots was less encountered than other cultivars. On the contrary, KDML105 was considered as the most susceptible cultivar, which showed the greatest number of galls and percentage of females inside rice roots. Regarding defense-related enzymes, PAL, PPO and POD activities in RD6 cultivar (with 100 J2s RKN inoculation) significantly increased in first stage, especially at 2, 3 and 4 DPI and then decreased in later stages, as compared with control (un-inoculation). On the other hand, the enzyme activities in KDML105 (susceptible cultivar) were not significantly different between RKN inoculation and un-inoculation. This result illustrated that nematode resistance shown in RD6 cultivar was correlated with increasing activities of PAL, PPO and POD, and these enzymes may play an important role in the mechanisms of plant resistance against RKN.

Conclusion

This study revealed that RD6 cultivar was the most resistant among evaluated six rice cultivars, with lowest gall numbers, gall index and reproduction factor. Moreover, RD6 induced plant defense-related enzymes including PAL, PPO and POD which may interrupt RKN infection and development in rice roots. However, further studies are needed, especially in determining the expression of pathogenesis-related (PR) genes in RD6 cultivar.

Keywords: *Oryza sativa* L., plant defense-related enzymes, rice resistance, RD6, root-knot nematodes

Selected References:

1. Boerma, H.R.; Hussey, R.S. Breeding plants for resistance to nematodes. *J. Nematol.*, **1992**, *24*, 242-252.
2. Dutta, T.K.; Ganguly, A.K.; Gaur, H.S. Global status of rice root-knot nematode, *Meloidogyne graminicola*. *Afr. J. Microbiol. Res.*, **2012**, *6*, 6016-6021.
3. Pandey, R.K.; Nayak, D.K.; Kar, R.K. screening and evaluation rice varieties/lines for resistance against root-knot nematode, *Meloidogyne graminicola*. *Int. j. adv. res.*, **2016**, *4*, 381-386.

Screening of the Antagonistic *Bacillus* spp. Isolated from Banana Rhizosphere Soil for the Control of Banana Blood Disease

Akkachai Laopha^a, Aphidech Sangdee^b, Panchewan Ponpang-Nga^a, Ladawan Rattanapolsan^a and Praphat Kawicha^{a*}

^aPlant Pest and Biocontrol Research Unit, Department of Agriculture and Resources, Faculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Sakon Nakhon 47000, Thailand

^bMicrobiology and Applied Microbiology Research Unit, Faculty of Science, Mahasarakham University, Kantarawichai District, Maha Sarakham 44150, Thailand

*Corresponding author: csnppkc@ku.ac.th

Introduction

Banana blood disease (BBD) is caused by *Ralstonia syzygii* subsp. *celebesensis* (Safni et al., 2014). BBD was first reported from southern Sulawesi, Indonesia, in the early 1900s. This disease is currently spreading in Indonesia, Papua New Guinea, and Malaysia (Davis et al., 2011; Safni et al., 2014; Teng et al., 2016). The disease is commonly found in ABB genome bananas such as the Pisang Kepok cultivar (Saba) and causes typical symptoms including leaf yellowing and wilting, vascular bundles, and fruit pulp exhibiting a reddish-brown discoloration (Eden-Green, 1994). In Thailand, the BBD was first occurred in Betong district, Yala province, in 2015; and causes losses in “Kluai Hin” banana plantation all over the province (National News Bureau of Thailand, 2019). In this report, we aimed to screen and use antagonistic *Bacillus* spp. to control the causal agent of BBD.

Methods

Bacillus-like colonies were isolated from banana rhizosphere soil in eight banana plantations in Yala province. All isolated bacteria were primarily screened for their antagonistic ability against blood disease bacterium (BDB) isolate TT4F01 by simple streak plate technique. Then, the isolates exhibiting antagonistic activity were confirmed their antagonistic efficiency against BDB isolates TT4F01, MY1F01 and BT1F01 by agar well diffusion method. Then, The potential isolates were identified using morphological characterization, biochemical tests, and 16S rDNA sequence analysis. The *Bacillus* isolates recognized as safe were further investigated their ability to control BBD in “Kluai Hin” seedlings, which were propagated by tissue culture technique, in a pot experiment.

Results

Eight of 355 *Bacillus*-like isolates, including isolate JK62, JK106, KB1-2B4, JK127, JK74, YH3-2B5, YH3-2B2 and YH3-2B4, showed significant inhibitory activity against the causal agent of BBD. All of the potential isolates were classified in the genus *Bacillus*. Based on 16S rDNA sequence analysis, the *Bacillus* isolates were closely related to the species *B. amyloliquefaciens*, *B. siamensis*, *B. velezensis*, *B. subtilis*, and *B. methylophilus*. Then, the identified *Bacillus* isolates were applied to control the BDB in Kluai Hin seedlings. The results showed that *Bacillus* sp. isolate JK106, JK74, and YH3-2B2 provided the highest disease control percentage, ranged from 70-78%, followed by isolate JK127 with 58% disease control value.

Conclusion

The antagonistic *Bacillus* isolates were isolated from banana rhizosphere soil and had significant ability to inhibit *R. syzygii* subsp. *celebesensis* and control BBD in greenhouse condition. *Bacillus* sp. isolate JK106, JK74, and YH3-2B2 could be a considerable BBD biocontrol agent, however, the experiments involved in-field application and *Bacillus* based bioproduct development need to be examined in order to provide the effective biocontrol to farmers.

Keywords: *Bacillus*, Banana, Banana Blood Disease, Biocontrol, Kluai Hin

Selected References:

1. Davis, R.I.; Moore, N.Y.; Fegan, M. *ACIAR Proceedings of the papua New Guinea*, **2011**, 816-821.
2. Eden-Green, S.J. *INIBAP Musa Disease Fact Sheet No.3*. **1994**.
3. National News Bureau of Thailand. (2019, April 23), Retrieved from http://thainews.prd.go.th/th/news/print_news/TCATG190423170312891
4. Safni, I.; Cleenwerck, I.; Vos, P.;...; Kappler, U. *Int. J. Syst Evol Microbiol*, **2014**, *64*, 3087-3103.
5. Teng, S.K.; Aziz, N.A.A.; Mustafa, M.; Laboh, R.;...; Devi, S. *Int. J. agri. Biol.*, **2016**, *18*, 92-97.

Laboratory Rearing of *Musca domestica* L. (Diptera: Muscidae) from Fishery Waste (*Lates calcarifer*) for Alternative Protein Source in Aquatic Feeds

Warin Klakankhai¹, Anirut Noochan¹, Nutt Nuntapong², and Krajana Tainchum^{1*}

¹*Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90110, Thailand*

²*Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90110, Thailand*

* Corresponding authors: roun gson09@hotmail.com

Introduction

Larval stage or maggot of the house fly, *Musca domestica* L.(Diptera: Muscidae) is a natural decomposer for organic matters and with potential for use in aquaculture waste treatment and feeds. This research objective was to examine the *M. domestica* maggot weight rate and analyze the maggot nutritionally component from two different types of maggot food under laboratory conditions.

Methods

The experimental design was a completely randomized design (CRD) comparing two different types of maggot food composed of milk powder standard media as positive control and fishery waste media (head bone of sea bass fish, *Lates calcarifer*) as a treatment. Approximately 200 eggs of *M. domestica* were transferred to each test maggot food tray. The 3- 4 days old flesh maggot was sampling from each maggot food tray for weight measurement. A paired sample t-test ($P<0.05$) was computed to compare the mean number of weight rate of maggot between two different types of maggot food. Nutritional analysis was done by sampling a hundred dried maggot from each maggot food tray.

Results

The result showed that the maggot from fishery waste media gave the mean number of weight per maggot 0.472 g/maggot. The percent of crude protein, crude fat, moisture content, and ash is 39.60 %, 23.50 % 28.84%, and 1.36 %, respectively. Even the maggot from fishery waste media presented a significantly lower value than milk powder standard media in all parameters with $P<0.05$.

Conclusion

Unsurprisingly, the results from this research could be explained by the different protein of media main component in which the standard media was milk powder, whereas fishery waste media was fish head bone. However, the results from this research confirm that fishery waste media maggot can be used for mass rearing of the house fly and house fly can compose the fishery waste. Besides, this finding is the basic information of future experimental design in house fly mass-rearing using fishery waste or other organic matters.

Keywords: House fly, *Musca domestica*, maggot, nutritional analysis, fish feed

Selected References:

1. Cickova, H.; Newton, G. L., R.; Lacy. C.; Kozanek, M. The use of fly larvae for organic waste treatment. *Waste Manage*, 2015, 35: 68-80.
2. Hussein, M.; Pillai V.V.; Goddard J.M.; Park H.G.; Kothapalli K.S.; Ross D.A., et al. Sustainable production of housefly (*Musca domestica*) larvae as a protein-rich feed ingredient by utilizing cattle manure. *PLoS ONE*, 2017, 12: e0171708.

Race Identification and Aggressiveness of *Fusarium oxysporum* f.sp. *cubense* Isolates in Northeast Thailand

Wanarat Natino^a, Thanwanit Thanyasiriwat^{a,b,c}, Aphidech Sangdee^d, Ratri Boonruangrod^e and Praphat Kawicha^{a,b,c*}

^aPlant Pest and Biocontrol Research Unit, Department of Agriculture and Resources, Faculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Sakon Nakhon 47000, Thailand

^bCenter for Agricultural Biotechnology, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

^cCenter of Excellence on Agricultural Biotechnology: (AG-BIO/PERDO-CHE), Bangkok 10900, Thailand

^dMicrobiology and Applied Microbiology Research Unit, Faculty of Science, Mahasarakham University, Kantarawichai District, Maha Sarakham 44150, Thailand

^eDepartment of Horticulture, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

*Corresponding author: csnpk@ku.ac.th

Introduction

Fusarium wilt of banana or Panama disease caused by *Fusarium oxysporum* f.sp. *cubense* (*Foc*) is one of the major diseases in Banana production worldwide. *Foc* strains are classified in races based on the pathogenicity in each set of cultivars and its genetic information. In Thailand, *Foc* race 1 was reported in 1985 (Pitakpaivan, 1985). *Foc* Tropical race 4 (TR4) was initially detected in confined cavendish banana farms in Chiang Rai province in 2019 (DOA, Thailand, 2019). Therefore, *Foc* TR4 survey and eradication is an emergency action plan in the country. In this report, we aimed to survey and collect *Foc* isolates in Northeast Thailand, then identify their race and aggressiveness.

Methods

Panama disease survey and *Foc* isolation were performed in banana plantations in Northeast Thailand from 2018 to 2019. *Foc* isolates were isolated from infected pseudostem of banana by tissue transplanting technique and identified based on colony morphology, micro- and macro-conidia production, and pathogenicity and disease severity test in micropropagated 'Namwa Pak Chong 50' banana seedlings. All *Foc* isolates were identified their race by PCR assay using the specific primers for *Foc* race 1 and race 4 (Li et al., 2012; Lin et al., 2009)

Results

Panama disease was surveyed, and 49 putative isolates of *Foc* were isolated from 21 banana plantations located in 6 provinces including Nong Khai, Nakhon Phanom, Nakhon Ratchasima, Sakon Nakhon, Surin, and Si Sa Ket. All isolates presented the typical *Fusarium* colony and conidia. All collected isolates showed a positive result for the PCR assay with the *Foc* race 1 primers but did not show the target band of the *Foc* race 4 primers. The aggressiveness of *Foc* isolates was determined from the value of the percent disease severity. The results founded that the aggressiveness of *Foc* isolates was varied from 4.8% to 100%. Sixty-five percent of the isolates were grouped in the most aggressive (disease severity >75%). The most aggressive isolates were isolated from most of the plantations except the fields in Nong Khai province.

Conclusion

Foc race 1 isolates were isolated and identified from infected bananas cultivated in northeast Thailand. Most of the *Foc* isolates were the most aggressive. This study provides information on the status of Panama disease. Besides, *Foc* survey throughout the country, race 4 or TR4 detection, biology, and genetic information need to be achieved for the significant disease control.

Keywords: Banana, Fusarium wilt, Panama disease

Selected References:

1. DOA (Department of Agriculture), Thailand. IPPC, 2019, Retrieved from <https://www.ippc.int/en/countries/thailand/pestreports/2019/11/detection-of-fusarium-oxysporum-f-sp-cubense-tropical-race-4-in-thailand/>
2. Pitakpaivan, P. *Rev. Trop. Pl. Path.*, **1985**, 2, 175-196.
3. Li, M. H.; Yu, X. T.; Wang, H. F.; Zhou, J. N.; Xi, P. G.; Jiang, Z. D. *Scientia Agricultura Sinica*, **2012**, 45, 3971–3979.
4. Lin, Y. H.; Chang, J. Y.; Liu, E. T.; Chao, C. P.; Huang, J. W.; Chang, P. F. L. *Eur. J. Plant Pathol*, **2009**, 123, 353–365.

Optimizing the Sex Ratio and Oviposition Material for Mass Production of Assassin Bug, *Sycanus collaris* (F.) (Hemiptera: Reduviidae)

Tewee Maneerat^{a*} and Pornsawan Poopat^a

^aAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: tewee.m@psu.ac.th

Abstract

Biological control of insect pests by releasing natural enemies relies on stable mass production of natural enemies. In Thailand, *Sycanus collaris* (F.) (Hemiptera: Reduviidae) has been mass-multiplied and released to control leaf-eating caterpillars and small beetles in the forests and crops. To mass produce *S. collaris* for release, there were gaps in knowledge about the process. This study aimed to determine the most suitable sex ratio of *S. collaris* which produced the maximum number of offsprings using yellow mealworm, *Tenebrio molitor* (L.) (Coleoptera: Tenebrionidae) as diet and to test oviposition materials that simplify egg collection. Colonies with adult sex ratios of 1:1, 1:2, 1:3, 1:4, and 1:5 (male:female) were reared separately to compare egg quantity, quality, and adult lifespan. The results showed no significant differences in number of eggmass, number of eggs per eggmass, percentage hatchability, longevity of male and female, and oviposition period ($P > 0.05$). Sex ratio of 1:3 was chosen due to lower cost of production, enough males in the container, and consistency of eggs produced. To reduce the cost of rearing while considering egg production over time, *S. collaris* adults should be reared up to 54 days. Colony with sex ratio 1:3 was tested with oviposition materials (craft paper, black, green, and clear plastic) in rearing containers, and found that craft paper was the most preferred material ($P < 0.01$). Number of eggs per eggmass and percentage hatchability were not different among materials ($P > 0.05$).

Keywords: sex ratio, oviposition material, mass production, assassin bug, *Sycanus collaris*

Agriculture– Technology

Development of the Suitable Water and Nutrient Managements for Economic Trees in Northeast Thailand

Supat Isarangkool Na Ayutthaya^{a*}

^aDepartment of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

*Corresponding author: isupat@kku.ac.th

Abstract

The northeast region of Thailand is a producer for many economic trees such as tropical fruits and rubber tree. The premium grade production requires several aspects of sound agricultural management. The 2 main important agricultural practices, which controlled the product quality, are water and nutrient supplying at the optimum level.

Firstly, the optimum water management is a water supply in the amount of the water loss from the plantation. The possible way to know the volume of tree water requirement can estimate from the tree transpiration (tree water consumption) by sap flow measurement technique. This method established the optimum water amount for supply to several economic trees e.g. 40-45 L tree⁻¹ day⁻¹ for 12 years old rubber tree, 60-80 L tree⁻¹ day⁻¹ for five to six years old pummelo and 32 L tree⁻¹ day⁻¹ for eight years old mango tree.

Secondly in the nutrient management, the precise nutrient guideline researches are working under the 2 concepts; 1) the fertilizer supply according to the leaf nutrient standard and 2) fertilizer supply according to the nutrient removal by crop. Leaf nutrient standard concept, the farmers send the leaves sample from their field to the laboratory, and then the fertilizer recommendation is done by comparing between leaf nutrient content of the farmer's field with each specific crop leaf nutrient standard. The disadvantage of this method is a requirement of laboratory for the nutrient analysis. Alternatively, crop removal concept is a knowing on the nutrient content in fruits and plant parts that are removed from the field. For example, one kilogram of jujube fruit removes 1,691 mg N, 69.55 mg P, 1,774 mg K, 106.28 mg Ca and 1.74 mg B from soil. Then, the amount of fertilizer supply can calculate by the removal yield and nutrient content. This method is the compensation of nutrient loss from the field by crop.

Impact of Land Use Change from Forest to Rubber on Soil Phosphorus and Microbial Biomass Phosphorus in Tropical Sandy Soils

Apinya Saentho^a, Worachart Wisawapipat^b, Tanabhat-Sakorn Sukitprapanon^a, and Phrueksa Lawongsa^{a,*}

^a*Department of Soil Science and Environment, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.*

^b*Department of Soil Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.*

*Corresponding author: phrula@kku.ac.th

Abstract

Land use change in the tropical regions increased over the past decades. The rubber tree plantations have rapidly expanded faster than other tree-crop plantations in Southeast Asia. In Northeastern Thailand, rubber tree plantations are expanding into unsuitable areas where soil is high weathered, sandy and fertility is very low. In this area, phosphorus is one of the main limiting nutrients for agricultural productivity. The effect of land use change on phosphorus availability and microbial biomass phosphorus (MBP) remains unclear. Therefore, the objective of this study was to investigate the impact of land use change from forest to different ages of rubber tree including 1) 5 years rubber tree plantation (5Y), 2) 11 years rubber tree plantation (11Y), 3) 22 years rubber tree plantation (22Y) on soil phosphorus and microbial biomass phosphorus in tropical sandy soil. The data suggested that the different ages of rubber tree plantation have an effect on soil phosphorus and microbial biomass phosphorus. The soil total phosphorus and available phosphorus of young rubber tree plantation (5Y) decreased when compared to forest. However, the higher age of rubber tree plantation (11Y and 22Y) showed higher available phosphorus than that of forest related to the result of soil total phosphorus. Interestingly, the results of MBP also showed the same trend. The findings of this study will be beneficial to recognize the amount of phosphorus accumulation in soil in term of labile and non-labile phosphorus for the purpose of soil and environment conservation.

Keywords: Available phosphorus, highly weathered soils, Microbial biomass phosphorus

Reuse of Piggery Wastewater for Cultivation of *Azolla microphylla* for Sustainable Agriculture and Environment

Phearun Lay^a and Chuleemas Boonthai Iwai^{a, b, *}

^aDepartment of Soil Sciences and Environment, Faculty of Agriculture, Khon Kaen University, 40002, Thailand.

^bIntegrated Land and Water Resource Management Research and Development Center in Northeast Thailand, Khon Kaen University, Khon Kaen, 40002, Thailand.

*Corresponding author: chuleemas1@gmail.com

Introduction

Piggery farms are a major source of environmental impacts, causing a lot of pollution, especially water pollution. Beyond freshwater has been being consumed approximately 15L/animal/day that enable to produce much wastewater, loading contaminants, such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphorous (P), nitrogen (N), copper (Cu) and zinc (Zn). Some of these, however, are nutrients (N, P, Cu and Zn) for plant or crop in case under limitation of reuse. *Azolla microphylla* (*A. microphylla*), an aquatic fern, not only could be used as phytoremediation for wastewater treatment, but also could be used as animal feeding and organic fertilizer. Therefore, this study aimed to identify efficiencies of *A. microphylla* in swine wastewater treatment, and the influence of surface area and time on biomass production and nutrient contents in the *A. microphylla* by using swine wastewater.

Methods

A completely randomized design (CRD) with three treatments and three replicates within 21 days was implemented in greenhouse condition at 30.5 ± 3 °C. The 9 plastic buckets with three various surface areas, including large, medium, and small with sizes 0.47 m², 0.22 m², and 0.16 m², respectively, were used. All treatments were inoculated 74 g of *A. microphylla* biomass, and swine wastewater at 5% with total amount volume of 60 liters, individually. Wastewater quality parameters, such as BOD, COD, NO₃⁻, PO₄³⁻, Cu, and Zn were monitored. Besides, biomass and nutrients of *A. microphylla* were investigated.

Results

The outcomes revealed that the *A. microphylla* was the most effective in reducing BOD and COD from (30 to 78%) and (75 to 76%), respectively in the medium and small size within 2 weeks. The nutrients, nitrate (NO₃⁻) and phosphate (PO₄³⁻) were removed 64% and 100% from swine wastewater in the medium and large, respectively within 3 weeks. Meanwhile, N, crude protein, and P were increased in biomass of *A. microphylla* from initial to final (1.65 to 2.41%), (10.3 to 15.04%) and (0.37 to 0.43%) in the medium and small, respectively. Furthermore, Cu and Zn were also up taken from swine wastewater 54% and 11%, respectively. Notably, Cu and Zn were increased in *A. microphylla* in respective around 22% (50 to 63 mg/kg), and 111% (112 to 249 mg/kg) in the large and small.

Conclusion

The *A. microphylla* was very effective to remove BOD, COD, NO₃⁻, PO₄³⁻, Cu, and Zn from swine wastewater 78%, 76%, 64%, 100%, 54%, and 11%, respectively, while N, crude protein, P, Cu, and Zn were attributed in the biomass of *A. microphylla* 2.41%, 15.04%, 0.43%, 22%, and 111%, separately. Hence, the *A. microphylla* not only reclaimed swine wastewater, but also produced biomass of itself in which a good source of nutrients, protein for feeding, fertilizer for sustainable agriculture.

Keywords: *Azolla*, reuse, swine wastewater management, biofertilizer

Selected References:

Amare, E., Kebede, F., & Mulat, W. (2018). Wastewater treatment by *Lemna minor* and *Azolla filiculoides* in tropical semi- arid regions of Ethiopia. *Ecological Engineering*, 120, 464–473.
<https://doi.org/10.1016/j.ecoleng.2018.07.005>

Agricultural System

Local Organic Foods and Consumer's Purchase Intention

Mei-Fang, Chen^{a,*}

^a*Department of Business Management, Tatung University, 40 Chung-Shan N. Rd., Sec. 3, Taipei 104, Taiwan..*

*Corresponding author: mfchen@ttu.edu.tw

Introduction

Production and consumption of locally available organic foods instead of following conventional agricultural practices will ensure more sustainable, more delicious, and healthier foods for local residences without sacrificing the economic benefits of local communities. Sustainable consumers concern themselves with not only price and nutrition issues but also the well-being of small farmers, the long-term viability of the local economy, and environmental protection and climate change mitigation. Based on the theory of planned behavior (TPB), this study measured consumers' attitudes toward local organic foods, toward consuming local organic foods, and toward supporting local farmers. Moreover, consumers must rely on their trust in the retailers and the local farmers to ensure that the foods are provided with good quality and the potential health risks coming from food consumption are minimized. This study incorporated consumers' trust in the retailers and the local farmers in the extend TPB model to have a better comprehension of consumer's purchase intention of local organic foods.

Methods

This study conducted a self-administered questionnaire online survey in Taiwan in 2020. A total of 354 valid surveys were collected for data analysis. Regression analysis was conducted after the reliability and validity of the measurement scales were confirmed by confirmatory factor analysis.

Results

Regression analysis results indicated that as expected consumers' attitudes (i.e., toward local organic foods and toward consuming local organic foods), subjective norms, and perceived behavior control were positively related to purchase intention of local organic foods. However, consumers' attitudes toward supporting local organic farmers were not statistically significant. In addition, consumers' trust in local farmers was also positively related to purchase intention of local organic foods.

Conclusion

Consumers' attitudes toward local organic foods and toward consuming local organic foods, subjective norms, and perceived behavior control were the determinants of purchase intention of local organic foods in this empirical study. After consumers' trust in retailers and local farmers were taken into account, consumers' attitudes toward local organic foods, subjective norms, and trust in local farmers were the determinant of purchase intention of local organic foods. Based on the research findings, some practical implications and suggestions are provided to promote the well-being of small farmers and the long-term viability of the local economy in the future. The sustainable goal of environmental protection and climate change mitigation can be achieved by purchasing more local organic foods.

Keywords: local organic foods, trust, theory of planned behavior

Selected References:

1. Chen, M.F. Consumer attitudes and purchase intentions in relation to organic foods in Taiwan: moderating effects of food-related personality traits. *FOOD QUAL PREFER*, **2007**, *18*, 1008-1021.
2. Hemmerling, S.; Hamm, U.; Spiller, A. Consumption behaviour regarding organic food from a marketing perspective—A literature review. *ORGANIC AGRICULTURE*, **2015**, *5*, 277-313.
3. Khare, A.; Pandey, S. Role of green self-identity and peer influence in fostering trust towards organic food retailers. *INT J RETAIL DISTRIB MANAG*, **2017**, *45*, 969-990.
4. Sage, C. The transition movement and food sovereignty: From local resilience to global engagement in food system transformation. *J CONSUM CULT*, **2014**, *14*, 254-275.

Beef Cattle Situation among Farmers in Rattaphum District Songkhla Province

**Seksan Duangsingtham^{a*}, Panuphan Prapatigul^a, Suraphol Sreshthaputra^a, Pornsiri Suebpongsung^b,
Apinya Ratanachai^c, Buncha Somboonsuke^c and Chaiyawan Wattanachant^d**

^a *Division of Agricultural Extension and Rural Development, Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.*

^b *Division of Agricultural Economics, Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.*

^c *Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

^d *Department of Animal Science, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: Seksanduangsingtham@gmail.com

Introduction

Beef Cattle raising was relevant to Thailand's farmers 792,148 households because that can be done with farming and making income for farmers. There are made economics 2.41 billion dollars. (Department of Livestock Development, 2018) In order that the Beef Cattle production in the country increased 7.15 percentages per year. In 2019, Beef Cattle production was 1.178 million cows, compared to 1.126 million cows in 2018, a 4.62 percentages increase because the Thai government extended livestock to be the leading career and done project to increase beef cattle dam and develop beef cattle pedigree to best and fast grown rate (Office of Agricultural Economics, 2019). The Department of Livestock Development in Rattaphum Distract has operated projects under government policy projects with developed beef cattle raising to increase the quantity and quality of beef cattle production and strengthen farmers, network farmers groups and beef cattle club. This research purpose to study beef cattle situation among farmers in Rattaphum District Songkhla Province.

Methods

This research was collected data between January and February 2020 from beef cattle farmers in Rattaphum District, set the quota sample size in 100 samples and used a simple random sampling method. There are used interview schedules for collected data of personal characteristics, socio-economic characteristics, characteristics of beef cattle, and used non-participant observation for observed beef cattle farm situation.

Results

The result found that the average age of beef cattle farmers is 50.97 years old. The standard of their education level was high school. The average years of their experience in raising beef cattle were 8.55 years. The purpose for beef cattle raising was for a part-time job. The number of farm labor was 1.87 people, who are household labor. In 2019, the farmers gained average income by beef cattle raising by 1,695.37 US dollars, with the average investment of 43.09 US dollars per cows. The beef cattle situation was used the free ranch system in the daytime and barriers system at nighttime. The aim of beef cattle was saving. Beef cattle production was consumption in the area. The cattle were typically Thai native. That was 10 – 11 cattle per farm. Who had grew Napier grass and Whip grass used agricultural by-products, such as rice straw, sweet corn trunk, and cassava pulp as livestock feed. In addition, 58.00 percent of farmers have planned cattle herd by lead breeding methods and Artificial insemination. Who had sold for a middleman that used the eyes and satisfaction to make the price of beef cattle. The main problem was foot and mouth disease that was happened every year.

Conclusion

Nowadays, beef cattle raising was a part-time jobs living savings focused on local production for local consumption. It gave importance to making and reserve rough food by using agricultural by-products to feed, which had effected to low cost for beef cattle raising. However, people who had no national standard for beef selling will get a lower income and total products than another raising system. Moreover, the farmer's main problem in beef cattle raising was foot and mouth disease which happened every year because they did not recognize disease and disease prevention. Thus, improving beef cattle raising among farmers will extend knowledge about disease prevention and market expansion, both domestically and abroad.

Keywords: beef cattle raising, Rattaphum District, Songkhla Province

Selected References:

1. Office of Agricultural Economics. Agricultural Statistics of Thailand. 2019. 177 – 185.
2. Department of Livestock Development. Strategic of Livestock Development 2018 – 2022. 2018. 32 – 35.

Alternative Farming on the Highland and Livelihood Assets of Small Scale Farmer in Na Noi District, Nan Province

Privanud Chuensin^{a,*}, Budsara Limmirankul^b, Prathantip Kramol^b

^a*Agricultural System Management Division, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.*

^b*Department of Agricultural Economy and Development, Chiang Mai University, Chiang Mai 50200, Thailand.*

*Corresponding author: gfpriyanud@gmail.com

Abstract

Farmers have relied on subsistence agriculture before changing to commercial agriculture. Maize was the important crop, which provided income higher than other crops. They have expanded maize planted area on the highland of Na Noi district, Nan province. Then, farmers have been facing soil erosion, flood, and drought from deforestation. While, they attempt to adopt alternative farm system to reduce those risks, but they are small-scale farmers who have different livelihood assets. Thus, some farmers cannot success on their alternative farm system. These situations lead to finding the alternative farming system on the highland. Therefore, to study the farm types on the highland and livelihood assets contribution of Na Noi district, Nan province. The objectives are 1) To study farm type on the highland and 2) To analyze the livelihood assets. The research methods are three data collections. First, the key informant's interview to understand society, economy, and natural resources. Second, a focus group discussion with representative farmers to describe a rich picture of farming systems. The purposive sampling collected the household data from 222 households. The sample is the farmers who do alternative farming on the highland of Na Noi district, Nan province. Then, those sets of data are analyzed by qualitative data and quantitative data.

The study found that farmers changed to three alternative farming systems as following, 1) 56 households based on only maize and rubber tree, 2) 153 households based on maize, rubber tree, and integrated farming, and 3) 13 households based on integrated vegetable and livestock. Comparing the livelihood assets found that the farmer of the three groups has a different livelihood asset level. They have well accessibility of natural assets. Both T2 and T3 have better human assets than T1. But, they have poor accessibility of physical assets such as transportation and internet access. Moreover, the financial assets should be the most provides to them such as revolving funds and agricultural input substitutions. While, they also have low accessibility of social assets, especially farmer associations. The different farm types on the highland of Na Noi district, Nan province are contributed by natural assets, human assets, social assets, financial assets, and physical assets.

Keywords: Alternative farming, Livelihood assets, Integrated farming

Selected References:

1. Allison, E.H.; Ellis, F. "The livelihoods approach and management of small-scale fisheries." *Marine Policy*, 2017, 25, 377–388.
2. DFID. *Sustainable livelihoods guidance sheet*, 1999
3. Dillon, L. J.; McConnell, J. D.. *Farm management for Asia: a system approach*, 1997, 111-135.
4. Ekasingh, B.; Gypmantasiri, P.; Thong-Ngam, K.; Grudloyma, P. *Maize in Thailand: Production Systems, Constraints, and Research Priorities*, 2004, 1-23
5. Janthasuwana, A.; Limmirankul, B.; Sirisunyaluck, R.; Kramol, P. *Assets Change Cropping in Nanoi district, Nan Province*, 2019, 47, 233-240.
6. Likert, R. *New Patterns of Management*, 1961
7. Office of Agricultural Economics. *Percentage and amount of maize yield in province*, 2018
8. Wuttisawat P. *Agricultural Extension and Development association: Project Result of Agricultural Extension Network of Nan Province*, 2011, 1-9

Assessing the Livelihood Strategies on the Sustainability of the Natural Resource Utilizations in Peat Swamp Ecosystems.

Lessons Learned from the Khreng Peat Swamp Ecosystem, South Thailand.

Rosawadee SUKKUM^{a,b,*}, Didier PILLOT^b, Penporn JANEKARNKIJ^a

^a *Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Bangkok 10900, Thailand.*

^b *Institut des regions chaudes, Montpellier SupAgro, Montpellier, France*

*Corresponding author: Rosawadee.s@ku.th

Abstract

Peat swamps are one of the most critical wetland ecosystems in Thailand, which contribute to a wide range of ecosystem services. The first of these is certainly the sequestration of carbon in the waterlogged soils and biomass, while, in the meantime, they also contribute to human well-being and diversified sources of income for the populations by the exploitation of the local natural resources. This, in turn, may reduce the vulnerability and increase the resilience of the local people in front of natural hazards (forest fires in periods of drought, or floods in the rainy season). However, in South East Asia, peat swamps are generally threatened by the extension of drainage and increment of plantations, as the results of several drivers of change which can be both environmental (climate change, droughts, fires, natural drainage) and institutional (market incentives, land access rights, and land-use policies, labor costs, and more recently COVID-19 impacted labor access facilities). Hence, the question is raised about the balance of the costs and advantages of various options of natural resource uses, for the whole society, from a triple perspective: environmental, social, and economic.

This study intends to contribute the policy discussion on the sustainable development challenges of natural resource degradation and poverty alleviation in rural areas. Using the livelihood approach, assess the livelihood strategies as a tool to minimize these challenges. Examine the outcomes of each livelihood strategies, and their economic and social impact, in the Khreng Peat Swamp Ecosystem. As for the Khreng peat swamp ecosystem, it is part of Kuan Kreng Landscape, where Thailand's second-largest peat swamp forest area, covering 74,000 ha, under three different provinces, namely Nakhon Si Thammarat, Phatthalung, and Songkhla provinces in the South of the Kingdom.

In Khreng representing the heart of the peat swamp ecosystem, a combination of observations and measurements have allowed distinguishing several landscape units, each of them being characterized by different dominant natural resources: a collection of natural products in the swamps, fishing, cropping systems including plantations of oil palm, rubber, paddy field. The economic outputs from these various strategies in various conditions of the peat swamp ecosystem are compared. If the agriculture clearly maximizes the income for local households, the direct and derived exploitation of the peat swamp ecosystem offers several other advantages, especially for the poor households to reach their subsistence needs in purpose to break out of the rural poverty. Managed they have access to enough surface of land in the swamp, which therefore becomes a crucial issue for the stage of natural resource degradation in these ecosystems.

A survey among 120 households using these different categories of natural resources has confirmed the importance of the traditional land access on the outcomes of their production system, especially in the heart of the swamp area. Cluster analysis was employed to classify households into different groups, based on their natural resource uses patterns. These demonstrate again that the households' assets and access rights, environmental state, and infrastructure accessibility are the key factors that explain the economic outputs in terms of added value produced and the outcomes in terms of poverty reduction and resilience of the livelihoods.

The conclusions of this research contribute to livelihood enhancement by the development of sustainable management of the Kuan Kreng Landscape, under certain conditions that are enlightened. Guiding the policy-making process generates additional economic incentives for communities and countries to be engaged in sustainable management and use of the peat swamp ecosystem. Different policies by the State or Provincial institutions are impacting the mechanisms mentioned above. By using the results presented here, they can be assessed not only with regard to their direct production benefits (which is normally done), but also with regard to their overall impact on sustainability from the overall economic, social, and environmental perspectives for the whole society.

Keywords: Livelihood, Peat swamp ecosystem, Poverty, Resilience, Environmental income.

Selected References:

Family Name, I.; Family Name, I.; Family Name, I. *ISI Abbreviated Journal Title*, **2000**, *53*, 1079-1082.

Development of Chinese Cabbage Production Processes for Distribution in “The Green Market” of Songkhla Province: The Agri-Market, Faculty of Natural Resources, Prince of Songkla University, Thailand

Keminee Tongma^{a,b}, Buncha Somboonsuke^{a,*} and Panuphan Prapatigul

^a *Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Thailand.*

^b *Department of Agricultural Extension and Rural Development, Faculty of Agriculture, Chiang Mai University, Thailand.*

*Corresponding author: buncha.s@psu.ac.th

Introduction

Chinese cabbage is an economically important vegetable in the country and can be grown in any region all year round (Department of Agricultural Extension, 2019). However, its quality is different depending on several factors. In different regions, the production may be unequal depending on environmental conditions and their pests that influence growth (Sirima, 1991). Another concerning-issue is the detected chemical residues in vegetables (Pesticide Alarm Network, 2019). This study aims to explore the production processes, problems or obstacles in Chinese cabbage farming system and factors affecting consumer demand for this vegetable leading to a development of high quality production processes for distribution in the Agri-Market.

Methods

The quantitative and qualitative studies were conducted at the Agri-Market, Faculty of Natural Resources, PSU. The quantitative data were collected from 138 Chinese cabbage consumers with a structured interview. The qualitative data were collected from 10 producers and distributors of this vegetable using a semi-structured interview. The quantitative data were analyzed using descriptive statistics (%), frequency distribution (Mean), and standard deviation (S.D.). Inferential statistics was used to analyze the relationship between independent and dependent variables including stepwise multiple regression analysis while the qualitative data were used in content analysis.

Results

Most Chinese cabbage consumers showed the demand for product of good quality, good price, trusted market, and promotional strategy. The average mean is 4.05, especially for distribution locations ($\bar{x} = 4.32$) followed by products ($\bar{x} = 4.03$). The motivation factors driving the purchase influenced the demand for the cabbage. Most producers organically grow the cabbage and 62.50% of them are organic standard certified. It was found that the main problem affecting production was disease and pests (25.00%) followed by production management problems (17.19%) which affect the production of quality vegetables.

Conclusion

This study revealed that consumer demand for Chinese cabbage is mainly on the confidence of the market distributing the products and quality vegetables. The results are useful in development of the Chinese cabbage production system in response to consumer needs for freshness, cleanliness, flavor, package size, safe vegetable production, and regular pesticide monitoring practices.

Keywords: Chinese cabbage, Pesticide residue- free vegetable, Consumer behavior, Marketing Mix

Selected References:

1. Sirima Thetprateep. 1991. Study on some species characteristics and growth of 3 varieties of Cantonese cabbage. Special Problems. Bachelor of Science. Department of Horticulture Kasetsart University. Bangkok.
2. Pesticide Alarm Network. 2019. Random results of pesticide residue testing in fruits and vegetables, https://www.thaipan.org/wpcontent/uploads/2019/pesticide_doc58.pdf. (Accessed on February 11, 2020).

Sustainability is Dynamic: Assessing Processes of Change and Innovation in Smallholders Agriculture Around Tonle Sap Lake, Cambodia

Donira KHAN^{a, b*}, Didier Pillot^a, Prapinwadee Sirisupluxana^b

^a *Institut des Régions Chaudes, Montpellier SupAgro, Montpellier, 34060, France*

^b *Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Bangkok, 10900, Thailand*

* Corresponding author; e-mail address: khandonira@gmail.com, donira.k@ku.th

Abstract

Sustainability of agricultural systems is often presented in the literature as the capacity of these systems to be maintained over time, even though the circumstances in their environment may be changing when resources available get rare, or when markets and value chains can be transformed. Such a vision tends to limit sustainability as a static concept, where the systems involved are presented as strong enough to face changes in their environment without changing by themselves. This paper challenges such a static conceptual framework to propose an opposed one, where sustainability is ensured when the systems are able to change and innovate to adapt to their environment, and achieve even better efficiency of the use of their resources (compared to before the modification in the environment).

For illustrating this point of view, we assess the dynamics of farming systems around Tonle Sap Lake, Cambodia. This rural province is facing a number of changes in its environment, which may be agroecological, as the regime of floods from the Tonle Sap every one year, or economical as the opportunity costs of the labor that are pulled up by the rapid growth of the neighboring city of Siem Reap. We examine the interaction between resource endowment, production orientation, household activities, and economic and social strategies of the major stakeholders, capture the agricultural transformation in the study area. This paper borrows agrarian system diagnosis framework to identify the changes in the strategies of the stakeholders, considering the diversity of these. The results reveal that five major distinctive farm types based on data from 50 farm households, which develop various innovative strategies in response to the modification of the environment to ensure their sustainability. However, there may also be some major innovations, like the extension of the broadcasting of the paddy extending in all systems at the same time to replace the transplantation. The conditions for such a “bulk innovation”, in response to sustainability needs, are discussed.

The conclusion of this research confirms that sustainability should be held as a dynamic concept, adapted to societies in movement, rather than a resistance concept, marked by the maintenance of previous systems in changing environment.

Keywords: sustainability of agricultural systems, innovation in agriculture, farming systems, Cambodia

Understanding Decision Drivers that Threaten Conservation Efforts amongst Hmong Communities Adjoining a National Park in Lao PDR

Maiyer Xiong^{1*}

Postal Address: Faculty of Agriculture, National University of Laos, Lao PDR

Corresponding author: xmaiyer@yahoo.com

Abstract

The Nam-Et Phou Louey National Park (NEPL), covering 4,000 square km within the three provinces of Houaphan, Luang Prabang and Xieng Khouang, is one of the most important biodiversity sites in Lao PDR. However, its biodiversity is threatened by the hunting and cattle raising activities of local communities that surround it.

This study, undertaken in September 2020, seeks to understand the decision drivers that lead to livelihood choices damaging to conservation in three Hmong communities living adjacent to a critical biodiversity corridor of NEPL in Xone District, Houaphan province, and how these might be ameliorated. It used qualitative methodologies, such as focus groups, key informant interviews and transect walks, to profile those engaged in damaging activities, their motivations for doing so, and how their decisions are influenced by others.

The results show that hunting is widespread amongst all sections of the community, and is encouraged by a cultural affinity to consuming wild meat, an unwillingness on the part of local community and clan leaders to sanction offenders and a low conviction rate for those who are caught by the authorities. The large numbers of cattle in NEPL reflect an increased social status amongst the better off section of the community which they are unwilling to relinquish, along with a reluctance to invest in forages and fencing in designated cattle raising zones on communal land. Poorer households are being marginalized as wealthy cattle owners are appropriating community land, and the habitat for vital non timber forest products, such as red mushrooms, is being degraded by frequent fire to promote natural grasses for cattle.

The paper makes suggestions to on which groups within the local Hmong community should be targeted for incentives to adopt behaviour changes in a culturally appropriate manner. It assesses the readiness of the community to adopt compliance linked conservation enterprises, which would provide favourable arrangements (such as higher prices for coffee, reduced interest rates for loans) for those willing to renounce livelihood activities that put NEPL's biodiversity at risk.

Keywords: Lao PDR, Nam-Et Phou Louey National Park, Hmong culture, wildlife conservation, conservation enterprises, biodiversity management.

Individual Social and Economic Position Versus the Impact of Collective Services: The Contribution to Small-Scale Farmers' Adoption on Single Origin (SO) Coffee Processing Scheme

Bayu Rizky Pratama^{a*}, Stephane Fournier^b, Kanchana Sripuetkiat^c, Suci Nur Utami^d, Wadli^e

^{a1} MOQUAS, *Institute des Regions Chaudes (IRC), SupAgro Montpellier, Montpellier 1101, France.*

^{a2} Agribusiness, *Dept. Agribusiness, Muhadi Setiabudi University, Brebes, Indonesia.*

^b MOQUAS, *Institute des Regions Chaudes (IRC), SupAgro Montpellier, Montpellier 1101, France.*

^c Agri-Res Economics, *Dept. Agri-Res Economics, Kasetsart University, Bangkok, Thailand.*

^d Agribusiness, *Dept. Agribusiness, Muhadi Setiabudi University, Brebes, Indonesia.*

^e Food Science, *Dept. Food Science and Technology, Muhadi Setiabudi University, Brebes, Indonesia.*

Corresponding author: bayu_rizkypratama@yahoo.com

Abstract

The protection of local food products in coffee industry by labels and quality or geographic indications is often presented as one option to protect the markets open to small scale farmers, encourage their investments, and finally, sustain their production. However, farmers basically only enjoy a limited direct benefit from this GI certification, and that the coffee's economic rent is still captured largely by the exporters. The research on which the proposed paper reports on attempted to overcome these limitations by creating more focused labels of single origin (SO) specialty coffee label to protect distinctive niche markets from other coffee producers within the whole GI area. Methods performed included in-depth interviews with coffee professionals (roasters, coffee shops, retailers), government, GI actors, coffee buyers, and exporters aimed to improve coffee farmers' adoption on SO coffee scheme and questionnaire given to 134 local coffee farmers located in Bandung (Indonesia), aimed to find the factors contributing to farmers adoption in SO specialty coffee. Finally, by using Analysis Hierarchy Process (AHP), the research assessed different public policies to support the efficiency of SO on the farms' economies to classify them from the very important to least important. Thanks to collective action through farmers groups, farmers are allowed to set up the attributes of coffee production, including some regulations and sanctions in the purpose of maintaining the coffee quality. On the adoption process, farmer groups could set up (1) Farmer support systems offering different services, such as (a) seed and fertilizer supply, (b) pest control system, (c) post-harvest control, (d) quality assurance control, and (e) branding and marketing system, and (2) Sanction system to control the farmer members' non-compliance with the groups' norms. Eventually, innovative accesses to these services go far beyond the individual position of each household to explain the final result in terms of adoption (full or partial) of the SO specifications and the final efficiency of the public efforts in this regard. Public policies therefore can find there leverages to play an efficient role in the promotion of small-scale farming and family-based production.

Keywords: geographical indication, coffee, innovation in agriculture, collective action, farmers' adoption, single origin.

Selected References:

1. Altalb, A., *et al. The Role of Agricultural Extension in The Transfer and Adoption of Agricultural Technologies.* Asian Journal of Agriculture and Food Sciences, **2015**, 3 (5), 2-9.
2. Chabrol, D., *et al. Establishing Geographical Indications Without State Involvement? Learning from Case Studies in Central and West Africa.* World Development Journal, **2017**, 98, 68–81.
3. Durand and Stephane. *Can Geographical Indications Modernize Indonesian and Vietnamese Agriculture? Analyzing the Role of National and Local Governments and Producers' Strategies.* World Development Journal, **2017**, 98, 93-104.
4. FAO and Siner-Gi. *Linking People, Place, and Products: A Guide for Promoting Quality Linked to Geographical Origin and Sustainable Geographical Indications*, **2010**, FAO Press Release. Italy.
5. Ostrom, E. *Beyond Markets and States: Polycentric Governance of Complex Economicsystems.* American Economic Review, **2010**, 100 (3), 641–672.
6. Putra and Yulius. *Performance of Java Preanger Arabica Coffee in West Java.* Sirinov Journal, **2015**, 3, 113-126.
7. Rangnekar, D. *The Socio-Economics of Geographical Indications*, **2004**, International Centre of Trade and Sustainable Development. Geneva.
8. Sri, *et al. The Impact of Coffee Certification on The Economic Performance of Indonesian Actors.* Asian Journal of Agriculture and Development, **2015**, 12 (2).

Impact of Climate Change on Farmer Adaption and Tobacco Productivity in Temanggung Regency

Bayu Rizky Pratama^{a*}, Nisa Sabtiningtias^b, Avi Budi Setiawan^c

^{a1} MOQUAS, *Institute des Regions Chaudes (IRC), SupAgro Montpellier, Montpellier 1101, France.*

^{a2} Agribusiness, *Dept. Agribusiness, Muhadi Setiabudi University, Brebes, Indonesia.*

^b Economics Development, *Dept. Economics Development, Semarang State University (Unnes), Semarang, Indonesia.*

^c Economics Development, *Dept. Economics Development, Semarang State University (Unnes), Semarang, Indonesia*

Corresponding author: bayurp@umus.ac.id

Abstract

Temanggung Regency is one of the largest tobacco producing areas in Central Java Province. To support the production, tobacco farmers learned how to set proper conditions from the beginning of cultivation, such as soil and water management, including seed maturity. However, there were external factors which made the tobacco production become fluctuations, such as pest, fungi, and especially climate change. In several years, tobacco farmers have struggled with the climate change conditions where they have to adapt rapidly due to the change in rainfall. The increase in rainfall was a problem for the sustainability of tobacco cultivation in the Temanggung Regency because it impacted the pollination process massively. In regards to these problems, farmers have to conduct some adaptation to sustain their tobacco production. This research aimed to evaluate how climate change impacted tobacco productivity and farmers' responses in addressing climate change. Data was conducted using in-depth interviews and questionnaires to tobacco farmers. The data analysis used a qualitative approach to observe some differences in tobacco farmers' productivity, by evaluating the factors that affect farmers' adaptation to climate change using logistical regression. The increase of rainfall, during the tobacco season, has impacted the decrease in tobacco productivity. However, it was found that farmers mostly reacted by conducting some adaptations to minimize crop failure risk. The use of *Pranata Mangsa* in tobacco cultivation needs to be combined with meteorology and climatology. Also, there were needs to establish a dissemination information center on climate change, both bottom-up and top-down, to minimize climate change risks.

Keywords: Tobacco, Climate Change, Adaptation Strategies

Multidimensional Database for Assessment of Novel Foods in Future Diets to Improve the Sustainability of Food Systems

Rachel Mazac^{ab*} and Hanna Tuomisto^{ab}

^a*Faculty of Agriculture and Forestry, Department of Agricultural Sciences, P.O. Box 27, Latokartanonkaari 5, 00014, University of Helsinki, Helsinki, Finland*

^b*Helsinki Institute for Sustainability Sciences (HELSUS), P.O. Box 4, Yliopistonkatu 3, 00014, University of Helsinki*

*Corresponding author: rachel.mazac@helsinki.fi

Introduction

Climate change and unsustainable agricultural practices are reciprocally affecting food production, nutrition outcomes, environmental wellbeing, and socio-economic and societal equity. Complex networks of interaction among the various components in food systems impact desired sustainability outcomes. Novel foods and future food production technologies (e.g. cultured meat, microbial proteins, cultured plant cells) may provide for future diets while meeting multiple sustainability goals of lower environmental impacts, meeting essential nutritional needs for more populations, and providing viable alternatives to current, unsustainable animal-based foods¹. Systemic consideration of dietary change with novel/future foods from technological innovations as widely-proposed interventions is lacking².

Methods

Following the data collection methods of ‘SusTable Database’ compiled by Gazan et al. (2018) for the French case, we focus on the integration of consumption, nutrition, cost, and environmental impact of foods in the Finnish diet³. The collection of the nutritional, consumption, and cost data for each food item was driven by the environmental data available since the future objectives of this study are to minimize environmental impact based on multiple impact categories.

The environmental impact data for our food nutrient and environmental database was sourced from Poore and Nemecek (2018). They created a multi-indicator global database covering five environmental indicators which collected Life Cycle Analysis (LCA) data and estimated European average GHG emissions (kg CO₂eq), land use (m²), terrestrial acidification (g SO₂eq), eutrophication (g PO₄-eq), and freshwater use (L) for 40 products⁴. To this, we added food products from the Agribalyse 3.0 Database⁵ to expand the food products in our database.

We obtained food consumption data on the national food item intake (g/capita/day) of food items for all subjects ($n=1,295$) in the 2012 FINDIET survey from the European Food Safety Authority (EFSA) Comprehensive European Food Consumption Database⁶ compiled from the National FINDIET 2012 Survey⁷.

We used the individual food items to create a nutritional database linked to the nutrient composition of each food item in Fineli⁸. Fineli is the National Food Composition Database in Finland maintained by the National Institute for Health and Welfare. We obtained food product amino acid data from the UN FAO Amino-acid content of foods and biological data on proteins⁹.

Environmental impact data for the novel/future foods will be obtained from LCA researchers matching the methods of Poore and Nemecek (2018) for all five of the impact categories. Each item's respective nutrition information and cost comes from analyses run by the producers.

Results

Outcomes will include a discussion of producing and including the various above databases in creating the Sust-Food Database for Finnish which includes novel/future foods. The resulting database will have around 250 food items and corresponding data to ask questions about optimization of diets for Finnish. Such databases can be used to assess the role, impact, and adoption of novel/future foods in future sustainable food systems through: i) socio-economic factors, ii) environmental impacts, iii) consumer interventions and cultural acceptability, and iv) nutrition and health outcomes.

Conclusion

There are many multidimensional and complex interactions in play when including novel/future foods in sustainable future food systems. Connections among the various aspects of sustainable foods must be considered with the production, promotion, and consumption of novel/future foods. When such multidimensional interactions are considered, compilation of sustainable food databases which include novel/future foods present an option for reaching sustainable future food systems.

Keywords: Sustainable food systems, novel foods, future technologies, cellular agriculture, nutrition, climate change

Selected References

1. Parodi A, Leip A, De Boer IJ, Slegers PM, Ziegler F, Temme EH, Herrero M, Tuomisto H, Valin H, Van Middelaar CE, Van Loon JJ. The potential of future foods for sustainable and healthy diets. *Nature Sustainability*. 2018 Dec;1(12):782-9.
2. Tuomisto HL, Scheelbeek PF, Chalabi Z, Green R, Smith RD, Haines A, Dangour AD. Effects of environmental change on agriculture, nutrition and health: A framework with a focus on fruits and vegetables. *Wellcome open research*. 2017;2.
3. Gazan R, Barré T, Perignon M, Maillot M, Darmon N, Vieux F. A methodology to compile food metrics related to diet sustainability into a single food database: application to the French case. *Food chemistry*. 2018 Jan 1;238: 125-33.
4. Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. *Science*. 2018 Jun 1;360(6392):987-92.
5. French Agency for Ecological Transition. Agribalyse® Version 3.0. Accessed: 2020
6. EFSA (European Food Safety Authority). The EFSA comprehensive European food consumption database. 2016.
7. Helldán A, Kosonen M, Tapanainen H, et al. 2013. The National FINDIET 2012 Survey. (In Finnish, summary, figures and tables in English) Helsinki: National Institute For Health and Welfare. Report 16/2013.
8. National Institute for Health and Welfare, THL. Fineli Database. Accessed: 2020.
9. [FAO] Food and Agriculture Organization of the United Nations. Amino acid content of foods and biological data on proteins.

In a Developing Economy, Cooperation and Contract Farming Operate as Complements or Alternatives for Each Other

Olta SOKOLI^{1a*}, Orjon XHOXHI², Reiner DOLUSCHITZ^{1b}

^{1a}Olta Sokoli, Department of Farm Management, University of Hohenheim, Stuttgart, Germany

²Orjon XHOXHI PhD; Faculty of Economy and Agribusiness, Agricultural University of Tirana, Albania

^{1b}Reiner DOLUSCHITZ Prof. Dr.; Department of Farm Management, University of Hohenheim, Germany

*Corresponding author: olta.sokoli@uni-hohenheim.de

Introduction: The need of cooperation and contracting in agricultural sector is a determining factor in developing countries. Whether, contracting has a positive affect on farmers' willingness to cooperate or substitutes it, there is a broad debate. Relational norms, such as trust, are viewed in this literature as substitutes for complex, explicit contracts or vertical integration (Poppo and Zenger, 2002; Dyer and Singh, 1998; Adler, 2001). Currently, in the Albanian framework, contracting might be more significant due to the inherited mentality from the history of socialist cooperatives (Sokoli and Doluschitz, 2019). Cooperation becomes an essential complement to the adaptive limits of contracts by encouraging continuance and bilateralism when change or conflict arise (Heide and John, 1992). Established on a profound literature review achieved by many scholars of vertical and horizontal cooperation, the following hypotheses have been raised in different contexts:

- A formal contract prevents the formation of cooperation bases
- Cooperation behaviors deter the use of contracts
- A higher cooperation behavior of farmers will augment contracting.

Methods: The study has taken place in two different sectors, milk as a processing product for domestic market and citrus as not processed and an exporting product. Two different groups of farmers were interviewed, in total 400 hundred quantitative face to face questionnaires.

Results: Already, in the descriptive analysis shown in the results we can recognize a difference in these two sectors. From the total sample of interviewees on citrus sector, 92% of the interviewees were male and 8% female, with average age 52 years old. Most of the interviewees, the head of household, had as main employment work on agriculture. In difference from the group interviewed in the milk sector there is a higher education of farmers. For instance, 13% of interviewees have a University degree, while 39% have only primary education and 48% have a high school education. From the total sample of interviewees on milk sector, 70% of the interviewees were male and 30% female, with average age 52 years old. Most of the interviewees, the head of household, with about 94% had as main employment work on agriculture. Only 3% of interviewees have a University degree, while 56% have only primary education and 42% have a high school education.

Conclusion: Contract farming promotes cooperation as a relational governance in exchange settings and relational governance enables the improvement of contracts and promotes stability in organizational exchanges. To identify whether, the presence of one governance arrangements such as, cooperation or / and contracting, prevents the need for the other (Dyer and Singh, 1998). Another factor which has been identified during the results was trust as a mediator in both cases. Trust reduces transaction costs by 'replacing contracts with handshakes' (Adler, 2001).

Keywords: cooperation, contract farming, citrus sector, dairy sector, Albania

Selected References:

1. Adler P. **2001**. Market, hierarchy, and trust: the knowledge economy and the future of capitalism. *Organization Science* 12(2): 214–234.
2. Dyer J., Singh H. **1998**. The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review* 23: 660–679.
3. Heide J., John G. **1992**. Do norms matter in marketing relationships? *Journal of Marketing* 56: 32–44.
4. Poppo L., Zenger T. **2002**. Do formal contracts and relational governance function as substitutes or complements? *Strategic Management Journal* 23: 707–725 DOI: 10.1002/smj.249
5. Sokoli O., Doluschitz R. **2019**. Cooperative evolution through political era/epoch: Albanian's case and comparisons. *Economics of Agriculture* 66/1, 189-204. DOI: 10.5937/ekoPolj1901189S

Carbon Sequestration in Coffee Agroforestry Systems of Southwestern Ethiopia

Sebastian Karol Peczek^{a,*}, Anna Planke^a, Areti Vlachodimou^a, Lukas Van Riel^a and Vincent van Roomen^a

^aFaculty of Science, University of Copenhagen, Bülowsvej 17, DK-1870 Frederiksberg C, Denmark

*Corresponding author: hlr421@alumni.ku.dk

Introduction

This study evaluates the potential for climate change mitigation through adoption of agroforestry for coffee production in Southwestern Ethiopia. It is expected that the future local climate will render some of the current coffee cultivation areas unproductive (Moat *et al.* 2017). Coffee cultivation is likely to be moved to cooler areas at higher altitudes, currently classified as areas with degraded land or Afromontane forests with little human interference. Agroforestry is discussed as a farming method with a large C-sequestration potential and as a possible approach for creating a resilient coffee farming system. The study compares the C-stock for following land use types: Afromontane forest, degraded land, coffee agroforestry system, shaded coffee plantation and full-sun coffee plantation and presents practical considerations for realistic and economically viable solutions for farmers to continue coffee cultivation in the future.

Methods

The study is based on a literature review, compiling existing research material in a order to provide a relevant and contextualised assessment of the topic. The review focuses on literature on C-stock of the selected land use types in geographical proximity to Ethiopian Highlands (e.g. Negash & Starr 2015), as well as additional literature on practical and policy implications for adapting agroforestry.

Results

The review of carbon stocks investigated land use types suggests that establishing agroforestry systems on degraded lands has the largest carbon sequestration potential of all the combinations. On the other hand, findings suggest that converting Afromontane forest into agroforestry systems results in a net loss of stored carbon, particularly due to a decrease in biomass. Nonetheless, these losses are not as significant as when converting to monoculture.

Conclusion

While the study concludes that establishing agroforestry is the preferred solution in terms of C-sequestration, establishing agroforestry systems may currently not be a viable possibility for many farmers, as it requires a large upfront investment. For this reason, financial support for farmers is necessary, e.g. through the REDD+ programme, state support, raising the commodity value of the product and creating a stable market, which requires investments in local infrastructure. Other barriers for adaptation of agroforestry include land preference for slash-and-burn practices as well as lacks in awareness and technical know-how.

Keywords: carbon sequestration, agriculture, coffee, *coffea arabica*, deforestation, Africa, Ethiopia, Afromontane, degraded land, agroforestry

Selected References:

1. Moat, J., Williams, J., Baena, S., Wilkinson, T., Gole, T. W., Challa, Z. K. & Davis, A. P.. Resilience potential of the Ethiopian coffee sector under climate change. *Nature plants*, **2017**, 3(7), 17081.
2. Negash, M., & Starr, M. Biomass and soil carbon stocks of indigenous agroforestry systems on the south-eastern Rift Valley escarpment, Ethiopia. *Plant and Soil*, **2015**, 393(1-2), 95-107.

Consumer's Attitudes Toward Insect Consumption in Cambodia

Techhong Lim, Chaloupková Petra

Department of Economics and Development, Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Prague 16500, Czech Republic.

*Corresponding author: xlimt001@studenti.czu.cz

Introduction

The concept of consuming edible insects as food, also known as entomophagy, has been integrated into the human diet centuries ago. In western countries, such as European countries and the United States of America, this concept is relatively new. People are still hesitant to consume. Whereas in Cambodia, food made from edible insects is widely available from urban to rural areas. Originated from being an emergency survival source of protein, edible insects have incorporated closely to Cambodians livelihood. However, in the era where the living standard is increasing and food is abundant. Cambodians' consuming behaviour toward edible insects is in uncertainty that need to be answered. The general objectives of this study were to understand the consumer attitudes toward edible insects in Cambodia, mainly to find out which insects are being eaten, and reasons for consuming it using primary factors of influence from other studies, which include sociodemographic data (i.e. gender, age, household size), taste, and degree of processing.

Pre-research was conducted to identify the common insect species sold on the consumer market in Cambodia. Pre-research was done through observation and informal interviews with some local insect vendors in Phnom Penh. The primary data were collected via a questionnaire-based online survey among Cambodian consumers using the snowball method.

Initial result has indicated that 97% of our respondents has eaten insects before, female accounted for about 48%. Main reasons that people started to eat insects in the first place were their curiosity about insects and their family influences through the incorporation of insects into their dietary since young ages. Cricket, red ant/weaver ant, and silk pupae are the most famous among eight mentioned species of insects, accounted for 95%, 77%, and 60% respectively. The three are also the most favourable insects, cricket was favoured by 40% of our respondents while red ant/weaver ant and silk pupae are selected by 12% individually as the most favourite insects. Insects are commonly consumed in visible/whole insects form (98%). Taste, price and degree of processing of insects as food are the three main important factors that influenced their purchasing behaviour of insects. Animal welfare and environmental friendliness of insects' production are the noticeable inspiration for the insects' consumption. Additionally, taste and the affordability of insects are also highly regarded as the consumption motivation for local Cambodian. Nutrition, environmental impact, animal welfare, and price are somehow marked as important factors in the consuming pattern.

The consumption of insects among Cambodians happened since they were young and largely influenced by their family dietary. Cricket, red ant/weaver ant, and silk pupae are the most commonly eaten species of insects as well as the most favourable insects by Cambodian consumers. Taste, price and degree of processing are the most important factors in their insects' consumption pattern. By looking into the level of acceptance of insects among Cambodians and the favourable conditions of their food choice, insects could be a future source of protein for Cambodia. It is a potential sector in food industry in Cambodia where there are market and supply. With new innovated concept and production of insects, it could be a new key player in future Cambodian food industry.

Keywords: Consumer's attitude, Edible insect, Consumption, Cambodia, Questionnaire-based survey

Selected References:

1. House, J. *Appetite*, **2016**, 107, 47-58.
2. Dobermann, D.; Swift, J.; Field, L. *Nutrition Bulletin*, **2017**, 42, 293-308.

*Aquaculture – Aquatic Animal
Nutrition*

Palm Oil and Myo-inositol Increase Survival Rate of Seawater-acclimated Nile Tilapia

Behnam Foroutan^a, Biboon Withyachumnarnkul^a, Chompoonut Kerdmusik^b, Boonsirm Withyachumnarnkul^{ab*}

^aFaculty of Innovative Agriculture and Fisheries, Prince of Songkla University, Surat Thani 84100, Thailand.

^bAquaAcademy Farm, Tha Chana, Surat Thani 84170, Thailand.

*Corresponding author: wboonsirm@yahoo.com

Introduction

Seawater-acclimated Nile tilapia, *Oreochromis niloticus*, has been produced continuously in the Prince of Songkla University at a new campus in Chaiya District, Surat Thani, following its first breeding program (Withyachumnarnkul *et al.*, 2007). The newly bred fish can survive in full-strength seawater (SW), at around 30 ppt; however, the survival rate was about 50% and the growth rate was about 60% of *O. niloticus* normally reared under freshwater. The SW-acclimated Nile tilapia has been continuously stocked for research purposes in the reservoir of the AquaAcademy Farm (AAF), Tha Chana District, Surat Thani, where salinity is 25-30 ppt (depending on the seasons). The lower level of the survival rate of the SW-acclimated fish, compared to those being stocked under freshwater, was hypothesized as being due to the osmolality stress of the fish. It was also hypothesized that the fish that survived elevated salinity is capable to up-regulation of the gene(s) responsible for adaptation to the hypertonic environment of seawater (Gardell *et al.*, 2013), as well as being able to shift the energy store in their bodies to suit the increasing requirement to fight against the hypertonic situation. With these, a series of experiments were therefore performed at AAF to test if feed supplemented with lipids of different kinds and doses, as the means to provide extra energy, could enhance the survival rate of the SW-acclimated Nile tilapia, and whether myo-inositol, the natural osmolyte (Kültz, 2015), could ease the osmolality stress and possibly help increasing survival rate of the fish.

Methods

Three experiments were performed to prove (or disprove) the hypothesis. The purpose of the first experiment was to select the suitable type of lipids commonly available in local markets, i.e., salmon oil, soybean oil and palm oil, as being the most suitable supplement for fish survival. The purpose of the second experiment was to determine the optimum dose of the selected lipid, and that of the third experiment was to find out whether the lipid-soluble myo-inositol could also increase the fish survival. In all the experiments, SW-acclimated Nile tilapias (approximate initial body weight of 3 g) were divided into control (providing normal pellets) and experimental (providing pellets supplemented with tested substances) groups. Each group, with 3 replicates, was composed of 40L seawater (27-30 ppt)-containing plastic buckets being stocked with 20 fish. The fish were fed three times a day, initially at 4% biomass, and was increased according to the fish's demand. Each experiment lasted for one month. Initial and final body weights of individual fish were determined, and mortality was recorded daily. Parameters of water quality (total ammonia nitrogen, total nitrite, alkalinity, pH and salinity) were monitored daily throughout the whole experiments. The protocol of the three experiments was summarized in Table 1.

Table 1. Experimental protocol

	Purpose	Grouping and treatment
Experiment 1	To find out suitable type of lipid	Control: normal feed Experimental (6 mL lipid/kg feed): Salmon oil supplement Soybean oil supplement Palm oil supplement
Experiment 2	To determine a suitable dose of lipid supplement	Providing feed supplemented with 0 (control), 3 mL, 6 mL, 9 mL and 12 mL lipid/kg feed
Experiment 3	To determine the efficacy of myo-inositol	Providing feed supplemented with 0 (control), lipid (at the suitable volume/kg feed), with dissolved myo-inositol at 250, 500 and 1,000 mg/kg feed.

Results

Results from experiment 1 suggested that the best lipid supplement was palm oil, based on the highest survival rate and optimum biomass at the end of the one-month experimental period. In experiment 2, the results suggested that the amount of palm oil supplement was 6 mL/kg feed. In experiment 3, it was found that feed supplemented with myo-inositol and palm oil (with 500mg myo-inositol and 5mL palm oil in 1kg feed) significantly enhance the survival and growth rate of the fish.

Conclusion

Feed supplemented with myo-inositol (500 mg) dissolved in palm oil (6 mL) per kg feed could enhance survival and growth rate of SW-acclimated Nile tilapia. This approach may be one, among other methods, to help Nile tilapia, the normally freshwater species, to grow and survive under elevated salinity.

Keywords: Seawater-acclimated, survival, *O. niloticus*, biomass, palm oil, myo-inositol

Selected References:

1. Withyachumnarnkul, B.I.; Palang, I.; Ruangsri, J.; Sirithammajak, S.; Jitrakorn, S.; Kiatpathomchai, W.; Saksmerprome, V.; Pongtippatee, P.; Withyachumnarnkul, B. *Aquaculture*, **2017**, *480*, 42-50.
2. Gardell, A.M.; Yang, J.; Sacchi, R.; Fanguie, N.A.; Hammock, B.D.; Kültz, D. *J Exp Biol*, **2013**, *216*, 4615-4625.
3. Kültz, D. *J Exp Biol*, **2015**, *218*, 1907-1914.

Effects on Growth Performance and Body Composition of Tilapia (*Oreochromis* sp.) Fed with Fish Waste Product in Practical Diet

Dg Siti Rahayu Zaihurin*^b, Annita Yong Seok Kian^a, Thumronk Amornsakun^b and Sarawuth Chesoh^c

^aBorneo Marine Research Institute, Universiti Malaysia Sabah, Jalan UMS, 88400, Sabah, Malaysia

^bDepartment of Technology and Industries, Faculty of Science and Technology, Prince of Songkla University Pattani Campus, Pattani, 94000 Thailand

^cDepartment of Science, Faculty of Science and Technology, Prince of Songkla University Pattani Campus, Pattani, 94000 Thailand

*Corresponding Author: dgsitirahayuzaihurin@yahoo.com

Introduction

Fish waste is one of the cost-efficient and easily obtained ingredients from the fisheries industries that has yet fully investigated and utilised (Harnedy and Fitzgerald, 2012; Rana et al., 2009). Study shown that fish waste can be converted into useful ingredient that can be used in aquafeed production (Fum et al., 2017). 70-days of experiment was conducted to investigate the effect of treated fish waste product (FWP) in formulated diet on growth, survival and feed utilization of tilapia, *Oreochromis* sp. FWP comprised mainly of visceral organ of fish was undergo heating and hydrolysis process before testing in formulated diet.

Methods

Three isoproteic (40%) and isolipidic (10%) diets were tested; control diet with 100% of fish meal (FM) (0% FWP), the other two treatments were formulated with 25% of heated FWP and 25% of acid-based hydrolyzed (2M acetic acid) FWP inclusion to replace FM and assigned to FM, H and AA respectively. The experiment was conducted in cylindrical tanks (V=3.142 x 55 x 70 cm) and fish were stocked at 10 fish in each (initial body weight 7.00±0.05, Mean±SD, n=60). Experimental diets were fed to fish in duplicate twice daily to apparent satiation.

Results

Results showed that fish fed with H and AA demonstrated no significant different in weight gain compare to control treatment, FM (P>0.05). However, there were no significant different on the total feed intake among the treatments. As for the feed conversion ratio, fish fed F0 performed better compared to other diets (P<0.05). In this trial, 100% of survival was observed in all treatments. The body proximate composition showed that fish fed FWP diets contained higher protein composition compare to FM (P<0.05). However, the lipid composition in FM was significantly different with fish fed with H and AA (P<0.05). Fatty acids content in fish fed with fish waste product higher in SFA and MUFA compare to FM (P<0.05) while FM showed high composition of PUFA and not comparable to other treatment (P<0.05).

Conclusion

In conclusion, growth performance of fish fed with treated FWP were comparable to control treatment. However, fish fed AA showed better FCR, composed with comparable body protein and fatty acid with fish fed with H hence indicating that hydrolysis using acetic acid a promising method and suggested to be tested at lower concentration to improve FWP quality as an alternative ingredient to replace fish meal.

Keywords: Fish waste product, Fish meal replacement, Tilapia, *Oreochromis* sp.

Selected References:

1. Fum, K-Y.; Shapawi, R.; Lim, L-S. *Fish by-product meal served as a good protein source in the formulated diets for Red Tilapia fry*. *Songklanakar Journal of Science and Technology*, **2017**, 39(6), 813-817.
2. Harnedy, P.A.; FitzGerald, R.J. *Bioactive peptides from marine processing waste and shellfish: a review*. *Journal of Functional Foods*, **2012**, 4, 6–24.
3. Rana, K. J.; Siriwardadera, S.; Hasan, M. R. *Impact of Rising Feed Ingredient on Aquafeeds and Aquaculture Productions*. FAO, Fisheries and Aquaculture Technical Paper No. 541, **2009** Rome. pp. 63

Ontogeny of Digestive System in Spotted Scat (*Scatophagus argus* Linnaeus, 1766)

Laddawan Krongpong^{a, *}, Wikrom Rungsin^b, Tanikan Buathong^a and Jirayuth Ruensirikul^c

^aDepartment of Fisheries, Chonburi Aquatic Animal Feed Research and Development Center, Chonburi 20110, Thailand.

^bDepartment of Zoology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.

^cDepartment of Fisheries, Coastal Aquaculture Technology and Innovation Research and Development Center, Songkhla 90000, Thailand

*Corresponding author: lkrongpong@gmail.com

Introduction

In the Songkhla area, Spotted Scat is considered a high-quality edible fish leading to high price and demand in the market. Artificial insemination of Spotted Scat, aimed to boost both natural and aquaculture productivity, has been done successfully by the Department of Fisheries since 2008 (Ruensirikul *et al.*, 2008). However, the survival rate from hatchery and nursery is still variable. A suitable feeding scheme for larvae is, therefore, important to improve the productivity. Study of the ontogenic development of the digestive system may aid the development of an appropriate diet.

Methods

Fertilized eggs and larvae of Spotted Scat were produced at Coastal Aquaculture Technology and Innovation Research and Development Center, Songkhla according to Ruensirikul *et al.* (2009). Eggs and larvae were collected randomly before feeding at 0, 3, 6, 9, 12, 15, 18 and 21 hours after hatching and then everyday until 33 days after hatching (DAH). Samples were fixed in 10% formalin for histological investigation.

Results

A digestive tract, located above the yolk sac, was seen 18 hrs after hatching. At 2 DAH, both mouth and anus of larvae opened, as did a digestive tract with clearly defined oropharyngeal, foregut, hindgut and midgut sections. The pancreas was formed on top of the midgut and the yolk sac was still attached to the liver and assimilated during the first 6 DAH. The digestive tract then progressed from hindgut, which developed from midgut, to foregut. The ileocecal valve was found in larvae 3 DAH. The duodenum appeared in larvae 5 DAH, and the stomach 8 DAH but the gastric gland had not been developed until 15 DAH. From 10 DAH, the intestinal loop, developed from the duodenum, moved to the right side of the abdominal cavity. The last structure developed, at 17 DAH, was the pyloric caeca, formed from duodenum.

Conclusion

From histological examination, Spotted Scat larvae can digest feed from 2 DAH, by digestive enzymes secreted by the pancreas, as indicated by zymogen granules in the pancreatic cell. The stomach was completely functional 15 DAH when a gastric gland was found. The digestive tract was fully developed, as in the adult fish, at 17 DAH.

Keywords: histology, digestive system, *Scatophagus argus*, ontogeny

Selected References:

1. Ruensirikul, J.; Assava-aree, M.; Danayadol, Y.; Chusrirat, L. *Thai Fisheries Gazette*, **2009**, 62, 13-22.
2. Ruensirikul, J.; Assava-aree, M.; Danayadol, Y.; Chusrirat, L. *Coastal Fisheries Research and Development Bureau*, **2008**, Technical Paper No.32/2008, 20 pp.

Effects of Fish Oil Replacement by a Combination of Soybean and Palm Oil in Asian Seabass (*Lates calcarifer*) Diet on Growth, Fatty Acid Profile, Digestive Enzyme Activity, Immune Parameters and Salinity Challenge

Md. Arefin Rahman^{a*}, Chutima Tantikitti^{ab}, Naraid Suanyuk^{ab}, Ian Forster^c, Bullika Hlongahlee^a, Watcharit Tunpairoj^a

^a *Kidchakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand*

^b *Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand*

^c *Centre for Aquaculture and Environmental Research, Fisheries and Oceans Canada, West Vancouver, British Columbia V7V 1N6, Canada*

*Corresponding author: md.arefin75@gmail.com

Introduction

Fish oil (FO) is a main ingredient in formulated diet for carnivorous marine fish to supply essential fatty acids (FA), particularly n-3 polyunsaturated FA. Aquaculture industry uses around 75% of the global production of FO. For sustainable development of aquaculture industry, searching for alternative lipid sources is prerequisite. Asian seabass is carnivorous euryhaline fish which is very popular in the Southeast Asia and Australian region. This study was conducted to assess effects of FO replacement in Asian seabass diet on growth, fatty acid profiles, health status and salinity challenge.

Methods

The experiment was in completely randomized design. Seven iso-nitrogenous and iso-lipidic diets were formulated having soybean and palm oil, an equal combination, to replace fish oil in diets at 0%, 25%, 37.5%, 50%, 62.5%, 75% and 100%, respectively. Each diet was fed twice daily to apparent satiation to five aquaria having 12 fish/aquarium (3.00±0.26g initial weight) for eight weeks. At the end of the feeding trial, survival rate, growth performance, whole-body proximate and fatty acid composition, digestive enzyme activities and innate immune parameters were assessed. The fish were challenged with 30 ppt salinity and sampled at 0 and 3 hours to observe for osmoregulatory responses and parameters.

Results

Zero mortality was observed during the culture period in all feeding groups. Fish growth responses, diet consumption, feed conversion ratio were significantly affected ($p < 0.05$) by the diets. Carcass proximate composition was similar in final fish except crude lipid ($p < 0.05$). Viscerosomatic index was influenced by the diets ($p < 0.05$). Fatty acid profiles of the whole-body reflected the dietary intake. Arachidonic acid (ARA, 20:4n-6), eicosapentaenoic acid (EPA, 20:5n-3), docosahexaenoic acid (DHA, 22:6n-3) and n-3/n-6 ratio were better in fish fed 37.5% fish oil replaced diet. Specific digestive enzyme activities in stomach, pyloric caeca and intestine were not significantly different among the dietary treatments ($p > 0.05$). White blood cells, serum respiratory burst activity and serum protein were influenced by the plant derived oil containing diets. For salinity challenge, similar osmoregulatory responses were observed among the dietary groups.

Conclusion

In short, combination of soybean and palm oil substituted for FO at 37.5% in the diets for juvenile Asian seabass provided the best performance.

Keywords: Alternative lipid source, Asian seabass, growth, fatty acid profile, salinity challenge

Selected References:

1. Rahman, M.A.; Tantikitti, C., Suanyuk, N., Talee, T., Hlongahlee, B., Chantakam, S., Srichanun, M. Effects of alternative lipid sources and levels for fish oil replacement in Asian seabass (*Lates calcarifer*) diets on growth, digestive enzyme activity and immune parameters. *Songklanakarin Journal of Science and Technology*. (In press).
2. Monge-Ortiz, R., Tomás-Vidal, A., Rodríguez-Barreto, D., Martínez-Llorens, S., Pérez, J. A., Jover-Cerdá, M., Lorenzo, A. Replacement of fish oil with vegetable oil blends in feeds for greater amberjack (*Seriola dumerili*) juveniles: Effect on growth performance, feed efficiency, tissue fatty acid composition and flesh nutritional value. *Aquacult Nutr*, **2018**, *24* (1), 605–615.

Effects of Crude Anthocyanins from Three Plants on Lipid Contents in White Leg Shrimp (*Penaeus vannamei*)

Pongsakorn Limlek^{a,d}, Umaporn Pastsart^b, Parichart Ninwichian^{a,d}, Pichet Plaipetch^c and Sarayut Onsanit^{a,d*}

^aDepartment of Fishery and Coastal Resources, Faculty of Innovative Agriculture and Fishery Establishment Project, Prince of Songkla University, Surat Thani Campus, Surat Thani 84000, Thailand

^bDepartment of Science and Agricultural Technology, Faculty of Innovative Agriculture and Fisheries, Prince of Songkla University, Surat Thani Campus, Surat Thani 84000, Thailand

^cChonburi Aquatic Animal Feed Research and Technology Development Center, Aquatic Animal Feed Research and Development Division, Department of Fisheries, Baang Pra sub-district, Sri Racha, Chonburi 20110, Thailand

^dDiscipline of Excellence Sustainable Aquaculture, Faculty of Innovative Agriculture and Fishery Establishment Project, Prince of Songkla University, Surat Thani Campus, Surat Thani 84000, Thailand

*Corresponding author: sarayut.o@psu.ac.th

Introduction

Marine shrimp products, whether they are products from wild catch or farmed, have high cholesterol content. Almost 90 % of shrimp production is farmed and fed with a commercial pellet feed. Recently, alternative sources of protein and lipid have been substituted in feed for cost reduction. Selected agricultural by-products were used in feed formulations, causing the shrimp meat quality to become more fats. This study had as objective to evaluate the crude extracts from three anthocyanin rich plants for fat reduction in shrimp meat. The types of anthocyanin plentiful in local plants included delphinidin-3,5-diglucoside derivative from butterfly pea, cyanidin-3-sambubioside from roselle, and cyanidin-3-glucoside from malabar fruit.

Methods

Local plants with rich anthocyanins (butterfly pea, roselle and malabar fruit). These were mixed in artificial diet formulations in 5 % substitution levels. Farmed white leg shrimp, *Penaeus vannamei* (25.78±0.71g) was subjected to dietary experiment for 45 days of rearing.

Results

The results show no effects on growth performance. The crude anthocyanins of cyanidin-3-glucoside derivatives from malabar fruit was the most accumulated in the experimental shrimp, with a highly significant difference ($p<0.01$) to other treatments. Proximate analysis, including total fat and energy in shrimp meat, shown highly significant difference ($p<0.01$) with lower levels for all crude anthocyanin mixed feeds than in the control group. Butterfly pea and malabar fruit additives gave lower levels of total cholesterol in shrimp meat than in the control group, with highly significant ($p<0.01$) differences.

Conclusion

In summary, crude anthocyanins provided in feed as anti-oxidants could be accumulated and reduce the fat content in shrimp, which has implications to the health concerns associated with shrimp consumption.

Keywords: Anthocyanin derivatives, *Penaeus vannamei*, Accumulation, Lipid contents

The Possibility of Using Zero Fishmeal Diets and Effect on Growth Performance, Immune Response of Pacific White Shrimp (*Litopenaeus vannamei*)

Kanin Patrachotpakinkul^{a,*}, Orapint Jintataporn^a and Srinoy Chumkam^b

^a Nutrition and Aquafeed Laboratory of Aquaculture Department, Faculty of Fisheries, Kasetsart University, Bangkok 10900, Thailand.

^b Faculty of Agricultural Technology, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani 13180, Thailand.

*Corresponding author: kanin.pa@ku.ac.th

Introduction

As industries around the world focus on sustainable businesses as well as aquaculture and aquafeed, it has to be adapted using alternative protein feedstocks especially substituting fishmeal in animal feed has been around for about 30 years and tends to reduce its continued use, including white shrimp feed. Therefore, this research was interested in the zero percent fishmeal diets and supplementing it with trace minerals (TM) on growth and the immune system, compared to 15% of fishmeal diets.

Methods

The 37% crude protein and 6% crude fat diets were designed in 3 treatments, the first treatment was a control group with FM 15%, the second and third were the zero FM diets, and supplementing with TM 0.12 and 0.18 kg/ton respectively. The growth and immune parameter were collected after 4 weeks of culture.

Results

The results showed no significant differences ($P>0.05$) on final body weight, total production, weight gain, average daily growth, specific growth rate, feed conversion ratio, and protein efficiency ratio of all treatments. Final body weight ranged from 5.77 ± 0.67 to 6.04 ± 0.38 g/shrimp. Feed conversion ratio ranged from 0.94 ± 0.08 to 1.02 ± 0.17 . Furthermore, the immune parameters such as THC, SOD, and glutathione showed no difference between FM15 and FM0 groups ($P>0.05$) except phenoloxidase activity exhibited a higher response when increasing the TM concentration ($P<0.05$).

Conclusion

These results indicated the potential to reducing fishmeal in white shrimp diet to zero percent without any adverse effect on growth and immune response base on TM supplementing and balancing mineral profile as same as the high FM diets.

Keywords: zero fishmeal diet, trace minerals supplementation, *Litopenaeus vannamei*, growth performance, immune response

Selected References:

1. Elkin, A.; Davis, D.A.; Rouse, D.B. Replacement of fishmeal in practical diets for the Pacific white shrimp (*Litopenaeus vannamei*) reared under pond conditions, *Aquaculture*, **2007**, 262, 393–401.
2. Katya, K.; Lee, S.; Yun, H.; Dagoberto, S.; Browdy, C.L.; Anon, M.V.; Bai, S.C. Efficacy of inorganic and chelated trace minerals (Cu, Zn and Mn) premix sources in Pacific white shrimp, *Litopenaeus vannamei* (Boone) fed plant protein based diets, *Aquaculture*, **2016**, 459, 117–123.
3. Ray, G.W.; Liang, D.; Yang, Q.; Tan, B.; Dong, X.; Chi, S.; Liu, H.; Zhang, S.; Rimei, L. Effects of replacing fishmeal with dietary soybean protein concentrate (SPC) on growth, serum biochemical indices, and antioxidative functions for juvenile shrimp *Litopenaeus vannamei*, *Aquaculture*, **2020**, 516, 734630

Effect of *Ulva intestinalis* Linnaeus to Optimum Dietary Inclusion on Growth Performance and Cooked Shrimp Color of *Litopenaeus vannamei* Boone, 1931

Pawinee Kleebthong^{ab,*}, Chokchai Luengthuwapranit^{ab}, Rapeeporn Ruangchuay^{ab}

^a *Fishery Science and Technology Program, Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.*

^b *Discipline of Excellence (DoE) in Sustainable Aquaculture, Prince of Songkla University, Songkhla 90110 Thailand*

* Corresponding author: pawineekleebthong@gmail.com

Introduction

The cost of Pacific white shrimp production was rising mainly from the diet which was 40-50 % of the total production cost. The selective ingredient of diet was the one efficient way to do. Green alga, *Ulva intestinalis* contain high protein which was mostly a utilized protein. It also contains chlorophyll-a, chlorophyll-b, and β -carotene, for the source of vitamin precursors including antioxidant and antibacterial substance for the health activity. The efficiency of the alga for raw material in the shrimp diet should be investigated.

Methods

Ulva intestinalis biomass as a raw material was collected from Pattani bay, Pattani province. The alga was cleaned and was dried under sunlight before grinding into powder for the material feed. Six experimental diets were prepared, each containing the percentage of the powder in six formulas; 0, 6, 12, 18, 24, and 30 %. Proximate analysis of each experimental diet formulae was set to 40 % protein and 10 % fat. The experiment was conducted in 50 L 60x30x30 cm³ of glass aquarium filled with 17 ppt of water salinity in the hatchery. Pacific white shrimp larva (post larva 30, 0.12 \pm 0.01 g weigh per individual) was rearing with 1 individual L⁻¹. Satiated feeding was done 5 times day⁻¹. Sludge suction was done every day before feeding. The water exchange was done by 50% every week. Bulk weight and density of the shrimp were done every 2 weeks until the end of 12 weeks. The colorimetric measurement of the shrimp was measured after the heat process for cooked products.

Results

In a total of 12 weeks, the Pacific white shrimp fed with a diet with of the alga 0% provided the maximum growth with 12.27 \pm 1.45 g per individual and showed significant differences of those with the other treatments. The Pacific white shrimp fed with the alga 18% showed the second maximum growth prospects of 6.93 \pm 2.66 g per individual. Specific growth rates of shrimp fed with the alga provided diet 0, 6, 12, 18, and 30% were not significantly different ($p>0.05$) of 5.57 \pm 0.13, 4.78 \pm 0.56, 4.65 \pm 0.19, 4.95 \pm 0.41, and 4.69 \pm 0.09 % day⁻¹, respectively and the feed conversion ratio showed non-significant difference ($p>0.05$) with of 1.78 \pm 0.05, 2.86 \pm 1.60, 2.69 \pm 0.18, 2.56 \pm 0.32, 7.45 \pm 7.08, and 5.34 \pm 0.85, respectively. The protein efficiency ratio of the shrimp was fed a diet with alga 0% showed the highest of 0.29 \pm 0.04 and showed significant difference ($p<0.05$) with those of the other remain. The survival rate of shrimp in the alga of 6 and 12 % provided the highest best with 24.00 \pm 10.39 and 20.67 \pm 4.62 % respectively.

The L* values of the cooked shrimp fed with alga 0 % and 6 % showed the highest of 71.19 \pm 3.14. The a* values of the shell from the shrimp fed with 0% the alga showed the highest ($p<0.01$) of 16.47 \pm 4.50 and the b* values of the shell from shrimp 6 % of alga showed the highest had 19.75 \pm 5.40 but not significantly different with those from shrimp fed with alga 0, 12, and 24 % diet.

Conclusion

The growth of Pacific white shrimp fed with a diet with *Ulva intestinalis* supplementation 0% had the best growth. The inclusion of *Ulva intestinalis* in the diet might cause growth in decreasing and cooked color displeasing.

Keywords: Pacific white shrimp, *Litopenaeus vannamei*, *Ulva intestinalis*, dietary inclusion, cooked shrimp color

Role of Pom-nang Seaweed, *Gracilaria* spp. on Growth and Survival of Juvenile Mud Crab, *Scylla paramamosain*

Wasina Rungruang^{a,*}, Jitima Suwanmala^a, Mohammad Tamrin Mohamad Lal^b, Chinnawat Pitagsalee^a, Supat Khongpuang^a, Amarin Thongwaan^a, Thodsaphol Pholrat^c, Pun Yeesin^a and Sukree Hajisamae^a

^a Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^b Borneo Marine Research Institute, Universiti Malaysia Sabah, Jalan UMS, Kota Kinabalu 88400, Malaysia.

^c Pattani Coastal Aquaculture Research and Development Center, Pattani 94150, Thailand

*Corresponding author: wasinattinan@gmail.com

Abstract

Effect of diets with different Pom-nang seaweed powder (PSP) level supplemented, and Pom-nang seaweed used as shelter was conducted using tested crablets with an initial body weight of 0.02 g. Two factors including five dietary treatments (PSP0%, PSP2%, PSP4%, PSP6%, and control; mysid shrimp) and two treatments of Pom-nang seaweed as a shelter (Pom-nang seaweed as a shelter and without shelters) on weight gain (WG), specific growth ratio (SGR), protein efficiency ratio (PER), survival rate and feed conversion ratio (FCR). The experiment was performed with 3 replicates for each treatment (10 crabs per replicate). Interaction between two factors on WG, SGR and PER were observed ($p < 0.05$). The WG and SGR of crablets fed with control diet were significantly higher than those of crablets fed with other diets ($p < 0.05$). However, PER fed with PSP4% was significantly higher than those of crablets fed with other diets ($p < 0.05$). Pom-nang seaweed as a shelter showed significantly higher than without Pom-nang seaweed as a shelter ($p < 0.05$) on WG, SGR and PER. The FCR and survival rate of crablets showed not significant effect of dietary diets with different Pom-nang seaweed supplementation's level ($p > 0.05$). However, Pom-nang seaweed as a shelter showed significantly lower than without Pom-nang seaweed as a shelter ($p < 0.05$) on FCR and Pom-nang seaweed as a shelter showed significantly higher than without Pom-nang seaweed as a shelter ($p < 0.05$) on survival rate of crablets. The experiment indicates that the optimum supplement of dietary diets shall be 4% of Pom-nang seaweed and Pom-nang seaweed as a shelter are suitable for nursing stage of the crablets.

Keywords: Juvenile Mud Crab, *Gracilaria* spp, Growth Rate, Survival Rate, Crablet

Optimal Feeding Frequency for Bigfin Reef Squid (*Sepioteuthis lessoniana*)

Jirapan Satjarak^{a,*}, Karun Thongprajukaew^{b,c}, Chantana Keawthapee^d, Naraid Suanyuk^{a,e}, Sappasith Klomklao^f and Kannika Preedaphol^d

^aAquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^bDivision of Health and Applied Sciences, Faculty of Science, Prince of Songkla University, Songkhla 90112, Thailand.

^cCenter of Excellence in Agricultural and Natural Resources Biotechnology Phase 3, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^dPhang-Nga Coastal Fisheries Research and Development Center, Phang-Nga 82120, Thailand.

^eKidchakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^fDepartment of Food Science and Technology, Faculty of Agro- and Bio-Industry, Thaksin University, Phattalung Campus, Phattalung 93110, Thailand.

*Corresponding author: 5910630003@psu.ac.th

Introduction

Bigfin reef squid (*Sepioteuthis lessoniana*) has been successively cultured through multiple generations but little is known about the environmental conditions for aquaculture, or of the factors affecting feeding regimens. The present study was designed to evaluate the effects of feeding frequency on growth performance, feed utilization, mantle quality and whole body composition. Practical feeding protocols from the current study could be used for mariculture of this species.

Methods

The five-week-old squids (1.48 ± 0.03 g initial weight) were assigned to four feeding frequencies: two (2TD), three (3TD), four (4TD) or five (5TD) times daily, and they were fed with post larval stage of Pacific white shrimp (*Litopenaeus vannamei*) over the three weeks of experiment. The amount of diet was initially set at 40% of body weight day⁻¹, and was then adjusted in 2% to 5% increments according to the actual feeding performance. At the end of the feeding trial, the growth performance and feed utilization, digestive enzymes assay, mantle quality and proximate chemical composition of body were determined.

Results

The squids receiving 4TD and 5TD had the highest growth and feed utilization, and the least size variation among the treatment groups. Significant decrease in chymotrypsin specific activity was observed across the remaining treatments. There were no effects of feeding frequency on specific activities of proteinase, trypsin, lipase and amylase. Mantle quality, in terms of RNA concentration, was the highest in squids fed 4TD or 5TD, while protein concentration and RNA/protein ratio did not differ across the four feeding frequencies tested. Also, the most crude lipid was observed in squids fed 5TD, followed by 4TD that were superior to 2TD or 3TD treatments, while crude protein and ash did not differ.

Conclusion

Base on growth performance and feed utilization, digestive enzyme activity, mantle quality and whole body composition, these findings indicate that feeding four or five times daily are most appropriate. This practical feeding protocol can be used for mariculture of this species.

Keywords: digestive enzyme, feed utilization, growth, mantle quality, size variation

Selected References:

1. Ibarra-Garcia, L.E.; Tovar-Ramirez, D.; Rosas, C.; Campa-Cordova, A.I.; Mazon-Suastegui, J. *Comp Biochem Physiol B Biochem Mol Biol*, **2018**, *215*, 10-18.
2. Saekhow, S.; Sae-khoo, H.; Thongprajukaew, K.; Songnui, A.; Phromkunthong, W. *Aquac Res*, **2018**, *49*, 1887-1895.

*Aquaculture – Aquatic Animal
Breeding*

Germ Cell Transplantation Techniques in Aquaculture-targeted Marine Fishes

Yutaka Takeuchi^{a,*}

^a*Noto Center for Fisheries Science and Technology, Faculty of Biological Science and Technology, Kanazawa University, Ishikawa 9270552, Japan.*

*Corresponding author: yutaka@se.kanazawa-u.ac.jp

Introduction

Surrogate broodstock technology consists of producing donor-derived gametes in a surrogate fish (recipient individual) by transplanting germ cells of a donor into a recipient of a different strain or species. This technology can be facilitated by the transplantation of a cell suspension from the embryonic gonads containing primordial germ cells (PGCs), testis or ovary containing germline stem cells into larvae immediately after hatching or sexually competent adults. The following applications of this technology are expected in the field of aquaculture: (1) production of gametes of large-bodied, commercially valuable species (e.g. tunas, yellowtails, groupers) in closely related recipients with small body size and shorter generation time; (2) preservation of elite breeds of fish harboring desirable genetic traits or of endangered species, in combination with cryo-banking of donor-germ cells; (3) production of mono-sex F1 offspring by inducing sex-fate change of donor cells in recipient gonads; (4) production of fish seeds with increased genetic diversity for use in stock enhancement program to mitigate the genetic impact of released fish seeds on wild fish populations. It is expected that a combination of these techniques will greatly accelerate the breeding of aquaculture species. It is important to adapt surrogate broodstock technology to a wider range of aquaculture-targeted marine fishes and further improve the efficiency of donor-derived gamete production when using surrogate broodstock.

Keywords: Surrogacy, Xeno-transplantation, Gametes

Selected References:

1. Takeuchi et al. Biotechnology: surrogate broodstock produces salmonids. *Nature*, **2004**, 430, 629-630.
2. Takeuchi et al. Development of spermatogonial cell transplantation in Nibe croaker, *Nibea mitsukurii* (Perciformes, Sciaenidae). *Biol Reprod*, **2009**, 81,1055-1063.
3. Morita et al. Functional sperm of the yellowtail (*Seriola quinqueradiata*) were produced in the small-bodied surrogate, jack mackerel (*Trachurus japonicus*). *Mar Biotechnol (NY)* **2015**, 17, 644-654.
4. Takeuchi et al. Chapter 17. Intraperitoneal Germ Cell Transplantation Technique in Marine Teleosts. M. Yoshida, J.F. Asturiano (eds.), *Reproduction in Aquatic Animals*, Springer Nature Singapore Pte Ltd. 2020, pp.357-379.
5. Yoshikawa et al. Efficient production of donor-derived gametes from triploid recipients following intra-peritoneal germ cell transplantation into a marine teleost, Nibe croaker (*Nibea mitsukurii*). *Aquaculture* **2017**, 478, 35-47.
6. Yoshikawa et al. Hybrid sterility in fish caused by mitotic arrest of primordial germ cells. *Genetics* **2018**, 209, 507-521.
7. Lacerda et al. Germ cell transplantation as a potential biotechnological approach to fish reproduction. *Fish Physiol Biochem* **2013**, 39, 3-11.
8. Xu et al. Germ cell-less hybrid fish: ideal recipient for spermatogonial transplantation for the rapid production of donor-derived sperm. *Biol Reprod* **2019**, 101, 492-500.
9. Xu et al. Production of donor-derived eggs after ovarian germ-cell transplantation into the gonads of adult, germ cell-less, triploid hybrid fish. *Biol Reprod* **2020**, ioaa168.

Exploring Various Cryopreservation of Spermatozoa of Tropical Oysters *Magallana bilineata* (Röding, 1798)

Poon Wing Yee¹, Noorain Ilias², Nithiyaa Nilamani², Teh Chiew Peng¹, Aileen Tan Shau Hwai^{1,2}

¹School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, MALAYSIA

²Centre For Marine & Coastal Studies, Universiti Sains Malaysia, 11800 Penang, MALAYSIA

*Corresponding author: aileen@usm.my

Abstract

Cryopreservation is a freezing method specific for cells such as gametes and tissues in a sub-zero temperature. The role of cryoprotectant (cryoprotective agent) is essential to reduce the cryoinjury and retain the original biological function of gametes during cryopreservation. This study looked into the effectiveness of four types of cryoprotectants (dimethyl sulfoxide, sucrose, egg yolk and honey) at four concentrations (5%, 10%, 15% and 20%) on the spermatozoa of tropical oyster, *Magallana bilineata*. Sperm exposed to DMSO 10% underwent freezing has recorded the highest fertilization rate, which was significantly higher than other treatments but showed no significant differences with the control (fresh sperm). The usage of sucrose is less effective compared to DMSO, but showed no significant differences with egg yolk. This study is important to determine the best cryoprotectant to be used for spermatozoa cryopreservation of *M. bilineata*, in order to provide a solution to oyster hatchery operators to secure all year-round spawning using cryopreserved sperms.

Keywords: cryopreservation, spermatozoa, fertilization rate, tropical oysters

Oogenesis, Spermatogenesis and Hatching Rate of Seawater-acclimated Nile Tilapia

Biboon Withyachumnarnkul^a, Behnam Foroutan^a, Chompoonut Kerdmusik^b, Boonsirm Withyachumnarnkul^{ab*}

^aFaculty of Innovative Agriculture and Fisheries, Prince of Songkla University, Surat Thani 84100, Thailand.

^bAquaAcademy Farm, Tha Chana, Surat Thani 84170, Thailand.

*Corresponding author: wboonsirm@yahoo.com

Introduction

Seawater-acclimated Nile tilapia, *Oreochromis niloticus*, has been produced continuously in the Prince of Songkla University (PSU) at a new campus in Chaiya District, Surat Thani, following its first breeding program (Withyachumnarnkul *et al.*, 2007). They have been also stocked for research purposes in the reservoir of the AquaAcademy Farm (AAF), Tha Chana District, Surat Thani, where salinity is 25-30 ppt (depending on the seasons). In contrast to *O. niloticus* rearing under freshwater, it was observed that the seawater (SW)-acclimated fish rarely have offspring under elevated salinity. The purpose of this study was therefore to find out whether the adult-sized *O. niloticus* have normal oogenesis, spermatogenesis, and whether the hatching of the fertilized eggs is possible under elevated salinity.

Methods

Nile tilapias, freshwater (FW)-acclimated females, FW-acclimated males, SW-acclimated females and SW-acclimated males, were randomly sampled from the freshwater pond at PSU Chaiya and the seawater reservoir at AAF, with N = 15-17 per group. To assure the adult stages of the fish, the female fish were selected at the size between 200-250 g and the male between 400-450 g. The fish were individually weighed, sacrificed and gonads weighed to obtain the gonadosomatic index. The small pieces of the gonads were incised, fixed in 10% neutral formalin and processed through routine paraffin sectioning with hematoxylin and eosin staining. The sections were examined under light microscopy focusing on the formation of mature eggs and sperm. To test if the fertilized eggs could hatch under elevated salinity, the eggs (stage 1) were obtained from the FW-acclimated, mouth-brooded, female fish, and incubated in 5L round-bottom flasks, under 0, 10, 15, and 20 ppt water. At 4-5 days of incubation, swim-ups with yolk sac hatched out, and the hatching rate was determined. It turned out that the normal hatching rate was achieved at 0, 10 and 15 ppt, but not at 20 ppt. The reason that the eggs could not hatch under 20 ppt was hypothesized that salinity at 20 ppt was too hypertonic for the eggs at the early stage (e.g., stage 1) to cope with the osmolality stress; and if the embryo had developed to the later stage (e.g., stage 4), they might be able to develop certain mechanisms (e.g. up-regulation of genes) to deal with the osmolality stress and thus might be able to hatch normally. To prove the hypothesis, the eggs were incubated under 10 ppt until the eggs reaching the stage of eye formation (stage 4), the salinity was then elevated to 20 ppt and the hatching rate determined.

Results

The gonadosomatic indices of the SW-acclimated Nile tilapia were comparable to those of FW-acclimated fish, in both sexes. Histological sections revealed the presence of mature ova and sperm, suggesting normal oogenesis and spermatogenesis. Regarding the hatching rate, it was found that normal hatching was observed under 0, 10 and 15 ppt; however, all the eggs (100%) failed to hatch under 20 ppt. The hatching rate at 10 ppt was non-significantly higher than that under 0 or 15 ppt. When the eggs were incubated at 10 ppt to the eye formation stage and the salinity was suddenly elevated to 20 ppt, the eggs hatched normally. It suggests that the hypothesis was right; i.e., the embryo required a certain period of growth to generate mechanisms for being tolerant of the osmolality stress imposed by the elevated salinity.

Conclusion

The SW-acclimated Nile tilapia have normal oogenesis and spermatogenesis, but the failure in the natural reproductive activity of the fish under elevated salinity (above 15 ppt) is likely due to the failure of hatching. However, the fish embryo may hatch under >15 ppt salinity if they are granted a period to develop certain mechanisms to cope with the osmolality stress.

Keywords: Seawater-acclimated, reproduction, *O. niloticus*, hatching, osmolality stress

Selected References:

1. Withyachumnarnkul, B.I.; Palang, I.; Ruangsri, J.; Sirithammajak, S.; Jitrakorn, S.; Kiatpathomchai, W.; Saksmerprom, V.; Pongtippatee, P.; Withyachumnarnkul, B. *Aquaculture*, **2017**, *480*, 42-50.

Reproductive Biology of *Rastrelliger brachysoma* of Pattani Bay, the Lower Gulf of Thailand

Kay Khine Soe^{a, c*}, Sukree Hajisamae^b, Nirattisai Petchsupa^b, Zeehan Jaafar^d, and Siriporn Pradit^a

^aMarine and Coastal Resources Institute, Faculty of Environmental Management, Prince of Songkla University, Songkhla 90112, Thailand.

^bFaculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^cDepartment of Marine Science, Myeik University, Myeik 14051, Myanmar

^dDepartment of Biological Sciences, National University of Singapore, 11543, Singapore.

*Corresponding author: kaykhinesoemyeik2013@gmail.com

Abstract

Monthly sampling of short mackerel, *Rastrelliger brachysoma*, was conducted with mackerel gill net of multiple mesh sizes (3.5cm, 4.0 cm and 4.5 cm) at the depths of 2–6m off Pattani bay mouth during February 2019 and February 2020. A total of 623 fish samples were used for reproductive studies including sex ratio, gonosomatic index (GSI), condition factor (K), size at first maturity (L_{50}), morphometric maturity classification, spawning season and fecundity. The sex ratio of 1: 0.63 ($\chi^2 = 32.82$, $p < 0.0001$) was observed. Female fishes had higher GSI and condition factor (K) values than that of male. Two peaks of gonosomatic index (GSI) and seasonal changes of condition factor (K) were found and it was coincident with spawning season of this species. Two spawning seasons were observed between pre-monsoon (February) and monsoon (June, August, and September), indicating multiple spawning type and the prolific breeders (6,638 and 27,000 eggs). The size at first maturity (L_{50}) was estimated to be 17.8 cm and 18.3 cm (TL) for male and female, respectively. The morphometric maturity classification indicated that *R. brachysoma* matured at the length of >18 cm (TL) in correspondent with the age of over >20 months. Results of the regression analysis showed positive relationships between fecundity and total length, fecundity and body weight, and fecundity and ovary weight and they were significant ($P < 0.001$). The correlation co-efficient was stronger between fecundity and total length than that of body weight and ovary weight. The dominance of immature and maturing stages found throughout the year indicated that the pattern of catch from this habitat might affect fish recruitment and stock. Thus, to implement sustainable fishery on this stock, an implementation of fisheries activities should be avoided during their spawning season and limiting mesh size of the net should be considered. This data can also be used as the basic information for future breeding and application to aquaculture of this species.

Keywords: *Rastrelliger brachysoma*, fecundity, gonosomatic index (GSI), size at first maturity (L_{50}), spawning season

Reproductive Features of Sultan Fish, *Leptobarbus hoevenii* (Bleeker, 1851)

Sajeenuth Srithongthum^{a*}, Thumronk Amornsakun^a, Sarawuth Chesoh^b, Sitthisak Jantarat^c, Lim Leong Seng^d, Nobuo Suzuki^e and Anuar Hassan^f

^aDepartment of Technology and Industries, Faculty of Science and Technology, Prince of Songkla University Pattani Campus, Pattani, 94000 Thailand

^bDepartment of Science, Faculty of Science and Technology, Prince of Songkla University Pattani Campus, Pattani, 94000 Thailand

^cBiology program, Department of Science, Faculty of Science and Technology, Prince of Songkla University Pattani campus, Pattani, 94000 Thailand

^dBorneo Marine Research Institute, University Malaysia Sabah, Malaysia

^eNoto Marine Laboratory, Division of Marine Environmental Studies Institute of Nature and Environmental Technology, Kanazawa University, Ogi, Noto-cho, Ishikawa 927-0553, Japan

^fSchool of Fisheries and Aquaculture Science Mengabang Telipot, Kuala Teregganu, Malaysia 21030

*Corresponding sajeenuth91@gmail.com

Introduction

Leptobarbus hoevenii or Sultan fish is a popular fish and became one of the expensive fish species in the Asian countries. This freshwater fish is innate and distributed in Southeast Asia countries including Vietnam, Cambodia, Myanmar, Laos, Thailand, Malaysia, and Indonesia (Truong *et al.*, 2003). Its artificial production has been succeeded since 1980 (Liao *et al.*, 2000). However, the knowledge on the reproductive features of sultan fish broodstock is limited. The present study examined the gonadosomatic index (GSI), fecundity, and egg diameter of sultan fish for supplementary information on the reproductive features of Sultan fish broodstock.

Methods

Twenty individual of *L. hoevenii* broodstock were sampled from the earthen pond. Afterward measured total length (cm) and body weight (g), the fish were immersed into the ice-water prepared before dissected and the gonad removed. The ovaries were weighted subsequently. The GSI of fish in this study was calculated by weight of ovary (g) divided by its body weight (g) and multiplied 100. Continue from previous calculation, 10 of them were randomly sampled to measure fecundity by using gravimetric method. One percent of ovary weight was sampled and counted the number of eggs (Amornsakun *et al.*, 2011). Subsequently, the fish body weight was plotted against the gonad weight, GSI, or fecundity to determine the strength of linear associations (*r*) among these parameters.

To measure the egg diameters, 1,500 eggs were sampled from the ovary of each fish. The frequency of the egg diameters was plotted against the egg diameter, then the weighted moving averages were applied in polymodal frequency distributions. The moving average formula $N_i = 0.5X_i + 0.25(X_{i-1} + X_{i+1})$, where N_i is the moving average number of eggs in class range *i*; X_i is the number of eggs in class range *i*; and X_{i-1} and X_{i+1} are the numbers of eggs in class range *i*-1 and *i*+1 (Kawamura *et al.*, 2009). As the frequency distributions of the egg diameters are usually skewed in polymodal and the modes can correspond to individual diameter-classes, the Bhattacharya's method and Normal probability plot analysis are useful to separate the normal distribution components from these frequencies distribution.

Results

The ranges of total length (TL) and body weight (BW) in the female *L. hoevenii* were 32.2 – 47.1 cm and 350 – 1,200 g, respectively. All females contained ovaries and the GSI was in the range of 1.81 – 12.28 %. The fecundity was 35, 467 – 128,067 eggs. The linear relationships of the gonad weight, GSI or fecundity versus the BW of the *L. hoevenii*. The correlation coefficient (*r*) of the gonad weight ($r = 0.75414$, $P < 0.01$), GSI ($r = 0.5418$, $P < 0.05$) or fecundity ($r = 0.7063$, $P < 0.05$) versus the BW was significantly high. The observed egg diameter was very variable, ranging from 500 to 1,855 μ m. The observed frequency distribution of egg diameter with a class range of 50 μ m and their moving averages. In the moving averages, the polymodal frequency distribution is evident.

Conclusion

It was confirmed that the GSI values of the female *L. hoevenii* broodstock (TL 32.2 – 47.1 cm; BW 350 – 1,200 g) was 1.81 – 12.28 %. The fecundity was 35,467 – 128,067 eggs. This study first reported for mature female *L. hoevenii* at the smallest sizes of maturity at 350 g. The 1 kg female *L. hoevenii* also was firstly found having the fecundity of 120,067 eggs. The egg diameters of *L. hoevenii* ranged from 500 to 1,855 μ m. Moreover, it was confirmed that this fish is a multiple-spawner.

Keywords: Gonadosomatic index (GSI), Fecundity, Diameter of egg, Sultan fish, *Leptobarbus hoevenii*.

Selected References:

1. Amornsakun, T.; Sriwatana, W.; Promkaew, P. *SJST*, **2011**, 33(6), 671 – 677.
2. Kawamura, G.; Naohara, T.; Tanaka, Y.; Nishi, T.; Anraku, K. *Mar Freshw Behav Physiol*, **2009**, 42, 19–30.

Some Biological Aspects of Mature Female Sepat Siam, *Trichogaster pectoralis* (Regan,1910) for Breeding

On-anong Siprasert^{a,*}, Thumronk Amornsakun^a, Sarawuth Chesoh^b and Phonpanom Promkeaw^c

^a Fisheries and Agriculture Technology Program, Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^b Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^c Inland Aquaculture Reserch and Development Regional Center12, Khonghoykhog Songkla 90230, Thailand.

*Corresponding author: tw3140thanrong@gmail.com

Abstract

The sexual maturity of female Sepat Siam, *Trichogaster pectoralis* was studied by determining and gonadosomatic index (GSI). It was found that the size at sexual maturity of female Sepat Siam was 17.31 ± 0.55 cm (Mean \pm SD, n=20) in average total length and 73.78 ± 7.18 g (Mean \pm SD, n=20) in average body weight. fecundity and 20 of them were randomly for measurements The expansion percentage of abdominal increases average $85.31 \pm 25.04\%$ in maturity fish (Mean \pm SD, n=20).

Newly hatched larvae of Sepat Siam were produced by the chemical injection (Suprefact and Motilium). The sexually mature fishes were cultured in Sement pound (water volume 50 ton) with the ratio of male and female brooders 1:1. The fertilization rate, time of hatching and hatching rate experiments were carried out using a 15-liter aquarium (water volume 10 liters) containing 500 eggs. The type of eggs were floating and rounded and yellow color. The fertilized eggs had a diameter of 822 ± 65.71 μ m (Mean \pm SD, n=10,000) with a diameter can divide ratio diameter of eggs into 5 groups as follows. The group 1 (500- 600) μ m, the group2 (601-700) μ m, the group3 (701-800) μ m, the group4 (801-900) μ m and group5 (901-1000) μ m, Which there were 0.10%, 1.63%, 47.56%, 40.28%, 10.43%, respectively. The fecundity was $17,140 \pm 1,017$ ova/fish and gonadosomatic index (GSI) $4.50 \pm 0.95\%$ (Mean \pm SD, n=20). The average fertilization rate was $89.49 \pm 0.5\%$ (Mean \pm SD, n=1,500). The average hatching rate was $86.07 \pm 0.33\%$ in maturity fish (Mean \pm SD, n=1,500). The time of hatching average 22.08 ± 0.01 hr (Mean \pm SD, n=1,500) at water temperature 27.0-30.5°C. The spawning ratio was $60.09 \pm 45.97\%$ in maturity fish (Mean \pm SD, n=20).

Keywords: Fecundity; GSI; Spawning ratio; Sepat Siam, *Trichogaster pectoralis* (Regan, 1910)

References:

1. Amornsakun, T., Sriwatana, W. and Promkeaw, P. 2004. Some aspects in early life stage of siamese gourami,
2. *Trichogaster pectoralis* (Regan) larvae. Songklanakarin Journal of Science and Technology. 26(3), 347 - 356.
3. Amornsakun, T., Kullai, S. and Hassan, A. 2014. Some aspects in early life stage of giant gourami, *Osphronemus goramy* (Lacepede) larvae. Songklanakarin Journal of Science and Technology. 36 (5), 493 - 498.
4. Chesoh, S. 1994. Compare Gourami natural breeding methods with synthetic and pituitary hormone injections. Fisheries journal. 1994(11), 16p.
5. Siswanto, D.K., Untung, B. and Indira, F. 2016. Reproductive response of female snakeskin gourami, *Trichogaster pectoralis* against the addition of supplements and food additives. Fish Sciencetiae Journal. 6(11), 53-64

*Aquaculture – Aquaculture
System*

Development of DHS-USB Reactors for Longtooth Grouper Closed Recirculating Aquaculture System

Takahiro Watari^{a,b}, Wilasinee Kotcharoen^d, Nur Adlin^d, Penpicha Satanwat^{e,f}, Wiboonluk Pungrasmi^{d,g}, Sorawit Powtongsook^{e,f}, Yutaka Takeuchi^c, Masashi Hatamoto^a and Takashi Yamaguchi^{a,d*}

^aDepartment of Civil and Environmental Engineering, Nagaoka University of Technology, Niigata 940-2188, Japan

^bDepartment of Chemical Engineering, Hanoi University of Science and Technology, Hanoi, Vietnam

^cNoto Center for Fisheries Science and Technology, Kanazawa University, Ishikawa, 927-0552, Japan

^dDepartment of Science of Technology Innovation, Nagaoka University of Technology, Niigata 940-2188, Japan

^eDepartment of Environmental Engineering, Chulalongkorn University, Bangkok 10330, Thailand

^fCenter of Excellence for Marine Biotechnology, Department of Marine Science, Chulalongkorn University, Bangkok 10330, Thailand

^gNational Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency, Pathum Thani 12120, Thailand

*Corresponding author: ecoya@vos.nagaokaut.ac.jp

Introduction

A recirculating aquaculture system (RAS) is an intensive fish farming technology used in water-restricted situations that produce safe, healthy, and high-quality aquatic products. Up to 90-99% of the water is recycled in a RAS in tandem with a highly efficient water treatment process. Therefore, an efficient water treatment process is necessary to maintain high water quality in aquaculture tank. In this study, a combination of down-flow hanging sponge (DHS) – upflow sludge blanket (USB) system was applied to a water purification system in a pilot-scale Longtooth Grouper RAS.

Methods

The temperature-controlled aquaculture tank facility has 5,000 L of water volume and 1.0 m depth. The artificial seawater was prepared by using synthetic seawater salt (Marine art, Tomita Pharmaceutical, Japan). The DHS-USB system was consisted by 2 DHS reactors (sponge volume: 400 L and 200 L) and 2 USB reactors (total volume: 40 L). The water quality of RAS was evaluated by pH, DO, TAN, nitrite, nitrate. The fish density in the aquaculture tank was ranged to 4.1 to 49.2 kg·m⁻³.

Results

Overall the experiment, the DHS reactors demonstrated high total ammonium nitrogen (TAN) removal efficiencies and the TAN concentration in the aquaculture tank was maintained at 0.32 ± 0.12 mg·N·L⁻¹. Moreover, the DHS reactors performed high oxygen transfer and the DO concentration of the aquaculture tank during the entire experimental period was kept at 6.4 ± 0.3 mg·L⁻¹. The nitrite and nitrate concentrations in the tank were 0.5 ± 1.3 mg·N·L⁻¹ and 54 ± 41 mg·N·L⁻¹, respectively. The USB reactor fed with sodium acetate acted as a denitrification unit and adjusted the pH through denitrification reaction. All longtooth groupers survived the entire experimental period and the daily weight gain rate of 0.6 %·day⁻¹ was comparable to that in marine aquaculture [1].

Conclusion

During the entire experimental period, all Longtooth groupers can survive. Therefore, the proposed DHS-USB system could be a promising system for water maintenance processes in recirculating aquaculture tanks and further large-scale experiment is recommended.

Keywords: Recirculation aquaculture system, DHS, Nitrification, Denitrification

Selected References:

1. I. Kuriyama, I. *Bulletin of Mie Prefecture Fisheries Research Institute*, **2008**, *16*, 37-44.

The Development of a Prospective Zero-water Exchange System for Aquaria Using the Ozone-DHS-USB System

Nur Adlin^a, Takahiro Watari^b, Masashi Hatamoto^b and Takashi Yamaguchi^{a,b*}

^a*Department of Science of Technology Innovation, Nagaoka University of Technology, Niigata 940-2188, Japan*

^b*Department of Civil and Environmental Engineering, Nagaoka University of Technology, Niigata 940-2188, Japan*

*Corresponding author: ecoya@vos.nagaokaut.ac.jp

Introduction

Water exchange is inevitable in aquarium maintenance. The purpose is to maintain the water quality and color of water. This practice consumes substantial amount of water, time and effort. As majority of the world is facing water scarcity, a biological reactor consisted of a down-flow hanging sponge (DHS) and up-flow sludge blanket (USB) system was developed to reduce water exchange necessity for aquarium. Ozone (O₃) was applied to remove 'yellow substances' that tainted the color of water in the aquarium. The goal of this study is to study the suitability and efficiency of O₃-DHS-USB system in removing color and nitrogenous components such as NH₃, nitrite nitrogen (NO₂⁻-N) and nitrate nitrogen (NO₃⁻-N) at long term operation. Additionally, the impact of moderate O₃ concentration on the performance of the biological DHS-USB system was investigated.

Methods

The performance of O₃-DHS-USB system in removing nitrogenous components in a 700 L on-site freshwater aquarium bred with carps was performed by routine analysis. The impact of moderate ozone concentration on the microbial structure was investigated by analyzing the media in the DHS and sludge from the USB reactor. Components existing in the water samples were studied for additional understanding on O₃ mechanism in reducing the 'yellow substances' that tainted the color of the water. Also, the carp's tolerance towards O₃ toxicity in the water and its impact on their health was observed.

Results

The combination of O₃ and biological reactors is inimical. Competition between NO₂⁻-N oxidation and biological nitrogen removal often led to the deterioration of the biological nitrogen removal system [1]. In this study, changes of microbial community in the reactors were observed but the DHS-USB system still capable of maintaining low NO₂⁻-N concentration in the aquarium over the 600 operational days. The most toxic component of all the nitrogen compounds, NH₃, was successfully maintained at 0.10 ± 0.12 mg N L⁻¹ and NO₃⁻-N concentration was consistently maintained at 6.4 ± 7.5 mg N L⁻¹. Color of the aquarium water and reduction of humic substances was observed when O₃ was used. The toxicity of O₃ often imposes a limitation on O₃ application in aquarium but no abnormal behavior of the carps was observed. The carps survived throughout the study despite water exchange was eliminated for 425 days.

Conclusion

The of success of O₃-DHS-USB in removing the nitrogen components below target level confirmed that the application of moderate O₃ in the aquarium does not deteriorate the overall performance of the DHS-USB. The system is predicted to bring huge benefits to the aquarium and aquaculture industries.

Keywords: recirculating aquarium system (RAS), biological nitrogen removal, ozone

Selected References:

1. Summerfelt ST. Ozonation and UV irradiation- an introduction and examples of current applications, *Aquacult Eng.* **2003**, 28, 21–36.

Sustainability of Recirculating Aquaculture Systems – The Aqualis Experience

Fabio Soller

Diana Aqua. Chartered Square Building, 20th floor, unit no. 20-04. 152 North Sathorn Rd. Silom. Bangkok, Thailand. 10500
Corresponding author: fsoller@diana-aqua.com

Abstract

Seafood consumption worldwide is steadily increasing year on year. Just recently, the aquaculture industry global production has surpassed the fisheries production and established itself as the main supplier of seafood to the world; hence, the seafood industry, particularly the aquaculture sector, must keep up with the high market demands.

Throughout the aquaculture industry growth trajectory, crucial advances in production techniques and feed manufacturing have taken place. Nevertheless, the sustainability and environmental footprint of the activity is still one of the main points for improvement for the industry.

A few production methods, such as co-culture, biofloc, in-pond raceways, recirculating systems, among others, can aid in maximizing the production per unit of area while minimizing the environmental footprint of aquaculture production, and increasing its social, economic and environmental sustainability.

Research facilities can and should be sustainable, as well as focused on minimizing its environmental footprint, for they are the showroom for knowledge, training, and the development of new techniques for the industry.

Aqualis, the research center of Diana Aqua located in Samutsakhorn, aims to be as close to self-sufficient as possible, leaving the smallest environmental footprint. This 1,000m² research center technology is based on indoor Recirculating Aquaculture Systems (RAS) and aquaponics vegetable production for in-house and commercial research trials on nutrition and palatability of fish and shrimp feeds.

Keywords

Indoor aquaculture; Recirculating aquaculture systems; Research; Sustainability; Environmental footprint.

Isolation and Characterization of Heterotrophic Nitrifying Bacteria *Alcaligenes faecalis* and Efficiency on Shrimp Wastewater Treatment

Sunipa Chankaew^a, Sompong O-Thong^c and Yutthapong Sangnoi^{a,b,*}

^a Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Thailand, 90110

^b Discipline of Excellence in Sustainable Aquaculture, Faculty of Natural Resources, Prince of Songkla University, Thailand, 90110

^c Department of Biology, Faculty of Science, Thaksin University, Phatthalung, 93110, Thailand.

*Corresponding author: yutthapong.s@psu.ac.th

Introduction

Ammonia and nitrite removals in shrimp aquaculture system are significant to prevent shrimps from their toxicities. Nitrification process is the biological process that involved transformation of ammonia and nitrite to nitrate (low toxicity) that performed by nitrifying bacteria. There are some bacteria such as *Alcaligenes faecalis* showed a characteristic of heterotrophic nitrifying bacteria in ammonium transformation process. Therefore, the study and isolation of heterotrophic nitrifying bacteria may be used to overcome wastewater problems inherent in shrimp pond.

Methods

Ammonium oxidizing bacteria were isolated from sediment in white shrimp ponds. Modified Pep-Beef-AOM medium was used to cultivate specimens for 28 days and ammonium oxidizing was screened by Griess-Ilosvay method. Heterotrophic nitrifying bacteria were isolated and their 16s rDNA was amplified using universal primers of 27F and 1492R. Ammonium removal efficiency of strains was preliminary studied in synthesis wastewater (modified Pep-Beef-AOM with 4 g of ammonium sulfate) into 250 mL flask. The cultivation was shake at 160 rpm, 28°C for 5 days and after that supernatant was measured concentrations of ammonium (NH₄⁺), nitrite (NO₂⁻), and nitrate (NO₃⁻). Then, ammonium removal efficiency was further conducted in 10L bottle containing shrimp cultured wastewater. Aeration was given throughout the experimental period for 14 days. Every day, 200 mL of wastewater were collected and measured the amounts of ammonium (NH₄⁺), nitrite (NO₂⁻), and nitrate (NO₃⁻).

Results

Isolated heterotrophic nitrifying bacteria strains SRNB23 and SRNB35 was Gram negative and rod shape. 16S rDNA gene sequencing data and phylogenetic analysis, indicated that strains SRNB23 and SRNB35 were *Alcaligenes faecalis* with similarity ranges of 98% and 91%, respectively. The ammonium removal efficiency in synthesis wastewater showed that isolates SRNB23, SRNB35 and mixture (SRNB23 and SRNB35) had the ammonium removal ability for 91.75%, 91.21% and 66.07%, respectively. Whereas in shrimp cultured wastewater, mixture strain (SRNB23 and SRNB35) exhibited highest ammonium removal of 63.07%, followed by strains SRNB35 and SRNB23 that had ammonium removal ability of 57.43% and 56.45%, respectively.

Conclusion

Heterotrophic nitrifying bacteria, *A. faecalis* SRNB23 and SRNB35 have an efficiency for ammonium removal. Single strain of both SRNB23 and SRNB35 showed high ammonium removal efficiency in synthesis wastewater. While mixture strain (SRNB23 and SRNB35) exhibited high ammonium removal efficiency in shrimp cultured wastewater. This suggests that the mixture of *A. faecalis* SRNB23 and SRNB35 might use for water treating in shrimp aquaculture.

Keywords: *Alcaligenes faecalis*, ammonium removal efficiency, heterotrophic nitrifying bacteria

Selected References:

1. Chankaew, S., O-Thong, S. and Sangnoi, Y., *Chiang Mai J. Sci.*, **2018**, 44, 11-20.
2. Lu, Y., Wang, X., Liu, B., Liu, Y. and Yang, X., *Chinese J. Chem. Eng.* **2012**, 20: 995–1002.
3. Sangnoi, Y., Chankaew, S. and O-Thong, S., *Pak. J. Bio. Sci.*, **2017**, 20, 52–58.

Optimum Stocking Density of Hybrid Catfish (*Pangasianodon gigas* x *P. hypophthalmus*) in Giant Freshwater Prawn Polyculture

Nongnaphat Jongkrajajak^{a,b,c}, Teeyaporn Keawtawee^{a,c,d,*} and Mintra Seel-audom^{b,c}

^aAquatic Science and Innovation Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^bDepartment of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.

^cParticipatory and Integrative Support for Agricultural Initiative (PISAI), Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^dThe Discipline of Excellence for Sustainable Aquaculture (DoE), Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: teeyaporn.k@psu.ac.th

Introduction

Polyculture in aquaculture is a system of fish farming where multiple species of producers. It is to utilize all the available niches in the pond area for increasing productivity and economic benefits. Recently, hybrid catfish *Pangasianodon gigas* x *P. hypophthalmus* have been developed into economic species for replacement of giant catfish and striped catfish. The supplementation of hybrid catfish in giant freshwater prawn *Macrobrachium rosenbergii* is an alternative that would be increasing the productivity and farmer income. Therefore, the aim of this research was to investigate the optimum density of hybrid catfish supplemented into giant freshwater prawn polyculture system.

Methods

A completely randomized design (CRD) was used to allocate four triplicate treatment in 1 m² (40 cm water depth) of cement tanks. Ten prawn (6.64±0.13 g) were raised in each tank. Hybrid catfish (3.31±0.66 g) were raised confines with 0, 2, 4 and 6 fish/m² in cages (50x50x25 cm³) for 92 days grow out period. Fish and prawns were fed with a commercial diet twice daily. Water qualities were controlled by 50% water change once a week. Measurement of growth performances as follow: percentage weight gain (%WG), specific growth rate (SGR), average daily growth (ADG), feed conversion ratio (FCR) and survival rate (%SR) after the trial. The data were analyzed by using One-Way ANOVA.

Results

Result of growth performance of prawns showed that, prawns cultured with 2 fish/m² attained significantly highest of %SR (50.00±0.00%) and lowest FCR (3.88±0.89) ($P<0.05$). However, there were no significant difference in %WG, SGR and ADG of prawns and fish in all treatments ($P>0.05$). Average of temperature, dissolved oxygen, pH, total ammonia and nitrite were 28.39±1.11 °C, 8.01±1.55 mg/L, 7.99±0.42, 0.01±0.01 mg/L and 0.24±0.36 mg/L, respectively. Therefore, all water qualities values were suitable for giant freshwater prawn and hybrid catfish culture.

Conclusion

This study indicated that the optimization of stocking density of hybrid catfish was 2 fish/m² in giant freshwater prawn. Therefore, it is possible to supplement hybrid catfish in giant freshwater prawn for increasing productivity and farmer income.

Keywords: polyculture, growth performance, hybrid catfish, giant freshwater prawn

Selected References:

1. Levy, T.; Rosen, O.; Eilan, B.; Azulay, D.; Zohar, I.; Aflalo, E. D.; Benet, A.; Naor, A.; Shechter, A.; Sagi, A. *Aquaculture*, **2017**, 479, 857-862.
2. Bhatnagar, A.; Devi, P. *Int. J. Environ. Sci.*, **2013**, 3, 1980-2009.

*Aquaculture – Aquatic Animal
Health and Disease*

Image Technology Based Detection of Infected Shrimp in Adverse Environments

Thi Thi Zin^{a*}, Takehiro Morimoto^a, Naraid Suanyuk^b, Toshiaki Itami^c, Chutima Tantikitti^b

^a Department of Electrical and Systems Engineering, Faculty of Engineering, University of Miyazaki, Miyazaki 889-2192, Japan

^b Department of Aquatic Sciences, Faculty of Natural Resources, Prince of Songkhla University, Songkhla 90112, Thailand

^c Department of Marine Bio-Science, Faculty of Life Science and Biotechnology, Fukuyama University, Fukuyama, Hiroshima 7290292, Japan

*Corresponding author: thithi@cc.miyazaki-u.ac.jp

Introduction

In recent years, the cultivation of white leg shrimp (*Litopenaeus vannamei*) has become popular in countries around Japan, especially in Southeast Asia, and at the same time, various diseases have occurred in the farms [1]. In the early stages of infection, shrimp show three abnormal behaviors: (1) they appear in the shallow waters of the farm, (2) they do not move and do not eat even when fed, and (3) they suddenly start moving. Early detection is important step to control this disease because there are no preventive measures. In addition, we are currently visually confirming shrimp that show characteristic of the disease. However, these lead to a burden on the farmers and delay in discovery [2]. Therefore, we propose an image technology based monitoring system for detecting shrimp showing the characteristics of diseases.

Methods

The proposed method consists of three functional modules such as (i) preprocessing module for extraction of bait area (ii) confirmation module for shrimp feeding to detect shrimp and the food area (iii) finally the infected shrimp detection module is performed. In the first module we perform the process of reading the background image where the shrimp is not staying in the bait area and convert it from RGB to HSV image. Then morphological operations are carried out and followed by noise removal process to obtain the food area is extracted. We next confirm the shrimp feeding by calculating the exclusive OR (XOR) operation. For an infection trial, we used white spot disease virus which has been causing heavy mortality in this species. Finally we distinguish between infected and non-infected shrimp based on the behaviors of shrimps while feeding.

Results

In order to confirm the proposed method, the experiments are conducted in the Department of Fisheries Resources, Faculty of Science and Technology, Prince of Songkla University, Kingdom of Thailand. For the experiment, there are 3 types of aquariums containing: uninfected shrimp in artificial seawater, shrimp infected in artificial seawater, and shrimp infected in farm water. Eight out of nine data on uninfected shrimp could be accurately identified. As for the data of infected shrimp, all the data could be accurately discriminated in both artificial seawater and aquaculture water. The accuracy obtained in this experiment was 96.4%.

Conclusion

In the proposed method, we focused on the shrimp behavior that the infected shrimp did not approach the food, and these shrimp were identified as the infected or non-infected shrimp from the difference in the number of visits to the food area and the length of stay. In future, we would examine more experiments under various environmental conditions.

Keywords: Infected Shrimp Detection, Image Processing Techniques, Shrimp Feeding Behaviors, Artificial Sea Water

Selected References:

1. Inada, M.; Mekata, T. and Itami, T.; "White spot disease of prawns", *Fish disease research*, pp.115-119, **2017**.
2. Morimoto, T.; Itami, T.; Thi Thi Zin; "A study on Abnormal Behavior Detection of Infected Shrimp", *Proc. of 2018 IEEE 7th Global Conference on Consumer Electronic*, Nara, Japan, pp. 258-259, Oct. 9-12, **2018**.

Isolation of Beneficial Bacteria from Nile Tilapia (*Oreochromis niloticus*) for Their Activity to Inhibit Fish Pathogens

Kantakan Thepnarong^{a,*}, Sommai Chiayvareesajja^a, Duangporn Kantachote^b and Yutthapong Sangnoi^{a,c}

^aAquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90110, Thailand.

^bDivision of Biological Science, Department of Microbiology, Faculty of Science, Prince of Songkla University, Songkhla 90110, Thailand.

^cDiscipline of Excellence in Sustainable Aquaculture, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90110, Thailand.

*Corresponding author: kantakan8393@gmail.com

Introduction

Aquaculture is an important cultivation for production a global protein source, particularly for fish farming; this leads to fast growing sector. Disease has become a major hurdle in the fish farming industry. The use of chemicals and antibiotics is one of the most common treatment options in aquaculture. However, the use of those drugs leads to accumulation in aquatic habitats and with dangerous consequences in antibiotic resistance genes. A new alternative prevention approach to aquatic animal disease is the use of probiotics to improve the overall health of aquatic animals. Hence, this study aimed to isolate beneficial bacteria such as *Bacillus* spp. and lactic acid bacteria (LAB) to be used as probiotics in economic fish like Nile tilapia.

Methods

Bacillus spp. and LAB were isolated from Nile tilapia (500 to 800 grams) and rearing water in tilapia ponds in Songkhla Province. The isolated bacteria were then tested for their characteristics as Gram positive bacteria, endospore forming for *Bacillus* and catalase negative with no spore forming for LAB. One of important probiotic properties, against the growth of fish pathogens, was investigated by Agar spot test with *Aeromonas hydrophila* and *Streptococcus agalactiae* as target pathogens. Any isolated bacteria that were able to inhibit the growth of fish pathogens were then taken to test for feed digestion on three types of nutrients: protein, carbohydrate and fat.

Results

A total of 51 bacteria were isolated from tilapia and water samples. Among them, 44 isolates were Gram positive bacteria by comprising of 30 isolates *Bacillus* spp. and 14 isolates LAB. Both Gram-positive bacteria were tested for antibacterial activity against both fish pathogens and found 14 isolates inhibiting fish pathogens. Of these isolates, 6 isolates were able to inhibit both pathogens, while 4 isolates for *A. hydrophila* and also 4 isolates for *S. agalactiae*. However, only 3 isolates were capable to digest protein; namely RN3B, AQ1/1B and HW3B, while 2 isolates had ability to digest carbohydrate, AQ1/1B and HW3B. None of them were able to digest fat.

Conclusion

It can be concluded that some *Bacillus* and LAB isolated from Nile tilapia and fish pond water acting like probiotics by inhibiting fish pathogens and digesting main ingredient in feed. The promising beneficial bacterial strains will be further investigated for using as probiotics for fish farming to solve such serious problem of farmers caused by fish pathogens.

Keywords: Aquaculture, Nile tilapia, Probiotics

Selected References:

1. Chumpol, S.; Kantachote, D.; Nitoda, T.; Hiroshi, K. *AQUACULTURE*, **2018**, 489, 85-95.
2. Chumpol, S.; Kantachote, D.; Rattanachauy, P.; Torpee, S.; Nitoda, T.; Hiroshi, K. *AQUACULTURE*, **2019**, 505, 72-83.

Test for the Ability to Inhibit Pathogenic Bacteria, *Vibrio Parahaemolyticus*, by Using Algae and Photosynthetic Bacteria

Wannisa Saengkaew^{ab,*}, Chonlatee Cheewasedtham^{ab}, Rapeeporn Ruangchuay^{ab}, Nirattisai Petchsupa^a

^a Fishery Science and Technology Program, Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^b Discipline of Excellence (DoE) in Sustainable Aquaculture, Prince of Songkla University, Songkhla 90110 Thailand

*Corresponding author: apisitkimtun1996@gmail.com

Abstract

Aquaculture practice of marine shrimp farming in Thailand has been greatly affected by many pathogens, especially by bacterial group of *Vibrio* that causes shrimp died in the very early stages of culture period after releasing into the pond, which is often called Early Mortality Syndrome (EMS). Previously, antibiotics were often used and incorporated into shrimp culture practice, but there was a risk of causing an adverse effect on farmed animals and consumers. Therefore, the concept of biological controls of pathogen in culturing system especially the use of probiotics has been increasingly applied in aquaculture. The aim of this study was to investigate the feasibility and selection a suitable algae and photosynthetic bacteria to have activity and ability against the pathogenic bacteria, *Vibrio parahaemolyticus*, via Agar well diffusion technique in using as alternatives to substitutes for antibiotics used in aquaculture. Alga and photosynthetic bacteria used in this experiment were *Ulva intestinalis* and its spores, *Tetraselmis* sp., and consortium of photosynthetic bacteria isolated from mangrove forest at Prince of Songkla University, Pattani Campus. The results showed that all specimens have ability to resist *Vibrio parahaemolyticus*. The resistant ability of algae to *Vibrio* might be resulted in sulfate polysaccharides and nutritional value that contain in those algae to enhance immunity and living performance of shrimp to withstand a wide ranges of environment under culture system. In part of photosynthetic bacteria may also play role in the same activity as in algae to enhance immunity against pathogenic bacteria. This result will be an important basis data for further application and investigation in increasing survivals and yields of marine shrimp aquaculture industry.

Keyword *Ulva intestinalis* *Tetraselmis* sp. Photosynthetic Bacteria *Vibrio parahaemolyticus*

Types of Cells in the Hepatopancreas of the Pacific Whiteleg Shrimp *Litopenaeus vannamei* Being Infected by *Enterocytozoon hepatopenaei*

Niroyhannah Nima^a, Pornsawan Duangsuwan^a, Pattira Pongtippatee^b, Duangkhaetita Kanjanasopa^c and Boonsirm Withyachumnarnkul^{c,d*}

^aDepartment of Anatomy, Division of Health and Applied Sciences, Faculty of Science, Prince of Songkla University, Songkhla 90112, Thailand.

^bDiscipline of Excellence Sustainable Aquaculture, Faculty of Innovative Agriculture and Fisheries, Prince of Songkla University, Surat Thani 84100, Thailand.

^cFaculty of Innovative Agriculture and Fisheries, Prince of Songkla University, Surat Thani 84100, Thailand.

^dAquaAcademy Farm, Tha Chana, Surat Thani 84170, Thailand.

*Corresponding author: wboonsirm@yahoo.com

Introduction

The Pacific whiteleg shrimp *Litopenaeus vannamei* are widely cultured in Thailand and worldwide. From 2018 on, the shrimp has been infected by *Enterocytozoon hepatopenaei* (EHP), the yeast-like, obligated intracellular, spore-forming fungus. The main target organ of the pathogen is the hepatopancreas. The infected shrimp develops slow growth and the infection may be associated with the white-feces disease, causing huge economic damage to the industry. The hepatopancreas is the organ that produce digestive enzymes, store nutrients, and produce hemocyanin, vitellogenin and other proteins. The organ is consisted of many cell types, and the function of each cell type is not clear. The purpose of this study is to reveal what cell types of the hepatopancreas is infected by EHP, and the frequency of infection in each cell type. It is hoped that the finding may point to the mechanisms underlying the slow growth phenomenon of the infected shrimp.

Methods

The shrimp, *L. vannamei*, were obtained from a commercial shrimp pond that is regarded as the slow-growth one. They were divided into normal and small-sized shrimp, of which their body weights (BW) were significantly different ($p < 0.01$). Their hepatopancreas were isolated, weighed and pieces (10-20 g) of the organ were taken for the detection of EHP by polymerase chain reaction (PCR) method and histological examination. Hepatopancreatic cell types were identified and the percentage of infection, as evidenced by the presence of EHP spores within the cells, were determined from 200 cell counts of each cell types, from normal and small shrimp, 10 from each group.

Results

By PCR, all the normal and small shrimp were EHP-positive, but only at the nested-PCR level. The average relative density of the positive bands on the gel electrophoresis, standardized by the actin band, of both groups of the shrimp did not differ statistically. By histology, all cell types of the hepatopancreas from both groups of the shrimp were infected by EHP, with the M- and F-cells at significantly ($p < 0.01$) higher frequency than that of the R- and B-cells. And, surprisingly, the percentage of the infected cells, in all cell types except M-cells, was significantly ($p < 0.05$) lower in the small shrimp, compared to those of the normal ones.

Conclusion

Low level of EHP infection, i.e., at nested-PCR-positive level, does not cause growth retardation of the shrimp. Since M- and F-cells were strongly basophilic, suggesting active protein synthesis, the finding that these two cell types were the most frequently infected suggests that EHP proliferate well in actively protein-synthetic cells.

Keywords: *Enterocytozoon hepatopenaei* (EHP), Pacific white shrimp, growth retardation, hepatopancreas cell types.

Selected References:

1. Tourtip S, Wongtripop S, Stentiford GD, Bateman KS, Sriuirairatana S, Chavadej J, et al. *Enterocytozoon hepatopenaei* sp. nov. (Microsporidia: Enterocytozoonidae), a parasite of the black tiger shrimp *Penaeus monodon* (Decapoda: Penaeidae): Fine structure and phylogenetic relationships. *J Invertebr Pathol.* 2009,102, 21–29.
2. Jaroenlak, P., Sanguanrut, P., Williams, B.A., Stentiford, G.D., Flegel, T.W., Sritunyalucksana, K., Itsathitphaisarn, O. A Nested PCR assay to avoid false positive detection of the Microsporidian *Enterocytozoon hepatopenaei* (EHP) in environmental samples in shrimp farms. *PLoS One*, 2016, 11, 11.

Isolation and Screening of Lactic Acid Bacteria (LAB) for Antagonizing *Vibrio parahaemolyticus* (AHPND strains) in White Shrimp (*Litopenaeus vannamei*)

Apisit Kimtun^{ab,*}, Pochanart Kanjan^b, Chonlatee Cheewasedtham^{ab}

^a Fishery Science and Technology Program, Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^b Discipline of Excellence (DoE) in Sustainable Aquaculture, Prince of Songkla University, Songkhla 90110 Thailand

*Corresponding author: apisitkimtun1996@gmail.com

Abstract

Shrimp farming in Thailand has been very problematical due to *Vibrio parahaemolyticus*, which causes acute hepatopancreatic necrosis disease (AHPND). To effectively overcome this problem, efficacious lactic acid bacteria (LAB) candidates were isolated from shrimp farms near coastal areas. Fifty strains of LAB were screened for their ability to control pathogenic *V. parahaemolyticus* (AHPND strains). LAB strain of TBPV1 exhibiting highest reduction of *V. parahaemolyticus* by agar spot and agar well assay was identified as *Enterococcus faecium* TBPV1 based on the nucleotide sequence of its 16S rDNA. Co-cultivation of *V. parahaemolyticus* and *E. faecium* TBPV1 showed complete reduction of *V. parahaemolyticus* at 12 h under aerobic condition, whereas *E. faecium* TBPV1 increased from 5.29 to 9.47 Log CFU/mL. Additionally, *E. faecium* TBPV1 could produce extracellular enzyme for utilization protein and lipid. The result from this study indicated the strong potential for the application of *E. faecium* TBPV1 for the control of pathogenic *V. parahaemolyticus* and also as a probiotic for Pacific white shrimp.

Keywords: Lactic acid bacteria; *Vibrio parahaemolyticus*; *Litopenaeus vannamei*

The Use of *Zooshikella* sp. as a Probiotic Against Vibriosis in Asian Seabass (*Lates calcarifer*)

Sumesa Puangpee^{1,2} and Naraid Suanyuk^{1,2}

¹*Kidehakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand*

²*Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand*

*Corresponding author: naraid.s@psu.ac.th

Introduction

Asian seabass (*Lates calcarifer*) aquaculture has increased enormously in Southeast Asia, particularly in Thailand. However, the success of Asian seabass production has been limited by the prevalence of vibriosis. Nowadays, probiotics have been suggested to be used for prevention and control disease problems in aquaculture. Previously, isolation of a marine bacterium, *Zooshikella* sp., have been reported by our group (Kongkapan *et al.*, In press). This bacterium showed to possess various antimicrobial activities (Rehman *et al.*, 2018). Therefore, the study aimed to evaluate the potential use of *Zooshikella* sp. as a probiotic to prevent vibriosis in Asian seabass.

Methods

Growth variability of *Zooshikella* sp. in seawater was assessed with 7 salinity levels (0, 5, 10, 15, 20, 25 and 30 ppt). To evaluate for potential use of *Zooshikella* sp. as a probiotic, healthy Asian seabass with an average weight of 0.5 g/fish were used in this study. Four groups of fish (20 fish each x 3 replicates) were cultured for 4 weeks in seawater (15 ppt) containing *Zooshikella* sp. which was applied every 4 days to achieve final concentrations of 0, 10³, 10⁴ and 10⁵ CFU/mL. Viable *Vibrio* spp. and *Zooshikella* sp. in seawater were determined everyday by drop plate technique. At 0, 3, 5, 7, 14, 21 and 28 days of culture period, the persistence of *Vibrio* spp. and *Zooshikella* sp. in fish intestine were examined by spread plate technique. At the end of the experiment, fish were challenged by immersion with *V. vulnificus*. Mortalities were recorded over a period of 3 weeks.

Results

In this study, viable *Zooshikella* sp. were isolated out of 96 h after inoculation in seawater at salinity levels of 10-30 ppt. Total *Vibrio* spp. were significantly decreased ($p < 0.05$) within 2 days after *Zooshikella* sp. at a concentration of 10⁵ CFU/mL was applied in the rearing seawater. Similar result was observed in the group received *Zooshikella* sp. at a concentration of 10⁵ CFU/mL where total *Vibrio* spp. in intestine was significantly decreased ($p < 0.05$) after 14 days of culture period in comparison with other groups. Study on persistence of *Zooshikella* sp. in seawater showed that *Zooshikella* sp. at concentration of 10⁴ and 10⁵ CFU/mL survived in the rearing seawater for 4 days. However, there was no *Zooshikella* sp. isolated from fish intestine in all treatments. Infectivity trials revealed 23.33 % mortality of fish cultured in seawater containing *Zooshikella* sp. at concentrations of 10⁵ CFU/mL which was significantly lower ($p < 0.05$) than those mortalities of fish cultured in seawater containing *Zooshikella* sp. at concentration of 10³ and 10⁴ CFU/mL as well as the control group which were 43.33, 40.00 and 46.67 % respectively.

Conclusions

This study indicated that *Zooshikella* sp. survived in seawater at salinity levels of 10-30 ppt for 96 h. In addition, *Zooshikella* sp. at concentration of 10⁵ CFU/mL exhibited effectiveness at reducing *Vibrio* spp. in seawater as well as in fish intestine. These findings indicated that *Zooshikella* sp. isolate from the present study could be used as a probiotic for the prevention of vibriosis in Asian seabass.

Keywords: *Zooshikella* sp., Probiotic, Vibriosis, Asian seabass

Selected References:

1. Kongkapan, T.; Suanyuk, N.; Kiriratnikom, S. *Songklanakar J. Sci. Technol.*, In press.
2. Rehman, Z.ur; Alam, I.; Kamau, A.A.; Bajic, V.B.; Leiknes, T. *Biotechnol. Rep.*, **2018**, *19*, e002783.

*Aquaculture – Aquaculture-Eco-
Management*

Composition of Nutrients in the Sediment in Relation to the Abundance and Size of Blood cockle (*Tegillarca granosa*) at Kuala Juru, Penang, Malaysia

Nur Syahirah R.^b, Nuramira Syahira S.^{a*}, Nooraini I.^a, & Aileen Tan S.H.^{a,b}

^aCentre for Marine & Coastal Studies (CEMACS), Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

^bSchool of Biological Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

Corresponding email: amirasaffian@usm.my*

Abstract

Blood cockle plays a major role on economic importance and a famous cheap source of protein in Malaysia since 1948. The statistics and studies from Department of Fisheries showed that production of blood cockle (*Tegillarca granosa*) in Malaysia had declined recently due to anthropogenic factors such as industrial discharge, overharvesting and low food availability in the culture beds. The quality of culture beds plays an important role for production of cockles particularly the sediment in which affecting the food availability and the survival of cockles. The analysis of the nutrients in the sediment, the composition of sediment and the abundance of cockles were monitored at Kuala Juru, Penang (Malaysia) on the northern Straits of Malacca. Mud samples were collected from three stations in Kuala Juru where Station 1 was located between Juru River estuary and cockle farming bed, Station 2 was located in an active production area of *T. granosa*, and Station 3 was located in a cockle beds area near to the sea with less production of *T. granosa*. The nutrients and the grain size of the sediment samples were analysed in the laboratory. The temperature in the study site ranged from 29.10°C to 33.20°C and salinity from 25.0 ppt to 27.0 ppt. The average concentration of ammonium in the sediment was 0.391mg/L, nitrate was 0.18mg/L and nitrite was 0.10mg/L. Meanwhile, the abundance of blood cockle was the highest at Station 2, which was the most productive area of *T. granosa* with 97 individuals per 5m² followed by Station 1 which was less productive area of *T. granosa* with 62 individuals. Station 3 was a least productive area with only 39 individuals. Generally, the concentrations of nutrients of ammonium, nitrite and nitrate in sediment had exceeded the permissible limit of class II for mariculture by the Malaysian Marine Water Quality Standards and Index (MMWQSI). Thus, Kuala Juru was classified as a polluted area due to high concentration of nutrients that had degraded the habitat suitable for blood cockle culture. Therefore, monitoring of nutrients in the sediment from the culture bed and measures to improve the sediment quality are needed to increase the production of cockles in the future.

Keywords: blood cockle, *Tegillarca granosa*, sediment, nutrient analysis, abundance

Species Diversity and Seasonal Variation of Coastal Crab in Pattani Bay of Southern Thailand

Pun Yeesin, Sarawuth Chesoh, Sukree Hajisamae, Rueangrit Promdam

Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

*Corresponding author: sarawuth.c@psu.ac.th

Introduction

Pattani Bay, located in the lower southern of gulf of Thailand, covers about 507.9 km square and is a semi-enclosed estuary, which free water flows into gulf of Thailand. Two rivers that jointed together, Pattani River that flows directly to the sea near the mouth of the Bay and Yaring River straightly runs into the Bay. Crabs plays economically important role worldwide. How many species of coastal crabs can be found in Pattani bay and how pattern of environmental factors have associated to those crabs species year-round in the Bay? These questions were investigated and the findings can be beneficial to authorized agents for sustainable resources management.

Methods

Based on habitat characteristics, 7 sampling stations of coastal crab habitats were monthly collected by traps and bare hands from January 2019 to December 2019 and classified samples into taxa. Water depth, salinity, dissolved oxygen and water pH, and were monthly measured. Abundance of crab was set as an outcome while some water quality parameters (water depth, salinity, pH, and dissolved oxygen) and seasons (Dry, Moderate rain, Rainy) were set as the determinants. Multivariate multiple regression analysis was used by R package program.

Results

Fourteen species of coastal crabs were reported namely *Portunus pelagicus*, *Dorippoides fachino*, *Myomenippe hardwickii*, *Halimede ochtodes*, *Scylla paramamosain*, *Scylla olivacea*, *Soceulia brunnea*, *Dorippoides fachino*, *Varuna yui*, *Scylla tranquebarica*, *Scylla serrata*, *Neodorippe callida*, *Episesarma mederi*, and *Charybdis affinis*. Five dominant crab species mostly found (96.9%) including *Portunus pelagicus* (64.3%), *Charybdis affinis* (19.7%), *Myomenippe hardwickii* (9.8%), *Halimede ochtodes* (1.6%) and *Scylla paramamosain* (1.5%).

Regarding those seven habitat types, the muddy, seagrass and seaweed bed habitat (station 1) and the sandy mud habitat (station 2) showed clearly statistically significant higher than overall mean of total crab abundance ($p < 0.016$). Whereas the muddy flat habitat near Pattani River mouth (station 4) and the muddy sand water channel habitat (station 6) and the sandy loam habitat (station 7) showed clearly statistically significant lower than overall mean. In addition, There were no statistically significant differences ($p > 0.05$) of the sandy mud habitat (station 3) and the sandy mud water channel habitat (station 5), compared with overall mean of total crab abundance.

Total crab abundance occurrence in dry season (February to May) showed clearly statistically significant higher than overall mean ($p < 0.0001$). Whereas in moderate rain (June to September), showed lower than overall mean ($p < 0.0001$) and no statistically significant differences ($p > 0.05$) presented in rainy season (August to January). Moreover, at the water salinity equal and lower than 15 ppt, showed clearly statistically significant lower than overall mean ($p < 0.0006$). While more than 15 ppt of water salinity showed higher than overall mean ($p < 0.0006$). Water depth, water pH, temperature and dissolved Oxygen showed no statistically significant differences ($p > 0.05$). However, these water quality parameters are within an appropriate range for aquatic life in the Bay.

Conclusion

Fourteen coastal crab species were record and dominant species were *Portunus pelagicus*, *Charybdis affinis* and *Myomenippe hardwickii*. Typically found in the muddy, seagrass and seaweed bed and the sandy mud habitat often in dry season (February to May) which the water salinity was more than 15 ppt. This finding reconfirmed that seasonal and zoning management is the one option to sustain coastal crab diversity and abundance in Pattani bay.

Keywords: Biodiversity, Crustacean, Gulf of Thailand

Selected References:

1. Fazrul, H., Hajisamae, S., Ikhwanuddin, M., and Pradit, S. Assessing Impact of Crab Gill Net Fishery to Bycatch Population in the Lower Gulf of Thailand. *TrJFAS*. 2015. 15, 767-777.
2. Kunsook, C. and Dumrongrojwatthana, P. Species Diversity and Abundance of Marine Crabs (Portunidae: Decapoda) from a Collapsible Crab Trap Fishery at Kung Krabaen Bay, Chanthaburi Province, Thailand. *ISI Trop Life Sci Res*. 2017 Jan; 28(1): 45-67.

GIS Application for Green Mussel (*Perna viridis*) Pole Culture for Natural Production Enhancement in Pattani Bay, Thailand

Supat Khongpuang^{ab*}, Somporn Chaui-aree^a, Jitima Suwanmala^a, and Sarawuth Chesoh^{ab}

^aFaculty of Science and Technology, Prince of Songkla University, Pattani Campus, 94000, Thailand.

^bDiscipline of Excellence (DoE) in Sustainable Aquaculture, Prince of Songkla University, Songkhla, 90110, Thailand.

*Corresponding author: supat.k@psu.ac.th

Introduction

Green mussel, the most potential cultured species in Thailand, provides both protein food source and income. Moreover, it can control plankton bloom in hypereutrophic waters. Empirically, the green mussel is rarely found in Pattani bay and the current land use of the bay is very competitive. Therefore, GIS technology is employed for mussel culture site selection to avoid resource use conflicts.

Methods

Suitable pole culture site of Green mussel for natural production enhancement in the bay was evaluated based on reported and field data using IDRISI Selva Software. Twelve water and sediment parameters were collected for 7 times from 8 sub-areas (24-40 sampling points) during November 2018-January 2010. Selected water parameters, DO, water pH, salinity, depth and temperature were transformed to data layers by interpolation. Then, calculate suitability score by fuzzy classification. These parameters were combined using MCE to obtain *water suitability* for targeted species. To avoid negative impacts on *fishery and aquaculture*, major fishing grounds (fish, shrimp, mollusc, crab), aquaculture sites (mussel and cockle), and seagrass bed were included. Moreover, ship rout was also added as a *constraint factor*. Overall site suitability was calculated by overlaying the water suitability, fishery and aquaculture land uses, and the constraint factor.

Results

Mean values of DO, pH, salinity, ammonia, temperature, depth, and chlorophyll a were 6.48 ± 1.09 mg/L, 8.35 ± 0.41 , 24.03 ± 6.47 ppt, 0.08 ± 0.05 mg/L, 30.81 ± 1.76 °C, 132.04 ± 56.14 cm, and 68.99 ± 22.81 mg/L, respectively. The values of those parameters were almost in the suitable range, except salinity, varies from 4-33 ppt, and the chlorophyll a, which indicated hypereutrophic condition. Only depth was found non-significant different ($p > 0.05$) among sampling times. The ranges of sand, silt, and clay particles were 0.03-92.54%, 7.4-99.03% and 0.01-90.27%, respectively. Sediment pH varied from 4.94-8.33. The water suitability area, at the cut-off score of ≥ 0.90 , was 30.498 km². The overall suitability area was decreased to 2.44 km² when fishery and aquaculture land use, and the constraint factor were taken into account.

Conclusion

Salinity is the major factors for water suitability of the bay. High chlorophyll a level ensures ample food for mussel. Although only less space is available, mussel restocking for natural enhancement in the bay still technically and socially feasible.

Keywords: GIS Application, Site selection, Mussel culture, Pattani bay, MCE

Selected References:

1. Ross, L.G., Telfer, T.C., Falconer, L., Soto, D. & Aguilar-Manjarrez, J., eds. 2013. Site selection and carrying capacities for inland and coastal aquaculture. FAO/Institute of Aquaculture, University of Stirling, Expert Workshop, 6–8 December 2010. Stirling, the United Kingdom of Great Britain and Northern Ireland. FAO Fisheries and Aquaculture Proceedings No. 21. Rome, FAO. 46 pp.

Diversity of Caddisflies (Trichoptera) Species and their Importance to Sustainable Aquaculture Production in Surat Thani Province, Southern Thailand

Valdon Solomon Boga^{1a*}, Pontipati pattira^{2a} and Laudee Pongsak^{3a}

Department of Fishery and Coastal Resources, Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, Thailand.

*Corresponding author: 5940330301@psu.ac.th

A study of diversity of Caddisflies (Trichoptera) species was conducted in four protected areas of Surat Thani Province including Khao Sok, Khlong Phanom, Kaengkrung National Parks and Khlong Saeng Wildlife Sanctuary. These areas are located at the western part of Surat Thani city. The area consists of granite and limestone mountains, of the Phuket range, with tropical climate and a marked evergreen rain forest vegetation. Samples collection was carried out from March – December 2019. Fifteen families of Trichoptera were observed with 150 species, from which five appears to be dominant species: *Amphipsyche gratiosa*, *Cheumatopsyche charites*, *Pseudoneureclipsis ramosa*, *Setodes minotauros* and *Setodes larva*. *Amphipsyche gratiosa* was selected for rearing, this is intended to produce larvae and adults to be used for feeding fish.

Keywords: Diversity, Caddisflies, Oriental region, Life cycle.

Pollution Assessment Through Macrobenthic Fauna Communities as Bio-Indicator in Human Activities Area at Koh Yo, Songkhla Lagoon

Thanaphan Jombodin^a, Sutinee Himyi^b and Eknarin Rodcharoen^{a*}

^aAquatic Science and Innovative Management Division, Faculty of Natural Resources; Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hatyai, Songkhla 90110, Thailand.

^bProgram of Biology and Applied Biology, Faculty of Science and Technology, Songkhla Rajabhat University, Songkhla 90000. Thailand.

*Corresponding author: eknarin.r@psu.ac.th

Introduction

Koh Yo located in Songkhla lagoon, is an important aquacultures and fisheries area of Thailand. In addition, Koh Yo has surrounded increasing human activities and the waste run-off from communities. The environmental matter become much more majority. The aim of present study is to find the bioindicator or biological measurement for pollution status used at Koh Yo.

Methods

Macrobenthic fauna and its environmental factors were investigated to evaluate pollution in specific human activities area by using AZTI's Marine Biotic Index (AMBI) with 5 stations since nearshore to offshore stations at a distance of 0 (D-0), 100 (D-100), 300 (D-300), 600 (D-600) and 1,200 (D-1200) meters. The sample collections were done in three months interval from February to November 2019.

Results

The cluster analysis of water and sediment quality between the stations of each month were analyzed by cluster analysis method which showed high similarities in the range of 89.24%-95.13%. Macrobenthic fauna revealed 3 phyla 37 families 59 species with the average abundance of 1,383±422 ind/m². Station D-0 has highest diversity (60 species, H' = 2.62) and lowest in station D-100 (35 species, H' = 2.02). The highest abundance was found in station D-300 (2,120±950 ind/m²) and lowest at station D-600 (891±804 ind/m²). *Melita latiflagella*, *Ctenapseudes sapensis*, *Heteromastus filiformis*, *Nephtys polybranchia* and *Arcuatula senhousia* were dominant species in the nearshore stations (D-0 to D-300), while *Upogebia* sp., *Kamaka appendiculata* and *Mediomastus* sp. were dominant in the offshore stations (D600-D1200). The cluster analysis of macrobenthic fauna between the stations of each month showed low similarities in the range of 3.50%-33.03%. The canonical correspondence analysis revealed that salinity was the main environmental factor relating to the distribution pattern of macrobenthic fauna in the area. *Balanus* sp., *Corbula* sp., *A. senhousia*, and *Eunice indica* had high abundance in the high salinity area, while the distribution of dominant species including *M. latiflagella*, *C. sapensis*, *H. filiformis*, *N. polybranchia*, *Upogebia* sp., *K. appendiculata* and *Mediomastus* sp. were not directly affected by environmental factors. They were found at all stations. The result of the AMBI index between stations of each month indicated that the nearshore stations (D-0 to D-300 m) had more pollution than the offshore stations (D-600 to D-1200 m).

Conclusion

This study showed that the waste from human activities around Koh Yo was accumulated in sediment and affected on distribution of macrobenthic fauna. Also, all nearshore has higher pollution than offshore in all seasons.

Keywords: Macrobenthic fauna, Koh Yo, Songkhla lagoon, AMBI, Pollution

Selected References:

1. Angsupanich, S.; Kuwabara, R. *Songklanakarin J. Sci. Technol*, **1995**, *1*, 115-125.
2. Borja, A.; Franco, J.; Perez, V. *Mar. Pollut. Bull.*, **2000**, *40*, 1100-1114.
3. Li, B.; Li, X.; Bouma, J. T.; Soissons, M. L.; Cozzoli, F.; Wang, Q.; Zhou, Z.; Clen, L. *Mar. Pollut. Bull.*, **2017**, *119*, 23-32.
4. Sahidin, A.; Zahidah; Herawati, H.; Wadiatno, Y.; Setyobudiandi, I.; Partasasmita, R. *BIODIVERSITAS*, **2018**, *19*, 1123-1129.
5. Wang, Z. *Open Access Theses and Dissertations*, **2019**, 85-93.

Poster Presentation

Agriculture– Plant Science

Appropriate Postharvest Handling for Extending the Shelf Life of Ready-to-Cook Leaves of Melinjo (*Gnetum gnemon* L.) Vegetable

Kanokpon Bunya-atichart^{a,*}, and Ladawan Lerslerwong^b

^aDepartment of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Chumphon 86160, Thailand.

^bAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: kbkanok@gmail.com

Introduction

The final product of ready-to-cook packaging adds value to Melinjo (*Gnetum gnemon* L.), a local and rare fresh leafy vegetable of Southern Thailand. Melinjo leaves are available at local markets in Asia, Southeast Asia, and selected Pacific Ocean Islands. However, postharvest handling of ready-to-cook Melinjo leaves for the retailer scale has not been reported. This study aimed to investigate what kind of packaging, packing leaves pattern, storage temperature, and transport of ready-to-cook Melinjo will fit the distribution channel, refrigerated and shelf-life, for the retailer.

Methods

The first experiment, one hundred grams of detached young mature leaves of Melinjo, were pattern- and jumble packed in three packaging types, including Low-Density Polyethylene (LDPE) bag, Equilibrium Modified Atmosphere (EMA) bag, and foam tray and over with food wrapping film (TF). The packaging was stored at $13 \pm 2^\circ\text{C}$ and $92 \pm 6\% \text{RH}$ for 21 days. The second experiment, low temperature of storage suitable for ready-to-cook Melinjo in packaging at 4 and 8°C were identified. In the third experiment, the transport simulation for 24 hours of Melinjo packaging in a foam box with- and without ice was conducted. For assessment, the shelf life of Melinjo was based on percentage decay leaves, weight loss, and senescence score. Only the first and second experiments, internal quality, including ethylene production, carbon dioxide percent, chlorophyll, and carotenoid content, and fiber, were also evaluated through the storage period.

Results

The results showed that the most suitable packaging for ready-to-cook Melinjo leaves was the jumbled pattern packing in LDPE bag stored at 8°C , which related to the lowest percent of decay leaves and weight loss, low ethylene production, and high carbon dioxide. However, the shelf life of all packaging did not statistically significant difference, 23 – 27 days. Besides, packaging, packing leaves pattern, and storage at low temperature did not affect chlorophyll and carotenoid content, and fiber. For 24 hours of transport, the ready-to-cook Melinjo in LDPE and EMA bag packaging must use an iced foam box to increase shelf life's two folds, while those of TF packaging could be transported using only a foam box.

Conclusion

In conclusion, this postharvest handling for extending shelf life and maintain the internal quality of ready-to-cook Melinjo to increase economic value will be a benefit in practical for the retailer scale.

Keywords: packaging, packing pattern, storage, transport, local vegetable

Selected References:

1. Bunya-atichart, K.; Ketsa, S. *Philipp. Agric. Sci.*, 2014, 97, 43-49.
2. Ramos, B.; Miller, F.A.; Brandão, P.; Teixeira, C.I.; Silva, M. *Innov Food Sci Emerg Technol*, 2013, 20, 1-15.

Comparison of Mono-papaya and Papaya-banana Intercropping Systems on Growth, Fruit Quality, and Nutrients

Chutisorn Deemak^{a,*}, Supatchaya Nampila^a, Somyot Meetha^a, Supat Isarangkool Na Ayutthaya^a

^a *Department of Horticulture, Faculty of Agriculture, Khon Kaen University, 40002, Thailand*

*Corresponding author: Chutisorndeemak@kkumail.com

Introduction

Mono-papaya planting system in northeast Thailand has a major problem with the ringspot virus; also, the dry condition affects on growth, yield, and papaya's fruit quality. The intercropping system of many fruit crops, especially intercropped with banana, can improve fruit production. Therefore, this work aimed to evaluate the intercropping system between banana and papaya on growth, fruit quality, and plant nutrients of papaya.

Methods

This work was a comparison between the mono-papaya (MPS) and papaya-banana intercropping systems (PBS). The 'Khak Dam' papaya seedlings were planted at the fruit tree section, Faculty of Agriculture, Khon Kaen University, in February 2019. The period of this experiment ranged from February 2019-July, 2020. The treatment of papaya intercropped with banana was three rows of papaya and one row of banana. The growths (tree height, leaf number, and trunk girth at 15 cm above the soil), yield (fruit number), fruit size (weight, volume, length, and width), and fruit qualities (pulp thickness, firmness, total soluble solid titratable acidity, peel color, and pulp color) were measured. Also, the nutrient content, e.g., nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and boron (B) in leaf, petiole, trunk, and fruit were analysis when the papaya was in the fruiting stage.

Results

The 18 months on growth investigation showed that the tree height and a trunk girth of papaya increased like a pattern of the sigmoid growth curve but were not significantly different between MPS and BPS systems. Also, leaf number in 2 cropping systems was not a significant difference. The leaf number was around 22-25 leaves per tree in the fruiting stage. The fruit number also had no difference. The average fruit number per plant was 9.3-13.7 fruits per plant at 13 months after planting (MAP), but there was no fruit on the plant in May 2020 (16 MAP). Results in fruit qualities showed that the fruit weight and fruit width of the fruits from PBS bigger than MPS ($P < 0.05$), but the fruits from MPS had more red pulp color (color a value) than PBS. There were not significant in the other fruit qualities between MPS and PBS. In addition to plant nutrient analysis in the fruiting stage, the intercropping system does not affect all plant parts' nutrients.

Conclusion

Papaya-banana intercropping systems did not affect the plant growths, fruit number, and plant nutrients compared with the mono-papaya system. However, papaya-banana intercropping systems showed the potential to increase yield per plant by induced the bigger in fruit weight and fruit width.

Keywords: macronutrient, micronutrient, growth, yield

Alleviation of Postharvest Fruit Dehiscence of ‘Chanthaburi II’ Durian Using Gibberellic Acid and Chitosan Coating

Chalermchai Wongs-Aree^{a,b,*}, Preuk Choosung^a, Pathompong Penchaiya^b, Yossapol Palapol^c, Chuchart Wattanawan^d and Sompoch Noichinda^e

^aDivision of Postharvest Technology, School of Bioresources and Technology, King Mongkut’s University of Technology Thonburi (Bangkhuntien), Bangkok 10150, Thailand

^bPostharvest Technology Innovation Center, Ministry of Higher Education, Science, Research and Innovation, Bangkok 10400, Thailand

^cDepartment of Agricultural Technology, Faculty of Science and Arts, Burapa University, Chanthaburi 22170, Thailand

^dPostharvest and Product Processing Research and Development Office, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkok 10900, Thailand

^eDivision of Agro-Industrial Technology, Faculty of Applied Science, King Mongkut’s University of Technology North Bangkok, Bangkok 10800, Thailand

*Corresponding author:chalermchai.won@mail.kmutt.ac.th

Introduction

Durian cultivars of Thailand, such as ‘Monthong’, ‘Chanee’, or ‘Kanyao’ have long been reputable in the global market. However, a new series of ‘Chanthaburi’ hybrids were bred by a scientist team of the Department of Agriculture of Thailand to obtain differently desired manners of ripe fruit. Although ‘Chanthaburi II’, bred from ‘Chanee’ and ‘Puangmanee’ cultivars, has been officially registered as a new durian cultivar (010/2556) since May 14, 2013, the information about the physiological changes and the postharvest quality was limited. The husk dehiscence during ripening is one of the serious problems reducing the marketability. Here, we firstly reported some postharvest changes of ‘Chanthaburi II’ and some postharvest applications to reduce the fruit dehiscence. Gibberellic acid (GA₃)¹, chitosan coating², and the combination were arranged and applied to the fruit in the present study.

Methods

‘Chanthaburi II’ fruit (1.6-2.2 kg) were harvested at 90-95% maturation (95 days after anthesis) from a commercial orchard in Chanthaburi province, eastern Thailand. Fruit without diseases and defects were pre-treated in 4 different groups of non-treated control, coating with 1% chitosan, dipping in 100 mgL⁻¹ GA₃, and coating with 1% chitosan including 100 mgL⁻¹ GA₃. The experiment was managed as a completely randomized design with four replications (one fruit per replication). All fruit were allowed to operate normal ripening by incubating fruit at 25°C, 70-75% RH.

Results

The highest respiration and ethylene production rates of ‘Chanthaburi II’ fruit incubated at 25°C were produced at 471.3 mg CO₂·kg⁻¹·h⁻¹ and 40.4 μL C₂H₄·kg⁻¹·h⁻¹, which were both taken place on day 8. The respiration rates were slightly increased by the treatments. Fruit dehiscence was found within 7.7 days after incubation. The dehiscence of 1% chitosan-coated fruit, 100 mgL⁻¹ GA₃ dipped fruit, and 1% chitosan + 100 mgL⁻¹ GA₃ coated fruit was delayed to 8.0, 8.2, and 9.3 days, respectively.

Conclusion

Coating with 1% chitosan containing 100 mgL⁻¹ GA₃ delayed the fruit dehiscence of ‘Chanthaburi II’ durian by 1.5 days than non-treated fruit when stored at 25°C.

Keywords: *Durio ziberhinus* Merr., pericarp abscission, postharvest treatment

Selected References:

1. Webster, A.D; Spencer, J.E.; Dover, C.; Atkinson. C.J. *Acta Hort.*, **2006**, 727, 467-472.
2. Soe Win; Mejunpet, N.; Buanong, M.; Kanlayanarat, S.; Wongs-Aree, C. *Int. Food Res. J.* **2015**, 22, 2219-2224.

Phytochemical Components and Antioxidant Activities Changes in Fresh and Dried of Tropical Water Lily (*Nymphaea lotus* L.) Flower

Supasit Sitthapanich^a, Patimah Chaelae^a, Sunisa Sonsiri^a and Surassawadee Promyou^{a,*}

^aFaculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermphrakiat Sakonnakhon Province Campus, Sakonnakhon 47000, Thailand.

*Corresponding author: csnsrwd@ku.ac.th

Introduction

Tropical water lilies or *Nymphaea lotus* L. are an ornamental flower and used as a medicinal plant for several health benefits, especially cardiovascular protection and anticancer effect. Many countries, especially in Asia, have long been used as a non-caffeinated drink, which dominates intense antioxidant activity and is used for food ingredients. This study aimed to determine phytochemical components and antioxidant activity from three cultivars of *Nymphaea lotus* L. flower, namely 'Nymphaea Mrs. George H. Pring' (white petals), 'Nymphaea Pubescens Willd.' (pink petals), and 'Nymphaea Lindsey Woods' (purple petals) at difference stage as 3 and 5 days of flower opening separated in petals and carpel part.

Methods

Three cultivars of *Nymphaea lotus* L. were obtained from the farmer who is commercially grown Tropical water lilies in Sakon Nakhon Province, Thailand. The flower's petals and carpel were divided into two groups; the first group was fresh samples, and the second group was dried under hot air drying at 50 °C for 6 hr. The data were recorded as follows: 1) total phenolic contents were assayed using the method described by Abu Bakar et al. (2009) 2) the total antioxidant capacity by using Ferric reducing antioxidant potential (FRAP) assay as described by Benzie and Strain (1996) 3) DPPH free radical scavenging activity was determined according to the method of Braca et al. (2001).

Results

The results indicate that *Nymphaea lotus* L. cultivars 'Nymphaea Lindsey Woods' (purple petals) at five days of the flower opening with dried carpel part showed highest in phytochemical components as determined in total phenolic contents and antioxidant capacity while 'Nymphaea Mrs. George H. Pring' (white petals) and 'Nymphaea Pubescens Willd.' (pink petals) were not significantly different in total phenolic contents, FRAP and DPPH in fresh flower petals and carpels at 3 and 5 days of the flower opening. When comparing the amount of phenolic contents FRAP and DPPH between 3 and 5 days of flower opening, all the *Nymphaea lotus* L. cultivars at five days in fresh and dried petals and carpel parts had higher than the flower opening at three days. Among different parts of all *Nymphaea lotus* L. flower in this experiment, the highest of total phenolic contents and antioxidant capacity found in the carpel part with dried processes while in fresh petals showed the lowest in antioxidant activity.

Conclusion

Nymphaea lotus L. cultivars 'Nymphaea Lindsey Woods' (purple petals) at five days of the flower opening with dried carpel part exhibited the strongest antioxidant capacity among three cultivars of *Nymphaea lotus* L. Thus, the results also help develop different products as a non-caffeinated drink, which dominance in strong antioxidant activity from *Nymphaea lotus* L. flower.

Keywords: Tropical water lilies, flower opening, antioxidant activity, total phenolics

Selected References:

1. Abu Bakar, M.F.; Mohamed, M.; Rahmat, A.; Fry, J. Food Chem, 2009, 113, 479-483.
2. Benzie, I.F.F.; Strain, J.J. Anal. Biochem., 1996, 239, 70-76.
3. Braca, A.T.; Nunziatina, D.B.; Lorenzo, D.; Pizza, C.; Politi, M.; Morelli, I. J. Nat. Prod., 2001, 64, 892-895

Effect of Coating and Temperature on Quality and Manage the Rot Disease of the Nam Dok Mai Si Thong

Chadaphorn Choeichaiyaphum^a and Supatchaya Nampila^{a,*}

^a Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

*Corresponding author: rumpna@kku.ac.th

Introduction

Mango (*Mangifera indica* L.) cv. Nam Dok Mai Si Thong is the economic fruit. Mango production is still faced with the problem of destroying fruit rot disease. The objective of this study was to the effect of coating and temperature on quality and managed the rot disease of the 'Nam Dok Mai Si Thong' mango.

Methods

Experiments were conducted based on a 6 x 2 factorial in a completely randomized design. Two Control Di and Control 42°. Two Chitosan wax concentrations (1.5 and 2%). Three carnauba wax concentrations (20 and 25%). Inoculation type of *Lasiodiplodia theobromae* and two storage temperatures (10 and 25 °C) were used. Samples were randomly collected every three days.

Results

It was found that 'Nam Dok Mai Si Thong' mango at 3-12 days showed skin color changes. L*, a* and b* values of pulp and rind in all treatments tended to increase over the storage period, showing that there was no change. From green to yellow with longer shelf life and weight loss was proportional to the increase in storage temperature. The physical characteristics from the preservation of the yield. After 12 days of storage, the physical characteristics of mango fruit were no different. All processes' firmness tended to decrease in firmness due to the increased storage time equal to 53.57-1 Newton. In addition, disease incidence was found in mango fruit to show symptoms after harvesting. Increased treatment throughout the retention period of all processes and changes in chemical quality. The amounts of soluble solids tended to increase. In contrast, the amount of titrated acid was reduced.

Conclusion

Mango cv. Nam Dok Mai Si Thong fruits was coated with carnauba wax 20% and stored at 10 °C, could reduce disease incidence of *Lasiodiplodia theobromae* and storage life could be extended to 12 days compared to only nine days for the control 42° and stored at 25 °C.

Keywords: Mango, *Lasiodiplodia theobromae*, Chitosan, Carnauba

Chitosan and Sodium Alginate - Double Coatings Integrated with Sweet-Flag Extract Affecting the Postharvest Quality of ‘Nam Dok Mai’ Mango

Juthamard Promboon^a, Piyasak Chaumpluek^b, Pathompong Penchaiya^c, Sudarat Khunmuang^c and Chalermchai Wongs-Aree^{a,c,*}

^aDivision of Postharvest Technology, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi (Bangkhuntien), Bangkok 10150, Thailand

^bDepartment of Botany, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand

^cPostharvest Technology Innovation Center, Ministry of Higher Education, Science, Research and Innovation, Bangkok 10400, Thailand

*Corresponding author: chalermchai.won@mail.kmutt.ac.th

Introduction

‘Nam Dok Mai’ mango is one of Thailand’s potential fruits, sold both in domestic and worldwide markets. Apart from rapid fruit ripening, the ripe ‘Nam Dok Mai’ mango fruit is susceptible to disease infections, in particular anthracnose. Chitosan coating has been introduced to maintain the postharvest quality of fresh fruits. However, ordinary coating methods could not completely protect the whole fruit adequately. In this present study, a modified coating technique using ionic linkage between 2 different chitosan and sodium alginate charges applied on mango was introduced. An extract from dried sweet flag was subsequently added into the chitosan layer to investigate disease growth during retailing.

Methods

‘Nam Dok Mai No#4’ fruit at the mature green stage of 110-120 days after anthesis were collected from a commercial orchard in Chachoengsao province, Thailand. Fruit were sorted for uniformity of size (average 420 g), colour, and free from defects. Fruit were washed in 200 mg·L⁻¹ sodium hypochlorite for 5 min. Fruit were then separated into 4 treatments of (1) non-coated control; (2) 0.5% chitosan (1st layer) and 0.1% sodium alginate (SA) (2nd layer) coated fruit; (3) 0.5% chitosan + 500 mg·L⁻¹ Prochloraz® (1st layer) and 0.1% SA (2nd layer) coated fruit; and (4) 0.5% chitosan + 1,000 mg·L⁻¹ sweet flag extract (1st layer) and 0.1% SA (2nd layer) coated fruit. The experiment was managed as a completely randomized design with six replications (one fruit per replication). All fruit were incubated at 25°C, 70-75% RH.

Results

Sweet flag extract at ≥ 1000 mg·L⁻¹ completely *in vitro* inhibited the growth of *Colletotrichum gloeosporioides* compared to other extracts (galangal at 5,000 mg·L⁻¹ and lemongrass at $\geq 20,000$ mg·L⁻¹). All double coating treatments delayed the peel colour changes and the increasing soluble solids of flesh during nine storage days. Double coatings of 0.5% chitosan + 1,000 mg·L⁻¹ sweet flag extract and 0.1% SA significantly reduced disease severity on fruit. Increasing the concentration of sweet flag extract in the chitosan layer showed a better reduction. However, above 5,000 mg·L⁻¹ caused mango peel injury.

Conclusion

Double layers of 0.5% chitosan + 1,000 mg·L⁻¹ sweet flag extract and 0.1% SA coated on ‘Nam Dok Mai’ mango slightly delayed the ripening and significantly reduced fruit disease severity at 25°C storage.

Keywords: layer by layer coating, mango, *Acorus calamus* L., retailing condition

Tolerance Evaluation of 10 Tian Corn Inbred Lines Under Temporary Waterlogging Condition

Suchada boonlertnirun^{1*} Laongsri Sirikesorn¹ and Kitti boonlertnirun¹

Agricultural Technology and Agro-industry Faculty, Rajamangala University of Technology Suvarnabhumi, Phra Nakhon Si Ayutthaya Province, 13000, Thailand

* Corresponding author, Email address: suchada.b@rmutsb.ac.th

Abstract

Tian corn is an important crop at the community economy level in central region of Thailand, where is a flood plain with clay soil that has poor drainage. The objective of this research was to evaluate 10 inbred lines of tian corn for tolerance to temporary waterlogging stress. It was carried out using split plot in Randomized complete block design, with the main plots being 15 days of waterlogging versus normal watering and the subplots being 12 genotypes, comprising 10 sixth generation (S6) inbred lines and 2 open pollinated check varieties. The results showed that waterlogging showed significantly negative effects on leaf greenness, chlorophyll content, leaf area, and shoot dry weight. The check varieties TAY 60 and TBK had the best waterlogging tolerance, better than all the inbred lines tested. Of the inbred lines, RSTi#8 had the best waterlogging tolerance. The parameters of leaf greenness and chlorophyll content were found to be poor indicators of waterlogging tolerance for tian corn

Keywords: Tolerance, inbred lines, waterlogging stress, waxy corn, *Zea mays* L.

Yield and Quality Evaluation Trials of Purple Sweet Waxy Corn Hybrids

Kitti Boonlertnirun^{1*}, Supaporn Pajareon², and Suchada Boonlertnirun¹

¹*Plant Science section, Faculty of Agricultural technology and Agro-industry, Rajamangala University of Technology Suvarnabhumi, Pranakhon Si Ayuthaya, 13000, Thailand*

²*Food Science section, Faculty of Agricultural technology and Agro-industry, Rajamangala University of Technology Suvarnabhumi, Pranakhon Si Ayuthaya, 13000, Thailand*

* Corresponding author, Email address: kitti.b@rmutsb.ac.th

Abstract

Purple sweet waxy corn is a very nutritious food. Developing a new hybrid with good eating quality and high yield could help boost farmers' income. In this research we crossed a sweet waxy corn containing the sugary gene with a purple waxy corn as the base population, then selected inbred lines. The fourth generation of selfed plants segregated into 2 groups: 30 lines of white sweet waxy corn and 5 lines of purple sweet waxy corn. These were crossed and 50 hybrid lines were selected and grown in field trials in 2 locations (Ayutthaya and Chachoengsao) with 8 commercial varieties. The experiment was done in 2 replications in RCB in each location. The hybrid L15/T3 gave the highest yield, ear size was appropriate and the eating quality was good, with high sugar content and medium anthocyanin content. The hybrids L15/T4, L16/T1, and L19/T4 also gave high yield but their sugar was only medium.

Keywords: Waxy corn, Purple corn, Sugary gene, F₁ hybrid.

Yield and Nutritional Composition of Sweet Potato Tips Genotypes with Varying Fleshed Colors and Various Application Fertilizer

Laongsri Sirikesorn^{a*} and Suchada Boonlertnirun^a

^aDepartment of Plant Science, Faculty of Agricultural Technology and Agro-Industry, Rajamangala University of Technology Suvarnabhumi, Huntra Sub-district, Phra Nakhon Sri Ayutthaya, 13000, Thailand

*Corresponding author: srisiri64@gmail.com, laongsri.s@rmutsb.ac.th

Abstract

Sweet potato young shoots (tips), comprised of young leaf and stalk, are consumed for daily diet or functional food in many countries. This study aimed to investigate the food potential of 5 sweet potato tips genotypes (Kapi, Pakchong, Carrot, Okud, and Japanese yellow) include various application fertilizers. The tips yield was the highest in Pakchong and also exhibited high antioxidant activity. Japanese yellow leaf had a greater amount of carbohydrate, fat, fiber, and ash (38.20, 0.11, 22.19, and 6.45 g/100gDW, respectively) than others accompanied by the highest content of antioxidants and antioxidant activity which was related to phenolic (0.71[DPPH], and 0.84[FRAP]). The fertilizer application based on soil testing can increase tips yield, some nutritional composition (fat, moisture content), and antioxidants (phenolic, anthocyanin) of the Pakchong leaf. While, conventional application fertilizer also extended the Pakchong leaf area, leaf greenness, chlorophyll content, and carbohydrate. Besides, the Pakchong leaf had the greatest protein and antioxidants although without fertilizer. These findings suggest the food potential of Pakchong tips by high tips yield and nutritional composition attributes.

Keywords: sweet potato tips, sweet potato leaf, nutritional composition, antioxidants, antioxidant activity

Promoted Early Flowering and Sweetness of Edible Curcuma Inflorescence by Nutrient Management

P. Hongpakdee^{1*}, C. Inkham² and S. Ruamrungsri²

¹Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

²Department of Plant and Soil Science, Faculty of Agriculture, Chiang Mai University, Chiangmai, Thailand

*Corresponding panupon@kku.ac.th

Introduction

Edible *Curcuma* is considered a nutritionally abundant food products since it contains a rich source of starch, carbohydrate, protein and vitamins. Various part of this species has been reported eaten in many Asian countries.

Methods

The study was conducted in CRD with four biofertilizer application rates as a treatment, i.e., 0, 3.75, 7.50, and 15.00 g/plant. All plants were grown in plastic bags contain mixed media under the greenhouse condition for 110 days after planting. Plant growth and flower quality were investigated.

Results

The 3.75 g/plant biofertilizer rate (T2) application gave the better plant height, canopy width, inflorescence length, inflorescence fresh weight, blooming day, and bracts number, but it not significantly different with control treatment (non-fertilizer), except for the time for flowering. This application rate was weekly faster flowering than non-fertilizer treatment (T1). While 15.00 g/plant application rate was enhanced flower quality via the higher sweetness °Brix value than the typical plant.

Conclusion

The recommended biofertilizer rate for proper nutrient management as better growth with fast blooming and sweeter inflorescence yields of edible fresh inflorescence *Curcuma* was 3.75 g/plant.

Keywords: *Nelumbo nucifera* Gaertn., water cooling temperature, total non-structural carbohydrate, reducing sugar.

Application of Gibberellic Acid to Improve the Seed Germination of Commercial Cactus Varieties

Timapon Artnafai^a, and Ladawan Lerslerwong^{a,*}

^aAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: ladawan.l@psu.ac.th

Introduction

The problem of germinating the cactus seeds is the low percentage rate due to its innate dormancy, preventing seed germination on the mother plant and for a time after dispersal. Gibberellins play a crucial role in physiological dormancy release and the promotion of seed germination in several plant species. However, the GA₃ application data for increasing the germination rate of commercial cactus varieties has not been reported. Therefore, the objective aimed to study the response of cactus seed germination to GA₃ treatments.

Methods

The seed of seven cacti, *Echinocactus grusonii*, *Mammillaria schumannii* and *albilanata*, *Melocactus matazanus*, *Gymnocalycium ochoterenae*, *Fraliea grahliana*, and *Ferocactus peninsulae*, which are favorite type in commercial varieties in Thailand, were used. The experiment was conducted in 7x4 factorial in the Completely Randomized Design (CRD) with ten pots or replications, 25 seeds/pot. Seeds were soaked in GA₃ solutions, i.e., 0, 25, 50, and 100 mL⁻¹ for 12 hours and then sown in the sowing media (peat moss and perlite, ratio 1 : 1). The germinated seeds were counted and calculated to the germination percentage and germination index every five days for one month.

Results

The results showed that there were two groups of cactus seeds. The first group was the germination rate less than 60%; i.e., *E. grusonii* (28%), *G. ochoterenae* (34%), *M. matazanus* (40%), and *F. grahliana* (56%). These cactus seeds responded to GA₃ treatments at 50, 25, 100, and 25 mL⁻¹, respectively, with an increase in the germination rate compared to control. Moreover, the germination index correlated with GA₃ concentration that improved the germination rate of each variety. The second group was a germination rate of more than 60%, i.e., *F. peninsulae* (67%), *M. albilanata* (76%), and *M. schumannii* (90%). For this group, the application of GA₃ did not affect the germination percentage. Furthermore, the germination index was not related to GA₃ treatments.

Conclusion

Application of GA₃ can improve the seed germination of some cactus varieties, *E. grusonii*, *G. ochoterenae*, *M. matazanus*, and *F. grahliana* germination rate <60%. In contrast, GA₃ did not affect the seed germination of *F. peninsulae*, *M. albilanata*, and *M. schumannii*, which germination percentage >60%.

Keywords: Cactaceae, Seed, Dormancy, Germination, Gibberellins

Selected References:

1. Rojas-Aréchiga, M. and Vázquez-Yanes, C. *Journal of Arid Environments*, 2000, 44, 85-104.
2. Rojas-Aréchiga, M.; Aguilar, K.M.; Golubou, J.; and Mandujano, M.C. *The Southwestern Naturalist*, 2011, 56, 393-435.

Stability Study of Select Mulberry Lines Based on Growth, Antioxidant and Chemical Compounds

Tanaporn Kajonphol^a, Wattawatit Chaisaentao^a, and Chontira Sangsiri^{b*}

^aFaculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Sakon Nakhon 47000, Thailand.

^bAgricultural Sciences Program, Mahidol University, Kanchanaburi Campus, Kanchanaburi 71150, Thailand.

* Corresponding author: chontira_sangsiri@yahoo.com

Introduction

Mulberry is in the Moraceae family. It is widely distributed in subtropical, tropical, and temperate regions of Asia, Europe, America, and Africa. Mulberry is good adaptability in different environment. In Thailand, mulberry can grow in all regions and commonly in the northern and northeastern regions. Mulberry fruit (*Morus nigra* L.) rich in carbohydrate, vitamin C, iron, and micronutrient and bioactive and antioxidants (Linghong *et al.*, 2012). This experiment aimed to study selected mulberry lines compared with control varieties by the chemical components and the morphological characteristics were studied in Kanchanaburi Province.

Method

Five selected mulberry lines viz. SKNM15101 SKNM15102 SKNM1510 SKNM15107 and SKNM15109 were compared with Chiang Mai variety as a control. Data collection of characteristics according to the BBCH scale system. (Sánchez-Salcedo *et al.*, 2017). In addition, all lines were studied on total solution solid; TSS, Titratable Acidity; TA, TSS/TA ratio, Ascorbic Acid Analysis, DPPH Radical Scavenging Activity, Total Phenolic Content; TPC in fruits. The statistical analysis was completed randomized design (CRD) with replications. This research was conducted at the Agricultural field in Sai Yok district, Kanchanaburi province, Thailand.

Results

The height of selected mulberry lines was 0.7-4.04 m, length of the canopy was the range of 0.17-4.36 m, and the length of the branches was in the range of 86.25-461.13 cm. Flower buds number was 33-3,012 buds. The analysis of chemical components in fresh fruits of selected mulberry lines showed that total soluble solid (TSS) of mulberry ranged from 14.03-17.27 °brix, the titratable acid (TA) content of mulberry fruit was in the range of 0.009-0.050%, the TSS / TA ratio of mulberry fruit was in the range of 293.46-1582.31, vitamin C content was in the range of 1.33-3.06 (mg/g DW). The antioxidant content of selected lines of mulberry was between 49.04-76.78%.

Conclusion

From the result, we found that SNK M15101 and SNK M15107 were fast growing based on plant height, canopy, and branches length. Moreover, SKNM15104, SNKM15107, and SKNM15101 gave higher TPC contents than the Chiang Mai variety (control). The total phenol content of the mulberry fruit was in the range 884.84-1347.90 (mgGAE /100g).

Keywords: Mulberry Fruit, Antioxidant Activity, Phenolic Compound, Vitamin C

Selected References:

1. Linghong, L.; Wu, X.; Zhu, M.; Zhao, W.; Li, F.; Zuo, Y.; Yang, L. *Journal of pharmacognosy magazine*, **2012**, 215-224.
2. Sánchez-Salcedo, E.M.; Martínez-Nicolás, J.J.; Hernández, Fca. *Journal of Annals of Applied Biology banner*, **2017**, 171: 441-450.

Effect of Coating and Temperature during Storage on Phenolic, Lycopene and β -Carotene Content of 'Nam Dok Mai Si Thong' Mango

Supatchaya Nampila^{a,*} and Chadaphorn Choeichaiyaphum^a

^a Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

*Corresponding author: rumpna@kku.ac.th

Introduction

Mango (*Mangifera indica* L.) cv. Nam Dok Mai Si Thong is the economic fruit. During storage and export, mango's problem is that the products' quality decreased and not acceptable to consumers. The coating has been used to prolong the shelf life of fresh fruits. Moreover, optimal storage temperatures can maintain the quality of harvested fruits and could prolong shelf life. This study aimed to investigate the effect of carnauba wax and temperatures during storage on Phenolic, Flavonoid, and β -Carotene on Nam Dok Mai Si Thong.

Methods

Experiments were conducted based on a 6 x 2 factorial in a completely randomized design. Two chitosan wax concentrations (1.5 and 2%) and three carnauba wax concentrations (20 and 25%) and two storage temperatures (10 and 25 °C) were used. Samples were randomly collected every three days.

Results

The results showed that Phenolic, Lycopene, and β -carotene content tend to decrease after an extended time of storage. It should be concluded that with good taste and high content of lycopene and beta-carotene on Nam Dok Mai Si Thong mango should be storage at nine days.

Conclusion

Mango cv. Nam dok mai si thong fruits were coated with carnauba wax 20% and stored at 10 °C showed high content of lycopene and beta-carotene Nam Dok Mai Si Thong mango.

Keywords: Antioxidants, Mango, Chitosan, Carnauba

Chemical Composition, Antioxidant and Antibacterial Activities of Ultrasound-Assisted Extract of *Annona squamosa* L. Leaves

Pornpun Siramon^{1a,*} and Thitima Wongsheree^{2b}

^aKing Mongkut's University of Technology Thonburi (Ratchaburi Campus), Rang Bua, Chom Bueng, Ratchaburi 70150, Thailand.

^bInstitute for Scientific and Technological Research and Services, King Mongkut's University of Technology Thonburi, Bangkok 10140, Thailand.

*Corresponding author: siramon_p@hotmail.com

Introduction

This research aimed to determine the optimal extraction condition of the bioactive compounds from *Annona squamosa* leaves by ultrasound-assisted solvent extraction. The chemical compositions of the crude extract were analyzed by a liquid chromatography-electrospray ionization-mass spectrometer (LC-ESI-MS). The antioxidant and antibacterial activities of the crude extract were investigated.

Methods

1. To collect the *A. squamosa* leaves from a plantation in Chom Bueng District, Ratchaburi province, Thailand.
2. To extract the bioactive compounds from *A. squamosa* leaves using ultrasound-assisted solvent extraction and the optimal extraction condition was determined.
3. To analyze the chemical compositions of crude extract from the optimal extraction condition by LC-ESI-MS.
4. To evaluate the antioxidant activity of crude extract by the 1,1-diphenyl-2-picrylhydrazyl (DPPH) and 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) methods.
5. To determine the antibacterial activity of the crude extract against three human pathogenic strains: *Staphylococcus aureus* DMST 8840, *Staphylococcus epidermidis* DMST 15505 and Methicillin-resistant *Staphylococcus aureus* (MRSA) DMST 20651.

Results

The extraction of *A. squamosa* leaf sample with 50% (aq) of ethanol at 50 °C for 60 minutes provided the highest crude extract yield of 30.5% on a dry basis and this condition gave the highest total phenolic content of 307.67 µg GAE/g DW and total flavonoid content of 16,893.92 µg CE/g DW. The chemical compositions of the crude ethanolic extract from the optimal extraction condition were analyzed by LC-ESI-MS. Quercetin-3-O-rhamnosylglucoside (Rutin) (MW 610) and Norisocorydine (MW 327) were detected in the crude extract. The antioxidant assay results showed that the crude extract exhibited an antioxidant activity with IC₅₀ of 947.99 µg/ml by DPPH and 620.89 µg/ml by ABTS, respectively. The crude extract also exhibited antibacterial activity against all tested bacterial strains with minimal inhibitory concentration (MIC) values in the range of 12.80-25.60 mg/ml and minimal bactericidal concentration (MBC) value of 25.60 mg/ml.

Conclusion

This research has revealed that the *A. squamosa* leaves, an abundant agricultural waste, rich in phenolics and flavonoids exhibited effective antioxidant and antibacterial activities, which could be alternative potential natural source antioxidants and antibacterial agents.

Keywords: *Annona squamosa* L., Antibacterial activity, Antioxidant activity, Chemical composition, Ultrasound-assisted extraction (UAE)

Effect of Coating and Temperature on the Quality, Extend the Shelf life of 'Nomsod' Indian Jujube Produced in the Phon Sub-district, Kalasin Province, Thailand

Sasithorn Niyanut^a and Supatchaya Nampila^{b,*}

^aFaculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

^bDepartment of Horticulture, Khon Kaen University, Khon Kaen 40002, Thailand.

*Corresponding author: rumpna@kku.ac.th

Introduction

Jujube (*Zizyphus mauritiana* Lamk.) 'Nomsod' Indian jujube is an economical fruit crop and a promising new jujube cultivar in Northeast Thailand. Jujube fruit is a climacteric fruit. Jujube can be stored for a short time and still experience post-harvest handling problems. This study's objective was to the effect of coating and temperature on the quality, extend the shelf life of Indian jujube 'Nomsod' produced in the Phon sub-district, Kalasin province, Thailand.

Methods

Samples of jujube (*Zizyphus mauritiana* Lamk.) were harvested from the orchard at Baan Pon, Tambon Pon, Amphoae Kham Muang, Kalasin province in the northeast of Thailand. The experiment arranged Factorial 5x4 in CRD divided into two factors: Control, Chitosan wax 0.5%, Chitosan wax 1.0%, Sucrose esters 5%, and Sucrose esters 10% and storage at temperature 5, 10, 15 °C and 25 °C.

Results

The study of the effect of coating and temperature on the quality extends the shelf life of Indian jujube 'Nomsod' produced in the Phon sub-district, Kalasin province, Thailand. It was found that 'Nomsod' jujube showed changes in skin color at 3-12 days. The change in L* and b* tended to increase, while a* tended to decrease over the storage period. There is also a change of color from green to brown fruit with a longer shelf life and decreased fruit weight loss. Because jujube fruit is a climacteric fruit, it is susceptible to skin browning, decay, perishable, and water loss. The firmness of the fruit tends to decrease equal to 49.31-16.60 N due to the long storage period. As well as high vitamin C content on the 3rd day after that tends to decrease. The storage time also affected the fruit chemical than the change in which the soluble solids tended to increase during the storage period of the 6th day and decrease on 9-12th days, from the amount of titrated acid is relatively stable.

Conclusion

The results extend the shelf life of Indian jujube found that 10% sucrose esters coated used in conjunction with storage at temperature 5 °C, can be stored at 12 days, that the optimum storage. That can slow down and reduce the weight loss of the best product.

Keywords: 'Nomsod' indian jujube, Sucrose esters, Chitosan, Storage temperature, Shelf life

Agriculture – Plant Science

Surveys and Characterization of Plant-parasitic Nematodes Associated with Medicinal Plants

Phornthawon Phanbut^{ab}, Anongnuch Sasnarukkit^a, Thanunchanok Chairin^b and Buncha Chinnasri^{a,*}

^aDepartment of Plant Pathology, Faculty of Agriculture, Kasetsart University, Bangkok, 10900, Thailand.

^bDepartment of Pest Management, Faculty of Natural Resources, Prince of Songkla University, HatYai, Songkhla 90110, Thailand.

*Corresponding author, Email address: Email: agrbcc@ku.ac.th

Thailand is rich in medicinal plants in nature and has a long history of utilization of these valuable crops in various ways; for example as traditional medicines or in culinary purposes. Plant-parasitic nematodes are one of the most significant threats to the quality and quantity of medicinal plants. Therefore, this current research project focuses on determination of the impact and characterization of plant-parasitic nematode in Thai medicinal plants. So far, surveys have been done in Phu Phan district of Sakon Nakorn province since February 2020. Soil samples were randomly collected from the rhizosphere of *Curcuma longa* L., *Curcuma mangga* Valeton & Zijp, *Kaempferia parviflora*, *Boesenbergia rotunda* (L.) Mansf, *Centella asiatica*, *Zingiber montanum*, *Persicaria odorata*, *Morinda citrifolia* L., *Indigofera tinctoria* and *Melientha suavis*. Nematodes were extracted from soil by the Cobb's Sieving and Baermann Funnel methods and identification conducted based on nematodes' morphological characteristics. As the results, three nematode genera including *Meloidogyne*, *Helicotylenchus* and *Tylenchulus* were found associated with these medicinal plants. *Meloidogyne* spp. was the most prevalent and observed at greatest densities in soil collected from medicinal plants. Furthermore, the medicinal plant *Persicaria odorata* was shown to harbour highest number of plant-parasitic nematodes, followed by *Curcuma mangga* Valeton & Zijp, and *Centella asiatica*, respectively.

Keywords: Medicinal Plants, Phu Phan district, Plant-parasitic Nematodes, Root-knot Nematode

Trichoderma Species Associated with Green Mold Disease of *Ganoderma lingzhi* in Thailand

Chosita Ubolsuk^a and Chaninun Pornsuriya^{a,*}

^aAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90110, Thailand.

*Corresponding author: chaninun.p@psu.ac.th

Introduction

Lingzhi or Reishi mushroom (*Ganoderma lingzhi*) have been used in traditional Chinese medicine for over two thousand years in Asian regions. *Ganoderma lingzhi* has been regarded as the mushroom of immortality (Stamets, 2000; Loyd et al., 2018). Green mold disease, caused by *Trichoderma* species, is a serious problem for Lingzhi growers. Several *Trichoderma* species such as *T. aggressivum*, *T. atroviride*, *T. harzianum*, *T. longibrachiatum*, *T. pleurotum* and *T. pluerotocola* have been reported as green molds pathogen in commercial mushroom farms worldwide (Samuels et al., 2002; Lu et al., 2016; Yan et al., 2019; Zhang et al., 2019). Recently, green mold disease of lingzhi mushroom caused by unknown species of *Trichoderma* was found in lingzhi farm at Songkhla province southern Thailand. Therefore, the aim of this research was to identify the species of the causal agent.

Methods

Trichoderma species were collected from *G. lingzhi* spawn to isolate and identify based on morphological characteristics and DNA sequence of the internal transcribed spacer (ITS) regions. The phylogenetic tree was constructed by maximum likelihood analysis base on the ITS sequence comparison with sequences of ex-type culture from closely related taxa.

Results

Three species of *Trichoderma* were identified. The occurrence of each *Trichoderma* species was *T. harzianum* (25%), *T. pleuroticola* (41.67%) and *T. reesei* (33.33%).

Conclusion

A total of three *Trichoderma* species were identified as *T. harzianum*, *T. pleuroticola* and *T. reesei*. *T. pleuroticola* was the dominant species on *G. lingzhi* spawn. *Trichoderma reesei* is a first report of green mold disease of *G. lingzhi* in Thailand.

Keywords: *Ganoderma lingzhi*, green mold disease, *Trichoderma* species

Selected References:

- Loyd, L. A.; Richter, S. B.; Jusino, A. M.; Truong, C.; Smith, E. M.; Blanchette, A. R., Identifying the “Mushroom of Immortality”: Assessing the *Ganoderma* Species Composition in Commercial Reishi Products. *Frontiers in Microbiology*, **2018**, 9, 1557.
- Lu, H. B.; Zuo, B.; Liu, L. X.; Feng, J.; Wang, M. Z., *Trichoderma harzianum* causing green mold disease on cultivated *Ganoderma lucidum* in Jilin Province, China. *Plant Disease*, **2016**, 100, 2524.
- Samuels, J. G.; Dodd, L. S.; Gam, W.; Castlebury, A. L.; Petrini, O., *Trichoderma* species associated with green mold epidemic of commercially grown *Agaricus bisporus*. *Mycologia*, **2002**, 94, 146-170.
- Stamets, P., Growing Gourmet and Medicinal Mushrooms. *Berkeley*, **2000**, CA: Ten Speed Press.
- Yan, Y.; Zhang, C. L.; Moodley, O.; Zhang, L.; Xu, J. Z., Green Mold Caused by *Trichoderma atroviride* on the Lingzhi Medicinal Mushroom, *Ganoderma lingzhi* (Agaricomycetes), *International Journal of Medicinal Mushrooms*, **2019**, 21, 515-521.
- Zhang, T.; Lu, M.; Zhang, C. L.; Xu, J. Z., First report of *Trichoderma longibrachiatum* causing green mold on *Ganoderma lingzhi*. *Plant Disease*, **2019**, 103, 156.

Potential of Edible Mushroom *Pleurotus* spp. for the Biocontrol of Root-knot Nematode (*Meloidogyne incognita*) and Their Cuticle Degrading Enzyme Production

Kanyani Chaiyadit^a, Thanunchanok Chairin^{a,b,*}

^a Agricultural Innovation and Management Division (Pest Management), Faculty of Natural Resources, Prince of Songkla University, 15 Kanjanavanich Rd., Hat Yai, Songkhla 90110, Thailand

^b Pest Management Biotechnology and Plant Physiology Laboratory, Prince of Songkla University, 15 Kanjanavanich Rd., Hat Yai, Songkhla 90110, Thailand

*Corresponding author: Thanunchanok.c@psu.ac.th

Introduction

Root-knot nematodes cause serious damage and yield losses in a wide range of crops throughout the world (Vestergård, 2019). In order to control root-knot nematode, the use of chemical nematicides are useful but can cause side effects on the environment and humans health (Kalaiselvi et al., 2019). A wide variety of fungi has been studied for nematode control purpose. Genus *Pleurotus* is reported as nematophagous fungi (Sufiatea et al., 2017). Thus, the purpose of this research was to select the effective *Pleurotus* sp. for controlling root-knot nematode (*Meloidogyne incognita*) in laboratory condition and to look for its biological characteristics.

Methods

The antagonistic potential of genus *Pleurotus*, i.e., *Pleurotus* sp. from Bhutan 4 isolates, *P. sajor-caju* 1 isolates, *P. cystidiosus* 2 isolates and *Pleurotus* sp. from Hungary 1 isolates for controlling root-knot nematode (*Meloidogyne incognita*) under laboratory condition were examined and selected the most effective fungi to inhibit egg hatching and increase mortality rate of infective stage juvenile (IJ) of root-knot nematode. The protease activity was determined by spectrophotometry method. The concentration of protein was determined according to the procedure of Bradford (1976) using bovine serum albumin (BSA) as the standard.

Results

The egg hatching were significantly inhibited by *Pleurotus* sp. from Hungary (No. 1) and *Pleurotus* sp. from Bhutan (No. 3) as 13.33 ± 7.69 and $15.00 \pm 8.38\%$, respectively within 48 hr. Moreover, both species caused mortality of IJ as 23.33 ± 8.60 and $18.33 \pm 6.38\%$ within 24 hr, that significantly higher than the other *Pleurotus* and distilled water (control). *Pleurotus* sp. from Hungary (No. 1) and *Pleurotus* sp. from Bhutan (No. 3) (the selected *Pleurotus*) growth rapidly on PDA at $28 \pm 2^\circ\text{C}$ and toxin droplets were found on fungal hyphae within 12 hr post incubation. The selected *Pleurotus* could produce protease on agar medium with 1% skim milk substrate. The specific activities of protease were 0.272 ± 0.464 and 0.171 ± 0.157 U/mg protein when *Pleurotus* sp. from Bhutan (No. 3) and *Pleurotus* sp. from Hungary (No. 1) were cultured on protein-enriched media.

Conclusions

Pleurotus sp. from Hungary (No. 1) and *Pleurotus* sp. from Bhutan (No. 3) were selected for controlling *M. incognita* because their biological characteristics including (1) require short time of cultivation; (2) ability to produce protease, a cuticle degrading enzyme; and (3) ability to secrete nematode toxin. Furthermore, the antagonistic potential to control root knot nematode disease in the field need to be conducted.

Keywords: *Pleurotus*/ Antagonistic fungi/ Root- knot nematode / Protease

Selected References:

- Bradford, M.M. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding, *Analytical Biochemistry*, **1976**, 72, 248-254.
- Kalaiselvia, D.; Mohankumara, A.; Shanmugama, G.; Thiruppathia, G.; Nivithab, S.; Sundararaja, P. Altitude-related changes in the phytochemical profile of essential oils extracted from *Artemisia nilagirica* and their nematicidal activity against *Meloidogyne incognita*, *Industrial Crops and Products*, **2019**, 139, 1-8.
- Sufiatea, B.L.; Freitas Soares, F.E.; Moreiraa, S.S.; Souza Gouveiaa, A.D.; Monteirob, T.S.A.; Freitasb, L.G.; Queiroza, J.H. Nematicidal action of *Pleurotus eryngii* metabolites, *Biocatalysis and Agricultural Biotechnology*, **2017**, 12, 216-219.
- Vestergård, M. Trap crops for *Meloidogyne hapla* management and its integration with supplementary strategies, *Applied Soil Ecology*, **2019**, 134, 105-110.

Prey Preference and Predation Efficacy of *Sycanus collaris* (F.) (Hemiptera: Reduviidae) on *Tenebrio molitor* (L.) (Coleoptera: Tenebrionidae)

Pornsawan Poopat^a and Tewee Maneerat^{a,*}

^aAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: tewee.m@psu.ac.th

Introduction

An assassin bug, *Sycanus collaris* (F.), was reported its potential as a biological agent to control Lepidopteran caterpillars and suggested that *S. collaris* should be mass reared and released in biocontrol programs (Ambrose and Ganesh Kumar, 2016; Rajan et al., 2017). *Sycanus collaris* was previously shown that the predator could be reared on yellow mealworm, *Tenebrio molitor* (L.) (Maneerat and Sakarind, 2018). However, little was known about size and stage of yellow mealworm used to feed different stages of *S. collaris*. Feeding the predator with its preferred prey could improve feeding capacity, survival (Pravalika et al., 2016) and possibly reproductive output which was advantageous to the mass rearing program. The aim of this study was to 1) determine *T. molitor* size and stage preference of *S. collaris* as the predator developed and 2) investigate how different prey sizes and stages affected predator survival, developmental time and number of preys consumed.

Methods

Stock cultures of *T. molitor* and *S. collaris* were maintained under laboratory conditions. Four *T. molitor* prey choices tested were small, medium and large sized larvae and pupae. Second to fifth instar and adult *S. collaris* were studied its prey preference and predation efficacy using choice- and no-choice test, respectively. Prey sucking behavior was used to determine the predator preference. In no-choice test, nymphal developmental time, adult lifespan and predation efficacy among treatments were compared using one-way analysis of variance.

Results

Choice test revealed that the most preferred prey of second, third, fourth and fifth instars were small larvae (55%), medium larvae (33%) and pupae (33%), large larvae (40%), and medium larvae (80%), respectively. Female and male preferred large sized larvae the most (56% and 44%, respectively). In no-choice test, four prey choices did not affect developmental time in second to fourth instar, but fifth instar grew faster when fed on pupae compared to medium larvae. Large larvae reduced survival rates in second and third instars. Pupae enhanced female lifespan but did not affect male lifespan.

Conclusion

Predator preference changed as they developed. Prey size and stage should be considered in the mass rearing of *S. collaris*. Future studies should investigate *S. collaris* lifetable to assess effect of preferred prey on predator performance and other parameters, such as, fecundity and reproductive output.

Keywords: alternative prey, assassin bug, biocontrol, prey preference, yellow mealworm

Selected References:

1. Ambrose, D.P.; Ganesh Kumar, A., Reduviid predators, in: Omkar (Ed.), *Ecofriendly Pest Management for Food Security*, **2016**, 217-257. Academic Press.
2. Maneerat, T.; Sakarind, P., Potential mass production of assassin bug, *Sycanus collaris* F. (Hemiptera: Reduviidae) using various stages of *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) as food. *Khon Kaen Agriculture Journal*, **2018**, 46, 195-200.
3. Pravalika, K.; Umamaheswari, T.; Shanker, C., Olfactometer studies on preference of *Rhynocoris marginatus* Fabricius to three lepidopteran preys. *Pest Management in Horticultural Ecosystem*, **2016**, 22, 28-33.
4. Rajan, S.J.; Suneetha, N.; Sathish, R., Biology and predatory behaviour of an assassin bug, *Sycanus collaris* (Fabricius) on rice meal moth, *Corcyra cephalonica* (Stainton) and leaf armyworm, *Spodoptera litura* (Fabricius). *Agriculture Update*, **2017**, 12, 1181-1186.

Agriculture – Technology

Research and Development on Water Onion's Micropropagation by Temporary Immersion Bioreactor (TIB) for Protection and Sustainable Use

S. Sachati^{a*}, U. Srappaew^b, Y. Kasinkasempong^a and D. Sriphota^c

^a Horticulture Research Institute, Department of Agriculture, Chatuchack, Bangkok, 10900, Thailand.

^b Sukhothai Horticultural Research Center, Horticulture Research Institute, Department of Agriculture, Si Satchanalai District, Sukhothai, 64190, Thailand.

^c Plant varieties Protection Office, Department of Agriculture, Chatuchack, Bangkok, 10900, Thailand.

*Corresponding author: sachati08@hotmail.com

Abstract

Water onion or Thai onion plant is an endangered aquatic plant and thrive in a particular habitat. This research aimed to develop micropropagation by temporary immersion bioreactor (TIB). The result showed that sucrose content, concentration of 6-benzyladenine (BA) and naphthalene acetic acid (NAA) affected the germination rate of new shoots. Explants cultured in TIB gave the germination of new shoots more than on solid and semi-solid medium system. The highest germination rate of new shoots was 19 shoots/ bulb when used halving bulb and cultured in liquid Murashige and Skoog (MS) medium supplemented with 6 mg L⁻¹ BA, 0.1 mg L⁻¹ NAA and 60 g L⁻¹ sucrose by feeding for 2 minutes with 48 times/days by TIB system. However, new shoots were very small size. And It took 6 months to germinate because of water onion is a slow growing plant. For rooting, the highest average numbers of roots were 2.5 roots/plant when cultured in liquid MS medium supplemented with 0.05 mg L⁻¹ NAA and 30 g L⁻¹ sucrose with TIB system. And the highest average length of roots were 1.9 centimeters when cultured in liquid MS medium supplemented with 30 g L⁻¹ sucrose with TIB system.

Keywords: *Crinum thaianum*, water onion, endangered aquatic plant, temporary immersion bioreactor, micropropagation

Effects of BA and LEDs Lights on the Growth of *Rhynchostylis coelestis* in vitro Culture

Supanath Kanjanawattanawong^{a,*}, Sililak Jittonglang^b and Thanwanit Thanyasiriwat^c

^aDepartment of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

^bProgram of Agricultural Science, Mahidol University, Amnatcharoen Campus, Amnatcharoen 37000, Thailand.

^cPlant Genome Technology Research Unit, Department of Agriculture and Resources, Faculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Mueang, Sakon Nakhon 47000, Thailand.

*Corresponding author: supanath@kku.ac.th

Introduction

Rhynchostylis coelestis is a native orchid in Thailand, has a beautiful purple color, and becomes a vulnerable and endangered species. Thus, *R. coelestis* express a value for conservation and enhance its population in natural habitats by tissue culture technique.

Methods

The seeds from 5 pods (6 months-old) of *R. coelestis* were mixed with distilled water and taken 25 ml to culture on semi-solid MS medium supplemented with 0, 2, and 4 mg/l BA with 18 replications. Then, in vitro shoot bud explants (0.5 cm) from seedling were excised and cultured on semi-solid MS medium added with 0, 2, and 4 mg/l BA with 10 replications for PLBs induction. Besides, the uniform young seedlings were cultured on a modified VW medium and exposed to 4 types of LED lights (white, blue, red, and 4blue:1red) with 13 replications for stimulating the growth of plantlets. Of these, a completely randomized design (CRD) was chosen for all experimental designs.

Results

The seeds mixed with distilled water which cultured on semi-solid MS medium supplemented with BA for 3 months showed protocorm germination only on BA-free MS medium (82.35% of the total cultured vessels). For PLBs induction, the explants cultured on BA-free MS medium were significantly different in developing dark green PLBs (100%). In the case of light-exposed for in vitro plantlet growth after cultured for 4 months, the plantlets cultured under white light LEDs were revealed the highest height, and the leaves number with statistic significantly different (7.68 ± 1.22 cm and 6.75 ± 0.638 leaves/plant, respectively) ($P < 0.05$). Moreover, the highest root number was observed on the plantlets cultured under blue and white LEDs light with statistically significantly different ($P < 0.05$) at 10.10 ± 1.97 and 9.80 ± 1.93 roots, respectively. However, the length of roots was no significant difference between 4blue:1red, red, and white lights (5.57-5.89 cm).

Conclusion

This study found that MS BA-free medium was suitable for seeds germination and PLBs induction on shoot bud explant of *R. coelestis*. Lastly, the white LEDs light showed the most appropriate for the growth of *R. coelestis* plantlet.

Keywords: orchid, plant growth regulator, shoot tip, PLBs

Selected References:

1. Pithayawutwinit, T.; Chinachit, W. *Acta Hort. Effect of culture media on in vitro culture of Rhynchostylis coelestis*, **2018**, 1285, 45-50.
2. Prasongsom, S; Thammasiri, K.; Chuenboonngarm, N. *Walailak Journal of Science and Technology. Efficient Adventitious Shoot Regeneration from Shoot Tip Culture of Rhynchostylis gigantea (Lindl.) Ridl. (amethyst-purple), a Rare Thai Orchid Species*, **2016**, 13(9), 757-767.

Agricultural System

Assessment of Farm Level Dynamics and Sustainability of Incorporating Cacao Production in Farm Systems in San Fernando, Camarines Sur, Philippines

Ciara Sophia L. Roxas*

**Institut des Régions Chaudes, Montpellier SupAgro, 1101 av Agropolis, Montpellier 34000, France*

The Philippines has a high potential to be an exporter of fine quality cacao beans due to its conducive environment for a larger plantation. However, despite this potential, local production cannot sustain even the domestic demand. The mixed quality of beans and unreliable amount of supply are some identified problems that hinder its market. To boost the production, the Department of Agriculture specifically promoted the production of cacao nibs through the Republic Act (RA) 7900, known as the High Value Crops Development Act of 1995, which aims to accelerate the growth and development of agriculture in general. It targeted to boost the quality and productivity of high-valued crops to augment the income of farmers and rural areas. This paper investigates how incorporation of cacao trees into existing farming systems could increase the livelihood income, modify the farm dynamics and affects the overall sustainability at the farm level. The research is conducted in San Fernando, Camarines Sur, in the Philippines wherein a cacao expansion project is in place. The study also specifically investigates the different farming systems existing in the area, describes the cacao production systems based on crop management practices, determines the existing cacao value chain, and finally assesses the sustainability of the farming systems taken globally, of which the cocoa production is just a component. Agrarian Systems Analysis is used to understand holistically the farming systems commonly practiced by the locals. Six farming system types are identified that characterized the common farming practices in the area. They are clustered according to several factors including kinds of their produce, crop rotations, labor distribution, capital, and the topography. Three of these types incorporate cacao trees in their plantation on different scales which varied on the compatibility of cacao in their land, and willingness of the farmers to put extra labor and land area for the new crop. However, insufficient local market for cacao beans is the most cited reason why most households do not want to incorporate cacao in their farms. The study highlights the methods for assessing sustainability of the farm system when market oriented perennial crops are involved. It proposes several types of possible market chains that are possibly appropriate for community situations of the province and the farm systems types. These farming clusters and proposed market value chains for cacao are examined to measure the farm level sustainability, and its perceived challenges and needs in the future.

Keywords: cacao, sustainability, faming systems, agrarian systems' analysis, Philippines

Study on Supply Chain Model of Coconut Production in Prachuap Khiri Khan, Chumphon and Surat Thani Provinces

Wilaiwan Twishsri^{a,*}, Hathaikarn Sittha^b and Supinya Junmee^b

^a Horticulture Research Institute, Department of Agriculture, Chatuchak, Bangkok 10900, Thailand.

^b Surat thani Agricultural Research and Development Center, Thachana district, Surat Thani, 84170, Thailand.

*Corresponding author: wtwishsri@gmail.com

Introduction

Prachuap Khiri Khan, Chumphon and Surat Thani provinces are important coconut product area of Thailand. The areas, however, currently have problems resulting in imbalance between production and demand, e.g. planting area decrease, pest infestation, and improper management. Therefore, this research aim to study the coconut model' supply chain in Prachuap Khiri Khan, Chumphon and Surat Thani provinces

Methods

The data were collected by interviewing three population groups regarding farmers, product collectors, and fresh coconut milk shops from October 2018 to August 2019.

Results

This study was found that the supply chain of coconut production of three provinces has the same model in which four levels consisting of farmers (upstream), product collectors and processing (midstream), and customers (downstream). Beginning with the farmers (upstream), the average age of them is over 60 years. Most of their coconut trees are in tall-stem tribes and the average age is over 50 years. The average quantity of yield is lower than 1,000 coconuts/rai/year. The next level is product collectors or merchants. They collect and manage coconuts in various commercial mature coconut fruits before delivery to customers, such as semi-dehusked mature coconut, dehusked mature coconut except for the perianth area, deshell coconut, kernel, copra, and fresh coconut milk, which depend on the area. The next level is processing, namely fresh coconut milk shop, deshell coconut factory, coconut processing factory, extract coconut oil factory, and coconut products from processing group. The end level is the customers. Furthermore, this study was found that the farmers lacked knowledge about proper management. Some coconuts sent to the processing factory were controlled by the factory regarding the price, quantity, and quality grading. However, for the coconuts sent to various regions for fresh coconut milk shops, the product collectors can control the price by themselves. Household processing of farmers lacked knowledge about the development of products and marketing for the customer's demand.

Conclusion

This study gave manageable guidelines for proposal policy to the relevant sectors to increase farmer's competitive and productive efficiency in order to increase their income-generating. There are two recommendations such as 1) develop the coconut production system for quantity and quality throughout the year to comply with GAP standards and 2) create networking among stakeholders in the supply chain, to support each other for a collaborative management approach.

Keywords: Coconut, Supply Chain

Selected References:

1. Department of Agriculture. Satisfaction of varietal application and technology of coconut production (In Thai). In Summary of the result of project evaluation of the application of DOA technology BE. 2559, **2017**, p.17-20.
2. Department of Agriculture. Coconut. Recommendation for Reducing cost of Horticulture production (Industrial crops) for increasing competitiveness of Thai farmers (In Thai). Horticulture Research Institute, **2016**, p.35-41.

The Competitiveness of Aromatic Coconut Product in case of Thailand Food Valley 1st year Agroindustry Networking

Taweesak Kritjaroen^{a*}, Thitima Wongsheree^b, Winai Homsombat^a and Wilaiwan Twishri^c

^aGraduate School of Management and Innovation, King Mongkut's University of Technology Thonburi (KMUTT), Bangkok 10140, Thailand.

^bInstitute for Scientific and Technology Research and Services, KMUTT, Bangkok 10140, Thailand

^cHorticulture Research Institute, Chatuchak, Bangkok, 10900, Thailand.

*Corresponding author: Thitima.won@kmutt.ac.th

Introduction

Due to a variety of weaknesses and challenging threats for the Thai food industry, this article aims to portray how to enhance the Agroindustry networking development under the Thailand Food Valley (TFV) project in the Western area. It focused specifically on searching collaboratively guidelines for strengthening the competitiveness of the aromatic coconut producer network in the value chain including coconut plant suppliers, coconut farmers, coconut collector, coconut factory, and community enterprises.

Methods

To analyze the competitiveness of the aromatic coconut producer network (TFVcoconut) under the Thailand Food Valley project in the first year supported by the department of industrial promotion. The network was formed by 21 producers from all stages of the production process, including upstream, midstream, and downstream industries, and developed by various activities, for example, seminar, workshop, and an industrial visit to leading innovative companies, as well as activities enhancing business opportunities. The network launched the pilot project on creating a communication channels among consumers and producers via the website <http://tfvcoconut.com>. Its competitiveness was analyzed by Diamond Model.

Results

The network launched the pilot project on creating a communication channels among consumers and producers via the website <http://tfvcoconut.com>. Analyzed by Diamond Model, it was found that the strength in the production factor was the special coconut variety and specific planting area, which gave unique yield in sweetness and aroma. However, output in each year depended on several factors and there was no formal agency to certify product quality. In demand conditions, it gained more popularity in foreign markets due to increased trends in health and wellness, though, consumer awareness in its nutrition was needed to raise. Despite of its uniqueness and quality, raw material shortage and unstable cost were still the major concerns. With respect to the supporting industry, there was a huge number of foreign direct investment to the packaging and exporting industry, which implied great market opportunities in the future. However, research in the value chain and product development were few ~~the~~ coconut enterprises. Concerning market rivalry, key strengths were found in the network, including clear vision and mission, assistance within the network, and support by the government, specifically the strategic plan, the budget, and the Geographical Indicator (GI) registration promotion.

Conclusion

Enhancing the competitiveness of the aromatic coconut producer network could be in fields of high value and quality production development with tracking-back capability, organic production, and national agency to support some specific the issue for continuous improvement.

Keywords: aromatic coconut, diamond model, value chain, network

Selected References:

1. Porter, M. E., *The Competitive Advantage of Nations*, 1990, New York: Free Press. (Republished with a new introduction, 1998.), 875 pp.

An Analysis of Factors Affecting Revealed Symmetric Comparative Advantage of Crude Palm Oil Exports of Indonesia, Malaysia and Thailand in the World Markets

Rungrat Saevang^{a*} and Ayut Nissapa^a

^a*Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: rungrat.s@psu.ac.th

Abstract

The objective of this study is to examine factors affecting comparative advantages of crude palm oil export of Indonesia, Malaysia and Thailand in the world markets during 2001- 2017. The Autoregressive Distributed Lag (ARDL) model is used to explore short-run and long-run relationships among Revealed Symmetric Comparative Advantage (RSCA) indices and selected economic variables. The results showed that the RSCA indices of Indonesia, Malaysia and Thailand as well as all independent variables namely exchange rate, real interest rate, foreign direct investment, trade openness, world price of crude oil and world price of soybean oil were stationary at different levels of data either in their original levels [I(0)] or their first differences [I(1)]. The ARDL model suggested that the exchange rate and the world price of soybean oil have significant negative and positive impact on the comparative advantages of Indonesia's crude palm oil export in the short-run, respectively. The world price of crude oil showed positive and significant relationship only in the short-run with Thailand's comparative advantage in crude palm oil export. It further found that there was no evidence of an existence of long-run relationships among the variables in comparative advantage model of Indonesia and Thailand. The model results also confirmed no short-run and long-run relationships between the comparative advantages of crude palm oil export and real interest rate, foreign direct investment, trade openness, world price of soybean oil and world price of crude oil in Malaysia.

Keywords: autoregressive distributed lag, crude palm oil, export, revealed comparative advantage

A Comparative Analysis of Maize-Based Smallholder Farming Systems (MSFS) Towards Household Food and Nutrition Security Improvement in Senqu River Valley (SRV) Agro-ecological Zone, Lesotho

Ohithiwe Anna Seko^a and Vichot Jongrungrot^a

^aAgricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

Abstract

This study aims to examine different types of maize-based smallholder farming systems (MSFS) practiced by farmers in Senqu River Valley agro-ecological zone in Lesotho and to evaluate MSFS practices to support recommendations of those that have potential for increasing farm income and improving household food and nutrition security. Purposive sampling method will be employed to select 12 study participants, on the following basis: a) 2 farmers from each of the five different types of MSFS practiced, notably: 1. Monoculture Farmer-Let System and Monoculture Contract System; 2. Polyculture; 3. Machobane; 4. Conservation Agriculture and 5. Agroforestry; b) Poor farmers who live below Lesotho poverty line of \$1.40/day, and c) farmers who have less than 1.5 ha of land. Interviews by means of structured questionnaires will be conducted to collect data from sample households. Content analysis will be used to identify different types of MSFS, descriptive analysis will be used to analyse food and nutrition security of sample households and to analyse the relationship between different MSFS and food and nutrition security of the same population. Olympe[®] software will be used to analyse economic returns of different MSFS and to perform a 7-year simulation from 2020-2026. Finally, SWOT analysis of different MSFS will be used to formulate recommendation for the types of MSFS that show potential to increase farm income and improve food and nutrition security. However, this study is currently on data collection stage.

Keywords: Maize-based Smallholder Farming Systems, farmers, Lesotho

Supply Chain Management of Golden Dried Longan in Lamphun Province

Ammarin Auparakat^{a,*}, Pornsiri Suebpongsung^a, Ayut Nissapa^b, Rungrat Sae-yang^b

^a Department Agricultural Economy and Development, Faculty Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand.

^b Department Agricultural Development, Faculty Natural resources, Prince of Songkla University, Hat Yai, 90110, Thailand.

*Corresponding author: ning.ammarin168@gmail.com

Abstract

The objective of this study was to examine supply chain operations management of the golden dried longan community enterprise in Lamphun. The population was Golden Dried Longan Community Enterprises in Mueang Lamphun District, Lamphun Province, and other stakeholders such as farmers and retailers. with in-depth interviews with a golden dried longan community enterprise and other stakeholders. To study operational processes and problems in operation to explain the supply chain management process. The result was analyzed through the Supply Chain Operations Reference Model (SCOR Model). This model consisted of 6 processes; namely, plans, source, make, deliver, return, and enable to assess strengths, weaknesses, and risks in the supply chain within the enterprise. The result of this study can be used in the development plan and improve the supply chain of dried longan gold in Lamphun.

Keyword: Supply Chain Management, SCOR model, Golden Dried Longan

Supply Chain Management of Rice cultivars in Chiang Mai and Phatthalung Province

Jirattikan Yontawong^a, Pornsiri Suebpongsung^{a*} and Ayut Nissapa^b

^a Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand.

^b Department of Agricultural Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand.

* Corresponding author, Email address: pornsiri73@gmail.com

The objectives of this research are to study the management model of the supply chain of the rice cultivars supply chain structure, to study the supply chain and the obstacles and the solutions to different problems from rice cultivars producers in Chiang Mai and Phatthalung Province. By using the interview data of rice cultivars and focus groups in Chiang Mai 2 groups and Phatthalung 2 groups. The data was analyzed by using percentage, sum, mean and standard deviation. Then SWOT analysis and SCOR model concept were applied. Expected results from this research suggest some possible ways to improve supply chain management of rice cultivars production and to provide information on the successful supply chain management of the rice cultivars producers in Chiang Mai and Phatthalung Province to develop further other farmers.

Keywords: Supply Chain Management, SCOR Model, Rice cultivars

Technical Efficiency of Soybean Production, Chiang Mai Province

Ploiphailin Tantiwit^a, Pornsiri Suebpongsung^{a,*} and Ayut Nissapa^b

^a Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand.

^b Department of Agricultural Development, Faculty of Natural Resource, Prince of Songkla University, Songkhla, 90112, Thailand.

Abstract

The study of the Technical Efficiency of Soybean Production, Chiang Mai Province aimed to know the technical efficiency of farmers in soybean production and find factors affecting the efficiency of soybean production of farmers.

To achieve objective using data obtained from interviews about 100 farmers, problems arising in soybean production were analyzed by descriptive statistics to find solutions to problems and obstacles among soybean farmers and Technical Efficiency of Soybean Production analyze by using secondary data about 5 years of soybean production. Including basic information on soybean production That has been gathered from various departments such as the Department of Agricultural Extension, Department of Agriculture Office of Agricultural Economics National Statistical Office. Method of Technical efficacy of soybean production analyzed using the Stochastic Frontier Approach (SFA) and the copula model to explain ability to manage use available of inputs and technology for efficient production and maximum yield. And analyze the factors affecting the efficiency of soybean production of farmers. To find a way to improve the efficiency of soybean production among farmers with Tobit model and descriptive statistical analysis. The results of this study Lead to facts to the current situation of soybean production and can be used as a guideline for improving or developing production and problem management of soybean production. To increase the total production sufficient to meet the needs of the country.

Keywords: Technical efficiency, Soybean production

Selected Reference:

1. Aree Wiboonpongse, Jianxu Liu, Songsak Sriboonchitta and Thierry Denoeux. 2015. Modeling dependence between error components of the stochastic frontier model using copula: application to intercrop coffee production in Northern Thailand. *International Journal of Approximate Reasoning*. 65: 34-44.

Production Management and Technical Efficiency of Tilapia Production, Chiang Rai and Nakhon Si Thammarat Province

Kawintip Kongin^a, Pornsiri Suebpongsung^{a,*} and Ayut Nissapa^b

^a Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand.

^b Department of Agricultural Development, Faculty of Natural Resource, Prince of Songkla University, Songkhla, 90112, Thailand.

Abstract

The aim of this study was to examine production management, the technical efficiency of in tilapia farming and factors affecting technical efficiency in tilapia farming of farmers in Chiang Rai and Nakhon Si Thammarat Province. To answer the first objective of this study, the general condition of tilapia culture, Management of production and marketing as well as problems and obstacles in the production of farmers with the analysis tools were descriptive statistics using a personal interview. The second objective was to analyze the efficiency of tilapia fish, with technical efficiency analysis using the Stochastic Frontier Approach (SFA). Eventually, analysis of factors affecting the tilapia production efficiency with tobit model. The results of this study can be used as a guideline for improving or developing production management and problem management of tilapia farming. To increase the total production sufficient to meet the needs of the country.

Keyword: Management, Technical efficiency, Tobit, Tilapia

Selected Reference:

1. Madan M, Ferdinand J, Gaspar B and Prescilla B. 2012. Technical efficiency of tilapia growout pond operations in the Philippines. *Aquaculture Economics & Management*. Volume 4, 2000: 33-47
2. Mahmoud E, Kimberly F, Delia G, Jonathan R, Barbara H. 2015. Characterisation of production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. *Food Policy* 51: 131–143

*Aquaculture – Aquatic Animal
Nutrition*

Physical Pretreatments of Food Waste and Its Possible Potential as Diet for Juvenile Striped Catfish (*Pangasianodon hypophthalmus*)

Chotiga Khaudtong^{a,*}, Karun Thongprajukaew^b, Nutt Nuntapong^a and Suktianchai Saekhow^b

^a*Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

^b*Division of Health and Applied Sciences, Faculty of Science, Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: 6210620030@psu.ac.th

Introduction

Food waste (FW) is a neglected source of inexpensive and readily available nutrients for use as feedstuff. In various agricultural by-products, physical pretreatments have been used to improve chemical composition and physicochemical property. Therefore, the aim of this study was to investigate the effects of different pretreatment methods (boiling, autoclaving, microwaving and hot air oven drying) on chemical composition, physicochemical property and *in vitro* digestibility of FW.

Methods

FW was randomly collected, classified, pretreated by various physical pretreatment methods (boiling, autoclaving, microwaving and hot air oven drying) and determined the proximate composition and physicochemical property in aspects to enhance enzymatic hydrolysis (microstructure, diffraction pattern and thermal property). Digestive enzymes extracted from juvenile striped catfish were used for studying *in vitro* digestibility of protein and carbohydrate.

Results

Classified FW contained cereal (55.82% of fresh weight), animal by-products (24.74%), vegetables (18.13%) and mixed FW (1.31%). Improved proximate composition was observed for FW pretreated by microwave irradiation relative to control and other pretreated methods ($P < 0.05$). Physicochemical properties and *in vitro* digestibility testing were superior for FW pretreated by autoclaving and microwave irradiation.

Conclusion

These findings indicate that autoclaving and microwave irradiation were the most physical pretreatment methods for improving chemical composition, physicochemical property and *in vitro* digestibility of FW. This process could be used to prepare FW for animal feeding.

Keywords: physical pretreatments, food waste, chemical composition, physicochemical property, *in vitro* digestibility

Selected References:

1. Mo, W.Y.; Man, Y.B.; Wong, M.H. *Sci. Total Environ.*, **2018**, 613–614, 635–643.
2. Nasser, N.; Abiad, M.G.; Babikian, J.; Monzer, S.; Saoud, I.P. *Aquaculture*, **2018**, 49, 3142–3150.
3. Thongprajukaew, K.; Rodjaroen, S.; Yoonram, K.; Sornthong, P.; Hutcha, N.; Tantikitti, C.; Kovitvadhi, U. *Aquaculture*, **2015**, 439, 45–52.

Effect of Lecithin-Enriched Diet on the Reproductive Performance of Eeltail Catfish (*Plotosus canius*)

Poosana Keawkong^{a,b}, Naraid Suanyuk^{a,b*} and Nutt Nuntapong^{a,b}

^a*Kidchakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

^b*Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

*Corresponding author: naraid.s@psu.ac.th

Eeltail catfish (*Plotosus canius*) is a popular marine fish because the tasty meat and high economic potential. This fish was found spread from the coast of Japan, the coast of Southeast Asia as well as the Indian Ocean coast until the coast of Australia. Environmental degradation, mangrove forest destruction, to catch small fish and the destruction of eeltail catfish spawning sources causing the number of eeltail catfish population to drop significantly. Therefore, developing eeltail catfish aquaculture is a sustainable way to increase the number of eeltail catfish to be sufficient for consumption and conservation. However, there is insufficient knowledge and information available on its breeding technique, seed production, larval rearing and culture. Broodstock nutrition is considered to be an important factor influencing successful breeding programs of many fish species. Lecithin (phosphatidylcholine), a by-product of the edible oil refining process, is widely used in feed for broodstock of various commercially important fish species. Available literature indicates that dietary supplementation of lecithin potentially improved fish reproduction because it is a source of phospholipids which play a vital role in increasing resistance to stress, improving growth and affecting reproductive performance of fish by participate in vitellogenin synthesis. The objectives of this study are to evaluate the histological characteristics of the eeltail catfish reproductive system and the effect of lecithin-enriched diet on the reproductive performance of eeltail catfish.

Keywords: Eeltail catfish, *Plotosus canius*, Lecithin, Reproduction

Selected References:

1. Amornsakun, T.; Krisornpornsan, B.; Jirasatian, P.; Pholrat, T.; Pau, T.M.; Hassan, A.B. *Songklanakarin J. Sci. Technol.*, **2018**, *40*, 384-389.
2. Jamalia, H.; Ahmadifarda, N.; Noorib, F.; Gisbertc, E.; Estevezc, A.; Aghb, N. *Aquaculture.*, **2019**, *511*, 734253.
3. Usman, B.I.; Amin, S.M.N.; Arshad, A.; Kamarudin, M.S.; Hena, M.K.A. *J. Environ. Biol.*, **2018**, *39*, 907-912.

Effect of Dietary Supplementation of Sea Lettuce (*Ulva* sp.) on Growth Performance and Survival Rate of Mud Crab (*Scylla serrata*)

Wanwisa Sangwong^{a,b}, Naraid Suanyuk^{a,b*} and Nutt Nuntapong^{a,b}

^a*Kidchakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

^b*Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

*Corresponding author: naraid.s@psu.ac.th

Mud crab (*Scylla serrata*) are important economic aquatic animals. It is considered as one of the most important food from the sea. There are a lot of demand and high commercial value in domestic and international markets because of quality meat, large size, and soft taste. However, high mortality during the larval and juvenile stage is still a problem for sustainable development of crab farming. Conventional diets such as trash fish are highly polluting to degrade water quality, difficulties of storage and risks related to the spreading of diseases. Therefore, formulated feed has become an important role in crab culture. Successful feed and feeding management require knowledge of dietary requirements, properties of various feed ingredients and appropriate feeding regime. Macroalgae is one of the aquatic plants that can be used as the supplementary feed. The multiple roles of macroalgae in aquatic animals on the enhancement of growth and survival, improved brood stock performance, as well as increase in resistance to disease has been reported. Sea lettuce (*Ulva* sp.) is rich in essential nutrients, polysaccharides (ulvans) and antioxidants that could improve animal growth and immunity. Therefore, this study aims to evaluate the effect of dietary supplementation of sea lettuce (*Ulva* sp.) on growth performance and survivability of mud crabs cultured in the plastic container and recirculating aquaculture system.

Keywords: mud crab, *Ulva* sp., growth, survival rate

Selected References:

1. Rabia, M.D.S. *Environ. Sci.*, **2016**, *4*, 53-61.
2. Yulianto, B.; Sunaryo.; Nur Taufiq S.P.J.; Djunaedi, A.; Subagiyo.; Santosa, A.; Soegianto, A. *Eco. Env. & Cons.*, **2019**, *25*, 119-128.

Effects of Climate Change on Spiny Lobster Aquaculture in Koh Yao District, Phang-Nga Province

Thanvapat Chamnina^{a,c}, Pornpimon Chuaduangpui^{a,c*}, Pilaiwan Prapruit^b

^a Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^b Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand

^c Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Songkhla 90112, Thailand.

*Corresponding author: pornpimon940@gmail.com

Introduction

Climate change is currently intensified by increasing of seawater temperatures, resulting in direct impacts on aquaculture in terms of lower productivity. Spiny lobster aquaculture in Koh Yao District, Phang Nga Province, there was higher mortality during culture. The molting process is incomplete and has a red body, it could be assumed that it may be due to the higher seawater temperature. However, there is no data on rising sea temperature to confirm that cause. Therefore, climate change on spiny lobster culture must be studied to know the impacts, including coping and further adaptation of the spiny lobster farmer.

Methods

In this study, socio-economic data was collected consisted of spiny lobster culture system, related factors in spiny lobster culture system, and the impact and perception on climate change. The structured questionnaire was a tool to interview 72 spiny lobster farmers. Then the statistical data were analyzed as mean, percentage, frequency distribution, and chi-square test. The data from in-depth interviews with key informants (head of the village, middlemen, fry collectors, spiny lobster farmers representative and related agencies) and focus-group discussion data were analyzed by the typological analysis technique.

Results

The study found that spiny lobsters aquaculture in Koh Yao, 56.9 % of spiny lobster farmers were affected by climate change. Higher seawater was the most damaged effects (76.3%), followed by severe storm winds at 30.5%, resulting spiny lobsters were stressed, weakness, slow growth, and less survival decreased. The cages for aquaculture were damaged, resulting in the spiny lobster escaping and causing the higher investment cost of cage repaired or new cages provided. As well as, some farmers had to stop culturing due to lack of variable cost. Few farmers were able to cope with the effects of climate change. There was relationship between higher seawater temperature and spiny lobster aquaculture systems both polyculture and monoculture. It was found that the higher water temperature was significantly associated with the spiny lobster aquaculture system ($P < 0.05$), increasing of water temperatures resulted in higher mortality rate of spiny lobsters. The results showed that 69.1% of the polyculture spiny lobster farmers affected by the higher water temperature. Meanwhile, 64.7% of monoculture spiny lobster farmers were not severely affected by increasing of seawater temperature, owing to the using of the shading net and increasing depth of the bottom of the cage to reduce effect from the temperature changing.

Conclusion

However, climate change is uncontrolled situation, further studies on coping and adaptation to impact of climate change on aquaculture are needed on the basis of the cooperation between the spiny lobster farmer, expert and related agencies to support and encourage farmers to cope with the impacts and have the ability to solve problems and being and self-reliant.

Keywords: Climate change, Higher temperature water, Spiny lobster aquaculture

Selected References:

1. Anantasuk, R.; Nitiratsuwan, T. *Fish. Res. Bull. Kasetsart Univ.*, **2015**, 39,10-21.
2. Dereje, T. *Int. J. Aquac. Fish. Science.*, **2015**, 1, 6-11.

Preliminary Study on The Culture of Seagrapes (*Caulerpa lentillifera*) in Semi-enclosed and Enclosed Area in Pulau Pinang, Malaysia

Sau Pinn Woo^{a,*}, Annette Jaya-Ram^a, Nithiyaa Nilamani^a, and Shau Hwai Tan^{a,b}

^aCentre for Marine and Coastal Studies, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia

^bSchool of Biological Sciences, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia.

*Corresponding author: abe_woo@hotmail.com

Introduction

The demand for the seaweed *Caulerpa lentillifera* or commonly known as seagrapes in Malaysia and the region is on the raise due to its popularity as food as well as health food supplement. Currently, this species of seaweed is cultured in Vietnam, Philippines, and Indonesia. In Malaysia, the supply of this seaweed is dependent from the culture outdoor in the open sea mainly in Borneo Island of Sabah. Preliminary study was done on the culture *C. lentillifera* in two different condition of semi-enclosed and enclosed hatchery system situated at the coastal area of Pulau Pinang.

Methods

Seagrapes with initial weight of about 21–29 g were used to evaluate the growth by weight cultured in two different conditions: 1) semi-enclosed area and 2) enclosed area. Three separate round tanks (1,000 litre capacity) were used in each area with five replicates each tank in each conditions. A flow-through system of filtered seawater was supplied to each tanks. The temperature of sea water and light intensity were recorded hourly for each tanks using HOBO Pendant® UA 002-64 Temperature/Light Data Logger. The wet weight of seagrapes were measured in weigh weekly for three weeks

Results

All seagrapes cultured in tanks at the enclosed area showed positive growth with the fastest growth recorded at average 48.2 g after three weeks of culturing. The remaining two tanks at the enclosed area recorded growth of 37.8 g and 39.2 g respectively. Unlike in tanks located in the enclosed area, only one tank in the semi-enclosed area recorded average positive growth of 19.6 g and the other two tanks recorded negative growth of -2.2 g. The average temperature of all the tanks in enclosed area was 29.20 °C with maximum temperature recorded at 32.17 °C and minimum temperature of 27.07 °C. The average temperature of all the tanks in semi-enclosed area was significantly lower ($P < 0.05$) lower than enclosed area recording at 28.54 °C with maximum temperature recorded at 31.33 °C and minimum temperature of 26.78 °C. At the enclosed area, the maximum light intensity received goes up to 74,400.5 lx whereas in the semi-enclosed area was 82,667.2 lx. The t-test determined that the average total light received by the two area were significantly different ($P < 0.05$). The optimum temperature for the growth of *C. lentillifera* from previous studies recorded at about 34 °C while not much was known on the total light intensity.

Conclusion

The preliminary data shows that the amount of maximum light intensity and higher temperature favors the growth of seagrapes. Further study will be conducted to ascertain the optimum total amount of light intensity require for the growth of *C. lentillifera*.

Keywords: Seaweed, water quality, indoor culture.

Uses of Para-rubber Seed Kernel Protein in Feed on Growth Performance and Feed Utilization in Red Claw Crayfish (*Cherax quadricarinatus*)

Sudarat Chantakam^{a*}, Chutima Tuntikitti^a and Suppasil Maneerat^b

^a*Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

^b*Department of Industrial Biotechnology, Faculty of Agro-Industry Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: Chantakam.S@gmail.com

Abstract

Para-rubber is an important economic crop in Thailand and having a yield of about 675 million kilograms of para-rubber seeds per year. However, only 25% of the yield is being utilized and the rest will be left to spoil. Alternatively, the para-rubber seed kernel can be used as an ingredient in animal feed such as in *Labeo rohita*, *Cyprinus carpio* and *Pangasius pangasius* feed. This study aims to explore the effects of using para-rubber seed kernel by three steps to remove the toxin and improve nutritional quality by boiling, oil pressing and fermentation using yeast (*Saccharomyces cerevisiae*). The processed seed kernel will then be applied as an ingredient for fish meal replacement at 0, 25, 50, 75 and 100% in red claw crayfish feed to evaluate its effects on growth and feed utilization. Parameters including growth performance, feed utilization, chemical composition, pathological tissue changes, hematological changes, digestibility, digestive enzyme activity, water quality, cost and economic return index will be determined at the end of growth trial. The results of the study can be applied for development of red claw crayfish feed, value added para-rubber seed products and helping increase a good return for the farmers.

Keywords: Para-rubber seed kernel protein, *Cherax quadricarinatus*, Red claw crayfish, feed development

Selected References:

1. Sharma, B.B.; Saha, R.K.; Saha, H. *Anim. Feed Sci. Technol.*, 2014, 193, 84-92.
2. Suprayudi, M.A.; Inara, C.; Ekasari, J.; Priyoutomo, N.; Haga, Y.; Takeuchi, T.; Satoh, S. *Aquac. Res.*, 2015, 46, 2972–2981.

Effect of Inversion of Cultured Frames on Growth and Characteristic of Green Caviar Seaweed, *Caulerpa lentillifera* (Chlorophyceae)

Manthana Donnoklai^{1,2}, Rapeeporn Ruangchuay^{*1,2}, Saweit Chaimongkol¹, Nuttapong Bovornruangroj¹

^a Fishery Science and Technology Program, Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

^b Discipline of Excellence (DoE) in Sustainable Aquaculture, Prince of Songkla University, Songkhla 90110 Thailand

* Corresponding author: rapeeporn.r@psu.ac.th

Introduction

The green seaweed, *Caulerpa lentillifera* or sea grape or green caviar which contains a high level of PUFA and multiple essential amino acids with a low level of total lipid, therefore making popular with consumers and has a high economic value (Paul et al., 2012). The aim of this study was to investigate new culture techniques for high production.

Methods

1. Cultured frames were made of PVC plastics with $0.3 \times 0.3 \text{ m}^2$ and were put with a honeycomb plastic base plate. The mother thallus of the seaweed of 150 g per frame or 1.67 kg m^{-2} was used. The mother plant was used to spread on the plastic plate and cover with another plate before tying.

2. The frame was cultured in 100-L cylindrical plastics tanks with 45-60 cm in diameter with tapering to the mouth and 55 cm high. The frames were at 30 cm high from the tank bottom. The side inversion of the frames was done in four treatments: every 0, 1, 2, 4 weeks within 8 weeks of culture. The culture environment parameter was at salinity 27 ppt, the maximal light intensity of $575 \mu\text{mol photon m}^{-2}\text{S}^{-1}$ in the hatchery, Modified Gillard's Medium, and aeration.

3. The medium was enriched every week while 20% of water exchange for salinity maintaining. The frames were weighed every week. The final thirteen branches were random to cut for number of a ramulus counting and measuring.

Results

The side inversion of the frame every four weeks provided maximal weight biomass of $14.69 \pm 2.31 \text{ kg m}^{-2}$ at the end of culturing and the second maximum was at every week inversion with $14.00 \pm 2.63 \text{ kg m}^{-2}$. The biomass from side inversion of every 1-4 weeks provided non significantly affect with that in no inversion of the frame. The relative growth rate of the seaweed showed $3.87 \pm 0.28 \text{ \% day}^{-1}$ in every four-week inversion. The maximal thallus height was at the inversion of every two weeks of 6.0 cm while those of the other inversions were in the same of 5.7 cm. The number of ramulus of branches was maximal at in every four-week and control of inversion of 42 ramuli. The size of the ramulus was $10.75 \pm 1.35 \text{ mm}$ while the minimal size of $8.87 \pm 1.39 \text{ mm}$ was in no inversion of the frame. The inversion of the culture frame provided a bigger size of ramulus when compare with no inversion of the frame. The number of ramuli seemed to be the opposite relationship with the size of the ramulus.

Conclusion

According to the results, the side inversion of the cultured frame for every four weeks provided high biomass of *Caulerpa lentillifera* because of the high relative growth of $3.87 \pm 0.28 \text{ \% day}^{-1}$ because of bigger ramulus was obtained in the condition. The growth rate in the culture was higher than the reports of Guo et al. (2015) on laboratory culture of *Caulerpa lentillifera* showed the relative growth rate of $2.04 \pm 0.47 \text{ \% day}^{-1}$.

Keywords: *Caulerpa lentillifera*, green caviar, sea grape, tank culture, frame culture

Selected References:

1. Guo H, Yao JJ, Sun ZS, Duan DL. 2015.. Effect of temperature, irradiance on the growth of the green alga *Caulerpa lentillifera* (Bryopsidophyceae, chlorophyta). Journal of Applied Phycology 27:879-885 DOI 10.1007/s10811-014-0358-7.

*Aquaculture – Aquatic Animal
Health and Disease*

Effects of Ground Pepper and Piperine on Growth Performance and Bacteria Disease Resistance in White Shrimp, *Penaeus vannamei*

Jareeporn Ruangsri^{*a,b}, Patjaramat Songjam^a, Saowanit Poolpeabprom^a, Sunee Wanlem^c and Pattira Pongtippatec^{a,b}

^a Department of Fishery and Coastal Resources, Prince of Songkla University, Surat Thani Campus, Surat Thani 84000, Thailand

^b Disciplines of Excellence in Sustainable Aquaculture, Prince of Songkla University, Thailand

^c Faculty of Veterinary Science, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand

*Corresponding: jareeporn.r@psu.ac.th

Introduction

White shrimp, *Penaeus vannamei* is economic and valuable marine shrimp species. In Thailand, farmed white shrimp is occurring largely and successfully since 2002. Somehow, a large amount of production lost each year due to infection, particularly diseases caused by bacteria, viruses, and parasites. Chemicals and antibiotics are being used as prophylactic and therapeutic agents. However, these agents could affect the consumer's health and the environment. Finding an effective within the eco-friendly method for disease control and prevention in aquaculture is essential. In this context comes the use of pepper, *Piper nigrum* traditionally medicinal plant. The effect of ground pepper and piperine supplement in the feed on growth performance of shrimp and their ability against bacterial infection are determined in this study.

Methods

This study five groups with triplicates each of white shrimp (initial weight 0.12 ± 0.02 g) were reared in polyethylene (PE) tank filled with 20 ppt seawater; 30 shrimps per tank. Two groups were fed 1 and 5% ground pepper coating diet, 2 groups were fed 0.5 and 2.5% piperine coating diet and non-agents coating diet was fed in a control group for 6 weeks period. Weight gain was measured each week to evaluate the growth performance, while survival rate, some hemato-immunological parameters were determined at the end of the feeding period. Besides, ten shrimps from each tank were used to challenge against *Vibrio parahaemolyticus*, Acute hepatopancreatic necrosis disease (AHPND) strain and their ability to resistant to disease were evaluated for 7 days period.

Results

Study results suggesting that daily fed 1% ground pepper coated feed able to stimulate the growth of white shrimp. This was indicated by significantly higher ($p < 0.05$) in their body weight, ADG and weight gain compared to other test groups. Also, the significance of low FCR value (1.07) was observed in the same fed group. White shrimp received either ground pepper or piperine coated dietary showed greater ability to resist bacterial infection. These indicating by high serum protein content and delay in mortality were observed in all test group as compared to control, and the highest survival rate was recorded in test group fed 1% ground pepper coated feed after being a challenge against bacteria strain caused AHPND.

Conclusion

Supplementation 1% ground pepper in the feed can stimulate the growth performance with potentially enhance the ability to resist bacterial infection in white shrimp.

Keywords: *Penaeus vannamei*, *Piper nigrum*, ground pepper, piperine

Selected References:

1. Saravana, P., Saranya, C., Manickam, N., Muralisankar, T., Radhakrishnan, S., and Srinivasan, V. *Bio Technol*, 2013, 58, 14824-14828.

Effect of Bioproducts from *Zooshikella* sp. on Growth Performance and Immune Responses in Nile Tilapia (*Oreochromis niloticus*)

Chalanda Kamnerddee^{a,b} and Naraid Suanyuk^{a,b*}

^a*Kidchakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

^b*Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

*Corresponding author: naraid.s@psu.ac.th

Nile Tilapia (*Oreochromis niloticus*) is an important economic cultured fish species in Thailand. Culture of Tilapia has rapidly expanded due to high economic value as well as consumers acceptance. However, to meet the rising demand in both domestic and foreign markets, farmers have changed the intensity of culture from extensive to intensive where a good farm management is crucial, particularly in disease prevention. The causative agents responsible for disease in tilapia are parasites, fungi, viruses and bacteria. Mainly, bacterial disease caused by *Streptococcus agalactiae* cause serious damage in tilapia farms. Nowadays, the use of chemicals and antibiotics to control and treat bacterial diseases is detrimental. On the contrary, use of extracts from microorganisms is one means which farmers may use to reduce the disease problems. In recent years, many researchers have focused on identification and characterization of secondary metabolites with pharmaceutical potential from marine resources. Therefore, this study is aimed to investigate the effects of *Zooshikella* sp. extract on growth performance and immune responses against streptococcosis in Nile tilapia. The results of this study will be useful for the farmers to prevent bacterial disease in a sustainable way.

Keywords: *Zooshikella* sp., Nile Tilapia, Immune responses, Bioproduct

Selected References:

1. Kim, J.S.; Harikrishnan, R.; Kim, M.C.; Balasundaram C.; Heo, M.S. *Fish Shellfish Immunol.*, **2010**, 29, 104-110.
2. Suanyuk, N.; Kanghear, H.; Khongpradit, R.; Supamattaya, K. *Songklanakar J. Sci. Technol.*, **2005**, 27, 307-319.

Factors Related to the Use and Production of Vaccine Against Motile *Aeromonas* Septicemia in Tilapia (*Oreochromis* spp.)

Suppanat Thaneerat^a, Naraid Suanyuk^{a,b,*} and Mintra Seel-audom^c

^a*Kidchakan Supamattaya Aquatic Animal Health Research Center, Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

^b*Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.*

^c*Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai, 50200, Thailand.*

*Corresponding Author: naraid.s@psu.ac.th

Tilapia (*Oreochromis* spp.) is one of the most economic cultured fish species in the world for its good taste, nutritional value, and relatively stable market price. However, tilapia production is subjected to large losses due to mortality caused by Motile *Aeromonas* septicemia (MAS) which is mainly found in fresh water source, especially those with high organic content. Vaccination is one means which farmer may use to prevent the disease problem. This study aims to investigate the factors affecting the use and production of vaccine against MAS in tilapia. The experiment will be divided into two main parts: 1) evaluation of the factors associated with the use of vaccine against bacterial disease in tilapia cultured in Nakhon Si Thammarat and Chiang Rai provinces and 2) development of MAS vaccine against *Aeromonas* spp. infection in tilapia. The result from this study will be useful to tilapia farmers and related agencies for sustainable development of tilapia aquaculture in Thailand.

Keywords: Vaccine, Motile *Aeromonas* Septicemia, Tilapia

Selected References:

1. Aly, S.M.; Albutti, A.S.; Rahmani, A.H.; Atti, N.M.A. *Int. J. Clin. Exp. Med.*, **2015**, 8, 4508-4514.
2. Gudding, R.; Lillehaug, A.; Evenson, Ø. *Vet. Immunol. Immunopathol.*, **1999**, 72, 203-212.

Characterization of Cyanobacteria strain Osci-TK01

Kanokwan Maa-ia^{a,b,c,d}, Teeyaporn Keawtawee^{a,c,d*} and Mintra Seel-audom^{b,d}

^aAquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^bDepartment of Animal and Aquatic Sciences, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.

^cDiscipline of Excellence Sustainable Aquaculture, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.

^dParticipatory and Integrative Support for Agricultural Initiative, Prince of Songkla University. Songkhla 90112, Thailand.

*Corresponding author: teeyaporn.k@psu.ac.th

Introduction

Cyanobacteria strain Osci-TK01 is one of new blue green algae species that occur in the shrimp ponds. It is a results of shrimp weakness, leading to susceptible of pathogenic infection and cause off-flavor in shrimp. Moreover, it is also the cause of water quality problems due to dissolved oxygen reducing and pH stabilization. However, there are less report about this species. Therefore, the aims of this study were to investigate the characteristics and the effect of temperatures, pH and salinity on the growth of the Cyanobacteria strain Osci-TK01.

Methods

Cyanobacteria strain Osci-TK01 was isolated from shrimp ponds in southern of Thailand. The algal were cultured in liquid BG-11 medium under light intensity 2,000 – 3,000 lux in a light:dark cycle 12h:12h. The morphologies were observed by light microscope and collected the sample during exponential phase. Thirty filaments were random for obtaining cells size, shape, sheath, apical and number of trichome per filament using Leica ICC50W with Leica LAS EZ software. The ultrastructure was studied by transmission electron microscopy (TEM). The factors affecting of temperature, pH and salinity on algal growth were conducted in the laboratory. Algal were cultured at 28 ± 1 °C and room temperature at 31 ± 1 °C, pH at 6 different levels: 6, 7, 8, 9, 10 and 11 and salinity at 7 levels: 0, 5, 10, 15, 20, 25 and 30 ppt, respectively. Algal growth in each treatments were measured at 650 nm wavelength using spectrophotometer.

Results

Morphological studies showed that Cyanobacteria strain Osci-TK01 is filamentous, no branch, not present mucilaginous sheath, the apical cell is rounded without calyptra. Sections of algal showed peripheral thylakoids. Cross-wall are not constricted or very slightly constricted. The average width and length of the trichome were 1.64 ± 0.11 µm and 5.41 ± 1.25 µm, respectively. The length of trichome is longer than the width in the ratio of 3:1 (length:width). The average length of filamentous and number of trichome were 41.51 ± 27.24 µm and 54.85 ± 54.02 trichome per filament. Result of growth showed that the maximum density of OD was 0.950 ± 0.13 at pH 8 on day 9 of culture. The maximum density of OD was 0.611 ± 0.02 at temperature-controlled treatment (28 ± 1 °C) on day 5 of culture and the maximum density of OD was 1.331 ± 0.13 at 15 ppt on day 12 of culture. However, Cyanobacteria strain Osci-TK01 showed a good growth rate in all temperature, pH and salinity.

Conclusion

The morphology of Cyanobacteria strain Osci-TK01 was similar to cyanobacteria genus *Limnothrix* sp. within the class Cyanophyceae, order Oscillatoriales, family Pseudoanabaenaceae under botanical taxonomic system (Komárek, 2003; Komárek et al., 2014; Gkelis et al., 2005; Zhu et al., 2012). The Cyanobacteria strain Osci-TK01 was growing well in wide range of pH and salinity. The results from this research can be applied as a guideline for shrimp culture in the future.

Keywords: Cyanobacteria, Characteristic, Temperature, pH, Salinity

Selected References:

1. Komárek, J.; Kaštovský, J.; Mareš, J.; Johansen, R. J. *Preslia*, **2014**, 86, 295-335.
2. Rubban, K.; Sughan, V.; Wong, L. S.; Meekin, C. 2014, *JOLST*, **2014**, 2, 78-81.

Species Diversity and Tetracycline Resistance of Pathogenic *Aeromonas* spp. in Nile Tilapia Seed Farms in Southern Thailand over a 5-Year Period (2016-2020)

Nion Chirapongsatonkul^a, Raja Sudhakaran^b, Toshiaki Itami^c and Kittichon U-taynapun^{a,*}

^aAquatic Animal Health Management Research Unit, Department of Agricultural Science, Faculty of Agriculture, Rajamangala University of Technology Srivijaya, Nakhon Si Thammarat 80110, Thailand.

^bAquaculture Biotechnology Laboratory, School of Biosciences and Technology, Vellore Institute of Technology, Vellore 632 014, Tamilnadu, India.

^cDepartment of Marine Bio-Science, Faculty of Life Science and Biotechnology, Fukuyama University, Fukuyama C., Hiroshima Pref., 729-0292 Japan.

*Corresponding author: kittichon.u@rmutsv.ac.th, e_aquatic1@hotmail.com

Introduction

Motile *Aeromonas* septicemia (MAS) disease caused by *Aeromonas* spp. are now becoming a common phenomenon in Nile tilapia. *A. hydrophila*, *A. caviae*, *A. veronii biovar veronii* and *A. veronii biovar sobria* are of particular clinical significance in Nile tilapia. Tetracycline resistance and genetic determinants responsible for tetracycline resistance have been previously reported in several *Aeromonas* spp. isolated from Nile tilapia. This study aimed to investigate the species diversity and occurrence of tetracycline resistance of the pathogenic *Aeromonas* isolated from cultured tilapia seed in Southern Thailand.

Methods

Pathogenic *Aeromonas* spp. were isolated from brain and liver of MAS-exhibiting moribund Nile tilapia fish from seed farms in five provinces in Southern Thailand between 2016 and 2020. Bacterial species was identified through biochemical and molecular methods using API 20 E kit (BioMérieux) and *16S rRNA* gene sequence analysis. The isolated *Aeromonas* spp. was checked for its antibiotic resistance profile against the drugs in tetracycline group through disc diffusion method. In addition, tetracycline resistance genes were also determined in the tetracycline-resistant *Aeromonas* spp. using PCR method.

Results

According to the biochemical test, 250 isolates were assigned to 7 different platforms. Five isolates from each biochemical platform were identified by *16S rRNA* gene sequence and phylogenetic reconstruction analysis. *A. veronii biovar veronii*, *A. veronii biovar sobria*, *A. hydrophila*, *A. caviae*, and *A. jandaei* were identified of which *A. veronii biovar veronii* was a dominant species. Tetracycline resistance genes were determined in 5 tetracycline-resistant isolates from each *Aeromonas* species. Efflux antibiotic gene group (*tetA*, *tetB*, *tetC*, *tetD*, and *tetE*) was only detected in the tetracycline-resistant *Aeromonas*.

Conclusion

A. veronii biovar veronii was a dominant *Aeromonas* species found in MAS-exhibiting Nile tilapia seed cultured in Southern Thailand. The main tetracycline resistance genes found in the tetracycline-resistant *Aeromonas* spp. included *tetA*, *tetB*, *tetC*, and *tetD*.

Keywords: *Aeromonas* spp., motile *Aeromonas* septicemia, Nile tilapia, *tet* genes, tetracycline resistance

Selected References:

1. Abd-El-Rhman, A.M. *Fish Shellfish Immunol.*, **2009**, 27, 454-459.
2. Akinbowale, O.L.; Peng, H.; Barton, M.D. *J. Appl. Microbiol.*, **2007**, 103, 2016-2025.

Cytokine Homologue Genes in Kuruma Shrimp, *Marsupenaeus japonicus*

Mari Inada^a, Toshifumi Yui^b, Tomoya Kono^c, Masahiro Sakai^c, Masaharu Mizukami^d and Toshiaki Itami^{d*}

^a Japan Fisheries Research and Education Agency, Watarai, Mie5160193, Japan

^b Faculty of Engineering, University of Miyazaki, Miyazaki 8892192, Japan.

^c Faculty of Agriculture, University of Miyazaki, Miyazaki 8892192, Japan

^d Department of Marine Bio-Science, Faculty of Life Science and Biotechnology, Fukuyama University, Fukuyama, Hiroshima 7290292, Japan

*Corresponding author: itamit@fukuyama-u.ac.jp

Introduction

Cytokines are small cell-signaling protein molecules for intercellular communication. In vertebrates, the macrophage migration inhibitory factor (MIF) is known as an inflammatory multi-functional cytokine and plays significant role as the regulator of innate and adaptive immunity. The vascular endothelial growth factor (VEGF) is known as cytokine which promotes angiogenesis, chemotaxis for macrophages and granulocytes, and lymphangiogenesis. On the other hand, in invertebrate, astakine is known as the invertebrate cytokine which can induce the hematopoietic stem cell differentiation in freshwater crayfish, *Pacifastacus leniusculus*.

Methods

We obtained adult kuruma shrimp (*M. japonicus*) from a commercial farm in Miyazaki, Japan. Synthesize of cDNA was performed from 500 ng of extracted total RNA in each shrimp sample and we prepared cDNA from the extracted total RNA. To identify the gene sequences, random amplification of cDNA ends RACE-PCR was performed.

Results

In this study, we report the identification and characterization of genes of a MIF, two types of VEGF and astakine from kuruma shrimp. The full-length cDNA sequence of the *M. japonicus* MIF (*MjMIF*), VEGF (*MjVEGF* and *MjVEGF2*) and astakine (*MjAstakine*) genes were 894 bp, 845 bp, 1,170 bp and 1,589 bp. In prediction of higher-order structure, *MjMIF* and *MjVEGF* formed trimer and dimer, respectively. The bioinformatics analyses such as domain, homology and phylogenetic analyses, gene expression analysis and gene knockdown by specific double-stranded RNA injection of *MjMIF*, *MjVEGF*, *MjVEGF2* and *MjAstakine* were performed.

Conclusion

These data suggested that *MjMIF*, *MjVEGF*, *MjVEGF2* and *MjAstakine* are important in innate immunity and homeostasis in kuruma shrimp.

Keywords: invertebrate, cytokine, shrimp, knockdown, expression

Selected References

1. Inada, M.; Mekata, T.; Sudhakaran R.; Itami T.; *Fish & Shellfish Immunology*, **2010**, 28, 701-711.

*Aquaculture – Aquaculture-Eco-
Management*

Environmental Factors Influencing the Distribution of Coastal Molluscs in Pattani Bay of Gulf of Thailand

Nureesawatee Samoh, Sarawuth Chesoh*, Apiradee Lim

Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

*Corresponding author: sarawuth.c@psu.ac.th

Introduction

Molluscs are recognized as the second major invertebrate groups followed Insecta in phylum Arthropoda. Pattani bay, located in lower gulf of Thailand, is known as one of main coastal biodiversity hotspots. Aims of this study attempted to analyze some aquatic environmental conditions that affected to distribute of mollusc population. Finally, this finding can be valuable for scientists to apply for regulation and management of coastal aquatic resources in this region.

Methods

Based on habitat characteristics, 8 sampling stations of coastal mollusk habitats were monthly collected by traps and bare hands from August 2018 to July 2019 and classified samples into taxa. Water depth, salinity, dissolved oxygen and water pH, and were monthly measured. Number of collected mollusc was set as an outcome while some water quality parameters (water depth, salinity, pH, and dissolved oxygen) were set as the determinants. Multivariate multiple regression analysis was used by R package program.

Results

Seventy species, (31 species of Gastropoda, 37 of Bivalvia, and 2 of Cephalopoda), of total coastal molluscs were reported that can be categorized into resident and seasonal larva state migration mollusc. The average number of mollusc was about 51 organism/m² (36-64). The common species of gastropods recorded were *Fairbankia* sp., *Chicoreus* sp., *Melanoides* sp., *Cerithium* sp. whereas the dominant bivalve being *Anodonta* sp., *Oliva* sp., *Anadara* sp., and *Donax* sp. Water depth of Pattani Bay that presenting water level less than 80 cm was 39.4%, followed by the water level more than 139 cm and water level range 80-139 cm were 30.8% and 29.8% by count, respectively. Mostly of annual water salinity was brackish (81.7%) and saline water (18.3%). Total dissolved oxygen that contented ≤ 6 mg/L was 67.3% and less than 6 mg/L was 32.8%. Water pH value that lower than pH 8 was 58.7% and water pH equal and more than pH 8 was 41.3%. Based on linear regression model, water depth ranged more than 80 cm, and saline water more than 25 ppt showed clearly statistically significant relating to the mollusc collected population. Quantity of dissolved oxygen in water and water pH showed no statistically significant relationships over the entire collected number of mollusc in Pattani bay.

Conclusion

Seventy species of total coastal molluscs can be found and confirmed that Pattani bay is home of seashell ground particularly blood cockle (*Anadara granosa*) and short necked clam (*Paphia undulata*). This study reconfirmed that to maintain water depth more than 80 cm. and to keep water salinity more than 15 ppt are necessary to sustain mollusc diversity and abundance in Pattani bay.

Keywords: Distribution of shellfish, Water quality, Gulf of Thailand

Selected References:

1. Swennen, C., Moolenbeek, R.G., Ruttanadakul, N., Hobbelink, H., Dekker, H. and Hajisamae, S. 2001. "The Molluscs of the southern Gulf of Thailand", Thai Studies in Biodiversity, 4, 1-210.
2. Tantikamton, K., Thanee, N., Jitpukdee, S. and Potter, M. 2015. "Species diversity and ecological characteristics of benthic macroinvertebrates in the intertidal zone of Satun Province, Thailand and the first record of *Petersenaspis* sp.", International Journal of Advances in Agriculture and Environmental Engineering, 2, 23-27.

Accumulation of Microplastics in Water Column at Koh Yo, Songkhla Lagoon, Thailand.

Sakarat Pat-iam^{a,b} Ponlachart Chotikarn^{c,d,e} and Eknarin Rodcharoen^{a,b,*}

^aAquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University 90112

^bThe Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University 90112

^cMarine and Coastal Resources Institute, Prince of Songkla University 90112

^dFaculty of Environmental Management, Prince of Songkla University 90112

^eCoastal Oceanography and Climate Change Research Center, Prince of Songkla University 90112

*Corresponding Author: eknarin.r@psu.ac.th

Introduction

Microplastics are widespread in coastal and marine environment and recognized as a growing environmental hazard. The aims of this study are to quantify and characterize microplastics in the environment at Koh Yo, Songkhla Lagoon, Thailand.

Methods

Water samples and environmental data from nearshores and offshore from eight stations around Koh Yo were collected from May 2019 to February 2020. Microplastics in water samples were quantified and characterized using standard methods.

Results

The results showed an average microplastics content from water samples from all stations was 45.19 ± 14.31 pieces/m³. May 2019 had the most abundant microplastics with 62.33 ± 3.80 pieces/m³ of microplastics followed by November 2019 (51.54 ± 4.10 pieces/m³), August 2019 (34.94 ± 4.43 pieces/m³) and February 2020 (31.95 ± 1.78 pieces/m³), respectively. Fourier transform infrared spectrophotometer (FTIR) analysis revealed 6 types of polymer in the area. There were significant higher Polyester-Cotton blend than other polymers ($P < 0.05$) followed by Polyester, Alkyd, Polypropylene, Polyvinyl chloride and Low density polyethylene, respectively. The Cluster Analysis (CA) revealed that similarity percentage of microplastics between stations in each month was in range of 53.87% – 61.13%. Canonical Correspondent Analysis (CCA) showed a distribution of dominant microplastic types were not directly affected by environmental factors. However, LDPE (such as plastic bags) founded at a higher depth and strong currents station (Station A2), while Alkyd (oil paint) showed high abundance at a shallow and low current station (Station B1).

Conclusion

Songkhla Lagoon especially at Koh Yo is an important fishing and aquaculture area in Thailand. However, there was contamination of microplastics in the water column around Koh Yo, especially the fiber from laundry process and fishing gears. These pollutants can be transferred to the food chain and might affect human being via the consumption of fishes.

Keywords: Microplastics, Water column, Koh Yo, Songkhla lagoon.

Selected References:

1. Bakir, A.; Rowland, S.J.; Thompson, R.C. *Estuar. Coast. Shelf Sci.*, **2014**, *140*, 14–21.
2. Cole, M.; Lindeque, P.; Fileman, E.; Halsband, C.; Goodhead, R.; Moger, J.; Galloway, T.S. *Environ. Sci. Technol.*, **2013**, *47*, 6646–6655.
3. Crawford, C.B.; Quinn B. *United Kingdom: Elsevier*, **2017**, 219–267.
4. Matthies, M. *Mar. Pollut. Bull.*, **2011**, *62*, 1589–1591.
5. Setälä, O.; Norkko, J.; Lehtiniemi, M. *Mar. Pollut. Bull.*, **2016**, *102*, 95–101.

Fecundity, Hatching Rate and Growth of Gravid Female Blue Swimming Crab (*Portunus pelagicus*) and Guidelines for the Management of Crab Bank: Case Study of Crab Bank Sub-Anan Local Fisheries Group, Singhanakhon District, Songkhla Province

Wachiraporn Seubhorn^{a, b} and Pornpimon Chuaduangpui^{a, b*}

^a*Aquatic Science and Innovative Management Division, Faculty of Natural Resources, Prince of Songkla University, Songkhla 90112, Thailand.*

^b*Discipline of Excellence for Sustainable Aquaculture, Prince of Songkla University, Songkhla 90112, Thailand.*

*Corresponding author: pornpimon940@gmail.com

Introduction

Blue swimming crab is an important economic aquatic animal of Thailand. It is popular for both domestic and foreign consumption and used as an important raw material in the industrial processing to export as processed products. However, increasing demand in both domestic and foreign markets of blue swimming crab products, cause overfishing of blue swimming crab resources in nature resulting in continuous declination of blue swimming crab. In addition, capture of gravid female blue swimming crabs to be utilized, cause reducing the chance of spawning and egg hatching and the recruitment of larval crab in nature will be less. The stated problem has made coastal fishing communities aware of the problem that occur with the blue swimming crab resources. Therefore, a community blue swimming crab bank was established with a simple method to conserve and rehabilitate blue swimming crab resources to be sustainable. The pattern of activities will have different details according to the community members' agreement and the suitability of each area. The objective of this study is to study fecundity, hatching rate and growth of gravid female blue swimming crab (*Portunus pelagicus*), and guidelines for the management of crab bank Sub-Anan Local Fisheries Group, Singhanakhon District, Songkhla Province.

Methods

The study will be conducted the scientific part that aims to study on the fecundity, hatching rate, and growth of gravid female blue swimming crab. The width and the length of carapace will be measured and weigh all the gravid female blue swimming crab with black grey eggs that the crab bank Sub-Anan local fisheries group collects them from sea. Data will be collected and recorded twice a month for 12 months and analyze the data. In the socio-economic part, the qualitative research will be studies. The data will be collected by in-depth interviews from key informants, namely the president of the blue swimming crab bank and 11 members of the community members who participate in the crab bank activities, to gather information on the management of the blue swimming crab bank, then the data will be analyzed by typological analysis.

Keywords: fecundity, hatching rate, growth, gravid female blue swimming crab, crab bank

Selected References:

1. Arshad, A.; Efrizal, E.; Kamarudin, M. S.; Saad, C.R. *Res. J. Fish. Hydrobiol.*, **2006**, *1*, 35-44.
2. Ikhwanuddin, M.; Azra, M.N.; Siti-Aimuni, H.; Abol-Munafi, A. B. *Pak. J. Biol. Sci.*, **2012**, *15*, 720-728.

Special Exhibition

Willingness to Study Abroad: Case Study of Thai Agricultural Students

David Zeman^a, Petra Chaloupková^b

^{a,b}Department of Economics and Development, Faculty of Tropical Agrisciences, Czech University of Life Sciences Prague, Prague 16500, Czech Republic

*Corresponding author: zemand@ftz.czu.cz; d.zeman.94@gmail.com

Abstract

Given the increasing level of globalization, international education has become an important part of the higher education sector and student mobility has been on the rise worldwide over the last decades. The process is believed to be advantageous for both student participants and participating countries. However, Thai outbound mobility has remained low over recent decades; only 1.3% of students participated in some form of international studies in 2016, which is one of the lowest in the South East Asia region.

This study investigates students' attitudes towards studies abroad, their preferences and their opinions about positive aspects and international mobility challenges. The data were collected in 2018/2019 online via Google forms with the help of PISAI; a total of 461 surveys were completed by the agricultural students from four Thai universities: Chiang Mai University, Kasetsart University, Khon Kaen University, and Prince of Songkla University, covering different regions of Thailand (North, Central, North-East and South region).

The results showed only minimal differences among the selected universities. An overwhelming majority of respondents (74.3%) were willing to study abroad, preferably for a longer period (65% for a year or more), in Asia (46.9%) or an English-speaking country (39.3%). The greatest challenges, according to the respondents, were lack of finances (93.5%) and lack of foreign language skills (88.7%).

The respondents showed a strong interest in international mobility. Nonetheless, the outbound ratio remains low due to various issues. In order to boost Thai student mobility, a greater focus on language teaching and financial support of outbound students is advised.

However, the current situation regarding the COVID-19 pandemic has had a negative impact on all ways of travel, including international mobility. Therefore, further post-pandemic research on this phenomenon is advisable.

Keywords: Agricultural studies. Employability, Student mobility, Higher education, Thailand

Challenges and Opportunities of Double Degree Master Program: Case Study in Thailand

Sreykhouch Ek*, Chaloupková Petra

Department of Economics and Development, Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Prague 165 00, Czech Republic.

*Corresponding author: sreykhouch334@gmail.com

Abstract

Thailand has transformed from an agrarian country to be a more industrialized country; however, agricultural sector still plays an important role in the country economics. To develop the country economy, “Thailand 4.0” which is used as current economic development strategy focuses on making Thailand’s labor force into knowledge workers (Jones C. & Pimdee P. 2017). Therefore, expansion higher education in agriculture is very crucial way to achieve the country’s development goals. The PISAI Project is co-funded by the ERASMUS + Programme of the European Union. The project main activity is to create double degree study programme at the master’s level among four key agricultural institutes, namely Prince of Songkla University (PSU), Kasetsart University (KU), Chiang Mai University (CMU), and Khon Khen University (KKU), with support from EU partners. Therefore, the study is designed to determine on students’ capacity building improvement and their satisfaction through Double Degree Master Programme (DDMP), and to understand challenges and opportunities in DDMP implementation.

To reach the objectives above, the study approach three different target groups involving in the PISAI project: i) Students, ii) Teaching/administrative staff, and iii) Agricultural companies/farmers as potential employers of graduates. All questionnaires are translated into Thai language and send via email.

According to the result, surprisingly, both PISAI students and PISAI staff perceive the same that the top five improvement of DDMP students are 1) Interact with other people and culture; 2) Capacity to adapt with new situation; 3) Responsibility; 4) Capacity to work in team 5) Ability to make their way through. Among all the criteria, however, only responsibility is what employer perceived important for students to be a competent employee. Mainly, employers expect students to improve on 1) Ability to apply knowledge into practice; 2) Time management; 3) Capacity to learn; and 4) Capacity to analyse and synthesis. The result also illustrated that students are very satisfied with the didactical level of the teacher, active learning environment, and the scientific level of teacher. Otherwise, language constraint, time management, and financial problem are the main challenges for them. Despite the challenges, DDMP students perceive positively on their future career. Most of them expect to find a satisfied job and more potential comparing to students who study regular master program.

In Thailand, DDMP implementation is common between Thai university with other foreign university. However, DDMP within the PISAI project is very special because its unique way of collaboration between four Thai agricultural higher education institutes in cooperation with four EU universities. Therefore, this study provides interesting insights and recommendations for future projects and implementation of similar activities at other universities, which will contribute to development of higher education.

Keywords: Agricultural Higher Education, Higher Education Institutes, Double Degree Master Program, Employability, Sustainable Agriculture

Selected References:

1. Knight J., *Doubts and Dilemmas with Double Degree Programs*, 2011, 8, 297-312.
2. Victoria K., Juha V., *Different, yet similar: factors motivating international degree collaboration in higher education: The case of Finnish-Russian double degree programmes*, 2019, 44, 379-397.

COMMITTEES

List of Scientific Committee

Agriculture

Name	Institute
Dr. Petra Chaloupková	Czech University of Life Science Prague, Czech Republic
Dr. Buncha Chinnasri	Kasetsart University, Thailand (KU)
Dr. Surassawadee Promyou	Kasetsart University, Thailand (KU)
Dr. Wachiraya Imsabai	Kasetsart University, Thailand (KU)
Dr. Supat Isarangkool Na Ayutthaya	Khon Kaen University, Thailand (KKU)
Dr. Panupon Hongpakdee	Khon Kaen University, Thailand (KKU)
Dr. Phrueksa Lawongsa	Khon Kaen University, Thailand (KKU)
Dr. Saowaluck Yammuen-Art	Chiang Mai University, Thailand (CMU)
Dr. Narit Thaochan	Prince of Songkla University (PSU)
Dr. Anurag Sanpapao	Prince of Songkla University (PSU)
Dr. Ladawan Lerslerwong	Prince of Songkla University (PSU)
Dr. Jessada Sopharat	Prince of Songkla University (PSU)
Dr. Sureerat Yenchon	Prince of Songkla University (PSU)
Dr. Pattamavadee Kunwandee	Prince of Songkla University (PSU)

Agricultural System

Name	Institute
Dr. Didier Pilliot	Montpellier SupAgro, France
Dr. Thilde Bech Bruun	University of Copenhagen, Denmark
Dr. Hanna Tuomisto	University of Helsinki, Finland
Dr. Yumi Kobayashi	University of Helsinki, Finland
Dr. Apinya Ratanachai	Prince of Songkla University (PSU)
Dr. Vichot Jongrungrrote	Prince of Songkla University (PSU)
Dr. Pornsiri Suebpongsang	Chiang Mai University, Thailand (CMU)
Dr. Arunee Promkhambut	Khon Kaen University, Thailand (KKU)

Aquaculture

Name	Institute
Dr. Toshiaki Itami	Fukuyama University
Dr. Yutaka Takeuchi	Kanazawa University
Dr. Naraid Suanyuk	Prince of Songkla University (PSU)
Dr. Sommai Chiayvareesajja	Prince of Songkla University (PSU)
Dr. Mintra Seel-audom	Chiang Mai University, Thailand (CMU)
Dr. Sutee Wongmaneeprateep	Khon Kaen University, Thailand (KKU)

List of Local Organizing Committee

Asst. Prof. Dr. Chutima Tantikitti Associate Dean for International Relations and Graduate Studies Faculty of Natural Resources, Prince of Songkla University	Chairman
Asst. Prof. Dr. Chaiyawan Wattanachant Associate Dean for Research and Innovation Faculty of Natural Resources, Prince of Songkla University	Committee
Asst. Prof. Dr. Ladawan Lerslerwong Associate Dean for Academic Affairs Faculty of Natural Resources, Prince of Songkla University	Committee
Asst. Prof. Dr. Wisut Sittichaya Head, Agriculture Innovation and Management Division Faculty of Natural Resources, Prince of Songkla University	Committee
Dr. Pornpimon Chuaduangpui Head, Aquatic Science and Innovation Management Division Faculty of Natural Resources, Prince of Songkla University	Committee
Dr. Thunchira Thepparat Head, Animal Production Innovation and Management Division Faculty of Natural Resources, Prince of Songkla University	Committee
Assoc. Prof. Dr. Narit Thaochan Faculty of Natural Resources, Prince of Songkla University	Committee
Dr. Kobchai Worrapiumphong Faculty of Natural Resources, Prince of Songkla University	Committee
Ms. Rungrat Saeyang Faculty of Natural Resources, Prince of Songkla University	Committee
Ms. Yaowalack Chaipondech Faculty of Natural Resources, Prince of Songkla University	Committee
Mr. Sothorn Detnakarin Faculty of Natural Resources, Prince of Songkla University	Committee
Ms. Pornpun Wonglampsingha Faculty of Natural Resources, Prince of Songkla University	Committee

List of Participants

Agriculture - Plant Science Session

No.	Salutation	Name - Surname
1	Ms.	Pattamawan Anusornpornpong
2	Dr.	Nongnat Phoka
3	Mr.	Somyot Meetha
4	Mr.	Tanapon Adultithipat
5	Ms.	Chattamas Promdach
6	Mr.	Sornnarin Suangto
7	Mr.	Poramet Kaewprasert
8	Ms.	Laksanaporn Sriyapunt
9	Ms.	Sujitra Sri-ubon
10	Ms.	Bhonbubcha Kayaphad
11	Ms.	Wantanee Meeloon
12	Mr.	Zar Ni Zaw
13	Mr.	Thanet Khomphet
14	Asst. Prof. Dr.	Kanokpon Bunya-atichart
15	Mr.	Chutisorn Deemak
16	Assoc. Prof. Dr.	Chalermchai Wongs-Aree
17	Assoc. Prof. Dr.	Surassawadee Promyou
18	Dr.	Supatchaya Nampila
19	Assoc. Prof. Dr.	Chalermchai Wongs-Aree
20	Assoc. Prof. Dr.	Suchada Boonlertnirun
21	Assoc. Prof. Dr.	Kitti Boonlertnirun
22	Asst. Prof. Dr.	Laongsri Sirikesorn
23	Asst. Prof. Dr.	Panupon Hongpakdee
24	Ms.	Timapon Artnafai
25	Mr.	Wattawatit Chaisaentao
26	Asst. Prof. Dr.	Pornpun Siramon
27	Ms.	Sasithorn Niyanut

Agriculture – Animal Science Session

28	Ms.	Chanmany Souphannavong
29	Mr.	Natcha Ketpanich

No.	Salutation	Name - Surname
30	Ms.	Kanokwan Sangthong
31	Ms.	Katalee Nulong
32	Mr.	Saeree Engsatittanawan

Agriculture - Pest Management Session

33	Ms.	Jureeporn Sukhatiphum
34	Ms.	Niyaporn Khwanket
35	Mr.	Natthidech Beesa
36	Mr.	Akkachai Laopha
37	Ms.	Warin Klakankhai
38	Ms.	Wanarat Natino
39	Dr.	Tewee Maneerat
40	Ms.	Phornthawon Phanbut
41	Ms.	Chosita Ubolsuk
42	Ms.	Kanyani Chaiyadit
43	Ms.	Pornsawan Poopat

Agriculture - Technology Session

44	Ms.	Apinya Saentho
45	Mr.	Phearun Lay
46	Ms.	Supaporn Sachati
47	Dr.	Supanath Kanjanawattanawong

Agriculture - System Session

48	Mr.	Seksan Duangsingtham
49	Ms.	Priyanud Chuensin
50	Ms.	Rosawadee Sukkum
51	Ms.	Keminee Tongma
52	Mr.	Donira Khan
53	Ms.	Maiyer Xiong
54	Mr.	Bayu Rizky Pratama
55	Ms.	Rachel Mazac
56	Ms.	Olta Sokoli
57	Mr.	Sebastian Peczek
58	Mr.	Techhong Lim

No.	Salutation	Name - Surname
59	Ms.	Ciara Sophia Roxas
60	Ms.	Hathaikarn Sittha
61	Asst. Prof. Dr.	Thitima Wongsheree
62	Ms.	Rungrat Saeyang
63	Ms.	Qhithiwe Anna Seko
64	Ms.	Ammarin Auparakat
65	Ms.	Jirattikan Yontawong
66	Ms.	Ploiphailin Tantiwit
67	Ms.	Kawintip Kongina

Aquatic Animal Nutrition Session

68	Mr.	Behnam Foroutan
69	Ms.	Dg Siti Rahayu Zaihurin
70	Dr.	Laddawan Krongpong
71	Mr.	Md Arefin Rahman
72	Mr.	Pongsakorn Limlek
73	Mr.	Kanin Patrachotpakinkul
74	Ms.	Pawinee Kleebthong
75	Mr.	Wasina Rungruang
76	Ms.	Jirapan Satjarak
77	Ms.	Chotiga Khaudtong
78	Mr.	Poosana Keawkong
79	Ms.	Wanwisa Sangwong
80	Ms.	Thanyapat Chamnina
81	Dr.	Sau Pinn Woo
82	Ms.	Sudarat Chantakam
83	Ms.	Manthana Donnoklai

Aquatic Animal Breeding Session

84	Prof. Dr.	Yutaka Takeuchi
85	Prof. Dr.	Shau Hwai (Aileen) Tan
86	Mr.	Biboon Withyachumnarnkul
87	Ms.	Kay Khine Soe

No.	Salutation	Name - Surname
88	Ms.	Sajeenuth Srithongthum
89	Ms.	On-anong Siprasert
Aquaculture System Session		
90	Asst. Prof. Dr.	Takahiro Watari
91	Dr.	Nur Adlin
92	Dr.	Fabio Soller
93	Ms.	Sunipa Chankaew
94	Ms.	Nongnaphat Jongkrajjak
Aquatic Animal Health and Disease Session		
95	Prof. Dr.	Thi Thi Zin
96	Mr.	Kantakan Thepnarong
97	Ms.	Wannisa Saengkaew
98	Ms.	Niroyhannah Nima
99	Mr.	Apisit Kimtun
100	Ms.	Sumesa Puangpee
101	Asst. Prof. Dr.	Jareeporn Ruangsri
102	Ms.	Chalanda Kamnerddee
103	Mr.	Suppanat Thaneerat
104	Ms.	Kanokwan Maaiad
105	Asst. Prof. Dr.	Raja Sudhakaran
106	Prof. Dr.	Toshiaki Itami
Aquaculture-Eco-Management Session		
107	Ms.	Nuramira Syahira Saffian
108	Dr.	Sarawuth Chesoh
109	Dr.	Supat Khongpuang
110	Mr.	Solomon Valdon
111	Ms.	Thanaphan Jombodin
112	Mr.	Sakarat Pat-iam
113	Ms.	Wachiraporn Seubhorn
Special Exhibition		
114	Mr.	David Zeman
115	Ms.	Sreykhouch Ek



Co-funded by the
Erasmus+ Programme
of the European Union



Co-funded by the
Erasmus+ Programme
of the European Union