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### Background

Much has been heard about SRI, and many groups and farmers have embarked on the journey of sustainability through SRI. Nonetheless, the economic potential of SRI and its capacity to enhance the quality of life of farmers and consumers deserves specific attention. This conference will bring forth expert views and experiences of professionals, practitioners or farmers to share and exchange information on the contribution of SRI in innovating shared market value in rice production and trade. The overall objective of this Conference is to promote innovations, either technological, social or business that can lead to improved farmers' livelihoods and quality of life for farmers and consumers through value creation of SRI. The specific objectives of this Conference are:

- To explore various technological, social and business innovations that have been derived or created from SRI
- To raise awareness on the market potential of SRI and products/services derived from SRI
- To promote regional networking of relevant stakeholders as means of expanding demand for sustainable SRI rice trade
- To highlight and document key recommendations for SRI integration in sustainable development policies nationally, regionally and internationally

SRI-Mas



We are a network of individuals and organisations, farmers, producers, consumers, professionals, agriculturalists, researchers and scientists, men and women, supporting the common cause of sustainable food production through natural farming practices that support community development and enhance the well-being of all people in Malaysia.

## Welcoming Note from Conference Chair



#### Assalamualaikum wbt and Greetings,

On behalf of the organizing committee of SEA SRI 2015 conference, first and foremost I would like to express my appreciation to all the organizing committee from Agro Ecology Association, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Utara Malaysia, Universiti Tuanku Abdul Rahman (UTAR) and various government linked agencies such as FELCRA Training Centre, BERNAS, SEACON, whom had given their full supports and commitment to the successful organising of the Regional Conference SEA SRI 2015. My sincere acknowledgement is also dedicated to our sponsors from local and international organizations that had sponsored this reputable event and supported us in many ways.

The conception of the Regional Conference SEA SRI 2015 is initiated from the past SRI National conferences, which were held respectively in 2011 and 2013 with a focus on local SRI development. From past experience, the SRI conferences had received high number of participation from farmers, agriculture based organization, private company, public and government organizations, non-government organization, local and international higher education institutions. Due to the warm reception from previous participation and currently, we expect around 200 participants attending this conference, we have decided to enrich SRI conference with content not only from local but also from global standpoint in order to spread and disseminate the SRI knowledge and results of the practices to SRI supporters.

The conference theme "Innovating the shared values" is indeed timely to the SRI community where SRI should not only view as promising cultivation method to improve rice productivity. However, most importantly, its contribution in enhancing the competitiveness of the rice industry without compromising the social and environment factors or sustainability factors while simultaneously advancing the economy of the country should be highlighted. Since SRI promotes sustainable agriculture, the main aim of this conference is to offer a common platform for academicians, students, government officers, social entrepreneurs, farmers, and other interested parties from local and international representatives to present their ideas and share their SRI best practices.

Due to that, the conference is expected to promote the SRI knowledge sharing on diverse issues ranging from technology, social as well as economic values and SRI hub building among participants of different countries who address different perspectives. This sharing session is in

forum and poster presentation as well as oral presentation with the focus in overcoming challenges and issues related to SRI implementation and promoting the SRI practices in the South East Asia region. Last but not least, it is a great pleasure to announce that renowned international keynote speaker from USA, who has vast experiences and knowledge in SRI and a local keynote speaker to present local sustainable agriculture initiatives, would be partaking their insights on SRI issues and challenges. It is hoped that this three day conference would be a beneficial platform among SRI supporters and interested parties to exchange their views and suggest ideas not only to improve the paddy ecosystem but also to find ways in creating values and high impact outcome to the rice industry. Again, it is my wish that this conference would spur more new and innovative ideas to promote SRI practices in a greater length regionally and worldwide.

Thank you, Associate Professor Dr Siti Norezam Othman Conference Chair Regional Conference SEA SRI 2015

# Welcoming Note from SRI-Mas President



#### **Dear friends**

We at SRI-Mas have come a long way and lots of progress has been made. We have endured and overcome many obstacles to bring the SRI methods to the hearts of farmers (men and women) and consumers.

We have also gained several acreage that opted for the SRI method for managing the planting of paddy.

Not as a new way but as a way that was successfully complementing rice culture and traditions. A lost, forgotten farming method and knowledge brought forth to agro-ecologically support growth of paddy. Taking into account the contributions of flora, fauna and the world of microbes in its togetherness. A holistic ecosystem that nurtures and does not impose.

Above all, we have grouped sincere proponents of the SRI approach who value friendship and sincerity in the transformation of farmers, legislators and researchers to believe that we can really plant paddy without a single drop of imported harsh chemicals - that was the accepted conventional way. We can still hear these words, *"how can paddy grow if no chemicals are used?"* echoing in conventional paddy farming communities and rather strangely in the minds of conventional paddy researchers. As if there is no other way.

Alhamdulillah, we have generated much field data that those echoed phrases are untrue, untruth and tantamount to a denial of the truth.

We can now celebrate our combined efforts to move forward for the increase in acreage that will adopt the SRI in natural manner. We have broken through the 10tons per hectare ceiling for the production of paddy in Malaysia and have started to venture into having our own rice mill, albeit a modest sized ones at two locations, Ledang in Johor and Sg Pinang in Kelantan. We have also explored selling SRI rice via several routes. If fact, marketed via social networking has been quite successful.

Allow me to say much much thanks to all at SRI-Mas for efforts WELL DONE.

A dream comes true. With blessings from God Almighty.

Wassalam. Prof Dr Hj Wan Mohtar Wan Yusoff President, SRI-Mas

# Welcoming Note from UUM



#### Bismillahirrahmanirrahim Assalamualaikum Warahmatullahi Wabarakatuh and Salam Sejahtera

First of all, I would like to express my gratitude to ALLAH (the Most Gracious and Most Merciful), for it is because of His finite blessings that we have been able to successfully organise the Southeast Asia Regional Conference on the System of Rice Intensification (SRI) 2015 in the state of Kedah, which is also fittingly known as the Rice Bowl of Malaysia.

It gives me great pleasure, on behalf of Universiti Utara Malaysia (UUM), to bid a very warm welcome to all the distinguished guests, keynote speakers, delegates, and participants who have come from the world over to add distinction and value to this conference. I would also like to take this opportunity to acknowledge the commendable efforts of the organising committee in diligently preparing the necessary groundwork to ensure the successful execution of today's event.

The Southeast Asia Regional Conference on the System of Rice Intensification (SRI) 2015 provides an excellent platform for researchers, educators, and professionals to continue their quest for strategic initiatives to ensure the continuous advancement of the System of Rice Intensification and, hence, bring about prosperity and wellbeing to farmers and consumers alike, both on the domestic as well as the international fronts.

With its apt theme, **Innovating Shared Values**, the conference is timely as it coincides with the nation's focus on increasing productivity in the rice sector. Through the sharing of knowledge that this conference will foster, innovations in technology as well as marketing and business strategies, will help enhance the socio-economic dynamics of the rice sector and raise the performance and the quality of life of farmers, especially in Malaysia and the ASEAN Community. Indeed, I am also hopeful that the various issues and challenges that the sector presently faces, particularly the challenge of preserving the rice industry while shaping a developing nation with zero impact on the environment, will be addressed through this conference. In addition, I hope that, through this noble practice of knowledge sharing, a more efficient system of management could be devised to improve the quality of rice production with a positive impact all around.

I would like to take this opportunity to express my sincere thanks and deep appreciation to the organising committee consisting of inspired individuals from UUM, UPM, UKM, UTAR and the FELCRA Training & Consultancy Sdn Bhd, Southeast Asian Council for Food Security and Fair

Trade (SEACON), Kedah Regional Development Authority (KEDA), PadiBeras National Berhad (BERNAS) and Koperasi Agro Belantik Sik Berhad, SRI Rice, Cornell University, USA, 2 and the Centre for Insect Systematics, UKM, for their commitment and cooperation in the successful organisation of this conference.

Finally, I would also like to extend my utmost gratitude and appreciation to the supportive keynote speakers, presenters, participants, and delegates, who have come from all over to generously share their insights and ideas to ensure the resounding success of the SRI 2015. I am confident that this conference will add impetus to the enthusiastic quest for innovation in the intensification of rice production as well as its marketing and business strategies. I wish everyone a most fruitful conference and a very memorable stay.

Best wishes, Professor Dato' Wira Dr. Mohamed Mustafa Ishak Vice-Chancellor UNIVERSITI UTARA MALAYSIA

### PREFACE

Alhamdulillah. The Conference was an overwhelming success, attracting 200 delegates, speakers and sponsors from 12 countries and provided great intellectual and social interaction for the participants.

I would like to convey my deepest appreciation to the participants, co-organizers, supporting agencies, sponsors and conference staffs for your contribution.

Thanks you,

Best wishes, Editor Dr Zakirah Othman SEA Regional Conference SRI 2015





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## **Table of Content**

Conference Overview1	
Pre-Conference Workshop on Rice IPM1	
Day 13	
Sharing Session 1 – Innovating Shared Technology Values with SRI Sharing Session 2 Forum 1 - Innovating Global Shared Value with SRI Sharing Session 2 Forum 2 - Innovating Shared Values with SRI in the Context of Sustainable Agriculture in Malaysia.	
Day 2 - Field Visit at SRI-Lovely: Innovating Shared Values with SRI in Actions	
Day 312	
Forum Three: Shared Value in Knowledge Transfer13	
Forum Four: Shared Value in Knowledge Transfer15	
The common issues and themes of the conference:16	
As a Follow-up to the Conference:	
Innovating Shared Social and Economic Values with SRI	
Exploring Innovative Practices of Sustainable Paddy Farming and Their Impact on the System of Rice Intensification (SRI) Rice Value Chain using Stakeholder Approah	
Siti Norezam Othman, Zakirah Othman, Noorulsadiqin Azbiya Yaacob, Ka mal Ab Hamid and Anizan Isahak	

Value-Added Biological SRI: An Economic Case Study from Northern	
Thailand	32
Boonsong Thansrithong and Abram J. Bicksler	

SRI Advocacy in the Philippines: A Case Study	.43
Roberto Verzolas	

Innovation in Paddy Planting By Adopting System of Rice Intensification	
(SRI)	ŀ
Kamal Ab Hamid, Nor AzNi Ahmad and Zakirah Othman	

A	eview of Paddy Residue Management in Malaysia6	6
S.	I. Shafie	

## Innovating Shared Technology Values with SRI

SRI Readiness Among Rural Farmers	.75
Noorulsadiqin Azbiya Yaacob, Zakirah Othman and Fadhilah Mat Yamin	

## Effect of UMAR-SRImat on Weed Management, Number of Tillers and Plant Height of MR219 Rice in System of Rice Intensification (SRI)......85

Umar Mohammed, Aimrun Wayayok and Mohd Amin Mohd Soom

An Evaluation of Mechanical Row-weeders and Effects of Wedding Levels on Vegetative Components of Rice under the System of Rice Intensification (SRI) 99
Suleiman.S, Wan Ishak.W.I, Muhammad Razif.M, Muhd Saufi M.K

Leveraging Persuasive Technology to Increase Awareness of Sustainable	
Agriculture	116
Safaie Mangir, Zulkifli Mohamed Udin and Zakirah Othman	

Comparative Study on Seedling Performance raised by New Single Seedling	
Nursery Tray and Conventional System129	
Aimrun Wayayok, Umar Mohammed, Usman Bashar Zubairu and Mohd Amin Mohd Soom	

# **Rice and Environment**

Effects of Rice Husk Biochar (RHB) on Soil Properties, Rice Plant Growth and Nutrients Uptake
Rosenani Abu Bakar and Cheah Poh Meng
Phytoavailability of Arsenic, Cadmium, Lead and Mercury in Rice Grains of Paddy Plants Grown in Malaysia142
Khairun Naim, Mulana, Che Fauziah, Ishak and Rosenani Abu Bakar
Assemblages of Insects Species in an Organic Paddy Field in Tanjung Karang, Selangor, Malaysia150
Salmah Yaakop, Rabibah Razali, Muhammad Azam Firdaus Saarani, Maimon Abdullah, Siti Zafirah Ghazali and Ameyra Aman Zuki
Biodiversity of Insects in Paddy Plots Planted under the system of Rice Intensification (SRI) using some Flowering Plants as Biological Control Agents against Paddy Pests: A Case Study at Kesang Tasek, Ledang, Johor 

Norela, S., Hamna, A.A., Anizan Isahak and Maimon, A.

#### **Conference Overview**

Safaie Mangir, Fadhilah Mohd Zahari and LC Lim safaie.mangir@gmail.com

First of all, on behalf of all rapporteurs, I would like to express my sincere appreciation for the quality of participation and enthusiasm that we observed throughout this conference. The overall objective of this conference is to promote innovations, from the perspective of technology, social or business that can lead to improvement of livelihood and quality of life of farmers and consumers through value creation of SRI. This conference has successfully allowed for the exchange of information, experience and sharing of knowledge amongst all participating representatives from Malaysia being the host country and regional countries such as Brunei, India, Indonesia, Laos, Nepal, Sri Lanka, Thailand and Vietnam. Your presentations and interventions have all been testaments to the cooperative nature and effectiveness of this conference as a whole. Recognizing the limitations of any summary and with many thanks to my fellow rapporteurs Dr. Fadhilah Mohd Zahari and LC Lim, please allow me to share the common issues, highlights and moving forward steps that we have captured from the outcome of this event.

### **Pre-Conference Workshop on Rice IPM**

**Dr Norela Sulaiman** the Chairman of Organizing Committee welcomed all the delegates for this pre-conference workshop. The conference was focused around conservation bio-control, Tungro virus, physiology, anatomy and morphology of rice under SRI, agroecological control of golden apple snail and rearing trigona stingless bee for biodiversity.

**Dr Peter Ooi** of UTAR, Malaysia discussed about major insect pests of rice, predators as the most most important natural enemies of rice pests and conservation biological control that highlighted how insecticides actually tend to remove natural mortality factors already present in the field. He also discussed about farmer education on biological control and ecological principles as foundation and ability of farmers to

Analyze and make decision around growing a healthy crop, conserving natural enemies and observing the fields regularly. Dr Ooi also shared with the delegates about Tungro virus which mostly affect cultivated rice. The primary source for tungro virus comes from the stubbles after harvesting and it can be perpetuated by overlapping cropping sequence. A more comprehensive information is essential to breed resistant varieties.

**Prof. Iswandi** from Bogor Agricultural University Indonesia presented physiology, anatomy and morphology of rice under SRI and comparison study between SRI farming versus conventional farming and made detail account on the roots health and agronomy parameters. In most cases, SRI agronomically is better than conventional farming.

**Mr. Mokhtaruddin Husain** from Malaysia Department of Agriculture spoke about natural control of golden apple snails (GAS) which is now a major pest in most rice area in Peninsular Malaysia and the trend is increasing. Natural disaster such as flood contributes to the spread and dispersal of the snail. The main impact of GAS infestations is reduction in rice yield and increase in cost of production. Management of GAS requires an integrated and concerted approaches and combination of various strategies are required to achieve effective control of the snails. The strategies may involve physical control (handpick, traps etc.), cultural (land levelling, mater level management, use of mechanical transplanter etc.), biological (involving tea seed cake, tobacco etc., habitat control, duck pasturing, fish farming) and chemical control. Failure to effective control is partly due to attitude of farmers who failed to practice proper snail management procedures.

**Madam Wan Noriah Wan Ramli** shared her experience on rearing stingless bees for commercialization and at the same time to achieve biodiversity.

### Day 1

#### **Official Opening and Keynote Session**

The conference was officially opened by **Yang Berhormat Dato' Suraya Binti Yaacob** a member of Kedah State EXCO on behalf of Yang Amat Berhormat Dato' Seri Mukhriz Tun Mahathir, the Chief Minister of Kedah. True to the spirit of sustainability, Dato' Suraya on behalf of the State Government of Kedah announced that SRI will be included in the Kedah Organic Initiative a state specific organic developmental agenda involving allocation and development of 425 hectare per year for the next 6 years. This is a historic development for sustainable development adoption and SRI in particular as the relentless and continuous effort to promote and adopt sustainable agriculture has managed to secure specific government-level support.

# Keynote Address: Overview of Global SRI in Supporting Family Farming and Mainstreaming SRI

**Dr. Erika Styger**, Director of Sri-Rice, Cornell University USA presented keynote address on scaling up SRI in Southeast Asia (SEA) elaborating on the challenges and proposing ways on how to achieve the objective to get there. SEA countries produce 25% of world's rice production and export more than 50% of rice trade worldwide. The diverse landscape covers lowland, irrigated and upland cultivation and generally involves smallholding farmers that generate relatively medium yield levels that are below the world average. Among the highlights of Dr. Styger's keynote address are:

- The characteristics, trends and challenges in rice production in SEA
- SRI achievements in SEA that covered development of organic SRI, equipment innovation, marketing initiatives and research and SRI journal articles publication
- SRI as paradigm change i.e. SRI has been established from traditional way of farming that is agronomy, farmers-centric and strong community of practice
- How to scale up SRI in SEA by creating a vision, thinking long-term and creatively, building on achievements, strengths and potentials, developing strategies, working as a team and promoting continuous communication and learning
- Identification of priority actions that include reinforcing the local, national and regional geographical network and thematic network in area of research, equipment etc. and improve the communication.

## Plenary Address: Sustainable Agriculture Policy

**Mr. Lee Chee Ping** on behalf of **Datuk Ahmad Loman**, Undersecretary for Policy and Strategic Planning Division, Ministry of Agriculture and Agro-based Industry Malaysia presented the Malaysia policy development in relation to sustainable agriculture. The main themes derived from Mr. Lee's address are:

- Malaysia has long established its commitment towards sustainable development.
- Among the reasons why the country needs sustainable agriculture policy are the rise in global food prices, increase in global agriculture input prices, increase in global population (Malaysia population is 30.1 million in 2014 and expected to increase to 38.6 million by year 2040) resulting in corresponding global increase of cereal demand, increase utilization of food commodities for bioenergy and climate change.
- Production of key food commodities in Malaysia has increased from 3.7% annually from the last 10 years to 4.0% per year until year 2020.
- The National Agrofood Policy (2011-2020) requires self-sufficiency level of key food commodities such as rice and beef to be increased from 69.8% to 100% and 32.7% to 50% by year 2020 respectively.
- The three main objectives of The National Agrofood Policy (2011-2020) are to ensure adequate food security and food safety, to develop agrofood into a competitive and sustainable industry and increase agropreneurs' income.
- The seven NAP strategic directions are ensuring national food security, increasing the contribution of agrofood industry, completing the value chain, empowering human, fortifying the activities of R&D, innovation and the use of technology, creating the environment for private sectors led businesses and strengthening the delivery system.
- There are seven specific agricultural industries to be given the focus: rice, fishery, livestock, crops (vegetables, fruits & coconuts), high-value agriculture (edible bird nest, aquaculture, seaweed mushroom, floriculture etc), agro-based industry and agrotourism.
- MyGap (Malaysia Good Agriculture Practices) was launched in August 2013 which is a rebranding and consolidation of Malaysian Farm Certification Scheme for Good Agricultural Practices (SALM), Livestock Farm Practices Scheme (SALT) and Malaysian Aquaculture Farm Certification Scheme (SPLAM).
- MyOrganic (Malaysia Organic Scheme) was launched in April 2015 to promote consumer acceptance towards organic products.
- Several campaigns related to sustainability have been conducted that include the launching of 'Peliharalah Tanah kita (Conserve Our land)' in April 2014, development of Guidelines for Agricultural Development on Hill Slopes, the development of National Strategies and Action Plans for Agricultural Biodiversity, Conservation and Sustainable Utilization and National Action Plan for Prevention, Eradication, Containment and Control of Invasive Alien Species (IAS) in Malaysia.
- The RM11 million National Agrofood Gene Bank was completed in September 2013.

#### Sharing Session 1 – Innovating Shared Technology Values with SRI

**Mr. Roberto Verzola** of SRI Pilipinas presented the development and progress of SRI in the Philippines. Mr. Verzola shared with the audience the challenges of spreading SRI awareness and adoption in the Philippines and the spread of SRI in the country has happened mostly contributed by the efforts of NGOs and local government units and agencies. The Department of Agriculture has not extended the support to SRI as expected by the various advocates and only few promotions have so far been established. He added that some of the unique ways to promote SRI in Philippines include primers, books, trainings, radio programs and specifically Mr. Verzola discussed at length the effective use of SMS for farmers and advocates to interact and sharing of information related to SRI. Overall in Philippines SRI is present in over 800 towns/cities that represent about 50% of the total. The Philippines Agricultural Training Institute has been very accessible and responsive to SRI Pilipinas requests and has allowed free use of its meeting facilities and dormitory. In addition ATI also has printed 6,000 copies of the SRI primer.

**Mr. Mohamed Bukhori Abdul Rahman** from Kedah State Department of Agriculture (DOA) shared his experience on Glorious Paddy Field Program (GPFP) which is a holistic program of development and extension of the rice plant, introduced by the DOA to deal with issues related to paddy infrastructure, implementation of field management methods according to "Rice Check", Agriculture Technological Package, Precision Farming and act based on Gap Analysis of an area of rice. More interestingly, DOA also has included organic into GPFP due to pest attacks, health impact and impact to natural predators such as spiders, birds and fish as it was found that application of pesticides especially the chlorinated ones eventually increases the amino acids and simple sugar in the plants and make the plants more vulnerable to predation and disease. The participants of the GPFP program also attended the training on producing organic fertilizer and application of organic fertilizer.

**Mr. Salehuddin Yahya** of SRI-Mas (Malaysia) shared the mechanization progress that may help further adoption of SRI in the future. He shared assessment on some of mechanized inter-row weeders which have some limitation such as unweeded strips of the plot and crop damage due to design limitation and lack of ground clearance respectively. Moving forward Mr. Salehuddin proposed to improve local wet-seeder, improvise dry-seeder for lighter soil, research in precision seeding/weeding , need for high clearance weeder and single direct dry seeding through pneumatic or mechatronics. Mr. Garawat Nulun from Bario Kelabit Highland Sarawak further commented that mechanization needs to attract youth in Bario and at the same time to avoid displacing the manual labor. This is significant as Bario is only a small community of about 10,000 population.

Further on mechanization and equipment development for SRI, **Mr. Stephen Leinau** of Earth Link Incorporated USA shared with the participants how Earth Link can help to provide more access to SRI equipment and information sharing which basically involves accessing research on SRI equipment development and effectiveness, information on locations to acquire the SRI equipment and sharing of designs, plans and specifications for SRI equipment. Earth Link can provide joint prototype testing, collaborative design, online equipment library and training resource for computer-aided-design (CAD). Earth Link is committed to create a process of creating and searching for well-used and well-tested designs to add to the online library and to reproduce designs already in use and help bring other people designs to light.

**Mr. Safaie Mangir** presented how ICT advancements can be utilized for information sharing, education and training. SRI-Mas (Malaysia) is reaching out to members, farmers and the public alike through the website, social media such as Facebook, Twitter (SRI-Mas) and WhatsApp (SRI Malaysia). In addition SRI-Mas also contributes to the e-agriculture platform called SAFSeN (SEA Network Facility on Technology for Sustainable Agriculture, Food Security and Nutrition) which is an initiative by SEACON (SEA Council for Food Security and Fair Trade) with the objective to inform, share, educate and train farmers in the Southeast Asia on agroecological-based farming techniques or sustainable agriculture technologies. Currently this e-agriculture platform involves five ASEAN countries namely Indonesia, Laos, Malaysia, Thailand and Vietnam. Mr. Safaie added that further extension of this e-agriculture platform is being reviewed to include other countries in SEA and incorporate improvements especially on contents and language translation.

## Sharing Session 2 Forum 1 - Innovating Global Shared Value with SRI Positioning SRI in the Context of Sustainable Development (Social, Economic and Environment) to Address Commitments for Greener Economy

Prof. Iswandi Anas from Bogor Agricultural University Indonesia presented the update of SRI in Indonesia. SRI is becoming a national strategy in Indonesia, particularly due to its ability to sustain the environment and the soil composition. Most of the soil in Indonesia has been degraded, therefore organic fertilizer not only a good approach to improve the soil properties, but also is able to increase the yield of the farmers. He further showed the study that compares rice cultivation according to the standard methods (that involves soil flooding, transplanting of older seedlings, narrow distance between plants and inorganic fertilizers) versus SRI methods (involves keeping the soil moist but not flooded, one seedling per hill involving only young seedlings, wider planting distance, using less seeds, more efficient use of fertilizers and less purchase inputs). Prof. Iswandi stressed that soil health is a very important factor for farmers to increase their yield and showed the evidence that rice plants that were grown using organic fertilizer were healthier than the ones grown conventionally. Overall the result indicated that SRI method produced average higher yield at 7.25 ton/hectare compared to conventional yield at 4.9 ton/hectare as reported by Indonesia Ministry of Agriculture in 2012. Nagrak Organic SRI Center has become important training ground for SRI in Indonesia and Prof. Iswandi also observed that national leaders and politicians in Indonesia are showing positive support to SRI.

**Mr. Mohamed Bukhori Abdul Rahman** highlights the initiatives towards organic farming in Kedah, which includes reducing of pesticide usage in paddy farming. The pilot project started with Program Sawah Gemilang in 2011, and successfully increased the yield of the farmers. The SRI initiative is still new, which started in 2013. He raised the concern that the infrastructure and social factors need to be considered before SRI could be implemented in a larger scale.

**Ms. Lucy Fischer** of SRI-RICE Cornell University USA shared her insight on development of SRI networks around the world. According to Lucy, SRI is present in over 55 countries around the world, with good mixture of formal and informal kind of networks available. SRI discussion groups /mailing lists are active in India, Indonesia, Malaysia Nepal, Nigeria and Philippines which mostly are conducted in English as medium of communication as well as local languages. As of 2013 the SRI National and Regional Network discussion groups are mostly found in India (57%). Few SRI networks mentioned include SRI-Pilipinas Network (Philippines), J-SRI Network (Japan), SRI National Network Bangladesh, SRI Nepal, Groupement SRI Madagascar and SRI Network Sri Lanka. The newest is SRI Network Vietnam which will have the first meeting in August 2015. Lucy also highlighted lack of equipment access that has become a bottleneck to SRI promotion in many countries. In view

of this issue, a network for SRI equipment design is available in Facebook with current membership of over 190 for sharing and communicating information related to SRI equipment development among the members worldwide. The SRI global research network at Cornell University is available to help global community of researchers to connect to each other, access and share resources, standardize methods and work collaboratively on multi-country studies.

**Maria Pilar** from Rice Watch Action Network (RWAN) Philippines discussed how SRI was used to rehabilitate the affected production areas in Philippines, due to climate change and natural disasters. Through the Rice Watch Action Network (RWAN), they are focusing on resilience aspects of their production in response to the climate change, and trying to get more support from the government. As Philippines are disaster prone, CRFS is established to promote resiliency and climate-informed livelihoods where farmers can defend their farms and families in the event of disaster. The CRFS involves increasing awareness, and enhancing the skills to improve the lives of the farmers. The resilient livelihoods involves access to climate information, having diversified livelihoods, sustainable and climate-friendly livelihood technologies (including SRI) and ensuring insurance (covering crop, life, accident, death) and access to emergency services. SRI is scaling up in Philippines however more research and documentation support is required with regard to water management, mechanization, marketing and extending SRI methods onto other crops such as corn and upland rice cultivation.

**Madam Noorazimah Taharim** from SRI-Mas (Malaysia) inspired the delegates to persuade others, as well as the policymakers on the advantages of SRI. She pointed to an example how SRI started in Selangor and gradually accepted in other states. However, in making SRI as an easy practice, appropriate equipment is imperative, and remains as a challenge. She shared her first experience with SRI as it was triggered by pest outbreak in 2009 that prompted the farmer to spend about RM30 million pesticides to contain the outbreak. Mdm. Noorazimah produced a self-made concoction as natural substitute for pesticides which she introduced and promoted to the farmers especially in the state of Selangor and Kedah. The year 2010/2011 were the most challenging time for promoting SRI fertilizers to the farmers and during this period, over 100 training sessions on organic fertilizers and pesticides were conducted in the State of Selangor and Kedah. Mdm. Noorazimah targeted that by year 2020, 10,000 hectares of land will be planted with organic rice as a strategy to win over the people.

Sharing Session 2 Forum 2 - Innovating Shared Values with SRI in the Context of Sustainable Agriculture in Malaysia.

The panelists for this forum are **Prof Madya Dr. Kamal Ab Hamid (UUM), Captain** Zakaria Kamantasha (SRI-Lovely, Malaysia), Haji Marzuki Md Zin (KEDA), Garawat Nulun (Bario) and Mdm. Salwati Ariffin (SRI-Mas).

**Mr. Garawat Nulun** shared his experience with Bario rice farming in Bario Sarawak. The main issue with Bario farming is acute labor shortage and product marketing. The development of farming land to produce Bario rice is done by having a JV undertaking between investors and Kelabit-owned NCR lands. The highland climate actually provides the opportunity to produce premium quality rice that fetches higher price of which MOA has successfully marketed the Bario brand rice since 2002. Moving forward for Bario farming adopting SRI methods, Mr. Gerawat spoke about the need of central management and support from SRI community is essential to raise the awareness and eventually adopt the SRI technique by the Bario community. He further added that Bario rice can be made organic and become global Malaysia brand.

**Captain Zakaria** Kamantasha (retired army personnel) shared his experience with SRI. He started with attending the 4-day SRI training in Nagrak Indonesia and instantly liked the idea. To him SRI is easy to understand and practice as it does not complicated scientific approach and resemble more to traditional kind of farming. He started SRI since 2011 and has developed SRI-Lovely together with some associates that has become SRI success story and reference point.

**Prof Madya Dr.. Kamal Ab Hamid** discussed about SRI innovation and dissemination and awareness. He explained the effective way to achieve awareness is via competition and participation in local and international exposition/ trade fairs. He shared his experience in Germany and how the Germans are very interested with SRI and strongly encourage to continue with the effort. This is a good international recognition and we should be able to take advantage to promote SRI and SRI products at international level. On local front, the SRI team won silver and bronze medal for water management competition and gold medal for mechanization. In 2014, a group of UUM students conducted SRI awareness and training program targeted at about 60 single mothers in State of Perlis.

**Haji Marzuki Md Zin** informed the audience that KEDA has won 2 awards related to SRI i.e. 2015 Anugerah Ilham Desa (Village Inspiration Award) and 2014 Anugerah Renovasi Negara (National Renovation Award). These awards show that SRI has reached a certain level of national acceptance. Haji Marzuki also shared his experience of disseminating SRI information to many other villages in other states including Sabah and Sarawak and also farmers who are outside of the granary areas. Various achievements show that SRI is gaining recognition. Currently, initiatives are taken to spread the SRI concept to Sabah and Sarawak. Haji Marzuki also briefed that there are 2 factors that inspires their commitment towards SRI, which are the religious perspective in preserving the environment and the SRI principles themselves. He parted with simple message how SRI defends the natural environment – the earth, water and air and inhabitants which are very much significant culturally.

**Madam Salwati Ariffins**hared her experience with SRI and the reason why she was attracted to it is because of her passion 'to save the world' and her mission to be the savior to the environment has driven her active involvement in SRI. She further shared the challenges to set-up a SRI group of farmers in Kelantan which initially gathered quite a number of participants but dwindled to only few left over time due to lack of motivation and quick result as most of them are smallholding farmers that depend solely on their small farms for livelihood . Among the main challenges that are to make the farmers understand the SRI concept, and to implement SRI in a greater scale because currently the farmers start SRI in a small scale (half to 2 acres only), which then raised the issues of storage and demand. On the good side of it, the farmers however do understand the danger of pesticides and inorganic fertilizers and the negative effect of it. The other issue raised was related to post-harvest and marketing of the organic products. Madam Salwati informed the audience that she also tried her hand in organic vegetable farming which later she found out that it was a lot more difficult to do than rice farming.

There were questions from the floor related to the cost associated with SRI operation. There are several areas that contribute to the cost of operation such as the case in SRI-lovely that the workers receive fixed monthly salary as a safety net to retain them in the company. In Philippines, the weeding and transplanting part is the most expensive while in the case of Bario Sarawak, companies charge farmers quite expensively for the use of farming equipment for transplanting and harvesting.

There was a question on possibility of the UUM's model to be used for SRI development in Bario. Haji Marzuki responded that KEDA is working closely with UUM and Sri Lovely to develop a model for SRI. They will come out with standard operating procedures (SOP) to guide the farmers on SRI. The tagline for SRI will be 'easy and profitable'.

# Day 2 - Field Visit at SRI-Lovely: Innovating Shared Values with SRI in Actions

All participants were given the opportunities to visit SRI field at SRI-Lovely which is about 50 km away from town. About 10.30am all participants arrived at the destination and were given warm welcome by the host. The welcome speech was given by **Haji Marzuki Md Zin**, Deputy General Manager, Kedah Regional Development Authority (KEDA). This was followed by a forum moderated by Mr. **Rohaizad Ahmad** from Felcra Training Center (Malaysia) that comprises of SRI-Lovely briefing session by the team of **Prof. Wan Mokhtar, Captain Zakaria and Haji Marzuki**. The participants then were taken to six demonstration stations comprising of bio-fertilizer preparation, nursery management, land preparation, planting and water management, mechanization, pest management and post-harvest management.

After lunch, forum discussion continued with the theme 'Sharing of Rice Production' represented by international panelists involving Thongdam Phongphichith (Laos), Hoang Van Phu (Vietnam), Khin Maung Latt (Myanmar), Ram Kahdka (Nepal) and Sanjeeva Ginigaddara (Sri Lanka) who all shared their experience of SRI in their respective country. The guests were treated with barbecue dinner before leaving for the hotel.

**Haji Marzuki** reflected in his speech that it took about four years to develop SRI-Lovely with the support from UUM, Agriculture Department and Malaysia agriculture research unit (MARDI). During the time, Sri Lovely also won several accolades and awards that recognized their effort to push forward with organic farming especially SRI and show that it can be done successfully. He mentioned two crucial achievements with SRI-Lovely i.e. SRI is now included in the Kedah State Transformation Plan and MADA Rice Training Center. SRI-Lovely also has gone downstream processing that involves brown rice, cereal drinks and stingless bee honey. **Captain Zakaria** informed that the whole SRI-Lovely area is about 9.46 hectares. And the whole set-up is quite similar to the one in Nagrak Indonesia. The average yield rate is 12 ton per hectare per season. In parallel SRI-Lovely also raise animals and fish to supplement the income of the center. SRI-Lovely also conducts training and field experience at a very reasonable rate with assistance from UUM on the training module.

**Prof Madya Dr. Kamal Ab Hamid** of UUM also discussed the issue of difficulty to influence the rice farming community to adopt SRI at the beginning but good awareness program and continuous effort and collaboration with government, NGO and local farming agencies, associations and community, has contributed to the increase in the SRI awareness that even now the local people are interested to participate in the program. **Prof. Wan Mokhtar** stressed that the key to buy-in of SRI idea is to share the information and benefits of SRI and not rushing into it.

The progress of SRI in Laos, Vietnam and Thailand is quite encouraging while Nepal has to reestablish the SRI program as it has been dormant for some time. Myanmar also has shown some interest in SRI while SRI in Sri Lanka is generally still at very early stage and not generally acceptable. Work is starting to form collaboration with a university to carry the program in more effective manner.

## Day 3

## Session Three: Innovating Shared Social and Economic Values with SRI

**Prof. Madya Dr. Anizan Isahak** spoke on behalf of Abha Mishra, Co-Director Asian Centre of Innovation for Sustainable Agriculture Intensification (ACISAI) Thailand on sustaining momentum for innovation and learning of SRI in Lower Mekong River Basin (SRI-LMB). The discussion on SRI innovation and learning was around the following areas:

- Developing low-cost technologies for healthy and profitable crops, and how to raise the productivity of their crops using principles of SRI and integrating with indigenous knowledge, plus other complementary crop management principles;
- How soil ecology processes contribute to healthier root and how to grow healthy root systems using SRI methods;
- Reducing external input use without compromising crop yield;
- Sustainable water management through utilizing various structures and make better use of organic matter;
- Development of abilities for critical thinking and ability to communicate and act in groups to articulate needs through the innovation platform to policy makers and scientific institutions for getting their cooperation and support;
- Ability to produce according to demands and specifications of the market, for achieving better marketability of their produce.

For year 2014, SRI-LMB on farm experiment showed positive result for SRI. In Cambodia, the net return is USD536/ha for SRI as compared to USD295/ha for conventional farming. Similar trend was also shown in Thailand that the net return is USD2121/ha compared to USD1234/ha for conventional farming.

**Mr. Michael Commons** from Green Net, Thailand shared with the participants how Green Net is involved in organic products in Thailand. Green net was established in 1993 as social enterprise with two principles, i.e. organic farming and fair trade which currently involves 1,200 members from eight provinces in Thailand of which 95% of the members are organic farmers. With organic farming and fair trade, Green Net attempts to support as many people as it can to produce food in a sustainable way, especially smallholders.

**Prof. Madya Dr. Siti Norezam Othman** of UUM shared her thought on exploring innovative practices of SRI and SRI value chain. The principles of SRI have elements of innovativeness in the aspect of efficiency, economy and sustainability which lead to improvement of rice production ecosystem and people's quality of life. The case samples are farming operations under personal (individual male and female), cooperative and private structure. The study discovered that innovative elements are present in SRI practices in forms of efficient water resource management, efficient use of seeds, putting importance and emphasis on root growth and plant health, protection of ecosystem i.e. weed control, pest repellant and use of organic input and promoting overall environmental sustainability. Although SRI activities also involve other actors such as government agencies, the study observed that the main actor in the value chain is the farmer himself due to small volume of rice production and not a mass production. In conclusion the study observed several challenges facing the SRI producers such as financial limitation, lack of marketing, lack of mechanization, readiness for mass production, lack of labor and lack of organic extension support. These constraints need to be resolved for the organic rice production to remain strong and become competitive.

#### Session Four: SRI Hub Building Network and Linkages

# Forum Three: Shared Value in Knowledge Transfer: Capacity Building and Training Network

The panelists for Forum Three were **Sam Mei Jean** (Seacon, SEA), **Dr Anizan Isahak** (SRI-Mas, Malaysia), **Roberto Verzolas** (SRI-Pilipinas, Philippines), **Supisra Arayaphong** (Weekend Farm Network, Thailand), **Budi Setiawan** (Ina-SRI, Indonesia) **and Thongdam Phongphicith** (Laos) and moderated by **Lucy Fischer**.

**Mr. Budi Setiawan** presented a brief report on SRI development in Indonesia. The SRI paddy field has expanded from low 1.1 thousand hectare to more than 200 thousand hectare in 2014. The expansion is expected to reach 2050 thousand hectare in 2016. There has been quite an encouraging support from the government in terms of seeds, fertilizers, pesticides, machinery, irrigation pump and composting equipment.

**Ms. Sam Mei Jean** shared her experience on e-agriculture (SAFSeN) as a platform for information dissemination and farming technology sharing among members from SEA countries. This ICT platform is expected to bring many benefits to its members however it is also constrained by access to ICT infrastructure, cultural difference, multi languages, lack of voice (if it is a text article) and expression and lack of instant question and answer, thus this lack of interactivity will slow down the learning pace.

**Ms. Supisra Arayaphong** presented an interesting topic on weekend farmer network which is a network of people with different background such as teacher, student, banker and IT consultant who are involved in weekend farming. The network mixes the knowledge gained from the internet and local wisdom and traditional practices including SRI and some innovative own-developed equipment to address their farming needs. Essentially the network develop the contents related to farming context, concept and equipment requirement, use of social media such as facebook and Youtube to connect the practice, experience and product marketing aspects, continuous sharing and learning involving local events, farm visit, collaboration and self-learning and community services.

**Mr. Thongdam Phongphichith** spoke about the SRI experience by Sustainable Agriculture and Environment Development Association (SAEDA) of Laos. The mission of SAEDA is to develop sustainable agriculture and environmental conservation through capacity development and income generation by using participatory approaches by empowering poor communities such as farmers, women, youth and ethnic groups. The program involves Develop/promote Sustainable Agriculture/Organic Agriculture/Natural Pesticides Risk Reduction Agro-Biodiversity Conservation. Some issues were also observed by SAEDA such water management, lack of labor, too big of land to manage, land sloping, too much work during transplanting and weed control hence some SRI practices are 'adapted' to co-exist with these challenges. The SAEDA study also indicates that the average yield of SRI farming is more than conventional. SAEDA targets more than 20,000 Laos farmers to adopt SRI practices in several years to come.

# Forum Four: Shared Value in Knowledge Transfer: Capacity building and Training Network

The panelists for Forum Four were Michael Commons (Green Net, Thailand), Amir Hussin Baharudin (UUM, Malaysia) and Roslan Bani Amin (SRI-Mas, Malaysia) and moderated by Clare Westwood (Third World Network, Malaysia).

**Mr. Michael Commons** shared the need to link small-scale farmers to consumers through organic and fair trade markets. Many small-scale farmers and rural poor are primarily rice farmers and small-scale farmers alone normally cannot influence sales price of their product. There are several benefits for this such as:

- Improved farmer incomes and livelihoods,
- Improved soil and ecological health of farms
- Develop community strength and knowledge exchange
- Provide greater resiliency against abnormal weather and climate change
- Provide access to consumers of high quality organic products

Organization such as Green Net can play significant role to bring together the organic farmers and buyers. Other roles extended include community enterprises, farmer extension, internal control system, product quality checking, farm inspection, farmer groups, packing system, organizing organic market, promoting self-reliance and conducting rice chain programs. Several SRI issues such as SRI branding as different country brands SRI differently from the others, marketing of SRI's strengths, competing or adapting traditional varieties, collaboration and overselling SRI were also discussed.

**Mr. Roslan Bani Amin** discussed about SRI product marketing and retailing providing the progress as it happens in Malaysia and the challenges that marketing faces.

The delegates were then involved in the roundtable discussion is to build database in identifying the available support system for all to practice SRI. The common question to address is what type of support is available or is required to practice SRI. The break-up groups were divided as:-

- Human Capital (Technical knowhow)
- Finance
- Machinery and Mechanization
- Market (Supply Chain Management)
- Advocacy (Policy and Government Incentives)

## The Common Issues and Themes of the Conference:

- The **challenges for rice production** in SEA involves climatic change, high input systems, crop intensification involving high pesticide use and water and environment pollution and lower productivity due to non-optimal agronomic practices and water and soil management;
- The relevant **government agencies** contribute to sustainable development of agriculture sector through policy, certification programs, campaigns, national commitment to international conventions to conserve the environment to ensure national food security, so that the future generations can have access to adequate, safe and nutritious food at affordable prices within the carrying capacity of the Mother Nature;
- In Philippines, the Department of Agriculture (DA) has not extended the support to SRI as expected hence several supports are further requested from DA in the forms of allocation of funds for SRI activities, support the weekly radio program on SRI, conduct SRI trials in every DA research station, conduct training at least one province per region per season and sponsor annual SRI workshop or conference;
- As demonstrated by GPFP program, the **organic method can be incorporated and mixed with conventional farming** as a way to gain traction towards the adoption of full organic in the future farming practices;
- **Mechanization** of key SRI activities involving manual seeding and weeding can be developed and improved further to assist farmers to adopt SRI farming approach. Design, prototyping and testing can be done collaboratively.;
- Equipment is one of the key contributing cost in the SRI operation chain and rapid development of mechanization will help greater adoption and eventually managing the cost more effectively;
- **ICT advancements** must be utilized to enable better information sharing and communication and monitoring of SRI progress among the stakeholders;
- **SRI yield** is typically higher than conventional method. However SRI equipment is one of the constraints for SRI promotion and adoption in many countries;
- **SRI networks** are available in many of the countries that have implemented SRI. These SRI networks are not however connected to other networks in other countries;
- For bigger **SRI adoption** in Malaysia, SRI team will continue to discuss with relevant government agencies and also private organizations to build rapport and obtain support. The SRI will be extended further to farmers in Kelantan and Johor and opening up marketing and sale of SRI rice through more cooperative channels;
- Most of the SRI initiatives are **small scale** and mainly driven by the **farmers** themselves;
- Product **post-harvest and retailing** have not been given adequate attention; **Cooperatives and specific-purpose organizations** for marketing, packing and retailing the organic products may reduce the issue with fair price and ensuring sustainable demand;
- Knowledge and education regarding **pest and pest control** are fundamental to farmers.

### **Participants Recognized:**

- SEA is in unique position to scale up SRI due to diverse regional achievement and long and deep experience with SRI. Global priorities such as reinforcing SRI network across geographical locations, improving equipment initiative by creating global community of designers, inventories, testing and 3D printing, better data collection and improve communication via Facebook, Youtube and monthly newsletter;
- The important drivers for successful SRI introduction in SEA are leadership and ownership;
- **Government supports** are crucial for the greater adoption of sustainable development and the MOA has shown promising contributions and commitments in the forms of policy deployment, certification programs and national campaigns;
- SRI Pilipinas, despite the challenges has established a **strong foundation** for SRI in the Philippines and a more commitment and support from the government will certainly help in extending the awareness and adoption in bigger areas;
- To facilitate the idea of SRI, SRI farming can be **intermixed with conventional farming** starting initially to complement conventional farming and eventually more extensive SRI farming;
- **Mechanization** will attract more farmers to adopt SRI as it can resolve some of the key issues with SRI method such as seeding and weeding;
- **ICT** can be utilized to contribute to SRI awareness and information communication and sharing;
- **Post-harvest, marketing and retailing** need to be given more attention as part of the overall component of SRI value chain;
- SRI **networking** can be more effective by allowing information sharing and communication across countries via the available SRI network in the respective countries. SRI is also requested to initiate networking with international organization such as FAO to achieve better global visibility and support;
- The elements of existing **SRI model** can be extended to **different sectors** in other parts of the country to benefit many more. Those organic **certifications** can be made more significant if they can be certified internationally. There is a need for a more specific and **standard framework** for SRI adoption that can provide ease of understanding and guidance to the community at large. More **cooperation and collaboration** between research, university and farming communities is sought to raise the confidence level of the farmers. Specific **strategies** are required to be in-line with the needs of the farmers old and traditional farmers, young farmers and families and generations of farmers;
- **Concerted effort and focus** can make the SRI successful as evident by SRI-Lovely. In addition, collaboration and support by relevant government units, NGO, university and farming communities are important factors that contribute to the success;
- More **funding** and involvement of **private sectors** is becoming important to bring SRI to greater height.

## As a Follow-up to the Conference:

- SRI-RICE Cornell University has been requested to organize SRI global conference;
- **Organic** fertilizer, plant booster and pest repellant are recommended to be adopted wholly in the GPFP program as the program has shown positive impact to the outcome of the production. This can be extended to other regions in Malaysia and other SEA countries;
- More **government support and commitment** is required for SRI to be more successfully implemented;
- **Mechanization** on SRI farming method is being prototyped and tested. The commercial version may be available in 1-2 years. Collaboration with international organizations can also be initiated to come up with the design, prototype and testing of mechanizations for SRI. Mechanization is one of the critical success factors for SRI;
- Extending the e-agriculture platform to improve the contents and language translation for seamless SRI communication and sharing across SEA countries. Also the e-agriculture need to be further extended to other countries that have not participated in the program. SRI network in these countries can become the contact point to represent their respective country;
- As cost is one of the most important aspects of SRI, there is a need to **standardize the measurement of yield** to avoid confusion and provide the very basic for incentive to adopt SRI;
- Work is currently in progress for **biodiversity microbial manual** at UKM;
- SRI-Ina will lead the organization of SRI conference for young farmers.

## Exploring Innovative Practices of Sustainable Paddy Farming and Their Impact on the System of Rice Intensification (SRI) Rice Value Chain using Stakeholder Approah

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**Abstract:** System of Rice Intensification (SRI) method had contributed towards environmental sustainability through improving paddy ecosystem, better sustainable economic due to improving paddy production and sales and social sustainability through local community development through community activity and health. This study aimed to find out whether the innovative practices of SRI affect the rice value chain and to determine the roles, activities of the actors in the value chain as well as challenges that impacted the value chain. Using interview as data collection method, case samples were selected from various SRI paddy site in Kedah, Selangor, Kelantan and Selangor. The findings indicated that implementing SRI practices in organic paddy cultivation had caused the value chain to be different from conventional paddy value chain in terms of actor and effect of middle man subject to the small scale paddy production. For organic rice value chain to become competitive, roles, activities and challenges were identified so that supports could be provided to the farmers and other related parties in the value chain.

Keywords: System of rice intensification (SRI), value chain, organic paddy, paddy farming

### **1.0 Introduction**

Agriculture sector in Malaysia had undergone different phases of development to ensure its sustainability and most importantly to cater to the food security issue that affects the world. Although Malaysia was considered as an agrarian state in its early independence, the motivation to develop the country's economy had influenced the industrialisation movement in the country due to the successful economy achieved in the developed countries. However, the transformation from agrarian to industrial state had caused the focus on the agriculture sector to become less prioritised. Only after experiencing the food crisis in 2008, where the international rice prices started to escalate due to the control on domestic rice prices and the stepping up of domestic supplies by main exporting countries such as India and export restriction by Vietnam and others (Tey, 2010), the government realised this action would affect the country's food security since Malaysia spent RM26.7 billion in 2009 for imported food. Realising the dependency on imported food and fear of encountering similar crisis in the future, government has stepped up its effort through the National Agricultural Policy (1998-2010) with one of the objectives being to set the

minimum rice self-sufficiency level to 65% (Najim, Lee, Haque, & Esham, 2007) and currently Malaysia is capable of achieving 73% self - sufficiency level (Mustaza, 2011).

At present, Malaysia's rice production is still considered as insufficient in terms of cost and quantity (Fahmi, Samah & Abdullah, 2013). Despite of the continuous government support through its First Malaysia Plan until 10<sup>th</sup> Malaysia Plan, for the past fifty years, the rice production was considered inefficient in terms of cost and productivity. There are many related problems that contributed to the high cost and low productivity such as high cost of labour, land, fertilisers, pesticides and outmigration of youth (Vijian, 2001). However, the importance of this sector towards the country's food security had caused the government to invest more in the sector especially in creating value chain to this sector. One of the efforts undertaken by government is through its transformation programme.

Malaysia, through its Economic Transformation Programme (ETP) highlighted that one of the National Key Areas is agriculture sector that is required to be transformed through modernising and upgrading the capability of the sector to be able to generate sufficient level of food stock for domestic consumption and develop value added agriculture products that can be exported and charged at premium price. This is because Malaysia has to move to a high income nation (Program Transformasi Ekonomi, 2011). For Malaysia, to become a high income nation, it is important for the country to strengthen its paddy value chain. Hence, this indirectly enables the country to improve its self sufficiency level (SSL) of paddy farming. The present practices of paddy cultivation, that are not sustainable would become a barrier for Malaysia to transform the country's paddy sector into a sector that is capable to secure food security of the country. The current paddy cultivation practices have degraded the environmental, social and health aspect of the farmers and consumers who consume the rice. The impact on the environment and health affects the productivity of the crops and also farmers and consumers. Additionally, the elderly workforce which has barely any successors in the sector had caused difficulty in transferring new technology as well as threatening the level of productivity which directly impacted the socio economy of the farmers. As a result, a vicious cyle has been created in this sector and a means to get out from this cycle need to be identified and implemented in order to revive the paddy sector. One of the initiatives that can be undertaken is to introduce innovative practices in paddy cultivation so that sustainability can be achieved and the value chain of the crop can be strenghtened. Due to that, the purpose of this study is to explore the innovative SRI practices and their impact on the rice value chain. The SRI practices promote sustainability in agriculture that are more environmentally due to the green practices, socially due to improving well being of the community and economically sustainable due to premium price of the organic rice.
#### 2. Literature Revies

In transforming to high value added sector and comparing to conventional paddy cultivation, the organic paddy farming had just gained its attention in the 1990's and was initiated by NGOs and personally owned land of private farm such as Kahang Organic Rice Eco Farm (KOREF) and Syarikat Sunnah Tani Sdn Bhd (STSB). Organic rice farming in West Malaysia began in the early 1990's under the guidance of a Non-Governmental Organization (NGO), working with smallholder farmers on rice storage in the state of Selangor. They found that the system was not sustainable due to a number of factors, such as poor production technology support, marketing problems, certification, and farmers' commitment. Then, in 1999, KOREF pioneered the organic method of rice farming practices in West Malaysia. It was found that the land size of organic paddy farming was not that large compared to the conventional paddy farming and the economies of scales were yet to reach.

However, in terms of market potential, the average annual growth rate of the organic market is projected to be in the range of 20-30% and expected to grow from the current estimate of USD\$11 billion to USD\$100 billion in 2010. Major organic markets are developed countries such as European Union (EU), Japan and USA. Many organic conversions in the developing countries are driven by export premiums to serve this market, but not in the case of Malaysia. Conversion to date has mainly come from the producers' personal interest and domestic market. Exports are minimal with a small quantity exported to Singapore (National Study on Malaysia, 2012). According to Quah (2000), Malaysia has the potential to develop new businesses through its organic agriculture opportunity. Unfortunately, based on the fact provided by Department of Agriculture (2007), organic paddy was not included in the organic products although it has a huge potential specifically with the growing preference by customers for organically produced food due to health reasons (Wan Abdul Wahab & Mustafa, 2009).

Since, the entire organic rice sector had not been explored in depth, the competitiveness of this sector is yet to be known. For existing conventional farming, the non-economical nature of this sector is due to the number of parties involved along the value chain for instance during field preparation, planting, cultivating, harvesting and processing(Asia Sentinel, 2013). Value chain development (VCD), a relatively new approach to agricultural development, is widely accepted and becoming the focus of agricultural development strategies. The concept of value chains, which was developed in the 1960s and 1970s, is to aid the analysis of mineral exporting countries and becomes widely known and popularized in the 1980s as a business tool to analyse and assess possible upgrading of technologies and processes in individual firms before being applied more broadly to supply chains and distribution (Porter, 1998; Kaplinsky & Morris, 2013). It is a relatively new approach to agricultural development (Altenburg, 2011), although the thinking about entire chains from production to consumption and increasing the share of value captured by farmers is not new to agricultural development. The original concept is based on the idea that a firm can develop strategies to improve and maintain its competitive advantage

by disaggregating its core activities and quantifying the value of each activity. This concept has been extended beyond individual firms to whole supply chains and distribution networks.

Hence, in this study, a new method such as SRI had to be explored in order for the organic rice to attain competitiveness and their impact on rice value chain would be investigated. Most of the studies conducted in Malaysia were addressing the conventional paddy farming and little was known related to sustainable rice farming and its value chain. Thus, the scarcity of the studies on SRI practices and its value chain effect requires further investigation specifically on the issue of whether the practices can be adopted to complement existing conventional paddy production. In addition, the effect of SRI method on the value chain of the organic paddy and important factors contributing to the success of organic paddy farming such as extension service, supporting system, and policy to motivate sustainable paddy cultivation among farmers.

#### 3. Research Method

This study employed qualitative method specifically the case study. It had been widely known that case study was widely used in the areas of organizational studies, public administration, political science and sociology. It had been particularly effective in studies that examine institutions with a high degree of complexity, especially when a 'how' or 'why' question was being asked about a contemporary set of events, over which the investigator had little or no control" (Yin, 2008). However, the qualitative case study research had been criticized as a methodology that lacked rigor and precision. One reason for this reaction was that case study research had none of the technical complexity that seemed to render statistical research more objective in the eyes of many academics (Yin, 2008). Nevertheless, this method had helped the researcher to understand a phenomenon in depth. Since the primary goal of this study is to explore the innovative practices of System of Rice Intensification (SRI) on organic paddy cultivation and to examine the value chain of the organic paddy in Malaysia, the case study method would help the researcher to understand the practices and the roles of the actors in the chain and the interrelationships of one actor to another in the value chain. In addition, through qualitative case study, the important determinants that made up a value chain of organic paddy could be explained. This study involved multiple respondents with different perspectives; hence, this would provide feedbacks from different angle. Thus, this was also known as multiple case studies. A multiple case approach would allow a comparison between cases. Such a study was especially suitable for this research because it allowed the researcher to make cross-case comparisons and helped to identify the SRI paddy cultivation practices among farmers from different sites and operational context as well as to comprehend the actors' that made up the value chain.

The selection of case samples were based on the actors that made up the SRI organic paddy cultivation. The respondents of this study were stakeholders in SRI organic rice industry such as

farmers, authority such as BERNAS, MARDI, Department of Agriculture in the state of Kedah and other related parties. The analysis is at an individual level. In the second phase, an interview was conducted with the case samples in order to find out their perspectives on the SRI technique and the constraints as well as opportunities in the organic paddy value chain. In qualitative study, for this technique, the issue of sample size was ambiguous. There was no fixed number of sample sizes because the sample size was dependent on the number of research questions and objectives. Hence, the issue was on what the researcher needed to find out, what would be useful, what would have credibility and what could be done within the available resources (Patton, 2002). The purposive sampling technique was one of the common techniques in identifying the case samples. Since purposive sampling was a non-probability sampling technique, therefore, its function was not to provide generalisation to the population. Case samples selection were based on the predetermined criteria as indicated;

- 1. The respondent must be familiar with the SRI technique in cultivating organic paddy
- 2. The respondent might cultivate the paddy using the SRI technique or had business with the person that cultivate the paddy using SRI technique
- 3. The respondent must be the primary actor in the organic paddy value chain

# 4. Results and Discussiom

The case studies were analysed using cross case analysis. The cross case analysis enables the researcher to compare similarities and differences in the responses given by the respondents based on the guided questions.

# 1. What are the innovative practices demonstrated in the SRI technique to ensure sustainability in the paddy cultivation?

# In terms of innovative practices demonstrated by the farmers were

- a. Water management- in conventional paddy farming, water was used profusely and was not manage well causing wastage of inflow and outflow of water from the paddy field. In SRI method, the water level requirement aimed to moisten the paddy soil, but not continuously saturated to ensure mostly aerobic soil could be prevailed. The water reduction for the irrigated rice could reach 25% to 50% or more especially when the paddies were not kept flooded
- b. Transplant the young seedling by selecting fertile seed and planting the seed singly in a space provided in a tray. The seedling would grow around 8-12 days but less than 15 days. This was to ensure the seedlings attained their potential growth. These young seedlings would be transferred and planted in the paddy field.
- c. Transplanting the young seedlings singly rather than in a clump, one at a time.
- d. The young seedlings then were planted in a square pattern after farmer measured and marked the paddy field in a square of 25cm × 25 cm or wider if or when the soil was more fertile. By doing this, the young seedlings would be able to grow and compete less with other seedlings. Then, they could get more access to nutrients and water and their roots would be much stronger and healthier. Using this method, from the single seedlings, the farmers would be able to get large multi tillered clump of rice from single seedling

- e. Controlling weed through frequent weeding by mechanical hand weeder to aerate the soil. In other words, grass would be kept away and the fertility of the soil could be increased through the weeding process. Indirectly, the root of the paddy plants would grow healthy
- f. Applying as much as organic matter or organic manure to the soil, although chemical fertilizer could be used, the best result could be achieved when compost, mulch were used

These six principles of SRI methods were predominantly adopted by farmers from Belantik, Baling, Kok Keli, Tumpat; Sg Leman. Nevertheless, farmer in Tunjong had modified on one of the practices. In Tunjong, they used transplanter machine to plant the seedlings and this modification had changed the custom practice of SRI paddy cultivation. Hence, single seedlings were not applicable since more than 2 until 5 young seedlings would be transplanted by the transplanter and sometimes none of the seedling was successful transplanted. From the interview, there was innovation adopted by the farmer in Tuniong compared to what had been practised in SRI system. Farmer in Tunjong aimed to produce mass organic paddy production and using a transplanter would enable him to catch up the time of harvesting of conventional paddy farming compared to using labour intensive, it would take him days to complete the cultivation phase. In conclusion, farmer in Tunjong had adopted 5 principles out of 6 principles in SRI. As indicated by farmer in Belantik, he had modified the system by producing compost using piping system. Previously, workers were used to aerate the compost and this process was required to conduct frequently. Using the piping system, the air could flow smoothly. Through this system, farmer in Belantik did not have to aerate for many times to ensure enough air flow existed and hence, this would help to expedite the process of making compost

# 2. To what extent the practices affect the value chain of the organic rice

The six principles in the SRI practices had affected the value chain of the rice in various ways. The actors in the value chain could be reduced and the middle man effect could be lessened. In the organic rice value chain, the main actor was the farmer. Farmer was involved from the preproduction phase until postproduction phase. The preproduction phase was the initial phase where land had to be prepared, huge initial investment had to be acquired to improve the soil health and all other necessary inputs such as seed, fertilizer, pesticides, weeding equipment, labour and machineries. In the SRI method, the inputs could be prepared by the farmer without depending on seed seller, fertilizer and pesticides manufacturer. For seed, farmer could outsource from the government agencies such as MADA, KEDA and also from other farmers at the initial stage but later they could self-propagate the seeds for next cultivation period. As for the fertilizer and pesticides, farmers could produce themselves using the natural resources such as fruits, leaves and others, where they could get around them. In addition, farmers had to be innovative in order to invent machineries and equipment that fitted the SRI practices although they had alternative to request higher education institutions to help them to produce prototype of the machine or equipment.

Since the production operated in small scale, farmer was able to handle small machinery and easy handling equipment such as paddy straw cutter, weeding machine and others during the production phases. Hence, the need for larger machine with higher rents was not an immediate requirement to the farmer. In terms of marketing, for farmers, they could market the rice themselves through the Cooperative or individually or through Non-governmental organisation (NGO) such as SRI Mas. Farmers were empowered and they could decide the selling price of the rice since they were not depended on subsidy. Thus, the value chain of the SRI organic rice was explained in the Figure 1



Figure 1 Value chain of the SRI organic rice of small scale production

3. What are the roles, activities and challenges of primary actors or stakeholders in the SRI organic paddy value chain?

# The roles and activities of input providers - At initial stage

Since this SRI method was purely organic without any mixture of chemical substances and SRI organic paddy farming was at the early stage, hence, the primary actor was farmer because almost all activities were under their responsibilities. Nonetheless, it did not mean that other actors like conventional paddy cultivation actors were not significant. The reason farmer became the main actor in all activities along the chain was the SRI organic value chain was new to conventional or potential farmers. This method also had its own requirements, which differed from the conventional paddy value chain and had to be fulfilled before a developed SRI organic paddy value chain could be developed. As indicated in Figure 1, the roles and activities of the actors in the value chain are explained.

In organic paddy specifically to SRI organic paddy value chain, at the initial stage of the organic paddy farming, the actors of the value chain analysis were input providers such as the government agencies like MARDI, KEDA, the farmer. This was due to the fact that government agency such as KEDA had initiated the establishment of cooperative among villagers in the rural area such as Baling and Belantik. KEDA was a Kedah development agency where its focus was on rural development. At an initial stage, high working capital and initial investments were required hence, KEDA had played the role of an agency that not only focused and supported the rural project but also provided initial investment or working capital in the form of machinery, fund to start operations such as levelling the soil, packaging, fertilizer, seeds and others to the project in Belantik and Baling. At initial stage, the investment was very high and rural community project needed to be supported. Other than KEDA, public research institute such as MARDI also involved in this project for instance, in terms of conducting studies related to water management, seed quality and by supplying seeds to farmer in Belantik. Certain allocation of Belantik paddy farming sites had become the research plot for MARDI, Department of Agriculture and also public universities such as UKM and UPM to conduct research related to soil quality and others. Compared to Belantik, farmer in Baling was given similar support in terms of machinery and funding to start the organic paddy project. The project was run by a cooperative structure similar to Belantik, whereby villagers were encouraged to become a member. The minimum number of members was 30 and the cooperative in Baling had successfully accumulated RM100, 000 to run the project.

Compared to Baling and Belantik, farmer in Tunjong was incorporated as a private company. Its organisational structure was different from Belantik and Baling. It was operated under Board of Directors and was managed by a manager cum farmer. Although the company was a private company, its main focus was not to gain profit only. The existence of this company was more toward fulfilling the community needs or social responsibility. There were permanent and contract workers employed at the site. The input provider such as seed supplier came from

friends while transplanter machinery was loaned by Department of Agricultural and also programmes for farmers conducted in Tunjong and apart from the support of Department of Agriculture, farmer in Tunjong also received assistances from State Government in terms of weeding machine.

# Development stage

After the initial stage, farmers in Belantik, Baling and Tunjong produced their own seeds to be planted at the paddy field. For SRI organic paddy, one hectare land only required 5 to 7 kilograms of seeds, which if compared to conventional paddy farming, the weight of seeds was heavier more than SRI organic paddy farming. In addition, the farmers at both sites produced the organic fertilizer to be used at their paddy fields. Either farmer in Baling whom developed smaller paddy field or farmer in Belantik and Tunjong, whom cultivated paddy at larger scale, they were capable of producing the organic fertilizer and also insect repellant to be utilized at their paddy fields.

# The roles, activities and challenges of farmers at initial and development stages

The roles and activities of farmers in Belantik, Baling and Tunjong were similar at initial and later stage. Both Belantik and Baling as well as Tunjong farmers rented the land from villagers at around RM150-200 per acre. The size of the land was huge and was underdeveloped compared to individual farmers in Tumpat and Sg Leman. The land size of organic farming for Belantik was 6 hectares, Tunjong was 4 hectares however, in Baling, and the developed land size was 1.25 hectares. The inability of farmer in Baling was due to constraints such as capital. Compared to Belantik and Tunjong, Baling farmer had received the support from KEDA on one off basis. This meant that the supports from KEDA including the advices were only materialized during its initial stage. Subsequent support after initial stage was hardly received by the farmer in Baling although request had been made to various government agencies besides KEDA. For Belantik and Tunjong, the support and networking with the government agencies such as KEDA and Department of Agriculture were on continuous basis.

In cultivating the paddy, farmer in Belantik and Baling adopted all SRI principles in farming the paddies except farmer in Tunjong, who had modified the single seedling practice. Farmer in Tunjong utilized the transplanter machine to plant the paddy seedling on the paddy field. However, using the transplanter, more than one seedling was planted on the soil. The modification was done to expedite the cultivating process and to solve the problem of getting enough labour. In addition, weeding also would be different because the row of seedlings produced by the transplanter was not in a straight line causing difficulty for the farmer to use weeding machine manually. Hence, a modification by using 30% of weeding machine and 70% manual weeding had been done to accommodate the SRI principle that required weeding process.

In Belantik and Baling, all the cultivation activities including weeding were done manually with the help of workers. The activities done by farmers at three sites were preparing land, preparing organic fertiliser and insect repellant and cultivating paddy.

In the next phase, after producing and maintaining the paddy fields, farmers were also involved in the post production stage. These post production stage activities covered harvesting, drying, storing and milling the paddies. The activities such as harvesting, drying and storing were done by the farmers and with the help of their workers. For farmer in Belantik, harvesting was done manually using the paddy straw cutter with the help from workers even though the land size was bigger than Baling site. These workers were capable of undertaking the task manually because paddy farming in Belantik was cultivated in staggering stages. At Baling site, harvesting activity was also done manually using the paddy straw cutter due to its small land size with the help of only one worker. At Baling site, the farmer separated the paddy seed from the plant traditionally by hitting the paddy plant on the mat in order to extract the paddy seeds. Then, the seeds were dried under the sun. In Tunjong, the paddy was harvested using large harvester machine similar to conventional paddy farming. Then, the paddy seed would be dried under the sun manually, which would take time for the workers to handle. For Belantik farmer, harvesting activity was done manually to separate the seeds from the paddy plant and similar to Baling, the farmer and his workers would dry the paddy seeds under the sun before milling or processing them.

# The roles, activities and challenges of miller

All Belantik, Baling and Tunjong farmers had two options to process their paddies. They had options either to process the dried paddies with BERNAS or using the rice milling machine owned by the Belantik and Tunjong farmer. By processing with BERNAS, there was advantage on farmers in getting quick payment from the miller. Processing paddies with BERNAS implied that selling the raw paddies to the miller and farmer could get money quickly from the sales. However, if farmer decided to process the paddy using its own milling, farmers had to wait longer time to sell the rice because it took time for the farmers to market the processed rice. In terms of profit, by processing using his or her milling machine and selling the processed rice to market, farmers would get higher profit compared to selling the raw paddies. For farmer in Baling, besides BERNAS, he also sent paddies to Belantik to process the paddies. The milling machine capacities at Belantik were one to three tonnes per day. Similar to farmer in Belantik, farmer in Tunjong acquired a mini milling machine that was capable of processing not more than 50 kilogrammes of paddies. The Tunjong milling facility was also sent by other organic farmer such as farmer in Tumpat.

The operations of large scale paddy producers with specific organizational structure were differed compared to paddy farmer who did farming at individual level. For an individual farmer such as in Kok Keli, Tumpat, initial investment in starting the project came from personal saving. The developed land was rented at RM40 for one season and initial land preparation was

done by hiring tractor to level the soil and this activity was paid personally. One of the actors in organic paddy value chain for individual farmer was seed provider or input provider that informally acquired from friends. Since the land size developed in Kok Keli, Tumpat site was 50 times 36 feet or in small scale and required only 50grammes. There was not an immediate requirement to purchase seeds from suppliers due to the small size of the paddy field. In terms of organic fertilizer and insect repellent, the farmer produced herself and then applied them to the In Sg Leman, SRI paddy organic was cultivated at individual level. Majority of paddy site. farmers in Sg Leman, Selangor adopted only organic fertiliser principle out of five other SRI principles. One farmer had farmed one of his 1 acre paddy field plots using SRI method. Similar to farmer in Tumpat, he got seed supply from friends and the input such as organic fertiliser and repellent was produced by him. For both of the farmers in Tumpat and Sg Leman, the harvesting, separating the seeds from paddy and drying paddies were done manually. These activities could be done manually and were manageable due to the small paddy plot size. Both of the farmers would send their paddies to BERNAS or small milling operators near to their place. For Tumpat farmer, she also milled her paddies at Tunjong, where organic paddies were farmed. Both of the farmers aimed to produce organic paddy for their own consumption and not for sales. Hence, they did not really need a marketing arm at this time.

# The roles, activities and challenges of marketers at initial and development stages

Interestingly, the marketing function of these three farming organisation was not a priority at the moment; however, farmer in Tunjong was concerned more on the marketing aspect. It became a concern when the organic paddy produced by them exceeding the demand, hence, this condition had forced them to market the organic paddy quickly. Farmer in Belantik and Tunjong had his or her own worker doing the marketing task. Basically, the sales of organic paddy were done among friends, pharmacies and mostly those individual that had health problem. The sales of organic rice were done at exhibition, exposition and sometimes they were offered booth to sell their products without any cost incurred by government agency.

Based on the analysis of multiple cases, for paddy farmers under specific organisational structure i.e. cooperative and private companies, it was interesting to find out that at an initial stage the actors were mainly two parties; the input providers that represented by government agencies, friends as seed suppliers, the farmers and the organisation as marketing arm. Two of the paddy sites Belantik and Tunjong, had received continuous support from government agency even though they were in the development phase, whereby they had their own milling facility and were capable of selling their organic rice. This was due to strong networking with the personnel at the government agency. These farmers from the three sites had similarity in terms of undertaking the activities of production or farming phase and also post production phase or harvesting, drying, and processing. Farmers in Belantik and Baling were still using traditional working method in harvesting, separating seeds from paddy however, farmer in Tunjong had

modified one of the SRI principles of single seedling by using transplanter machine and he also had changed the weeding practices for instance 30% of weeding tasks used machine while another 70% of the tasks were done manually.

At individual level, the farmers concerned more about the production phase and post production phase, however the marketing aspect was not considered as a primary function of their activities. Due to the land size, both farmers in Tumpat and Sg Leman produced rice for their own consumptions and they did not intend to sell the organic rice.

# **5.0** Conclusion

Based on the results of the study, SRI practices have promoted the sustainability focus on betterment of environment, which could be achieved through practices such as well managed water resources, using organic matter that would improve fertility of the soil through healthy living microorganism and hazardous free chemical substances that might cause affluence and negative impact on consumer health. In addition, the practices have improved the paddy ecosystem and subsequently improved the productivity of the paddy.

The SRI practices have effect on the value chain of the organic paddy in terms of number of actors involved in the chain. Due to the small scale production of paddy cultivation, the main actor at paddy farming phases, preproduction, production and post - production is the farmer. Middle man can be reduced or eliminated, hence increases empowerment of the farmer. Farmer is the important actor due to the capability of the farmer to sustain in cultivating paddy, for instance, farmer is capable to propagate the seeds, produce the organic fertiliser and pesticides. In addition, farmer becomes more innovative since he or she has to invent equipment or machine that fits in the SRI principles. Thus, reliance on huge machinery such as weeding, milling machine can be reduced. The roles and activities involved by the actors in the value chain can be categorised in three phases; the preproduction, production and post - production. The activities under preproduction are providing seed to farmer (initial stage -govt agency), self -propagated seeds by farmer, labour input, land, machine and equipment. In a production phase, the activities are preparing organic fertilizer and repellent, harvesting, drying, storing and processing while in post-production phase, the activities are packaging, marketing and selling. In a production phase, challenges faced by farmers are high initial investment especially in preparing and treating the soil, lack of committed workforce in paddy farming while in production phase, it is found that there hardly mechanical tools such as machine and weeding equipment since majority of the farmers preferred to farm manually. Finally, the post – production phase, farmers highlighted that drying and milling facilities for organic rice are needed so that organic rice would not mixed with conventional rice. In addition, they also required programmes and workshop especially related to marketing competencies.

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# Value-Added Biological SRI: An Economic Case Study from Northern Thailand

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**Abstract.** Rice is a staple food of many parts of the world, with Thailand always in the top 3 global rice exporters. The government of Thailand is proud of its farmers and rice's value as the "Nation's-spine." However, due to the practice of costly input utilization over several decades, the sustainability and biological backbone of rice production has deteriorated around the country, pushing many Thai farmers to use more synthetic chemical inputs and go greater into debt. Although many of the input costs continue to increase, the price of rice remains volatile.

Besides the production of rice for quantity, some farmers are increasingly concerned with quality and the sustainability of their systems. One such example is a Northern Thai farmer, Miss Fah Mui, from Chiang Rai, Thailand. Because she cares about her consumers' health and the biology of her rice paddy, she is always keeping her eyes open for options to cultivate rice without using synthetic chemicals that will also increase the quality and quantity of the rice she produces. One day, she found an SRI manual that was published by McKean Rehabilitation Center in Chiang Mai, and she tried it out for a few years using organic fertilizer and fermented herbal spray to control insects and diseases in her paddy.

She was satisfied with her yields and as a result of of the carefully-applied organic practices, her rice price was higher than the government's fixed price. Whereas the government's price of rice was \$0.50 per kilogram, she could produce brown rice and sell it at \$2.6 per kilogram on-farm (or \$4 per kilogram in Bangkok). As an additional income stream, she began to produce GABA (Gemma-aminobutyric acid) powder, which is a rice powder (germinated brown rice that is turned into powder). She sells GABA under the nice-marketing that it is good for peoples' health. She packs 200 grams of GABA rice powder/bag and sells it for \$1.6 (or \$8 per kilogram).

SRI and biological rice production might require more labor, but the overall profitability can be very high for a farmer willing to learn the techniques, experiment, and put in the hard work. For Miss Fah Mui, she is convinced that it is totally worthwhile to practice SRI and biological rice production, for the sake of the environment, her profit, the economy, and for the "Nation's-spine."

Keywords: Northern Thailand, SRI, economics, case study.

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#### 1. Introduction

Thailand is 513,115 square kilometers in area [14], making it the 50<sup>th</sup> largest country in the world and third largest in Southeast Asia. By comparison, Indonesia is 1,811,570 square kilometers and is the second largest in Southeast Asia [13], and Myanmar is 653,520 square kilometers [12]. Thailand has a very diverse geography: the Northeast is predominantly dry land which is difficult to cultivate, but the Northern part is mountainous, covered with forest, home to Doi Inthanon (the highest mountain in Thailand at 2,565 meters above sea level), and acts as a watershed for the main rivers that feed the fertile Central Lowlands of Thailand (Fig 1). Thailand's four great rivers (the Ping, Wang, Yom and Nan) meet at Pak Nam Poh District, Nakorn Sawan Province, and become the mighty Chao Phraya River which runs through Bangkok and empties into the Gulf of Thailand. The Chao Phraya basin is a fertile flat land that is an area of key importance for rice production.



Fig. 1: The four main rivers of Thailand watering the fertile

#### Central Lowlands. From [16]

At the location where these four great rivers meet, one finds flat land and rich soil. This region is well known throughout Thailand as one of the chief rice production areas. Rice farmers in this area are able to cultivate rice year round. Some farmers will cultivate two crops of rice, while many are able to cultivate up to three crops, with proper irrigation. The Chao Phraya basin is a fertile land and one of the primary rice growing regions of Thailand. Historically, Thai rice farmers have never had much of a concern in regards producing higher yields, as the land in this

area is fertile and the water is plentiful and their main concern was to produce enough food for the household first and then to sell within the community. Since World War II, Thai rice farmers shifted their focus to growing as much rice as possible as a commodity crop, selling to millers and middlemen, and have remained at the mercy of government policy and international commodity prices which tend to promote volatility [2]. In addition to the volatile rice prices, the cost of rice growing inputs have traditionally increased year-over-year, often forcing many farmers to look for loans to purchase fertilizer, machinery, pesticides, and other inputs. In some cases, if farmers spiral into too much debt. They may have to look for alternative sources of income and give their land as debt payment [11].

Stories abound during the 1997-98 economic crisis of farmers who had to rent their land from loan brokers to cultivate rice on the land they once owned. During that time, many young people became jobless and decided to go back home and depended on their parents for survival, who were rice farmers. Throughout that period of time and increasingly today, Thailand is seeing more hybrid-livelihoods develop as farmers not only grow rice for food and for sale, but being to work in other sectors to provide income in order to make up for the economic windfall from the rice crop [5].

Some Thai farmers grow rice primarily for home consumption and depending upon water availability, will cultivate a paddy crop at least once a year. If there is excess rice, they may sell to an agent or the government to be transported and milled by a company. It is only with irrigation that certain parts of Thailand are able to produce 2 - 3 crops per year [7]. The majority of the farmers that are growing rice for reasons other than home consumption are vulnerable to the unstable commodity price of rice, causing economic problems for them and the country (Table 1). Smart farmers have to find ways to escape from this volatility. Fah Mui is one such farmer.

	2006	2007	2008	2009	2010	2011
Jan	7,720	8,725	10,900	13,660	15,100	1,388
Feb	8,100	8,875	12,500	14,150	14,775	13,013
Mar	8,260	9,000	13,190	14,010	14,320	12,813
Apr	8,345	9,170	18,463	14,320	14,125	12,900
May	8,445	9,060	17,275	14,060	13,750	12,950
Jun	8,630	9,055	15,015	14,280	13,260	13,200

Table 1: Jasmine rice prices for Sakon Nakorn, Thailand, by month, from 2006-2011.

SEA Regional Conference on the SRI 2015

July	9,290	9,135	14,150	15,316	14,160	14,200
Aug	9,450	9,120	13,375	15,730	14,430	14,460
Sep	9,195	9,010	12,840	15,775	15,120	15,075
Oct	9,180	8,920	12,650	15,787	14,360	15,730
Nov	8,250	9,175	11,725	13,170	13,760	15,025
Dec	8,175	10,150	12,310	14,987	13,750	15,325
Average	8,587	9,116	13,699	14,604	14,243	14,018

Data Source: Thailand Department of International Trade [9]

#### 2. Rice Farming Methodologies in Thailand

#### 2.1. Traditional Thai Rice Farming Depending upon Farm-Derived Inputs

As seen in the economic phenomenon above, Thailand is a fertile land that is able to produce a high quality paddy-type rice to sell to people all over the world. In the past, farmers produced rice just for family consumption and if they could produce more than the family consumed, the excess rice was traded for other things from the community. Water is required to cultivate rice, so traditional rice farmers used to construct a ditch to supply water for their paddy.

Before the year 1960, Thailand's land area was 50 - 70 percent forested [4]. The people living in the mountains used to practice upland rice in a traditional rotational farming (or swidden fallow) system [10]. The rotational farming system depended upon clearing forested land every year that was then planted in upland rice and other traditional staple crops [10]. When the rain began during the rainy season, the water washed the topsoil down to the lowland paddy areas [10]. Lowland farmers capitalized upon this water by constructing a ditch above their paddy and redirecting water to irrigate their paddy rice. Because this water was from the upland areas, filled with sediment and dissolved nutrients, it also fertilized the lowland paddy.

Farmers also raised animals such as cattle (cow and buffalo) that were often used for draft power. Farmers would plough their paddy with cattle, and after the ploughing season, the farmers would drive their cattle to the mountains so that they would not damage their rice. In the mountains, the cattle manure would fertilize the forest and also be washed downstream, fertilizing the paddy. After harvest (dry season), the cattle would typically not have sufficient grass, so they would come back to the paddy to eat straw and fertilize the paddy by their manure. Because of this system, the farmer did not have to carry manure to their paddy and did not have to burn the rice straw and stubble, because the cattle used it as their food source. According to this cycle, farmers never had to over-produce for export, and were not reliant upon synthetic fertilizers and other expensive inputs. The system worked well for centuries, until Thailand aimed to develop an export rice market, at which time everything began to change little by little. Instant fertilizer replaced the natural fertility system, machines replaced animal labor, and rotational farming even become "illegal" [11].

# 2.2. A New Era of Thai Rice Farming Depending Upon Synthetic Inputs

With the new historical paradigm at beginning of the 20<sup>th</sup> century, Thailand no longer produced rice purely to eat at the household level, but farmers began producing rice as a commodity for cash, which in turn influenced their aim and mindset. When farmers began growing rice with maximum inputs in order to maximize yield and profit, culture began to change - Thai farmers began ignoring many taboos, local knowledge, and ceremonies [1]. The environment suffered tremendously with the abandonment of traditional nutrient regimes and the addition of synthetic fertilizer, over-reliance and use of synthetic pesticides, fungicides, molluscicides, and other synthetic inputs. Although input reliance increased and input costs increased, yield output only increased to a certain point, after which they stagnated. These various treatments did not guarantee that the farmers did not go into debt, but actually made their financial situation worse. These changes also made the farmers susceptible to health effects and environmental pollution [6, 1].

The increasing input costs, increasing farmer debts, and stagnant commodity prices eventually forced the Thai government to intercede. In 2011, the Thai government realized that farmers were in economically dire straits, so Thai Rak Thai Party implemented a rice pledging scheme whereby the government would buy rice at a price of 15,000 THB (\$500) per ton irrespective of the world market price.[15]. In essence, the Thai government made the domestic value of rice higher than the true international price, making it very difficult to export rice to other parts of the world.

Fortunately, not every consumer is content with buying Thai Jasmine Hom Mali rice regardless of the economic, environmental, or social costs that its production may create. In fact, there are many people who are ready to pay a higher price for a high quality premium rice that has beneficial impacts on people and the environment.

#### 3. Case Study: Alternative Rice Farming for Increased Profit and Environmental Health

In contrast to the modern rice farming that the government has been advocating since post World War II years [2], there are farmers around Thailand returning to biological considerations for their farm systems and reaping environmental and economic benefits in return. One such example is Fah Mui, a farmer from Chiang Rai, Thailand. Her story is one of a farmer who went from being beholden to middle men and government policies, to economic and agricultural freedom.

Fah Mui started out as a fertilizer shop owner. However, because she didn't want to sell chemical products, most of the products in her shop were biological goods such as effective microorganisms (EM) and molasses. "I am not a rich person, and before I was even in debt," Fah Mui relates. To pay off her debt, she had been looking for various opportunities. Her family was interested in growing rice, especially rice that was free of chemicals, a product that was especially desired by a customer in Singapore. Because of this, about 6-7 years ago, her hunt for alternative agriculture practices led her to find a book about SRI that was translated by the Agriculture Extension branch of McKean Rehabilitation Center (MRC), located in Chiang Mai. MRC is a Christian leprosy healing and rehabilitation center that was established by an American missionary over one hundred years ago. The book was translated from English to Thai by a team of MRC staff: Klaus Prinz, Ratchakorn U-Seang, Sombat Chaleamleamthong and Boonsong Thansrithong. The book was academically vetted by Professor Pruk Yebmantasiri of Chiang Mai University.

Fah Mui carefully read every single word of the book. She had her doubts, but she wanted to see if what the book said about SRI was true, so she called MRC and was able to talk with Mr. Sombat, who explained to her as much as he could. After their conversation, she gained much more confidence and wanted to try her own hand at SRI.

"At the time I had 36 acres of paddy land in Phayao province [Note: Phayao is a province in mountainous northern Thailand], but during that first year, I practiced SRI only on a small 0.4 acre piece of land. This small piece of land had a very good yield in the first year. She recalls, "According my calculations (if nothing went wrong), if I practiced SRI on all 36 acres, I could pay off my debt." With this projection, Fah Mui practiced SRI on all of her land during the second year. Unfortunately, the rice fields that year witnessed heavy rains and much flooding all over Thailand. Her paddy flooded and all of her rice was damaged. Instead of paying off her debt, she actually acquired more debt. Thankfully, her Singaporean customer came to visit and was able to help her with a 30,000 THB grant.

"I kept growing rice. I continued at this place in Phayao for another four years and rather than improving, the yearly flooding became worse," she explains. Finally, she decided to move north, where she bought six acres of rice paddy land in Mae Chan District, in the mountainous Chiang Rai province. She had come to learn from her previous experience with rice-growing which taught her that she shouldn't use a single method for the entirety of her land, at least not until she became more sure and sufficiently confident in the technique. That first year [in the new location], she planted rice with three different methods in order to test them: the first method used the traditional technique (planting 8-10 older seedlings together with close spacing in the paddy), the second method was a "double transplant" method (prepare the seedlings like SRI in a seedling bed, transplanting them into a special bed in the paddy and then planting the field using the seedlings from the special bed), and the third method was the SRI method (planting single young seedlings, spaced further apart). At the end of the season, it turned out that the yield of the first two methods didn't even compare with SRI, which had significantly higher yield. With these results, she bought another six acres (a total of twelve acres of paddy). Fah Mui notes, "In the coming years, I will continue to grow SRI on all twelve acres. Because the land has enough water to grow a second crop, I am also able to grow rice using the SRI method through the dry season on six of the acres."

Fah Mui also explains, "Not only do I practice SRI, but I also mix it with a 'biological agriculture concept." She does not use any synthetic chemicals and only uses biological and natural materials. She uses "Fermented Herb Juice" for repelling insects, manages water levels in order to control weeds, and uses natural methods to prevent crab and snail damage to the rice. She applies only 250 kilograms of organic fertilizer per acre.

Regarding the overall health of her paddy, Fah Mui states: "My healthy SRI rice makes me very happy - I even visit the paddy and talk with my rice. When I look at my paddy I can see that there are many kinds of fish and various species in the water of the paddy. Hovering about the rice I can see a cloud of dragonflies looking for insects to eat. There are also spiders and many other good insects present. With biological controls, my healthy rice is able to resist many potentially harmful diseases that can otherwise be transmitted by insects."

While at first she might have had questions or concerns about SRI, such as the labor required or the amount of time that needs to be spent weeding, after the first month, she realized that she wasn't suffering from these two main concerns at all. Instead, she found that she actually enjoyed spending time in the healthy rice paddy. She found that "I love seeing my rice every day because it makes me happy! It's funny, when it's time to harvest the rice, workers actually complain that my rice is heavier, per volume of rice, than other farmers. They don't like to work for me unless I pay them a little bit higher wage than other farmers! I am happy to pay a bit more because I produce better quality rice."

One economic benefit that Fah Mui has derived from her production is that she is able to pursue non-traditional economic markets. While typical Thai rice farmers sell their rice to a rice storage facility, she mills her own rice to produce brown rice (rice with the bran still attached, which is considered healthier, but has a shorter shelf life). She then packs it in 1 kilogram bags using a vacuum packing machine (for a longer shelf life) and sells it at \$2.6 per kilogram (on farm), and \$4 per kilogram in Bangkok (Table 2). This price is 2-3 times higher than the general market price, and thus she doesn't need to rely on the government subsidy price, because her price is already several times higher.

In addition to her niche market in Bangkok, and in order to create more income from her rice, Fah Mui has begun to produce GABA (Gemma-aminobutyric acid) powder, which is a rice powder (pre-germinated brown rice that is turned into powder). She sells that GABA under the niche marketing that it is good for peoples' health. She packs 200 grams of GABA rice powder/bag and sells it for \$1.6 (\$8 per kilogram). This GABA rice is also economical. If traditionally milled rice has a conversion ratio of 60% (10kg unmilled rice : 6kg milled rice), GABA rice has a conversion ratio of 80% (10kg unmilled rice : 8kg of GABA rice) (Table 2). Currently, she has been selling the GABA rice at \$8.00-\$10.00 per kilogram and each day she will sell 100 bags or 20 kilograms on average.

As an example of how technology can be used to help farmers, her son has even begun selling this GABA rice powder on the internet using a dedicated website and a Facebook page, and she has found that she has received so many orders that she almost can't produce enough to keep up with the customers! Although she doesn't have internet, her son does, and he takes the orders and uses the Line app to send her daily orders, which she packs and mails it directly to the customer. She sends on average 100 bags per day, so the postman has begun offering the special service of picking up packages directly from her house in the mountains 2 times a day at 11AM and 3PM so that she does not need to drive into town to the post office.

Fah Mui relates that it is not difficult to make GABA rice, but producing this requires the highest quality of rice. She loves using SRI rice not only because it produces the highest quality of rice but also because it produces it with very little input, meaning a higher profit! Fah Mui and her husband have come to believe that there is a better way forward than to keep practicing agriculture that has been prevalent in the last several decades: that we need to learn from our ancestors about ecological farming, which will make rice farmers happy farmers like they should be.

Item	Price	Source
Non organic, paddy rice	\$266 – 433 per ton	[8]
Organic brown paddy rice	\$530-560 per ton	[9]
Fah Mui biological brown paddy rice	\$2,600/ton (local market) \$4,000/ton (BKK market)	[3]
Fah Mui biological GABA rice	\$8,000-10,000/ton (BKK market)	[3]

Table 2: Comparison of Value of Different Paddy Rice Types

#### 4. Conclusion

The Chao Phraya basin, is one of the best lands for paddy production in world because it receives rich nutrition from Northern Thailand. Thailand has consistently been in the top rank of

rice exporters even though Thai farmers are still typically poor. This is in contrast to the historical Thai farmer, who grew rice for self-sufficiency and community and the slogan that farmers and rice are the "Nation's Spine." In the past, nutrient cycling used to work quite well, receiving nutrient inputs from upland rotational farming and animal integration, but since Thailand turned rice into a commodity cash crop at the beginning of the 20<sup>th</sup> century, rice production has relied upon expensive intensive synthetic chemicals and inputs, leading to economic and environmental issues. The government has tried to help the "Nation's Spine" with several policies, such as a rice price pledging scheme, but often these policies only work well for a short period of time. Now Thailand produces more rice than it can consume, making it one of the world's top rice exporters, even as production costs continue to increase, returns dwindle, and farmers go more into debt.

The Nation's Spine has to fix itself. The way forward is to slowly change the mindset and behavior of the common farmer that produces commodity rice, selling at low prices even while using expensive inputs. SRI is one such alternative option such that may be practiced as an organic or biological method, offering reduced input costs, increased environmental health, increased profit for farmers, and increased niche marketing opportunities.

Farmers like Fah Mui, must be the ones to lead the way into a new paradigm of rice growing. Coming to grips with the dire situation of the status quo, she was on the lookout for new ideas and techniques, finding that she could combine SRI with organic and biological agriculture to reduce her costs and increase her profits. Fah Mui added value by selling niche produces like GABA rice and using an online market space. The result is that she can sell her GABA rice at \$8-10 per kilogram (\$8,000-\$10,000 per ton) in comparison to the going rate of \$266-\$433 per ton for commodity rice. When the "Nation's Spine" is socially, economically, and environmentally healthy, it can play a significant role to drive country forward. Likewise, when a farmer cares about biology and ecology of a place, the land will pay that farmer back more than she can imagine. SRI can help play a significant role in rebuilding the Nation's Spine of Thailand.

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# SRI Advocacy in the Philippines: A Case Study

by Roberto Verzola (rverzola@gn.apc.org), National Coordinator, SRI Pilipinas

On behalf of the participants from the Philippines, I would like to greet everyone in this conference on the system of rice intensification (SRI). In this paper, I will be sharing with you the experiences of SRI Pilipinas in promoting the method in the Philippines.

# The slow spread of SRI in the Philippines

As you may have realized, the Philippines is somewhat behind among the rice-growing countries in the world as far as the spread of SRI among farmers is concerned. Today, we count maybe a few thousand SRI practitioners in the country, many of them still in the trial stages.

Our group SRI Pilipinas was set up in 2002, after Prof. Norman Uphoff visited the country and gave a seminar on the method before a small assembly of NGOs and farmers' groups. We have since then been promoting the method among farmers and in the government. We didn't have regular funding at all, however, until 2007. That year, we managed to raise P875,000 (about \$20,000) from the Department of Agriculture (DA) during the term of Secretary Arthur Yap, thanks to the persistent nagging of former DA Undersecretary Ernesto Ordonez. From this fund, we managed to do 50 one-day SRI trainings in 49 provinces (twice in one province; our original target was 50 provinces). Out of these trainings emerged the national network of SRI Pilipinas. Our next funding was in 2009 (about \$6,000), to hold a national trainers' conference, to evaluate the results of the earlier nationwide trainings, and to make plans for the future. Since then, we have been running on an average budget of roughly P750,000 (\$17,000) per year, conducting an average of 75 one-day trainings per year, nationwide, each training attended by 20-25 farmers on the average. We have also distributed more than ten thousand of our SRI primers, a few thousand SRI videos, and about a thousand SRI books.

# Why do we only have a few thousand farmers to show for this?

We do not discount the possibility that we might have chosen a poor strategy. We have focused on nationwide coverage from the beginning, even when we had little funds. So our adopters are thinly spread throughout the country, like seeds broadcast very sparsely throughout the field instead of being sown carefully on a seedbed, to be transplanted later. It is possible, as some have suggested to us, that we could have concentrated our funds better in a few season-long trainings in a few areas and spent more on proper scientific documentation to convince the government quickly and thereby invite substantial government funds for rapid expansion. This is a matter of continuing debate even internally, among us. Another reason is that we only count those farmers who are in touch with us. It is possible that a few thousand more are trying SRI under the radar, so to speak. Also, we count only those who implement most of the SRI practices. Those who do only early transplanting, or only wider spacing, or only alternate wetting and drying (AWD), we do not count. They might be on their way to becoming SRI adopters, but they are not there yet.

And because we teach SRI the organic way (we believe that chemicals damage the soil and kill soil organisms, and are therefore inconsistent with SRI principles), we cannot discount the powerful agrochemical lobby either. Many gatekeepers in the agriculture establishment have close ties with agrochemical firms.

A big reason for the slow spread, in my opinion, is that the perceived gatekeepers of rice knowhow, the International Rice Research Institute (IRRI) and the Philippine Rice Research Institute (Philrice), expressed very early on a knee-jerk negative reaction against SRI. Highly negative, even insulting, articles by IRRI scientists about the method were published in scientifical journals, while early unsuccessful attempts by Philrice researchers were published in local journals and regularly cited in media. IRRI and Philrice are of course very prestigious institutions. They are supposedly *the* experts in rice, and our agriculturists and policy-makers listen to them. The anti-SRI arguments in these early articles have unfortunately stuck in the minds of many Filipino agriculturists at the national, provincial and lower levels. Whenever we talk to a municipal or a provincial agriculturist, we often hear echoes of IRRI's early attacks on SRI. In the national government, we hear things like "you might get your proposal approved, as long as you don't call it SRI''. Or "call it anything but SRI." The anti-SRI bias in the agriculture establishment is so strong that our agriculture secretary today, Secretary Proceso Alcala although a strong proponent of organic farming, ignored SRI for a long time and only last November 2014 did he order some lower officials to "settle this matter once and for all."

IRRI has not published negative SRI pieces for several years now. They must have reevaluated their position and realized that they reacted too soon, without having done any trials themselves. It must have dawned upon them eventually that the millions of farmers now practising SRI throughout the world must be seeing something that they haven't. Yet, they have neither retracted those early anti-SRI articles nor apologized for their insulting remarks. So our agriculturists who go back and review old journals still come across these articles, and they still use the old IRRI arguments against us.

Today, IRRI continues its prideful stance, grudgingly acknowledging that SRI involves some good practices but that it should lead farmers towards IRRI's best management practices for rice. They continue to delude themselves that the IRRI management practices are the "best." If I may be so bold as to correct them: *the best set of rice management practices today is SRI*. Sumant Kumar of Bihar, India proved it, when he exceeded 20 tons/hectare using SRI, a record which

was recognized by the State of Bihar and published in the Indian journal *Agriculture Today*. The IRRI management practices can rightfully claim the title of "best" *only* if they break Sumant Kumar's record.

Philrice did some SRI trials, but their results have not shown the dramatic results that farmers often get. I offer the following explanation why SRI tends to perform better in farmers' fields compared to research stations:

A minimum set of skills is needed to practice SRI successfully, and it takes time to acquire these skills. Our experience in SRI trials is that roughly one in three farmers will show dramatic results, another one will show slight or no improvement in yield (but their costs will have gone down), and the third gets a lower yield, for one reason or another. If farmers are willing to learn from their mistakes, the odds get better on the second try, and even more on the third. I have not heard any farmer fail for three consecutive trials. Sooner or later, farmers acquire sufficient knowledge and learn to consistently produce many tillers per rice plant, the obvious mark of the SRI method.

Learning SRI is like learning how to ride a bicycle (or to swim). One must pick up a set of skills. We believe that some researchers doing SRI research did so without the humility of learning the skill set first. They are like researchers evaluating the energy efficiency of a bicycle by testriding one, without first having learned how to ride a bicycle properly. We have on several occasions asked Philrice to include us in their SRI research so that our farmer-trainers may help them learn SRI better, but no cooperation with Philrice has materialized so far, despite our occasional follow-ups. Thus, today, we promote SRI in the Philippines against a background of indifference by our department of agriculture and the established rice experts, spiced by their occasional derogatory comments. A lead researcher in a recent World Bank funded economic study by the Department of Agriculture on Philippine rice self-sufficiency and the impact of ASEAN trade liberalization, for instance, told me that the study did not refer to SRI even once because "they have not come across it."

# Making inroads in government agencies

Let me hasten to note, however, that this might change in 2015, given DA Secretary Proceso Alcala's instruction to his subordinates to settle the SRI matter once and for all. Let me further note that for two years now one national agency, the Agricultural Training Institute, has been printing for us our SRI primers; another national agency, the National Irrigation Administration, has invited us several times in the assemblies of irrigators' associations; a third national agency, the Department of Agrarian Reform, has started to sponsor season-long SRI trainings itself; and

a fourth agency, the Bureau of Soils and Water Management, has shown enough interest that its director has asked us to train farmers in his hometown. So, we are in fact making inroads into the national government although at a very slow pace, and then in the periphery, rather than the government's central decision-making bodies on rice policy.

Unlike other countries, therefore, where governments were drawn early towards supporting efforts to promote SRI among farmers, we have done it from below, working upwards.

For years, we trained farmers and some farmers organizations, working at the same time with local governments at the village level, whenever they showed interest in working with us. Then, since 2013, we reached the municipal level, when the municipalities of Mercedes, Camarines Norte (in the Bicol region); Molave, Zamboanga del Sur (in western Mindanao), and Aringay, La Union (in northern Luzon) conducted their own season-long SRI trainings. We made another major breakthrough when the entire province of Davao del Norte (also in Mindanao), through the efforts of its rice program coordinator Edgar Cabrera and its IPM coordinator Marilou Runas, launched province-wide season-long SRI trainings. (We have 81 provinces in the Philippines.) This year, they are planning to do similar season-long trainings, but throughout Region 11, which Davao del Norte is part of. (We have 16 regions in the country.) We are now working on a second region to follow Region 11's footsteps.

By the way, not yet included in this report are the efforts of other organizations which are also promoting SRI. One of the most successful is the Rice Watch Action Network (RWAN), which includes SRI training as part of its 16-week climate resiliency field school (CRFS) directed at municipalities. Our colleague from RWAN can tell you more about it. Through their efforts, more than 30 municipalities have now conducted official season-long trainings on SRI. And because adaptation to climate change has become a top government priority, more municipalities are queuing up for the trainings. The Pambansang Kilusan ng mga Samahang Magsasaka (PAKISAMA, or National Movement of Farmers' Organizations), also includes SRI in its sustainable agriculture program. Another NGO, PASALI, has been active in parts of Mindanao. Finally, the Philippine Rural Reconstruction Movement – the oldest NGO in the Philippines, and still one of the largest – continues to promote SRI among rice farmers that it reaches.

# SRI champions in government

We have realized that the key to mainstreaming SRI in government is to find champions within government. We need government champions who will stick their necks out and push for the promotion of SRI, against the objections of nay-sayers, of which there are many inside the government. Without these champions, a strong objection – or even a casual negative comment – from one contrarian is enough to delay decision or kill a pro-SRI proposal. An SRI champion will respond to the objector and debate with him, present all the supporting evidence, and convince other committee members to approve a proposal. A champion will not stop but will

find ways within the byzantine government bureaucracy to get an SRI project approved, funded and implemented. Gradually, we are drawing such champions from inside the government into our network.

For the record, our earliest champion in government was the director of Agricultural Training Institute (ATI), the late Atty. Edwin Acoba. It was he who urged all ATI researchers to try SRI. Only one of them, Noe Ysulat of ATI Region 12 (Central Mindanao), responded to Atty. Acoba's call and started his SRI research in 2000, with spectacular results. There are more SRI champions in government now, but not as many as we would want. Still, we already have enough government champions to feel confident

that SRI will be spreading more rapidly in the Philippines in the future. One of our colleagues in this conference, is retired regional director Adelberto Baniqued of the Department of Agrarian Reform in western Mindanao. Although he learned about SRI and adopted it only after retirement, having turned into a farmer himself, he has enough government contacts and seniority to wield significant influence within the government. Another colleague here, Dr. Carmelita Cervantes, heads the extension work of a regional government university for Agriculture, the Central Bicol State University for Agriculture, and has played a key role in her region in promoting SRI within the government.

We will have our presidential elections in May 2016. Thus, starting on the second half of 2016, we will have a new set of elected officials, from the President down to the town mayor, as well as their legislative counterparts. SRI Pilipinas intends to work very hard to get more champions in government, so that in the next six years of the new administration, we can tap more government funds and other resources for nationwide SRI promotion.

# **Promoting SRI from below**

Thus, even if we have been slower than other countries, we hope to reach a similar level too in the future, based on our own approach of starting from the bottom, going up<sup>`</sup>. Let me explain in more detail how we do this bottom-up approach at SRI Pilipinas.

From our governnment-funded trainings in 2007-2008, we built a core network of more than a dozen farmer-trainers spread throughout the Philippines. Based on this core, we publicly announced our commitment to give a one-day training to any group of 20 or more farmers, anywhere in the Philippines, who request SRI training. Thus, when we get requests for training, the trainer usually comes from the same, or a nearby region, reducing our travel costs. We only do one-day trainings, to stretch our funds. Internally, we have a continuing debate between one-day trainings and the more expensive but more effective season-long trainings. So far, we do only season-long trainings if a local government or another NGO is willing to shoulder a larger part of the cost.

Aside from our own one-day trainings and the season-long trainings done together with local governments or other NGOs, we also do long-distance one-on-one trainings. Our platform for doing this is the SRI Hotline, three mobile phones connected to a netbook, through which we communicate by text/SMS with all contacts. We announce the mobile phone numbers in radio interviews, during news coverage, and in magazine articles we write ourselves. For a year, we even advertised the number in a nationally-distributed local-language tabloid, inviting readers to text us their name and address, to receive a free SRI primer, which we send via postal mail.

Since our postal system is not very efficient, we have also reformulated the printed primer into 45batches of text lessons, in the local language, of course. One batch, consists of 6-15 text messages, explaining a specific topic. The 45 topics of text-based lessons cover not only SRI but related topics like making organic fertilizers and sprays, composting, vermiculture, and so on. The modules are sent once (sometimes twice) a day, over a period of around 45 days. Within this period, the printed SRI primer would have hopefully arrived from the post office, supplementing the text lessons with pictures.

Although we have been doing this SMS-based distance education with farmers for a long time, our first experience doing it in cooperation with the government occured during the second cropping season last year, when SRI Pilipinas and the City of Antipolo, Rizal (site of the famous Hinulugang Taktak waterfalls) and less than an hour east of Manila, ran a 45-day SMS-based SRI training for Antipolo farmers.

We have also managed to get access to a radio program. Every Saturday from 4am to 6am, two of our SRI trainers host a radio program on organic farming, half of which is devoted to vegetables, and the other half exclusively to SRI. The radio program regularly announces our training offers, and has been a consistent source of recruits for SRI trials. As far as we know, this is the only radio program in the country that specifically covers SRI regularly.

At the end of the lessons, we encourage the farmer to do a 100- to 500-square meter SRI trial. At the end of the trial, if farmers decide to use SRI again in the next season, we send them a copy of our SRI book. Many of our farmers learned SRI this way, rather than through face-to-face trainings. Those who do not try (they may just have been curious non-farmers), can still help us, if they agree to distribute our SRI primer. Then we send them a dozen copies by courier, which turns out to be cheaper than postal mail. We currently have more than 5,000 contacts registered on the SRI Hotline. Because we already have their numbers, we can send them updates, news, and other materials. Our core network still relies on face-to-face meetings and workshops, but a significant portion of our expansion is due to these long-distance SMS-based contacts.

Through these face-to-face and long-distance trainings, we have gradually spread news and knowledge about SRI. Through our contacts and adopters, we have reached into village councils

and subsequently municipal governments. This is how we made connections with our SRI champions in government who initiated municipal-level season-long trainings and, later, province-wide trainings season-long trainings. The following details will give an idea of the extent of our ground work.

Of the 81 provinces in the Philippines, we have at least one contact in every province. There are:

7 provinces with at least one contact in every town (100% coverage): Metro Mla (counting it as a province), Aurora, Bataan, Zambales, Nueva Ecija, Bulacan, Tarlac

3 provinces with one town remaining unreached: Marinduque, Rizal, Oriental Mindoro

6 provinces with two towns remaining unreached:

Laguna, Davao Del Norte, Pampanga, Pangasinan, Aklan, Occidental Mindoro 65 provinces with three or more towns remaining unreached:

Of the 1,633 towns (cities or munipalities) in the Philippines, 872 towns (53.4%) have at least one Hotline contact, while 761 towns (46.6%) have no Hotline contacts.

Of the 872 towns where we have contacts,

378 have 4 or more Hotline contacts.

105 have exactly 3 Hotline contacts.

175 have exactly 2 Hotline contacts.

214 have exactly 1 Hotline contact.

Note how we define contacts: individuals who have requested the SRI primer through SMS (thus, we have their phone numbers for futher contact) and have given us their full name and address (thus, we can send them more printed materials). Through these contacts, we have a foothold in their area for further extending our reach.

That is the SRI Pilipinas experience: from the ground, up. Today, knowledge of SRI is diffusing - almost invisibly, slowly but surely - in all provinces of the country. With this bottom-up approach, we are certain that we will eventually reach every rice farmer too, faster with government support, more slowly without it.

# **Talking to farmers**

None of this would happen, if we were promoting a method that did not work. SRI does work, farmer after farmer, season after season. It is a robust method, and the plants grown under SRI are resilient to long dry periods, flooding, and typhoons. So far, as I said earlier, our batting average is two out of three. Of the two successes, one involves dramatic yield improvements that impress everyone, and the other is a slight yield improvement, but nothing to really get excited about. In this instance, the main benefit is in the cost reduction.

In terms of yields, we are very confident in assuring farmers of at least a 20% increase once they have learned SRI properly, as long as no disastrous factors like typhoons, long droughts or pest/disease attacks occur. In trials, yield increases in fact often exceed 20%.

In terms of costs, we can confidently claim the following results: around 70-80% reduction in seed costs; around 40-50% reduction in irrigation costs; and more than 50% reduction in pesticide/herbicide costs.

Note that most of us at SRI Pilipinas were already organic advocates before we adopted SRI. Thus, we teach SRI the organic way. To us, it is a tool for helping farmers shift from chemical to organic farming.

Fertilizer costs are about the same during the organic conversion process, which can take several seasons. This is because we suggest to farmers that they initially spend all their fertilizer budget on compost instead, resulting in a massive application of compost. But the adopters' fertilizer costs will go down steadily as natural soil fertility and soil organisms return, and as they learn to make their own compost and organic sprays using natural fermentation methods.

Labor costs may go up 20-30% initially (but not always), but will also go down eventually as farmers learn or innovate with labor-saving approaches under SRI. At the initial stages of adoption, labor costs are sensitive to local labor practices and payment methods for various transplanting and weeding jobs. Overall, farmers still usually spend less under SRI, even at the initial stages of adoption.

But to be convinced to adopt, farmers have to try the method first. So the issue among farmers is how do we get them to try. How do we convince them to make that first step of setting aside 100-500 square meters for their first SRI trial?

In our experience, this involves a mix of convincing arguments and minimizing the risk of failure.

To get the farmers' attention, we truly need convincing arguments. We have used the following:

1. We cite Sumant Kumar's experience to open up farmers' minds about possibilities. We make it clear that they should not expect to reach that level of yield themselves, just as no one should expect to win a world boxing championship in eight weight divisions, even if they learn the boxing style of Filipino boxing great Manny Pacquiao (who holds such a world record). But we do assure them of at least 20% higher yields, based on Philippine experience.

2. We show them pictures of high tillering rice plants, also to open up farmers' minds about possibilities. They usually admit having seen such high number of tillers, but only on rare occasions and certainly not as an average throughout the field. Once they are told that SRI makes 20 or more tillers per plants possible *on the average*, they sit up and start to listen.

3. We inform farmers when the first tiller starts to form (on the emergence of the fourth leaf, 16-20 days after sowing in the Philippine experience). Although farmers would be expected to know this, few apparently make the connection between this vulnerable period and the time of transplanting (18-21 days after sowing). Once we tell them that the timing is completely wrong, and that the best time to transplant is before the first tiller starts to form (hence, on the second leaf, 8-12 days after sowing), one can see their faces light up, as they see the connection for the first time. It would be very helpful to us if rice experts can actually tell us, based on their own observations at the microscopic level, at what stage of the plant's growth (emergence of the 4th leaf? the 5th leaf?) the proto-tiller within the rice plant starts its growth, before it is visually observable. It would be much better if we can actually get microphotographs of the process.

4. We show them a picture of four emaciated children sharing a plateful of food, a telling argument for giving each rice plant "its own plate," Based on this argument, we do not count "two seedlings per hill" as SRI practice. We insist, as Henri de Laulanie also did, that each plant should have its own space, without having to compete for sunlight and nutrients. Competition for food, even within a litter, always results in winners and losers, and at least one runt. And the runt is usually sickly, more vulnerable to pest and disease. In rice too.

5. It will be hard for a rice plant to grow many tillers if it has few roots. And the secret of dense, deep roots is for the rice plant to experience dryness occasionally. Dryness will make the rice plant search for water by sending out more roots. If dryness is somewhat prolonged, a moisture gradient will establish itself in the soil (drier nearer the surface, wetter as you go deeper). Since all roots grow towards the water, the prolonged dryness will make them grow deeper, towards greater moisture. Again, it will be helpful for us to actually cite scientific studies and show photographic evidence about this.

We have developed similar down-to-earth arguments for each SRI practice, which farmers quickly understand, leading them towards a decision to try SRI, to see for themselves.

At this point, once farmers are willing to try, we also need to curb their enthusiasm. Some want to try it immediately in one hectare. We dissuade them. In our approach, we give importance to maximizing the probability of success on first try. This is a priority for us.

Thus, we recommend that a first trial should be done on 100-500 square meters first. We explain that it is like learning how to swim. You should not jump immediately into the deep ocean in your first attempt to learn how to swim. Most of SRI failures in the Philippines are due to

farmers doing it on one-half or one hectare. on their first try. Even those who did succeeed would have had a much better chance of success (and a less worrisome growing season too), if they had started on a smaller scale.

# Raising the chances of success on first try

With our approach, we get a "two in three" success rate and "one in three" dramatic results at this time. We continually ask ourselves what else can be done to improve the chances of "success on first try" (SOFT). Here are a few more measures we advocate to stack the probabilities in our favor:

1. Do as many of the SRI practices as possible. Do not leave out the early transplanting, single seedling per hill, alternate wetting and drying, and the weeding. This is about the synergy between the practices.

2. Instead of trying it alone, convince other neighbors to do trials too. The more trials, the greater the chances that at least one will show dramatic results. A single trial has 33% chances of at least one dramatic result. Two trials raise the chances to 56%. Three trials to 70%; five trials to 87%; ten trials to 98%. Our trials usually involve 20 or more farmers. If they all had a 100-500 sqm trial plot, the chances of at least one dramatic results, 99.7%), the chances of at least two dramatic results, 99.7%; of at least three dramatic results, 98.2%; of at least four, 94%; of at least five, 85%. This is also the reason why we do not believe in a single demonstration plot for 20-30 trainees, which is in effect a single trial only, with a 33% chance of showing dramatic results. We insist that each trainee in our season-long trainings, set up their own 100 to 500-square meter trial plot.

These probabilities of course assume that the trials are independent. This assumption breaks down for weather events and major disease or pest outbreaks.

3. In their first trial, farmers should put as much compost as they can afford. We normally suggest one 50-kg bag per 100 square meters of trial plot, applied at the land preparation stage. (It can be less subsequently, especially when doing SRI on a large-scale.)

4. Instead of using only one variety, divide the trial plot into several sections and use different varieties for each. Often, some varieties respond to SRI treatment better than other varieties.

5. Do not let the weeds gain momentum. Failure to control weeds is another common source of failure. In the SRI Pilipinas network, we continue to fine-tune these guidelines, so that we may keep raising the chances that our new adopters, even if they are trying SRI with only our primer as their guide, can succeed on their first try.

Dear friends in the international and local Malaysian networks, I hope I was able to give you a good picture of the status of our SRI advocacy in the Philippines. This is not to say that our experiences are all applicable to your own situations. Pick up what is useful; shelve the rest.

Thank you very much.

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# Innovation in Paddy Planting By Adopting System of Rice Intensification (SRI)

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Abstract. The Malaysia Government is committed to achieve 100% self-sufficiency level of domestic rice consumption in 2020. Currently, local rice productions are insufficient to meet the growing domestic demand of 30 million of its citizens, and the international food trade drew millions of Ringgit out to foreign countries. Local paddy farmers have to increase their production by adapting innovation and technology in agriculture. System of rice intensification (SRI) is an innovation in rice cultivation practices that have the potential to increase productivity, reduce costs, reduce water usage and balance the ecosystem. SRI method underwent many field experiments in world's major rice-producing countries. However, this method is still in preliminary stage in Malaysia and not widely known. Therefore, it is important to introduce the SRI method effectively at the micro level in order to start the adoption process. This paper aims to discuss the factors that promote and accelerate the process of diffusion and adoption of innovations within the social system, particularly in the rice agriculture sector. Lastly, an effective strategy will be developed through an understanding of the characteristics of adopters of innovations to accelerate the process of innovation diffusion among farmers.

Keywords: Diffusion of Innovation Theory, Innovation Adoption, Rice, SRI.

# 1. Introduction

Innovation plays an important role in the survival of human civilization. Most dictionaries give the meaning of innovation as new or changed. This meaning is considered quite loose and not very clear. Rogers [1], describes the innovation is something that is considered new and better than the old one by an individual. Kotler [2] also shared the same view, saying innovation is an idea, practice or material artifact that seems new to the individual who uses it. While a more complete definition was presented by Van den Ban and Hawkins [3] stated that 'an Innovation was an idea, method, or object, which is regarded as new by an individual, but which is not always the result of recent research'

Thus, by the meaning of the above scholars, we can conclude that innovation can be described as a unique, easy and valuable. Innovation is a term used in many fields such as manufacturing, services and agriculture. Innovation in agriculture has changed the landscape of the agriculture sector, especially in the food sector by transforming self-sufficient farming to commercial farming. Rice cultivation is one of the Agri-food sectors in Malaysia, and it is vital to our country Alam *et al.* [4] and Fahmi *et al.* [5]. This is because rice is the staple food of the country's population and nearly 3.5 billion people in the world Satyanarayana *et al.* [6].

The government's commitment to develop the country's rice sector started since our country's independence day. This commitment is demonstrated through the existence of many government policies (National Agricultural Policy 1-3), construction of infrastructure and the establishment of agencies (MARDI, FAMA, MADA, KADA, IADA). Apart from that in recent years, the rice production sector has been listed as one of the 12 National Key Economic Areas (NKEA) which have the potential to contribute directly to economic growth.

Malaysia is one of the foods importing countries. The low productivity of rice in the country has forced the government to import rice from Thailand and Vietnam. Minister of Agriculture and Agro-based Industry Minister Datuk Seri Ismail Sabri Yaakob said that in the years 2012 and 2013, the country had to import rice at 764.878 and 658.120 tonnes valued at RM1.3 billion and RM812 million from Vietnam. This amount represents 30% of the country's rice needs for the domestic market [7].

If our nation experiencing food shortages and hunger, this situation would lead to political turmoil thus threaten national security. This scenario would have a negative impact on the development of the country in which peace and harmony in the country are the main attraction of foreign investments to be further boost economic growth.

Therefore, the adoption of innovation in rice farming is the main agenda in achieving the objectives of the Food Security Policy (DJBM) which was created on May 2, 2008 by Malaysian Prime Minister Datuk Seri Najib Tun Razak and it aims to ensure the country's food supply is adequate and at an affordable price to the consumers. The main objective of this policy is to increase the production and productivity of agriculture to meet food self-sufficiency level of 85% in 2015 [8].

Malaysia paddy farmers have a great responsibility in delivering a local rice supply to 30 million Malaysians. Farmers need to make changes to improve productivity in line with the latest developments by adopting innovation. They are the target groups and user innovation in the agricultural sector fields. It is fundamental to understand the factors that promote the spread of innovation and further accelerate the adoption of innovations at the micro level

#### 2. System of Rice Intensification (SRI)

System of Rice Intensification (SRI) is an innovation in sustainable rice farming methods. This method manages to increase revenue, reduce input costs and contribute to sustainabilities of ecosystems [9],[10].

SRI method is based on the philosophy and method of natural farming. The cultivation of rice by this method encourages organic input without the use of chemical inputs. According to Norman Uphoff [11], SRI techniques reduce the use of seeds, water, fertilizers and chemical pesticides. This method is done by changing the management of plants, soil, water, and nutrients to liberate the potential of rice plants to the optimum level. Through this method, the paddy plant is grown at a young age, have a set distance, periodic soil aeration and low level of water usage.

SRI had managed to increase rice productivity by over 100%. In Tamil Naidu, India, a farmer has managed to increase productivity up to 15 tonnes per hectare by using fewer inputs compare to the conventional methods [12]. It is also reportedly in Cambodia, where the farmers have managed to increase productivity up to 100% without using chemical inputs [13].

The importance of environmental awareness and sustainability of resources for future generations had increased recently. Sustainability in agriculture has been understood as an agricultural development that occurs when natural resources are controlled and managed well. However, agricultural sustainability cannot be based on one thing only that is related to the environment. The concept of sustainable agriculture must be comprehensive and does not separate economic and social factors.

Fatimah [14] explains that the concept of sustainable agriculture in Malaysia is based on three main objectives that are economic sustainability and profitability, environmental awareness and social acceptance. Most models of sustainable agriculture practices are based on organic farming or commonly referred to as *'organic farming'*. Organic farming is one method of sustainable agriculture that uses only eco-friendly input and involves no harmful chemicals to the environment.

SRI is a revolution and innovation in rice farming and have been successfully adapted in 48 countries. *Cornell International Institute For Food, Agriculture And Development (CIIFAD)* reported that the world's major rice-producing countries such as China, Indonesia, Vietnam and India had tried and adopted this method since 1999. Other rice producing countries have also expressed their confidence in SRI methods and is committed to expanding the use of this method in the future.

Since the emergence of SRI in the early 1980s, many countries in Asia had adopted this innovation as in Bangladesh [15], India [16], Thailand [17], Cambodia [18], China [19], the Philippines, Indonesia, Vietnam [20] and Malaysia [21]. However, the adoption of SRI paddy cultivation in Malaysia is still at a beginning level and not widely known. Thus, it may become necessary to identify the factors that will drive SRI adoption among the target group and in this case farmers.

#### **3.** Diffusion of Innovation Theory

Innovation should be communicated and adopted by the targeted group. An innovation which is not adopted by the targeted group will fail and did not achieve its goal of existence. Diffusion of Innovation Theory basically explained the process of how a given innovation is communicated through certain channels over time to the members in a social system. This is in line with the meaning of the diffusion of Rogers [22], which stated,

The Rogers Innovation Diffusion theory was initially developed to understand the process of innovation acceptance among farmers, but eventually this theory had been used to understand the same issues in other areas. To date, the innovation diffusion theory has been widely used in fields of study that involves an understanding of the adopters of innovation at the macro level of the organization or at the micro level of the individual. The innovation diffusion theory has been tested in more than 6000 studies in various fields and the theory is among the most reliable in the social sciences" Robinson, [23].
The process of innovation diffusion involves four main elements, namely: Innovation, communication channels, time and social system as shown in Figure 1: -



### Figure 1: Diffusion of Innovation Theory (Rogers, 2003)

#### 3.1. Innovation

Innovation is something new or an improvement that will benefit all of us. However, the novelty of the innovation measured subjectively perceived by the individual who receives it. Rogers [22] also shares the same view, saying that innovation is "" *an idea, practice, or object perceived as new by the individual.* The nature of the 'new' does not only refer to the latest discoveries, but previous finding is also known as innovation once it discovered by the targeted group.

Innovation is a new concept to the targeted group, who have a sense of doubt, hesitation and reluctant to accept changes. According to past studies, a group of people will doubt, reluctant to try it and even reject it if the innovation does not meet their needs. Adaptation of innovation start with innovation decision making process. A person goes through different stages in the decision making process before the implementation of the innovation. They will be discussing it with friends or relatives in order to get information and greater understanding of the possible risks and benefits of the implementation. Rogers and Singhal [24] suggested that,

"A person evaluates a new idea and decides whether or not to adopt it on the basis of discussions with Peers, who have already adopted or rejected the Innovation.... Organizations, like Individuals, adopt an Innovation in a manner that suggests various degrees of resistance to the new ideas."

One of the factors that influenced the speed of adoption of innovation is characteristics of the innovation itself. Previous studies show that the characteristics of innovation have been able to answer questions that arise and affect the speed of innovation, adaptation [25], [26].

Rogers [22] suggests there are five characteristics of innovation, namely:

- Relative Advantage the extent to which the benefits of innovation to the idea, program or product that it replaces.
- Compatibility What are the advantages of comparison with the values of innovation, experience and the needs of adopters of innovations.
- Complexity extent of complexity in understanding and practicing the innovations introduced.
- Triability is this innovation can be tested prior to use.
- Observability the extent to which these innovations provide significant results.

#### 3.2. Communication Channels

Channels of communication in this model refer to how a piece of information that can be conveyed by one individual to another in pursuit of common goals [22]. In other words, the communication channel is a tool to convey a message of innovation from its source to the receiver. It plays an important role in influencing the speed of the innovation diffusion process. This is because at every stage of the innovation decision, the individual requires a specific communication channel to obtain the relevant information. If communication is intended only to introduce innovations to an audience of many and widespread, the mass media of communication channels is more accurate, fast and efficient. If the communication was intended to change the behavior or the recipient personally, the most appropriate communication channel is interpersonal channels that include friends, relatives, change agents and opinion leaders will be discussed further in chapter social system.

#### 3.3. Time

Time is an important dimension in the diffusion of innovation. This is because the time dimension is concluded of the decision making processes of innovation, the rate of adaptation and adopter category (*adopter*), which is an important aspect of the adaptation process. The adoption of innovation is a process of mental or behavioral changes in terms of cognitive, affective and behavior of individuals. Everyone has to go through the process of making a decision to adopt the innovation before implementation. This process is based on the time at which the level of acceptance of innovation may vary depending on individual personality traits and individual surroundings. These features are important in determining the categories of innovation adopters and the speed of innovation adoption by the community.

#### 3.4. Social System

The social system is the last element in the process of diffusion of innovation. Rogers [22] defines a social system as "a set of interrelated units that are engaged in joint problem solving to accomplish the common goals" (p. 23). The members or units of a social system may be individuals, informal groups, organizations, and/or subsystems. The social system constitutes a boundary within which an innovation diffuses. Diffusion of innovation happens in the social system and was influenced by the structure of the social system in several ways. Rogers [22]

explains, the structure is the "the patterned arrangement of the units in the system" (p. 24). This structure gives regularity and stability to human behavior in a system. He also claimed that the nature of the social system affects individual innovation, which is the main criteria to categorize adopters of innovation by their respective levels.

The structure of a social system can facilitate or impede the diffusion of innovations. The impact of social structure on diffusion is of special interest to sociologists and social psychologist, and the way in which the communication structure of a system affects diffusion is a particularly interesting topic for the communication scholars.

Katz [27] remarked, 'It is as unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located as it is to study blood circulation without adequate knowledge of the veins and arteries. Compared to other aspects of diffusion research, there have been relatively few studies of how the social or communication structure affects the diffusion and adoption of innovations in a system.

Two key personnel responsible for moving the process of innovation adopters among members of the community are opinion leaders and agents of change as introduced by Rogers [22]. The main function of opinion leaders and change agents is to promote and accelerate the process of innovation diffusion.

### 3.5. Adopter Category Classification

Researchers have found that individuals adopt innovations early have different characteristics compare to individuals who adopt the innovations at following stage [28] [29] [30] [31] [32] and [33]. Thus, each individual in a social system can be categorized according to their level of innovation, thus creating smaller groups. This is important because when promoting innovation to the target group, it is necessary to understand the characteristics of the target group that will help or hinder the use of an innovation.

The concept of segmentation is to focus on a specific audience and is widely used in the fields of marketing and is based on the premise diversity of user needs. Thus, in one group, there are several small communities that share the same criteria and requirements. Burke [34], says that the technology must be adapted to the needs of different customer segments and understand the impact of innovation in the categories of adopters.

In each category of adopters, its members have in common related to their tendency to accept the use of innovation. Therefore, an understanding of the needs and capabilities of each category is necessary when promoting innovation as different strategies should be used to appeal to different categories of adopters.

Rogers [22] defines categories of adopters (*adopter*) as "state classification on the basis of social systems of innovation" (p.22). Classification of the social system is divided into five groups as shown in Figure 3 below and the majority generally tends to fall in the middle category.



Figure 3: Adopter Categorization on the Basis of Innovativeness (Rogers, 2003)

Rogers [22] explains that not all individuals within a social system adopt innovation at the same time. Rather, the adoption takes place in an over-time sequence that allows for classifying individuals in adopter categories, based on the time individuals first begin to use a new idea, or more accurately, they are classified based on their innovativeness. Innovativeness, according to Rogers (2003, p. 22), is the "[. . .]degree to which an individual (or other units of adoption) is relatively earlier in adopting new ideas than other members of the system." This classification can provide the opportunity to target first specific groups of people more receptive to innovation. These groups can function as agents for innovation diffusion in their community, helping more sceptical individuals come in contact with new technology.

Rogers [22] suggests these individual differences can be identified by their socioeconomic; personality variables and communication behaviors influence the speed of adoption of innovations as in Figure 4 stated below :



Fig. 4: Variables related to rate of adoption.

- Socio-economic characteristics. Earlier adopters are no different in age from later adopters, but have more formal education, are more likely to be literate, has a higher level of upward social mobility and social status. Income, level of living, occupational prestige and self-perceived identification with a social class are some of the variables indicative of social status.
- Personality variables. Earlier adopters may be less dogmatic than late adopters. "Dogmatism is the degree to which an individual has been relative closed belief system [...] A highly dogmatic person would not welcome new ideas [...] and would instead prefer to hew in the past" (Rogers, 2003, p. 273). Moreover, earlier adopters have greater ability to deal with abstractions, more capable to deal with uncertainty and risk effectively. DOI suggests that earlier adopters have a more favourable attitude toward change and science and since innovations are usually the product of scientific research, they have a more favourable attitude toward science. Additionally, early adopters are less fatalistic. "Fatalism is the degree to which an individual perceives a lack of ability to control his or her future" (Rogers, 2003, p. 273). Individuals with a high degree of fatalism usually believe that their future is largely determined by fate and they have a low self-efficacy (Bandura, 1997). Fatalism and dogmatism are negatively related to innovativeness, whereas the effect of all the other variables presented above is positive. Finally, earlier adopters have higher aspirations for formal education, occupation, higher status, etc.

• Communication behavior. Individuals in different adopter categories have diverse communication behaviors: earlier adopters have more social participation and more actively seek information about innovations (Rogers, 2003). Communication behaviors expose individuals to innovation through early awareness, discussion with colleagues, information search behavior and the use of various print media or electronic media.

### 4. Conclusion

Diffusion of innovation among paddy farmers in Malaysia is one of the crucial steps to further increase domestic rice productivity. Paddy farmers are the targeted group to adopt the innovation of SRI method. Thus, it is necessary to understand the potential of farmers in order for them to accept changes. The best strategy should be designed based on the needs and ability of farmers to accept it effectively. With a better understanding, the authorities can formulate appropriate policies, programs and reaching out to farmers using the most efficient means of communication to accelerate the adaptation innovation process at the micro level of our domestic paddy industry.

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### A Review of Paddy Residue Management in Malaysia

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**Abstract.** Rice straw and rice husks are the main residues from paddy cultivation, generated during the harvesting and milling process. Malaysia is one of the leading producers of paddy. It has gained 0.48 Million tonnes of rice husk with 3,176,593.2 tonnes production of rice straw in a year due to the emerging technological development in Agra-industry. Malaysia's agriculture department is targeting to improve the productivity of the paddy sector from the current yield from 3 to 5 tonnes per hectare to around 8 tonnes per hectare in 2012 and 9 to 10 tonnes per hectare by 2020. If the target is achieved with 10 tonnes per hectare, the output of paddy will be increased to 6,575,474.8 tonnes per year. According to national news agency 200,000 ha idle land in Malaysia will be used for paddy plantation. This will increase to about 30% of paddy production. Parallel, to these the production of paddy residue also increases. Malaysia will face the problem regarding the paddy residue or waste management in the future. Unfortunately, the burning of rice straw remains the current cultural practice of disposal in Malaysia. Also, rice husk are being burned along the road that give the impact to the environment. Hence, the further studies are needed to identify the best practice to overcome this problem regarding the paddy residue management in the near future.

Keywords: Paddy residue management; Malaysia; review study;

### 1. Introduction

Goverment of Malaysia under the National Agriculture Policy has introduced the granary area for the systematic paddy plantation in Malaysia. Granary area refers to major irrigation schemes up to 4000 hectares of paddy plantation. There are eight Granary Areas in Malaysia, namely Muda Agriculture Development Authority (MADA), Kemubu Agriculture Development Authority (KADA), Kerian-Sungai Manik Integrated Agriculture Development Area, Barat Laut Selangor Integrated Agriculture Development Area, Seberang Perak Integrated Agriculture Development Area, North Terengganu Integrated Agriculture Development Area (KETARA) and Integrated Agriculture Development Kemasin Semerak. Fig.1 shows the paddy production in Granary area in 2011[1]. Half of the total paddy production is from MADA area.

Paddy seedlings are planted twice a year in Malaysia, in main season and off season. The main season paddy plantation in Northern region is defined as paddy which has a commencement month of planting between August to February of the following year.

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However, there is no significant difference regarding the tillage energy, fertilizing consumption and harvesting energy between the main season and off season[2]. Fig. 2 shows the paddy harvesting calendar in Peninsular Malaysia.



Fig.1: Paddy production in Granary Area in 2011[3]



Fig.2: Paddy harvesting calendar in Peninsular Malaysia [4]

The current practice on paddy plantation in Malaysia is based on four stages, which are land preparation, crop establishment, crop management and harvesting. Fig.3 shows the stages of paddy plantation in Malaysia. The paddy field is usually ploughed twice before sowing or planting. The ploughing technique uses tractor and power tiller. After irrigation water is introduced, around of puddling and land travelling is done. Crop establishment can be done either by direct seeding or transplanting. Direct seeding is a broadcasting of pre-germinated rice seed directly into the field using agriculture machinery. Transplanting method is planting 25 to 35 day old seedling into the main field by manual labour or mechanical transplanter using seedling sown on trays. Crop management is a method to protect the plantation, fertillizer application and weed control. The last stage is harvesting after the paddy has grown for 105 to 120 days from starting of seedling day.

Since 1999 Department of Agriculture are invented the baler machine used in rice straw collection that suitable in local condition and reduce the cost for 55% compared to import baler machine[5]. Rice straw issues has been discussed in Parliment in 2005 due to burning activities that cause to global warming and other potential uses of rice straw [6] but until now the rice straw still burnt in the fields.



Fig.3: Stages of paddy plantation at Malaysia

# 2. Development of rice straw disposal management

About 80% of rice straw industries in the world are applying improper disposal management that causes pollution. Rice straw is rarely used as sources of renewable energy[7] and open burning is a common practice applied in majority of Asian countries[8]. Table 1 lists the current rice straw disposal management across the world.

Table 1: Lists the current rice straw	<sup>,</sup> disposal	management across	the world
---------------------------------------	-----------------------	-------------------	-----------

Country	Practice	Sources
Indonesia, Philippines	Straw is heaped into piles at threshing sites and burned after harvest	[9]

Thailand, China,	All straw remains in the field and rapidly burned in situ	[9]
Northern India		
India, Bangladesh, Nepal	Straw removed and used for cooking, fodder and stable	[9]
	bedding	
Valencia (Spain)	A project for rice straw blankets to dry farming	[10]
California	Burning the rice straw due to low cost disposal method	[11]
Thailand	Annually, 8.5-14.3 M tonne about 90% of rice straw is	[12, 13]
	burned in the fields	
Malaysia	Open burning practice of rice straw	[14, 15]

### 3. Paddy residue production in Malaysia

Rice straw and rice husks are the main residues from paddy cultivation, generated during the harvesting and milling process. Malaysia is one of the leading producers of paddy. It has gained 0.48 Million tonne of rice husk [16] with 3,176,593.2 tonnes production of rice straw in a year [3] due to the emerging technological development in agro-industry. Malaysia's agriculture department is targeting to improve the productivity of the paddy sector from the current yield from 3 to 5 tonnes per hectare to around 8 tonnes per hectare in 2012 and 9 to 10 tonnes per hectare by 2020 [17]. Fig.4 shows the time line of paddy and paddy residue production from, 1980 to 2010 [3]. If the target is achieved with 10 tonnes per hectare, the output of paddy will be increased to 6,575,474.8 tonnes per year. According to national news agency [18], 200,000 ha idle land in Malaysia will be used for paddy plantation. This will increase up to 7 million in 2020. These need the good waste management practice to handle with this residue.



Fig.4: Paddy and paddy residue production, 1980-2011[3]

Fig.5 show the area production of paddy residue in Malaysia. Mainly the production of paddy residue in Malaysia are from Granary area. Granary Areas refer to major irrigation schemes (areas greater than 4,000 hectares) and recognised by the Government in the National Agricultural Policy as the main paddy producing areas. There are 8 granary areas in Malaysia, namely MADA, KADA, IADA KERIAN, IADA BLS, IADA P. Pinang, IADA Seberang Perak, IADA KETARA and IADA Kemasin Semerak [19].



Fig.5: Paddy residue production area in Malaysia

## 4. Malaysia paddy residue management

Rice husk is the main residue from the milling process in the rice mill industries. Approximately 22% of paddy production will produce the rice husk. Before this, rice husk is being applied as fuel in boilers for drying the wet paddy and in sugar industries for power generation. Since 2012, the most of sugar industries in Norhern region of Malaysia has shut down the operation of power generation. This created the rice husk disposal problem, due to this reason the irresponsible rice mills burned the rice husk along the road to settle the rice husk disposal method for their company. Fig.6 show the rice husk being burned along the main road in the Mada granary area and current rice straw management practice in Malaysia.



(a) (b) Fig.6.Rice husk and rice straw disposal method in Malaysia

### 4.1 MADA Granary area

From the results of the survey, it is found that MADA collects of rice straw from only three areas. This only contributes 0.25% from the available rice straw. The remaining rice straws in the fields are left for burning or rotting. Table 2 shows the amount of rice straw collection in MADA area.

	Area Block	<b>Collection (tonne)</b>	Total Potential(tonne)
B-II		1350.00	282789.32
	C-III	213.30	178804.89
	F-IV	585.00	235266.50

Table 2: Amount of rice straw collection in MADA area

In Mada area some rice straw are use for raw- vermicompost and worm vermicompost. In project are between MADA and Jabatan alam sekitar in the way to reduce the pollution from rice straw burning. PPK IV, Sungai Limau dalam is choose as case project. The rice straw are being use for animal feeding in three area under MADA management. The third project is used for craft activity under Centre of Craft in Pendang ,that started operated in 2012. The product craft produced from straw such as furniture,table lamp,accessories and etc. Table 3 lists all the area block involved in rice straw project production.

		(	,		<u> </u>		
Location	Area	Straw project production (tonne)					
	Block	2008	2009	2010	2011	2012	2013
	(PPK)						
Sanglang	B-II	774.90	1521.45	959.85	1812.15	2147.40	1494.00
Kokbah	E-III	401.40	141.75	385.2	498.15	352.35	713.25
Pengkalan	B-IV	-	-	-	139.50	118.35	229.50
Kubur							
Sungai	F-IV	521.10	559.80	580.50	1084.05	3193.20	571.95
Limau							
Total		1674.40	2223.00	1898.55	3524.85	5811.30	3008.70

Table 3: Area block (PPK) invovled in rice straw project production

An overall, the rice straw in MADA area go through the control burning, cutting the rice straw stubble before burning, and the usage of rice straw as alternative material in products such as livestock food, organic fertilizer, straw mat and mushroom plantation[20]. Fig.7 show the rice straw utilization in MADA area. Until now MADA are focuses on livestock feed due to high demanding from the breeders. MADA also buy the rice straw from farmers then sold to the breeder.



Fig.7: Rice straw utilization in MADA area

### 4.2 Others granary area in Malaysia

The program start on 2006 use haft of straw production in the paddy field to create compost, anti-erosion mats for securing slope, cattle feed, and use for mushroom growing. Another half use for fertilizer in the field for next plantation .The main rice straw collection centre in Selangor (WAF) are manage to produce the compost rice straw and ruminant animal feed in pallet[21]. According to the result obtained from[22], the rice straw are potentially use for animal feed, compost, vermi compost, nursery mat and paper for Sekinchan area, Selangor.

KADA (Kemubu Agricultural Development Authority) is a body to provide quality, efficient and effective service in areas of water supply resources, irrigation and drainage management systems, and agricultural applications technology through an integrated development approach towards the increase in paddy crops productivity and other food products, and increase the socioeconomic standards of farmers and their families within the areas under the KADA jurisdiction[23]. The study from [24] indicate that five criterion in rice straw agribusiness development due to lack of support from authority, lack of technology, lack of capital and low level of knowledge.

### 5. Conclusion

As a developing country, Malaysia should fully utilized all the resources available to generate the economic growth for the state. The awareness of paddy residue consumption among farmers should be gain for the sustainable nation. Appropriate policies with the fully support from the government can give the positive impact to the paddy industries in Malaysia.

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## **SRI Readiness among Rural Farmers**

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**Abstract** In order to start a new practice the transformation procedure has to undergo through various challenging factors. From a management perspective, these transformations will involve awareness and technology readiness. Therefore, this study was conducted to to assess the extent to which the theory of planned behavior (TPB) may explain the willingness of farmers in rural areas of Sik, Kedah to change using SRI techniques in rice cultivation. This study employed an exploratory study for which data were collected through interviews. The findings of this study show, the respondents are not ready to practice SRI, where attitudes, subjective norms, and perceptions of behavioral control factors are influencing the readiness of respondents. This research will provide guidance to the researchers and other agencies to plan continuity programs related to rural farmers.

Keywords: Technology readiness, SRI, Theory of Planned Behavior (TPB)

#### 1. Introduction

Generally, the cultivation of rice in Kedah can be divided into two parts, under the control of Lembaga Kemajuan Pertanian Muda (MADA) and Lembaga Kemajuan Wilayah Kedah (KEDA). Area under surveillance of KEDA face some infrastructure problems, especially water needs. Accordingly, the management of SRI method of paddy cultivation can have a big impact on area residents of KEDA. However, the factors that influence the willingness to change and the readiness of the farmers must be clearly identified. Referring to the TPB model, the behavior of an individual can be explained based on the behavioral intention which influenced by the attitude, subjective norms, and perceived behavioral control. Attitude refers to an individual assessment on implementation of a behavior whether it is positive or not (Ajzen & Madden, 1986). Whereas, subjective norm refers to an individual's perception on the people surrounding who influence them in determining certain things to do (Ajzen, 1985) and perceived behavioral control refers to people's perceptions of their ability to perform a given behavior. Thus, this study was undertaken to assess the extent to which the theory of planned behavior (TPB) may explain the willingness of farmers in rural areas of Sik to change using SRI techniques in rice cultivation.

### 2. Literature Review

There are various theories and approaches to present the development that have been conducted in order to explain differences in human behavior. Fishbein and Ajzen (1975) have

developed a framework to address the problem of the attitude-behavior relationship in the Theory of Reasoned Action (TRA). TRA has been extended to improve the Theory of Planned Behavior, (TPB) by Ajzen (1985).

TPB predicts that the intended behavior is partly influenced by individual attitudes toward the behavior, subjective norms, and perceptions of their control over individual behavior (Ajzen, 1975). TPB model has expanded the TRA model by incorporating one additional variable, perceived behavior control. Ajzen and Fishbein (1980) have submitted a theory called TRA which is an extension of Theory Acceptance Model (TAM). Fishbein and Ajzen (1975) has been researching the relationship between beliefs, attitudes, and behaviors by developing a model of attitude structure. This theory is based on several assumptions, for instance human generally do things in a way that makes sense or people will consider all available information. It also considers the explicit or indirect human behavior to present the implications of their actions.

TRA state that people's attitudes affect their behavior utilizing a thorough and reasoned decision-making process. TRA also says that the decision is the best way to predict intentions. The intentions usually refer to the attitude and subjective norm. According to the TPB, confidence is influenced by the attitude towards a certain behavior, the subjective norms and behavioral control. These three components are interdependent and are determinants of intention which decides whether it will be done or not. Moreover, the TPB also directly affects the intention to perform a behavior and may also affect a situation where users intend to perform a behavior but is prevented from doing the action (Ajzen, 1985).

Attitude towards behavior is influenced by the fact that whether such behavior will result in desirable or undesirable situations. Confidence about what behavior is rooted in normative expectations of others and the motivation to act in accordance with the expectations is the factors which shape the subjective norms within the individual.

Referring to the TPB model, the behavior of an individual can be explained considering the behavioral intention which in turn is influenced by the attitude, subjective norms, and perceived behavioral control. Attitude refers to an individual assessment for implementation of a behavior, whether it is positive or not (Ajzen & Madden, 1986). Whereas, subjective norm refers to an individual's perception of the people surrounding who influence them in determining certain things to do (Ajzen, 1985).

Theoretical models of TPB contain many variables such as background factors, behavior, behavioral belief, normative beliefs, subjective norm, control beliefs, and perceived behavioral control.

### 2.1 System of Rice Intensification

SRI is a process to maintain organic cultivation. System Rice Intensification (SRI) was invented and promoted in Madagascar in 1983. Initially it was regarded as a revolutionary paddy cultivation method to achieve very high yields with reduced resources such as irrigation water, fertilizers and chemicals. In the study of Uphoff (2006), paddy farming application using SRI is depends on six main principles as follows: (1) When (if) transplanting, start with young seedlings (2-leaf stage); (2) Plants were set out carefully and gently in a square pattern, 25 x 25cm or wider if the soil was very good. (3) Seedlings are transplanted singly; (4) Rice paddies are irrigated intermittently (minimum of water) rather than continuously flooded; (5) Weeding for at least twice and (6) using basic organic fertilizer or compost, any decomposed biomass.

The very concentration of sustainable agriculture in this study goes to the social innovation in management practice in sustainable agriculture. The management of sustainable agricultural practice in Malaysia paddy farming is yet not in advanced level but still in its initial stage (Othman, 2012). Recently, a renowned process in organic farming in Asia is SRI (Uphoff, 2011), started to be implemented in Malaysia since year 2009 at Bandar Baru Tunjong. It was afterward noticed in Kampung Lentang, Sik. In the aspects of SRI management, Lovely Farm at Sik, which is the areas in this study, is the **first and only certified organic farm in Malaysia** in 2013. **Present** issues in SRI management in West Malaysia were noticed in many papers and studies studies (Othman, 2012; Othman *et al.*, 2012; 2013 and Musa *et al.*, 2012).

#### 3. Methodology

This study uses a case study of rural farmers. Six respondents have been interviewed regarding rice cultivation using SRI methods and techniques. Respondents were the farmers who have attended training courses at the National Organic SRI Center in Indonesia or obtained training, courses and coaching at the SRI Lovely Farm in Sik.

Detailed description of respondents comprised of demographic information, i.e. name, age and employment. The next three dimensions of attitudes, subjective norms and perceptions of behavioral control based on TPB theory were presented in the interview questions. The main research question relates to the dimensions of attitudes and subjective norms. Conversely the perception of control behavior can be divided into two categories: the self-effectiveness and state of the facilities.

A pilot study was conducted on 24 December 2012 while data collection and analysis for this continued from February 13, 2013 until 14 September 2013. The methodology of the analysis of Strauss and Corbin (1990) and Saat (2009) was used to analyze the data. Data from the interview were recorded and transcribed for coding and categorizing items based on TPB theory.

Processing of qualitative data involves several stages for analysis. These include the following tasks: i) Data Transcription ii) Data Organization iii) Coding and Data category iv) Theme v) Saturation Level Data and vi) Report.

## 1. Findings

Findings indicated that the willingness to use and accept the SRI method can be determined by demographic background, attitude, subjective norm and perceived behavioral control.

### 4.1 Demographic Background

The study involved six SRI paddy farmers (R1, R2, R3, R4, R5 and R6). Five of the respondents possessed part time jobs as three rubber tappers, a Cooperative Manager (1) and a tractor driver (1). Ages of the respondents were between 26 and 55 years. Most of the respondents (5) were married, and all of them are men.

Item Information		Frequency
Job	Farmer (paddy field)	6
Part time job	i. Rubber tapper	3
	ii. Cooperative manager	1
	ii. Tractor driver	1
Age	26-35	2
	36-45	2
	46-55	2
Marital status	Single	1
	Married	5
Academic Qualification	Primary School (UPSR)	2
	Malaysian Certificate of	3
	Education	
	College/University	1
Source of income	RM1000 and below	6
Rice growing period	1-5 years	4
	6-10 years	0
	11-15 years	2
Paddy land ownership	Yes	1
	No	5
Rental or lease of land	Yes	6
	No	0

Table 1: Demographic Backgr	round of Respondents
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Further, Table 1 shows one respondent qualified Primary School Assessment Test (UPSR),

four respondents qualified Malaysian Certificate of Education (SPM) and also qualified from college and university. In terms of planting experience, four respondents had experiences ranging from 11 to 15 years, while two respondents had less than 5 years of experience in planting rice. Income level of all respondents is below RM 1,000 per month. Table 1 also shows that only one of the respondents had his own rice-field soil of a niche, but the rest of the respondents did not have the land; they cultivated rice in the paddy land leased by the cooperative.

### 4.2 Attitude

Attitude towards the behavior refers to the assessment which includes the implementation of a behavior, whether it is good or bad. Factors which influence the attitude of readiness to use SRI methods are relative advantage, compatibility, complexity and usability.

Individual beliefs influence individual attitudes and eventually form the intention to produce behavior. This factor has been found to influence the attitude of farmers to readily adopt SRI. Farmers are also encouraged this method because it is cost effective, simple and have similarities with the teachings of their religion which tells them to protect the environment and ecology.

The findings regarding attitudes can also be associated with demographic factors. The findings show respondents who have farming experience can resolve the challenges faced in SRI method. One of the challenges is that SRI method requires the use of labor in the management of weeding. However, all respondents perceived that the weeding problem can be solved by mechanization of the equipment. This will be achieved after causing the existing technologies from other countries to adapt in Malaysian environment.

All respondents agreed that SRI method can be easily implemented. R4 and R6 say that SRI will be easier if the farmers can understand the method. This can be seen as an interview with the fourth respondent:

"SRI is for me... If you do not learn, do not know what one. .... Farmers must ... Give the knowledge. Learn not one, two days... Courses and hands-on, meaning the field. .... He touches down himself, he touches down and then he feels himself, and he knows what to do. "

(Respondent 4, personal communication, 14 September 2013)

The study also showed that all the respondents have attended training courses on SRI, feel comfortable with the techniques and methods learned and also they are ready to execute. If the farmers were given adequate support in terms of finance and infrastructure, especially from the government the intimidation to apply the techniques of SRI can be minimized.

#### 4.3 Subjective Norms

Subjective norm refers to the human perception of the fact that other man is important to him and think whether or not the perpetrator should behave the same (Fishbein & Ajzen, 1975). This relates to human actions based on perceptions which imply that they should do what the others think. In terms of subjective norms, it is found that all respondents have the motivation to implement SRI practices from fellow farmers who adopt the same method under cooperative system. Subjective norms which exist in the form of the influence of consumer groups did not significantly influence the willingness to accept the SRI method fully. This is because the respondents got information from organizations such as KEDA and training centers which reduced dependency on friends, neighbors or family.

#### **4.4 Perceived Behavioral Control**

While considering the behavioral control, self-effectiveness factor and government support are important. All respondents using SRI methods who learnt safety motivation for planting technique do not use pesticides. However R2 emphasized that this method must preserve the environment for generations to come.

Some respondents said that government support is important for the continuation of use of SRI methods. R1, R4 and R6 state method require funds from management to stabilize the area. Conversely, R5 state receives aid for its work where rice machine is needed. R4 thinks all agencies should give emphasis on the promotion and ongoing support.

Facilities can be enhanced from making their own equipment such as stamp tool plant, weeding tool and hoes. However, infrastructure is provided by KEDA like providing a tractor, preparing the way and clearing the area. Besides, MARDI and Department of Agriculture, particularly the Department of Agriculture Sik provides assistance to the farmers in many districts. They also get advice from SRI development agencies.

This study uses a case study of rural farmers. Six respondents have been interviewed regarding rice cultivation using SRI methods and techniques. Respondents were the farmers who

have attended training courses at the National Organic SRI Center in Indonesia or obtained training, courses and coaching at the SRI Lovely Farm in Sik.

Detailed description of respondents comprised of demographic information, i.e. name, age and employment. The next three dimensions of attitudes, subjective norms and perceptions of behavioral control based on TPB theory were presented in the interview questions. The main research question relates to the dimensions of attitudes and subjective norms. Conversely the perception of control behavior can be divided into two categories: the self-effectiveness and state of the facilities.

A pilot study was conducted on 24 December 2012 while data collection and analysis for this continued from February 13, 2013 until 14 September 2013. The methodology of the analysis of Strauss and Corbin (1990) and Saat (2009) was used to analyze the data. Data from the interview were recorded and transcribed for coding and categorizing items based on TPB theory. Processing of qualitative data involves several stages for analysis. These include the following tasks: i) Data Transcription ii) Data Organization iii) Coding and Data category iv) Theme v) Saturation Level Data and vi) Report.

## 4. Findings

Overall, the study found a willingness to use and accept SRI method can be determined by attitude, subjective norms factor and perceived behavioral control (Figure 1). The results show the respondents are not ready to practice SRI, where attitudes, subjective norms, and perceptions of behavioral control factors are influencing the readiness of respondents.

Attitude factors found to influence farmers' attitudes to be willing to adopt SRI method. Farmers are also compelled by this method because of cost effective, easy and conform to Islamic Shari'a. The findings regarding attitudes can also be attributed to demographic factors. Study found that respondents who have SRI method farming experience can determine the challenges faced. Among the challenges faced, the management of SRI method requires the use of labor in the management of land. Respondents proposed to overcome this problem by providing better equipment mechanization by adapting existing technologies in other countries to Malaysian environment.

In terms of subjective norms, it was found that all respondents were motivated to implement SRI practices from fellow farmers who practice the same method under cooperative. Subjective norms that exist in the form of consumer groups were not significantly influence the willingness to fully accept SRI method. Likely due to the respondents received information from KEDA, this reduces dependence to a friend, neighbor or family.

In consideration of perceived behavioral control, self-effectiveness factors and government support is more important compare to technology support. Respondents see government support is important in continuing the readiness using of SRI method. Respondents require financial funds to develop their area. Respondents also perceived that all agencies should give emphasis on the promotion and ongoing support.



Figure 1: Framework of SRI Readiness among Rural Farmers in Sik

### 5. Conclusion

This study aimed at exploring the factors which influence the willingness of respondents to use the SRI method. For extension to future research, several recommendations can be considered. Firstly, studies can be conducted on existing farmers who use organic methods of cultivation as well as SRI. Secondly, SRI is a method of management that is still new in Malaysia. Therefore various other studies also can be explored such as the concept of commercialization and value chain in the method of this crop. The findings of this study provide important implications to organizations like KEDA and the Department of Agriculture to formulate course and training which would start a change in the existing agricultural management.

Basically, this study will provide a complete understanding and perception of willingness of farmers in rural areas of Sik to SRI techniques. The findings of this study will enable the

researchers and other agencies in planning continuity programs that are appropriate with the readiness level of the farmers in this area.

#### 6. Acknowledgements

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# Effect of UMAR-SRImat on Weed Management, Number of Tillers and Plant Height of MR219 Rice in System of Rice Intensification (SRI)

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Abstract. System of Rice Intensification (SRI) is an innovation in rice farming cultural practice for increasing the productivity of water, capital, labour and land. SRI is all about altering the management of soil, water, rice plants and nutrients. However, weeds growth is one of the major problems of SRI due to alternate wetting and drying (AWD) and wide planting spacing  $(25 \times 25 \text{ cm or more})$ . Thus, if weed management is not being attempted it will lead to harmful competition between the weeds and the rice plants for water, nutrients, solar radiation, carbondioxide and space. Currently, manual weeder is being used to remove the weeds up to 40 days after transplanting (DAT) which is labour intensive, while motorized weeder reduces the intensive labour but cannot be able to remove the weeds up to 40 DAT as practiced by farmers. This research was designed to determine the effectiveness of SRImat known as "UMAR-SRImat" on weed control, and to determine the influence of UMAR-SRImat on number of tillers and plant height. The experiment was laid out using randomized complete block design (RCBD) with four treatments [without soil cover (T1), SRImat (T2), UMAR-SRImat without LGE (T3) and UMAR-SRImat with LGE (T4)] and three replications. Weed density (WD), weed dry weight (DW), weed dry weight ratio (DWR), summed dominance ratio, plant height and number of tillers were examined and recorded from the treatment plots for analysis. The dominant weed class associated with SRI were sedges, due to higher summed dominance ratio (SDR) followed by grasses and broadleaves, respectively. The effectiveness of UMAR-SRImat mulched was 100% (WCE) at 20 DAT and 99.64% at 40 DAT. The research exposed the opportunity of UMAR-SRImat mulch in controlling weeds up to 40 DAT with higher plant height and larger number of tillers at 30 and 50 DAT.

Keywords: mulching; seedling performance; weed control

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#### **1. Introduction**

System of rice intensification (SRI) was started in 1980s by Fr. Henry de Laulanie, S.J., who was in Madagascar since 1961 from France, working with Malagasy farmers for 34years in order to progress their Agricultural systems especially rice cultivation, which is the steady food of the people in Madagascar. Considering the historical as well as cultural aspect of Malagasies, rice is among the important crop that provides most of the calories consumed by Malagasies on daily basis. Fr. Laulanie thinks of helping farmers to increase their productivity without using of external inputs, because of poverty<sup>1</sup>. SRI consist of six simple hints in order to provide a good environment for the individual rice plant to accelerate their rate of growth performance as stated by Satyanarayana, Thiyagarajan, &Uphoff, <sup>2</sup>:-

- Young seedling of less than 15days old
- Seedling are raised in non-flooded area
- Transplanting single seedling per hill
- Seedlings are not transplanted in a flooded field with permanent water, but in muddy field. Also, at the vegetative stage SRI Field retained moisture not always saturated, because rice roots degenerate due to hypoxic soil condition created by the flooding.
- Weed control is done by using mechanical weeder
- Initially SRI methods used chemical fertilizer. But due to the removal of subsidies on chemical fertilizer since 1980s by the Madagascar governments, SRI farmers were advised to use compost which gave superior result than the chemical fertilizer and is cheaper to the poor people. Therefore, chemical fertilizer can be used in the absence of organic matter.

Weed emergence is among the critical constrains of SRI farming <sup>3</sup>. The weed emergence is due to the transplanting of single seedling per hill at wider spacing <sup>4</sup>, alternate wetting and drying (AWD) irrigation system <sup>5</sup> thereby creating moist or aerobic soil environment <sup>4</sup>. These factors allow the weed number to increase in the SRI environment compares to the conventional system that allows stagnant water in the field. Hence, the increase in weed number makes the weeds to compete with the rice plants in term of using of the survival elements i.e. nutrients, solar radiation, water and carbondioxide <sup>6,7</sup>. Chellamuthu and Rammohan in <sup>8</sup> reported that the yield loss of rice crop is up to 64.0%. Various researches have been conducted using different approaches as well as different effects of achievement on weed control in SRI farming. Usually weeds risk is being controlled by chemical, cultural, mechanical, physical and integrated weed management (IWM) <sup>8</sup>. Haden et al., <sup>3</sup> reported the application of permanent flooding, mechanical method and competitive cultivars on weed suppression in SRI farm. The application of hand weeding, herbicides, mulching, mechanical weeding and Integrated Weed Management (IWM) were also been used in SRI farming <sup>9,10</sup>. The used of hand weeding method to suppressed weeds in SRI farming is labour intensive i.e. uneconomical and difficult.

These days, mechanical hand weeder (conoweeder or rotating hoe) is being used for weed control in SRI up to 40 DAT which is labour intensive. The application of row weeding machine have overcome the problem of the hard labour, but it only control the weeds up to 30 DAT <sup>11</sup> starting from 10 DAT with interval of 10 days due to the height of the rice plants <sup>12</sup> and the sideways growth of the vegetative portion of the rice plants, which are being injured by the motorized weeding machine<sup>3</sup>. Also, due to the design of the width of the manual weeder and the weeding machine, the total number of the infested weeds within the rows cannot be removed efficiently, thereby, resulting to unsafe competition against the rice crops <sup>13</sup>. Again, some weeds use to regrow from their roots after the weeding operations, especially, the rhizomatous weeds  $^{13}$ . The important benefit of using the mechanical weeder is aerating of the soil during the removal of the weeds  $^{7}$ , resulting to the circulation of oxygen in the soil  $^{14}$ . This benefit of soil aeration can also be made by the natural movement of soil microbes in the soil, for instance, tunnelling the soil layer to create burrows by earthworms <sup>15</sup>. The existence of the burrows in the soil layer leads to the deeper circulation of oxygen within the soil, resulting to microbial nutrients cycling at deeper soil level, which made the plant roots to penetrate deeper in to the soil layer having higher moisture content <sup>15</sup>. Other applications of earthworm are manufacturing of nutrients (warm cast) with higher solubility than the nutrients in the original soil, distributing of nutrients and organic matter within the soil layer, provides the stimulant for plant growth and processed 200 tonnes of soil per acre<sup>15</sup>. Effective environment for earthworm is found in non-till farm, because 90 % of the earthworm is being reduced due to the effect of frequent tillage operation, it demolished the vertical worm burrow, killed the worms and buried the crop residues which serve as their feeds <sup>15</sup>.

SRI farming increases the number of tillers per hill, because one of the aspects of SRI is to transplant younger seedlings, thereby producing significant number of tillers than transplanting older seedlings. This is in conformity with the findings of Krishna & Biradar Patil, <sup>16</sup>, reporting that transplanting of 12 days old seedlings produce larger number of productive tillers 25 days old seedlings in SRI farming. Furthermore, research has been conducted by comparing the combination of conventional factors with one of the SRI factors (transplanting younger seedlings) and conventional system of rice farming. The treatment with transplanted younger seedlings produced the highest number of tillers per hill <sup>17</sup>.Study showed that weed control management in SRI farming using four times conoweeding from 10 DAT up to 40 DAT at 10 days interval and by transplanting 15 days old seedlings resulted to increase in number of tillers which finally returned to higher yield <sup>18</sup>.

Plant height is among the imperative parameters of all crop plants which determine the features of growth performance. SRI transplants younger seedlings using wider spacing practice. Transplanting of younger seedlings and attempting of weed control management provide sufficient light, space, moisture and mineral uptakes by the plant at the vegetative stage as well as the reproductive stage <sup>7</sup>. These may be due to the less competition between the rice crops and the weeds in term of solar radiation, nutrients, water and space as a result of weed control

management. Meyyappan et al., <sup>18</sup> also, found that weed control management in SRI farming using four times conoweeding from 10 DAT up to 40 DAT at 10 days interval resulted to increase in plant height.

New technique on weed management up to 40 DAT without destructing the sideways vegetative branch of the rice plants is essentially needed. The main purpose of this study is to assess the influence of UMAR-SRImat on weed control and performance of tillering and plant height behaviour. This study aims to develop an effective and sustainable weed control strategy in SRI.

### 2. Methodology

# 2.1 Experimental Design

The treatments consist of two mulching materials as soil cover, i.e. SRImat<sup>19</sup> and UMAR-SRImat. The treatments trial comprised of four treatments and three replications as shown in Table 1.

Treatments	Descriptions
T1	No soil cover
T2	SRImat
Т3	UMAR-SRImat without LGE
T4	UMAR-SRImat with LGE

Table 1 Details of the treatments studied

The experimental field was designed using a randomized complete block design (RCBD) with four treatments and three replications. The total area of the study site was 8.2 m  $\times$  8.9 m (72.98 m<sup>2</sup>). The size of any single plot was 1 m  $\times$  1 m (1 m<sup>2</sup> area). The bund of each plot was 0.2 m width. The rice crop planting pattern was 30 cm  $\times$  30 cm (row to row and hill to hill spacing). The numbers of planted seedlings were single seedling per hill. Thus, each plots contained a total number of nine seedlings.. Recent developed single seedling tray with seedling capacity of 924 seedlings was used for raising the seedlings up to 8 days <sup>20</sup>. Three blocks containing 4 plots each were made manually using hand hoe, to design the field layout by pulverising and digging of soils. The preparation of the experimental site was done using manual digging followed by weeds removal, after field layout design. Nitrogen fertilizer applied as recommended by

Department of Agriculture, Malaysia. Single seedlings per hill were transplanted in each plot using 8 days old seedlings at 30 cm  $\times$  30 cm planting geometry. Nine seedlings were transplanted per plot, 36 seedlings per block and a total of 108 seedlings for all the three blocks. Gap filling of the unrecovered seedlings was done. Irrigation water was applied based on demand, in order to maintain moist environmental condition. During the vegetative growing of the rice plants, the plots were left unirrigated for at least 2 to 4 days, until after the appearance of hairline cracks as a result of drying of the soils. The soil was not allowed to in continuous flooded unless through frequent natural rainfall. The weeds of each treatment plot were control according to the above individual investigational treatment plots (Table 1), to decrease their competition against rice plants for nutrients, water, carbon dioxides and solar radiations.

#### 2.2 Observations and Measurements

Three types of weeds (Fig. 1) were identified, observed and measured as follows: Sedges weed were identified by its triangular stem cross sections, long, flat and narrow leaves that are arranged in triple set, fibrous root system, stolon or rhizome and tubers <sup>21</sup>. Grasses were identified by its narrow leaves with parallel veins arranged in two set, flatten or rounded, and hollow stems excluding the nodes, flower, rhizome or stolon, auricle, sheaths, legules and collar <sup>21</sup>. While broadleaves were identified by its wide leaves, one main vein with branches with various shapes, edges, stalks and grow pattern. The number of weeds (weed density) was collected, categorized based on weed classes (sedges, grasses and broadleaves) and counted from  $30 \times 30$  cm in each treatment plot at 20 and 40 DAT. The weed density is expressed as the weed number/0.09m<sup>2</sup>. The various classes of weeds (sedges, grasses and broadleaves) were oven dried for 48 hrs at  $70^0$  C <sup>22</sup> and weighted using weighing balance to determine the weight of the various weed classes. The weed dry weight is expressed in  $g/0.09m^2$ . Number of tillers per hill was randomly selected from 3 hills of each treatment plots at 30 and 40 DAT during the growing stages. The tillers were counted and average values were calculated. Rice plants were also, randomly selected, measured and recorded at 30 DAT. The measurement was started from the base of the plants up to the tips of the highest leaf of the central tillers using a measuring tape.



Fig. 1: Types of weed found in SRI field.

# 2.3 Computation and Analysis

Weed control efficiency (WCE) (%) was calculated using weed dry weight ratio (WDWR) (equation 1), while the weed classes contribution to the weed diversities were calculated using summed dominance ratio (SDR) using equation  $2^{19}$ .

$$WDWR = \left(1 - \frac{T_{dt}}{T_{dc}}\right) \times 100$$
(1)  
$$RD = \frac{density of a given weed type}{total density} \times 100$$
(2)

$$RDW = \frac{dry \, weight \, of \, a \, given \, weed \, type}{total \, dry \, weight} \times 100 \qquad \dots \qquad (3)$$

$$SDR = \frac{RD + RDW}{2} \tag{4}$$

Where;

 $T_{dt}$  = dry weight of weeds in a mulched plot

T<sub>dc</sub>= dry weight of weeds in unmulched plot

RD = relative density

RDW = relative dry weight

SPSS statistical analytical package (version 21) was used to analyse the data collected using analysis of variance (ANOVA). Means were compared using Duncan assumption to determine the significant differences among the diverse treatments.

### 3. Results and Discussion

#### 3.1 Number of Tillers

The young seedlings transplanted in the farm were able to develop well, and the number of tillers per hill recorded was high even with the varying of the environmental situation of the SRI field due to the influence of SRImat and UMAR-SRImat mulched treatment plots. The effectiveness of the weed control treatments in T2, T3 and T4 made the number of tillers per hill to be significantly higher than in T1 because of less competition between the weeds and the rice plants in term of solar radiation, nutrients, carbon dioxide and water. Parallel outcomes were revealed by Babar & Velayutham, <sup>7</sup> and Shad, <sup>23</sup>. While the unmulched plot with less weed control efficiency and severe weed competition depicted the lowest number of tillers per hill. This was also reported in previous researches <sup>7,18,24</sup>.

#### 3.2 Plant height

The plant height results presented at 30 DAT (Table 2) showed significant difference between unmulched plots (T1) which produced shorter plants (44.44 cm) than SRImat (T2) and UMAR-SRImat with LGE (T4) plot with longer plants of (49.96 cm) and (48.42cm), respectively. However, SRImat (T2) has the highest significant plant height among all the treatments followed by T4 and T3. The existence of the longer rice plants in the mulched plots may be due to the better weed suppression of the SRImat resulting in the availability of the survival elements (nutrients, sun light, water and space) to the rice plants for effective growth and development <sup>25</sup>. Equivalent results were reported on the existence of shorter rice plants in the unweeded control treatment plots, and longer rice plants in the weeded treatments <sup>7,18,26</sup>. Similar findings were also found by Karki, <sup>27</sup>; reporting that transplanting younger seedlings with effective weed management, give sufficient plant mineral uptake at the vegetative and reproductive stage, which eventually leads to increase in plant height.

		Pittito	
Treatments	Plant height (cm)	Tillers/hill (30 DAT)	Tillers/hill (40
			DAT)
		(NO.)	
			(No.)
T1	44.44 <sup>c</sup>	10.33 <sup>c</sup>	17.33 <sup>c</sup>
T2	49.96 <sup>a</sup>	23.89 <sup>a</sup>	41.56 <sup>a</sup>
Т3	46.42 <sup>bc</sup>	16.11 <sup>bc</sup>	29.11 <sup>bc</sup>
T4	48.42 <sup>ab</sup>	18.00 <sup>ab</sup>	36.33 <sup>ab</sup>
LSD	0.05	0.05	0.05

Table 2 Impact of various weed control on plant height and number of tillers per hill of SRI rice plants

Note: Plot without soil cover (T1), plot with SRImat (T2), plot with UMAR-SRImat without LGE

(T3), plot with UMAR-SRImat with LGE (T4), least significance difference (LSD)

Means followed by different alphabet along the same column are significantly different at

P≤0.05.

### 3.3 Weed flora

The most abundant and dominant weed classes of the unmulched treatment plots (T1) at 20 and 40 DAT were sedges (82.32% and 85.59% respectively), due to the highest summed dominance ratio than both the grasses and broadleaves as shown in (Table 3). Similar results were reported by Haden et al., <sup>3</sup>, recorded sedges weeds with the highest density and dry weight in the SRI farm.

# 3.4 Weed dry weight ratio

Weed control efficiency was determined by weed dry weight ratio, which showed the degree of reduction of weed dry weight due to the effects of the treatments using SRImat and UMAR-SRImat. Considering the weed control efficiency at 20 DAT, there is significant difference at P $\leq$ 0.05 between the plots without soil cover and the other treatments (T2, T3 and T4) (Table 4). Likewise, at 40 DAT, there is significant difference at P $\leq$ 0.05 between the plots without soil cover and T4) (Table 4.8).Similarly, weed dry weight ratio (Table 4) also depicted that both SRImat and UMAR-SRImat had the highest degree of weed suppression than the unmulched treatment due to higher weed dry weight ratio in the mulched treatment plots; T2 (100%), T3 (100%) and T4 (100%) than T1 (0%) at 20 DAT, and T2 (98.68%), T3 (98.79%) and T4 (99.64%) than T1 (0%) at 40 DAT. Hence, the least weed control
efficiency (0% and 0%) was shown by plots without soil cover (T1) at 20 DAT and 40 DAT. similar results were found using mechanical weeding method at 42 DAT with highest WCE (89.42 %) in treatment plots with three times weeding and lowest WCE (0.00%) in unweeded plot  $^{28}$ .

Table 3 Influence of soil cover on summed dominance ratio in SRI-field									
Summed dominance ration (%)									
Treatments	Sedges		Gra	sses	Broad leaves				
	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT			
T1	82.32	85.59	10.70	3.44	6.98	10.97			
T2	0.00	77.79	0.00	10.74	0.00	11.46			
Т3	0.00	72.80	0.00	24.91	0.00	2.29			
T4	0.00	85.64	0.00	14.36	0.00	0.00			

Note: Plot without soil cover (T1), plot with SRImat (T2), plot with UMAR-SRImat without LGE

(T3), plot with UMAR-SRImat with LGE (T4)

Means followed by different alphabet along the same column are significantly different at  $P \le 0.05$ .

Table 4 Influence of week	Table 4 Influence of weed dry weight ratio (weed control efficiency) in SRI						
Treatments	Weed dry weight ratio (%)						
-	20 DAT	40 DAT					
T1	0	0					
T2	100	98.68					
T3	100	98.79					
T4	100	99.64					

Note: Plot without soil cover (T1), plot with SRImat (T2), plot with UMAR-SRImat without LGE

(T3), plot with UMAR-SRImat with LGE (T4).

Means followed by different alphabet along the same column are significantly different at  $P \le 0.05$ .

#### 3.5 Weed Density

Weed control at 20 DAT and 40 DAT using SRImat and UMAR-SRImat mulched was significantly ( $P \le 0.05$ ) showed least total weed density compared to the unmulched plot (Fig. 2). Similar results were also reported <sup>29</sup> on significant least weed infestation on polythene and straw mulched plots than unmulched plots. At 20 DAT all the mulched plots gave the least total weed density (0, 0 and  $0/0.09m^2$  respectively) whereas the unmulched treatment has the highest total weed density  $(37.0/0.09m^2)$ . Likewise, at 40 DAT all the mulched plots gave the least total weed density (9, 5.33 and 3.33 /0.09m<sup>2</sup> respectively) whereas the unmulched treatment has the highest total weed density  $(80.67/0.09m^2)$ . This is in conformity with the findings reported by Haden et al.,<sup>3</sup>, recorded highest weed density in unweeded plot, but lowest weed density in the weeded plots. This showed that the application of SRImat and UMAR-SRImat was effective in the reduction of total weed density than the uncovered plots. The efficiency of SRImat on weed control may be due to the phenolic composites released by the rice straw during its degradation <sup>30,31</sup> as allelophatic composite for weed control <sup>22,30</sup>. Plain rice straw <sup>29</sup> has some limitations over SRImats due to it loosely packed structure when spread in the SRI farm. Therefore, sun light can be able to reach the soil surface to serve as energy for photosynthesis to take place which lead to weed infestation.



Fig. 2: Total weed density variation under mulched and unmulched treatments at 20 and 40 DAT.

# 3.6 Weed Dry Weight

Total weed dry weight depicted significant (P≤0.05) differences among the treatments because of SRImat and UMAR-SRImat mulch (Fig. 3). However, there were no significant differences in total weed dry weight of all the weed classes between T2, T3 and T4. At 20 DAT the mulched treatment plots (T2, T3 and T4) depicted the least total weed dry weight (0g, 0g, and  $0g/0.09m^2$  respectively) while the plots without soil cover gave the highest total weed dry weight  $(1.94 \text{ g}/0.09 \text{m}^2)$  as shown in Figure 4.17. Still at 40 DAT the mulched treatment plots (T2, T3 and T4) gave the least total weed dry weight (0.22g, 0.26g, and 0.07g/0.09m<sup>2</sup> respectively) while the plots without soil cover gave the highest total weed dry weight  $(20.66 \text{ g}/0.09 \text{m}^2)$  as shown in Fig. 3. Similar results were reported on significant increase of weed dry weight in unweeded plots than the weeded plots <sup>3,28,32</sup>. Therefore, the function of SRImat mulched was effective in weed control on growth and development of weeds in SRI farming because of the significantly lower total weed dry weight at 20 DAT and 40 DAT (Fig. 3). This may be due to the allelophatic effect of SRImat and UMAR-SRImat on progression or development of the associated weeds. The allelophatic effect may be due to the release of phenolic composites by rice straw in the soil which leads to control of weed growth <sup>22,30,31</sup>. Research depicted that the most efficient way for controlling the most problematic weed in paddy farm is by using rice straw mulch <sup>30</sup>. Scattering of plain rice straw<sup>29</sup> has some limitations over SRImat and UMAR-SRImat due to it loosely packed structure when spread in the SRI farm. Therefore, sun light can be able to reach the soil surface to serve as energy for photosynthesis to take place which lead to weed infestation.



Fig. 3: Total weeds dry weight variation under mulched and unmulched treatments.

# 4. Conclusion

The research results showed that the use of UMAR-SRImat mulch at 20 and 40 DAT was effective in weed suppression under SRI farming. Because at 20 DAT UMAR-SRImat treatment depicted zero weed density, weed dry weight, and highest weed control efficiency of 100% for T2, T3 and T4. While at 40 DAT the mulched treatment depicted low weed density, weed dry weight, and highest weed control efficiency of 98.68% (T2), 98.79% (T3) and 99.64% (T4) indicating the effectiveness of both UMAR-SRImat on weed suppression. In contrast, because of increase in weed density, weed dry weight and lowest weed control efficiency (0%) in the control treatment T1, seedling performance such as number of tillers of the rice plants was significantly decreased. Dominant weed classes among the weeds in all the treatment were sedges based on summed dominance ratio in all the treatments. Despite the changing of the environmental condition of the SRI field, all the transplanted seedlings were able to raise and develop in good health condition.

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# An Evaluation of Mechanical Row-weeders and Effects of Wedding Levels on Vegetative Components of Rice under the System of Rice Intensification (SRI)

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**Abstract.** The System of Rice Intensification (SRI) is a new and promising resource-saving method of growing rice under irrigated or rain-fed conditions with an impressive average yield of 7tons/ha. However, the major constraints to achieving the full adoption of SRI practice are the intensive labour requirement especially in transplanting and mechanical weeding up to 40days after transplanting (DAT), hence farmers in Tanjung Karang of Malaysia adopting SRI fabricate locally made rotavators for row weeding in paddy fields. This research was conducted to evaluate performance of four different types of local SRI rotavators that control weeds at different paddy growth stages, and the effect of weeding levels (10, 20, 30 & 40DAT) on the vegetative component of rice. Experimental field was located at Tanjung Karang Irrigation Scheme, Malaysia. A split plot design with four main plots and four sub plot treatments (speed levels) was used, with four replications. Results indicates that due to low ground clearance, all four treatments (rotavators) were not able to weed at 40DAT. The effect of machine revolution per minutes (rpm) on weeding efficiency, field capacity and crop damage were evaluated and found to be significance at ( $P \le 0.05$ ) levels. Similarly, the effect of weeding levels was significant on number of tillers and paddy height at ( $P \le 0.05$ ) level of significant.

**Keywords:** Rotavator, Evaluation, Weeding, System of rice intensification, Rice & Vegetative components.

## 1. Introduction

Rice (*Oriza sativa L.*) is one of the leading food crops of the word; it is a popular and staple food for nearly three quota of the world population. During the last decades, rice consumption has been expanding beyond the traditional rice-growing areas, particularly in western Asia and Europe [14]. In Asia where 95% of the world's rice is produced, rice contributes 40 to 50% of the calories of Asian diet [2]. The average global rice production is 466.47 (Million Metric Tons) for the year 2014 with an average yield of 4.25 ton/ha [15]. The ever-growing and global demand for rice can only be met by increasing its production through enhancing productivity and intensive cropping. Hence, it is imperative to improve the yield by intensive agriculture which necessitates better inputs and better management. However, dietary habit, health and environmental concerns have lead consumers increasingly demand natural, quality produce, without any or with limited chemical treatment. Similarly, concern about the ecological impact of agriculture is growing globally. To follow the market trends, new methodologies and procedures have to be introduced

in agriculture to obtain satisfactory production levels, with sufficient quality, and without damaging the environment [3]. The system of rice intensification (SRI), a new and promising resource-saving method of growing rice under irrigated or rain-fed conditions, with an impressive yield at an average of 7tons/ha is based on the application of the following six practices: **1.** Transplant young seedling 8 to 12days old, **2.** Transplanting single seedlings per hill quickly with minimal root disturbance, **3.** Row and intra-row spacing from  $20 \times 20$  up to  $50 \times 50$ cm, **4.** An alternate wet and dry soil moisture regime (No permanent flooding) to maintain aerobic soil conditions, **5.** Apply organic rather than chemical fertilizers, **6.** Intensive mechanical weeding at 10 to 12days interval up to 40days during early crop development stages to control weeds and aerate the soil. [11], [12], [14], [6] and [13]. Considering the global fixed land nature available for agriculture, promising practices on increased yield such as SRI can match the contineous demand in rice for food due to population growth, health and environmental concerns. However, the constraints to smooth adoption of SRI are the high labour demand in terms of manual transplanting and intensive weeding requirement.

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Weed control accounts for substantial cost in agricultural production and an important constraint to increasing yields wherever rice is grown. Weeding is one of the critical stages in rice cultivation and affects yield and quality of rice [2]. Similarly [16] reported that weed control within crop rows is one of the main problems in organic farming. Scientist and researchers have come up with a great amount of useful scientific information and technologies on weed control. Thus, there is an increasing interest in the use of mechanical inter-row weeders because of concern over environmental degradation and a growing demand for organically produced food [7]. Organic agriculture is characterised as labour intensive than conventional agriculture, as it is assumed that chemical inputs are substituted by factors, such as increased management knowledge, new practices and techniques, capital and labour. The reported impressive yields of above 7tons /ha under SRI and its organic nature, the high labour demand especially its intensive mechanical weeding requirement has both stimulated the interest and concern of farmers. Farmers in Tanjung Karang rice irrigation scheme of Malaysia adopting SRI faced by its challenges developed locally fabricated rotavators of different configurations and capacities. This research work was conducted to evaluate some of the locally fabricated rotavators with a view of establishing their performances, effect of weeding levels on vegetative components of rice, their ability to meet the intensive mechanical weeding up to 40DAT as required by SRI practice.

## 2. MATERIALS AND METHODS

## 2.1. Study Area

The experimental study plot was located at Sungai Burong, Tanjung Karang, Malaysia. The study area was a flat plain with a mean annual rainfall of about 1600 mm and a standard deviation of 75 mm. Climate is semi and subtropical continental with mean monthly temperature of  $28^{\circ}$ C. The soil type in the study area is predominantly silty clay, belonging to the Selangor soil series (Vertic to Typic Dystropept) with mechanical analysis of 1.1% sand (2000-50 µm), 45.4% silt (2-50 µm), and 53.5% clay (< 2µm) [1]. The experimental plot was located  $3^{\circ}28'01.8"N 101^{\circ}14'16.6"E$ .



**Fig.1.0.**Map of Tanjung Karang Rice Irrigation Scheme with Location of plot shown in red balloon red Source: Google map 3°28'01.8"N 101°14'16.6"E

# 2.2. Experimental Layout

The experimentals plot of (6.85 m x 28.14 m) each were set up in a split plot design with four main plots, four sub plots treatment factors and four replications. The main plot treatments are: **A**: Three-row low clearance Weeder Figure 2.0(a), **B**: one-row Weeder Figure 2.0 (b), **C**: Fourrow low clearance Weeder Figure 2.0 (c) and **D**: Five-row Weeder Figure 2.0 (d). The sub plot factors are four (4) levels of rotor blade rpm (1000, 1100, 1200, & 1300) obtained using Laser Photo/Contact Tachometer (EXTECH 461995) as in Figure 3.0 (c). The specifications of the mechanical inter-row weeders are as presented in Table 1.0. MR219 rice variety commonly cultivated by farmers in the study area was prepared in an un-flooded nursery as required by SRI practices on the 3rd of January, 2014 and transplanted manually at 25cm x 25cm row and intrarow spacing on the well leveled/puddled experimental plot on the 13th January, 2014. Mechanical weeding, weed sampling, crop damage count, tiller count and vegetative paddy height were conducted at 10, 20, 30 and 40DAT (Days after Transplanting).

	ROT	TAVATORS		
	Α	В	С	D
Particulars				
Power (Hp)	2.0	1.2	2.5	8.0
Power source	Vitsubishi TB 50	Sthil KM85R	Kawamoto G430	Yanmar HSK4
No. of rows	3	1	4	5
Working width (o	cm) 80	23	140	160

Table 1.0 Specification of Rotavators Evaluated

Weed count, number of tiller per five hills and vegetative paddy height of paddy were conducted before and after each weeding cycle using 0.5m<sup>2</sup> square pegs and 5m steel tape as shown in **Figure 3.0** (a-b) respectively.



(a) Three rows

(b) One row

(c) Four rows (d) Five rows

Figure 2.0 Mechanical Rotavators Weeding Machines evaluated 10DAT







(a) Weed sampling

(b) Vegetative Height measure

(c) rpm measurement

Figure 3.0 Weed sampling, vegetative height and rpm measurement.

## 2.3. Performance Evaluation of Inter-row Weeders

To establish and compare the field performances of the mechanical inter-row weeders, different parameters were evaluated. The parameters evaluated in this study are: Weeding efficiency (%), Plant damage (%), Field capacity (Ha/h), Performance index and ability to weed up to 40DAT. The procedure adopted for the evaluation is as reported by [2], [7] & [10].

## 2.4. Weeding Efficiency (%)

The effectiveness of a weeding machine is measured with respect to the number of weeds cut, uprooted or damaged after weeding operation. It is generally referred to as weeding efficiency (We) %.

$$We = \frac{W1 - W2}{W1} X 100\%$$

(1)

(2)

(3)

Where:

We = Weeding efficiency (%),

**W1** = Number of weeds before weeding

W2 = Number of weeds after weeding

## 2.5. Field Capacity (Ha/h)

The field capacities of the inter-row Weeders were determined using the equation,

$$F_{c=\frac{60}{t}X\frac{A}{10,000}}$$

Where:

A = Area covered (m<sup>2</sup>)

t = Time taken (minutes)

2.6. Crop Damage Factor (*DF*) %  

$$DF = \frac{Q1}{Q2} \times 100$$

Where:

**Q1** = No. of plant in 10m hills before weeding.

**Q2** = No. of plant in 10m hills after weeding

(4)

# 2.7. Performance Index (*PI*) $PI = \frac{Fc - DF \times We}{r}$

Where:

F<sub>c</sub> = Field Capacity (Ha/h),

**DF** = Damage Factor (%)

We = Weeding efficiency (%)

**Pw** = Power rating of machine (Hp)

#### 3. Results and Discussions

### 3.1. Effect of Machine rpm on Weeding Efficiency

The ANOVA (Table 2.0) of weeding efficiency in relation to the machine revealed that there is statistical significance at the ( $P \le 0.05$ ) probability level, thus indicating that machines had significant effect on weeding efficiency experimentally. An R-Sq = 83.57% indicates a strong relationship between machines and weeding efficiency. A mean comparison of the weeding parameters as dependent factors and machines as independent factors showed there was statistical significance as shown in (Table 3.0) using LSD at ( $P \le 0.05$ ) level of significance.

Source	DF	SS	MS	F	Р
Machines (Treatments)	3	1846.1	615.4	20.35	0.000
Error	12	362.8	30.2		
Total	15	2209.0			

Table 2.0 ANOVA: We versus Machines (Treatments)

S = 5.499 R-Sq = 83.57% R-Sq(adj) = 79.47%

Machines			
(Treatments)	Ν	Mean	Grouping
А	4	90.901	А
С	4	85.751	А
D	4	68.714	В
В	4	65.795	В

Table 3.0 Grouping Information Weeding eff. versus Machines Using Tukey Method

\*Means that do not share a letter are significantly different.



Figure 4.0 Normal probability plot of Machine and Weeding efficiency

The relationship between the weeding efficiency and machine rpm was studied to establish the best operating condition for each machine. The best operating for optimum weeding efficiency with respect to individual treatment (machines) are represented by dotted lines in Fig 5.0



Figure 5.0 Graphical representation of Machine versus weeding efficiency

Treatment (A), (B) and (C) had their best operating speeds at 1200rpm, with weeding efficiencies at 91%, 65% and 86% respectively. Treatment (D) had its best operating speed at 1000rpm and weeding efficiency of 67%. The general trend of the weeding efficiency on the rpm was found to be effective at 10 and 20 DAT for all the machines. However, a deviation from the trend was observed at 30DAT and 40DAT respectively. This general weeding trend is shown in table 4.0. Among the four inter-row Weeders (A, B, C & D) evaluated, the highest weeding efficiency of (91%) was recorded with treatment (A), this result is higher than the efficiency range of 79 to 72.25% for conical and rotary weeders reported by [13]. The high weeding efficiency of treatment (A) may be attributed to the crop guard provided on the machine, which made its operation easy with less crop damage. The width of cut of the rotor unit covers 22cm of the 25cm inter row crop width, is also contributor the high weeding efficiency of the machine. The lowest weeding efficiency of (65%) was recorded with treatment B. The low efficiency of treatment (B) could be due to the absence of crop guard on the machine and single weeding unit in contact with the soil makes the machine unstable, therefore causing high crop damage and low wedding efficiency. Treatments (C) & (D) had weeding efficiency of 86% and 65 % respectively, see table 4.0. Treatment (C) had higher efficiency mainly because four weeding unit with working width of 140cm. The low efficiency of treatment (D) can be attributed to small width of cut of 14cm against inter-row distance of 25 cm, thus leaving 11cm of un-weeded porting along the row.

Main Plot Treatments (Machine Types)					
A	B	_C	]	D	
	91	65	86	67	
0.2		0.03	0.1	0.05	
	3.7		32.5	24.7	3.75
	16.33		30.50	44.96	10.93
yes		yes	yes	yes	
yes		yes	yes	yes	
No		No	No	yes	
No		No	No	No	
42	40	39		45	
	Creatm A 0.2 yes yes No No 42	A         B           91         91           0.2         3.7           16.33         yes           yes         yes           No         42	A         B         C           91         65           0.2         0.03           3.7         16.33           yes         yes           yes         yes           No         No           No         No           42         40         39	A       B       C       I         91       65       86         0.2       0.03       0.1         3.7       32.5         16.33       30.50         yes       yes       yes         yes       yes       yes         No       No       No         No       No       No         42       40       39	Treatments (Machine Types)         A       B       C       D         91       65       86       67         0.2       0.03       0.1       0.05         3.7       32.5       24.7         16.33       30.50       44.96         yes       yes       yes       yes         yes       yes       yes       yes         No       No       No       yes         No       No       No       No         42       40       39       45

Table 4.0 Result of Mechanical Inter-row Weeders performances

# 3.2. Effect of Weeding Levels on Number of Tillers and Vegetative Paddy Height

The data for number of tillers and vegetative paddy height per treatment at 30DAT was statistically analyzed. The ANOVA tables 5.0 and 7.0 revealed that a significant difference between the treatments at P = 0.05 levels. This means that frequency of weeding have significant effects on number of tillers and vegetative height of paddy. Tables 6.0 and 8.0 show the mean comparison.

 Table 5.0 ANOVA: Paddy Height 30 DAT (cm) versus Machines (Treatments)

Source	DF	SS	MS	F	Р	
Machines (Treatments)		4	159.80	39.95	10.56	0.000
Error	15	5	6.75 3.7	8		
Total	19	2	216.55			

S = 1.945 R-Sq = 73.79% R-Sq(adj) = 66.81%

Machines			
(Treatments)	Ν	Mean	Grouping
D	4	52.750	А
А	4	52.500	А
С	4	51.000	А
В	4	49.500	А
Е	4	45.000	В

Table 6.0 Grouping Information Using Tukey Method

\*Means that do not share a letter are significantly different.



Figure 8.0 Normal probability plot of Paddy height at 30DAT

Source	DF	SS	MS	F	Р	
Machines (Treatments)	4	879.70		219.93	66.64	0.000
Error	15	49.50	3.3	30		
Total	19	929.20	)			

Table 7.0 ANOVA: Number of Tillers 30 DAT versus Machines (Treatments)

S = 1.817 R-Sq = 94.67% R-Sq(adj) = 93.25%

Table 8.0 Grouping Information	Using Tu	key Method
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Machines			
(Treatments)	Ν	Mean	Grouping
 D	4	41.500	А
А	4	40.500	А
В	4	38.000	А
С	4	37.750	А
Е	4	23.250	В

\*Means that do not share a letter are significantly different.



Figure 9.0 Normal probability plot of tillers at 30DAT

## 3.3. Field Capacity

The result of machine performances in terms of field capacities indicates that machine (A) had the highest field capacity of 0.2Ha/h while machine (D) has the lowest field capacity of 0.05Ha/h, as in table 4.0. The ANOVA (Table 9.0) of field capacity in relation to the machines shows significance at ( $P \le 0.05$ ) significance level. The mean comparison (Table 10.0) of machine field capacities indicates that machine (A) with a mean of 0.22125Ha/h is significantly different to machine (B) with a mean of 0.012625Ha/h, however machines (C) and (D) had no significant difference in their field capacities. Figure 10.0 shows the Normal probability plot of residuals.

Table 9.0 ANOVA: FC (Ha/h) versus Machines

Source	DF	SS	MS	F	Р		
Machines		3	0.08992	0.029	731	94.98	0.000
Error	12	0.0	03756 0.000	0313			
Total	15	0.09	2948				

S = 0.01769 R-Sq = 95.96% R-Sq(adj) = 94.95%

Machines	Ν	Mean	Grouping
 А	4	0.22125	А
С	4	0.12625	В
D	4	0.04625	С
В	4	0.03500	С

Table 10.0 Grouping Information Using Tukey Method

\*Means that do not share a letter are significantly different.



Figure 10.0 Normal probability plot field capacity and machines

## 3.4. Crop Damage Factor

Treatment (**A**) had the least crop damage of 3.7% due to the crop guard provided on the machine, while treatment (**D**) had 3.75% as shown in table 3.0. The low crop damage in treatment (**D**) could be attributed to the small width of cut of the rotor unit of 16cm of the 25cm inter row distance. Treatments (**B**) & (**C**) had high crop damage of 32.5% and 24.7% respectively, due principally to lack of crop guard to protect the paddy. ANOVA (Table 11.0) for crop damage for the machines also indicates significance at ( $P \le 0.05$ ) level of significance. The mean comparison (Figure 12.0) of the machine crop damage reveals that machine (**B**) single row Weeder is significantly different from machine (**C**). However, there was no significant difference in crop damage between machines (**A**) and (**D**). The normal probability plot of residuals is presented in Figure (11.0).

 Source	DF	SS	MS	F	Р	
Machines (Treatmen	ts) 3	1942.	4	647.5	33.13	0.000
Error	12	234.5		19.5		
Total	15	2176.	9			

Table 11.0 ANOVA: Cd versus Machines (Treatments)

S = 4.421 R-Sq = 89.23% R-Sq(adj) = 86.53%

Fable 12.0 Grouping	Information	Using '	Tukey	Method
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Machines			
(Treatments)	Ν	Mean	Grouping
 В	4	31.015	А
С	4	21.137	В
D	4	7.142	С
А	4	3.525	С

\*Means that do not share a letter are significantly different.



Figure 11.0 Normal probability plot machine and crop damag

## 4. Conclusion

From the results of this study, the following conclusions were drawn for the comparative performances of the treatments to control weeds under System of Rice Intensification: The machine performance and rpm had an effect on the weeding efficiency. The performance of all the machines in terms of the intensive weeding requirement of SRI up to 40DAT was not achieved with the existing mechanical inter-row Weeders due to clearance height. Hence, the needs for inter-row Weeder to be developed for SRI to effectively address its intensive mechanical weeding requirement up to 40DAT. The four inter-row Weeders (A, B, C & D) evaluated, the highest weeding efficiency of (91%) was recorded with treatment (A), this result is higher than the efficiency range of 79 to 72.25% for conical and rotary weeders reported by [13]. The high weeding efficiency of treatment (A) may be attributed to the crop guard provided on the machines shows significance at 0.05significance level. The number of tillers and vegetative paddy height both revealed significant difference with increase in weeding levels at 0.05significance level.

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# Leveraging Persuasive Technology to Increase Awareness of Sustainable Agriculture

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Abstract. Social barriers to sustainable agriculture adoption include knowledge and training. There is limited and unstructured effort to elevate farmers' perceptions toward sustainable agriculture and wide information disparity occurs between research and practice as critical information is not disseminated in timely fashion. A moderate level of e-learning knowledge, language barrier and overall scepticism such as doubts, negative attitude, insufficient knowledge and confusion have brought significant constraint to farmers to comprehend and it can be the barrier for active involvement of the farmers in sustainable agriculture. Objective: The purpose of this study is to evaluate an awareness behavior framework utilizing persuasive technology and supported by underlying behavioral model to raise the level of sustainable awareness among the target stakeholders. Approach: The study will adopt action research methodology and the framework will employ the integration of persuasive technology and behavior model as the underpinnings for information context and requirements. Results: An awareness behavior framework will be designed to facilitate awareness behavior toward sustainable agriculture among the stakeholders. A corresponding prototype will be developed to validate the framework. Future plan: The awareness behavior framework can be further tested by domain experts in other sectors to address awareness and promotion in other capacity such as environment protection and recycling.

Keywords: persuasive technology, sustainable agriculture, awareness

## 1. Introduction

This research discusses the study of persuasive technology in alleviating the concern of sustainable agriculture awareness. Persuasive technology is given a specific attention as it inherently incorporates the elements of persuasion and behavioural change that can motivate the stakeholders to increase the awareness of sustainable agriculture. Rice is the essential food of the most population in the country hence it is only coherent that rice and paddy farming have become the most important crop and agriculture respectively in Malaysia. Hence in relation to that, the level of awareness among the stakeholders on system of rice intensification (SRI) as a practice of sustainable agriculture is also given specific attention. The study explores building of framework through the integration of persuasive technology and behavioural theory to complement the initiative to improve the awareness of sustainable agriculture among the target stakeholders.

#### 2. Background

The world's landscape is presently dominated by digital world of interconnectivity encompassing laptops and personal computers, Internet, worldwide web and mobile technology. The hardware is becoming affordable, and effectively the devices are bundled with unlimited connectivity, power and memory. Software for office suites such as presentation, spreadsheets, data-handling and word processing featuring familiar user interfaces are ubiquitous and widely used by the public. On top of that, the technology has incorporated now-familiar features like music and sound, still and moving pictures, animation and graphics while connected to mobile communication. The voice technology which initially only has basic feature just to make or receive calls has made great leaps forward such that voice recognition is now a common feature available in mobile technology. The speed and variety of capability of information communication technology (ICT) has surpassed our earlier conceptions, that it is not dominated anymore by selected few and business entity but is all-pervasive everywhere whether at community, social places, workplace or home. As ICT is advancing at fast pace, the cost of procuring the IT hardware is also becoming affordable. Highly available off-the-shelf database, data warehousing, information and knowledge management technology can be utilized as repository of information that may contain text, image, audio and video [1].

Launched in December 1996 by the National IT Council (NITC), the National IT Agenda (NITA) aims to make available the framework and foundation for ICT utilization in Malaysia. In coherent with Vision 2020, it is the aspiration of NITA to transform the country into a developed country in our own norm and characters with the vision "to exploit ICT to transform all of Malaysian society into an information society, then to a knowledge society and finally to a values-based knowledge society. NITA focuses on the development of people, infostructure and applications to create value, to provide equity and access to all Malaysians, and to qualitatively transform our society into a values-based knowledge society by the year 2020."

Malaysian Commission of Multimedia and Communication (MCMC) in its annual report 2013 highlighted that Alliance for Affordable Internet 2013 (A4AI) has recognized Malaysia as the top developing country in its effort to provide internet to the population at the very affordable rate. The report also mentioned that in 2013 a total of 1.5 million youths (those below age of 30) have benefited from the Youth Communication Package (YCP) which is an initiative to purchase mobile devices with RM200 rebate. The National Broadband Initiative (NBI) which was initiated in March 2010 with nationwide penetration rate of 31.7% has reached 66.4% by end of 2013. One of the key initiatives of NBI is to upgrade the speed of the existing broadband services to 10Mbps or more and 2Mbps for high economic impact areas and general population respectively.

The roll-out of 4G spectrum has increased the adoption rate of smart devices such as tablets and smartphones. The situation demonstrates the vibrant information technology (IT) retail market alluding to the progress in the local connectivity and telecommunication segments. From a wider viewpoint, it remains that ICT has enabled Malaysia to transform into a high-income nation and knowledge-based society [2]. From technology trend standpoint, in December 2014 International Data Corporation (IDC) reported that the growth of "3rd Platform" will be the major technology theme for year 2015 while spending trend is declining for 2nd Technology platform which is typically based on PCs. Based on next generation of software, the 3rd Platform technology is characterized by cloud computing, repository of big data (audio, video and image either still or moving), mobile devices and social media. In 2015 the technology trend will encompass growing wireless data, cloud services, big data and analytics, Internet of Things (IoT), 3D printing and security with mechanisms including biometrics on mobile device, encryption in the cloud and threat intelligence.

Gartner Group in its December 2014 report forecasted that for year 2015, the leading trends of technology include 'computing everywhere' that involves mobile devices and advanced, pervasive and invisible analytics to process large amount of data and accurately provide right information at the right time to the right person. This large magnitude of data is primarily contributed by smart devices, social media and IoT. Further the report highlighted that the technology trends will cover context-rich systems, cloud computing, smart machines, web-scale IT, 3D printing, self-protection and risk-based security as Gartner concludes that security will be the main concern for all digital paths in the future.

As appropriately emphasized by Neil and Hajhashemi [3], the world has progressed into digital age at rapid rate and the outlook of present-day society has been shaped by the digital domain and ICT innovation. And Malaysia is no exception.

Parallel to worldwide digital growth, many forms of technology have been used in marketing, education, safety, environment preservation, commerce, health and information exchange to attract, encourage and persuade people to buy and/or utilize the products and services and change the attitude or behaviour. Fogg [4] positioned that these interactive computing systems designed to change people's attitude or behaviour is collectively called persuasive technology. For persuasion, there are several existing channels of technology such as the web, computer software, mobile applications, social platforms and games. It is a challenge for the persuasive technology design people as they must consider the appropriate technology channels that match closely the target behaviour [5].

At the home front, the Malaysia Department of Agriculture (DOA) has adopted internet technology considerably for provision and dissemination of agriculture information and services to the general population. The DOA's official website www.doa.gov.my has allowed the public especially farmers to be able to access services and information related to agriculture such as new products, new technology, printed materials and news. In country like India and China, the method of applying mobile web services to spread agriculture information has shown some success hence DOA has been encouraged to initiate the same approach to achieve greater accessibility of agriculture information by the farmers especially and public in general [6].

Looking at the state of awareness of sustainable agriculture and/or SRI, there are several key specific problems that hamper the achievement of awareness. These barriers or issues with

regard to awareness of sustainable agriculture and/or SRI as drawn from the past literatures can be summarized as follows:

Problems	Author(s)
Social barriers to adoption of sustainable agriculture/SRI can be attributed to social organization, academic support, and training.	Ferichani and Prasetya [7]
Effort to raise perceptions of sustainable agriculture has been minimal.	Jayaratne [8]
Big gap of information mismatch between practice and research. Information as crucial as scientific or expert advice does not reach in timely fashion to the target users.	Reddy and Ankaiah [9]
Youth are encouraged to attend training so that extensive use of ICT can be maximized.	H. Azman, Z. Amir, T. N. R. T. M. Maasum, S. H. Stapa, J. Mustafa, K. Ibrahim, N. A. Zabidi, and N. M. Yusof [10]
E-literacy awareness level is only moderate among the rural youth and restricted only to basic knowledge of computer usage.	H. Azman, Z. Amir, T. N. R. T. M. Maasum, S. H. Stapa, J. Mustafa, K. Ibrahim, N. A. Zabidi, and N. M. Yusof [10]
Complicated or lack of process involved in promotion and dissemination of the SRI information.	Jayaratne [8]
Failure or success of SRI adoption process at early stage is very much determined by the speed and acknowledgment of the information related to SRI technology.	Namara et al. [11]
Dissemination of sustainable agriculture is not easily comprehended by farmers and has become a significant constraint.	Moser and Barrett [12]
Doubts and negative attitude also play important role towards the difficult adoption of SRI to the farmers.	Moser and Barrett [12]
Sustainable agriculture scepticism is probably due to insufficient knowledge and confusion and it can be the barrier for active involvement in sustainable agriculture.	N. Uphoff [13]
Limited access and the high latency with respect to	K. W. Husain [14]

information and resources.

Wide gap in IT as only the urban population shows	I. N. Kamal-Nasir and D. D.
high level of acceptance while the opposite happens to	Dhanapal [15]
the rural population.	
The strategy for integrated rural development and	N. Uphoff [13]
poverty alleviation should include SRI dissemination	
that not only increases rice output but also to accelerate	
agricultural progress and expansion.	
Language barrier.	I. N. Kamal-Nasir and D. D.
	Dhanapal [15]

Table 1: Barriers to sustainable agriculture awareness.

The objective of this paper is to explore what is required to achieve effective and high-impact awareness of sustainable agriculture and SRI. From the summary of the issues, it is easily noticeable that most of the sustainable agriculture and/or SRI awareness issues are social and behavioral in nature. The research will explore persuasive technology and social behavioral aspect to help address most if not all of the challenges mentioned above. The driving goal of behavior change technologies is to motivate individuals and maintain behavioral change to become regular part of their lives [16]. Adopting qualitative action research methodology, the sustainable agriculture awareness requirements will undergo an iterative and cyclical process with the selected stakeholders to refine, improve and evaluate further the framework until the point that the stakeholders feel that it has reached the optimum effectiveness. A greater understanding of how the framework evolves and is evaluated will enable the relevant stakeholders to harness a broader use of persuasive technology for the purpose of sustainable agriculture awareness by planning, exploring, identifying, and implementing the necessary strategies.

#### 3. Present Situation

There are two pervasive trends of computing that are mutually generating fresh opportunity. The sophistication of mobile computing devices (MCD) such as mobile and smart phones, wearable devices and personal digital assistants, has enabled collection and processing of data via wireless sensors and delivered the information in form of audio and video via liquid crystal display (LCD) touch screens. The future MCDs are embracing exciting features such as high-mobility, affordable to the mass, lighter and smaller form factor. These phenomena have led to increasing population adoption of MCD and as such provide such a convenient way to send and receive messages at appropriate time and place. The next pervasive computing wave is the rise of real-time 'context-aware' system that, based on the sensor data received from the individual via the MCDs, the system can pretty much infer correctly the behaviour of the person and deliver the message timely and appropriately. This innovation can bring great impact as easy-to-understand

system-generated message is delivered specifically at the point when the user wants to make decision or select some options [17].

Many existing techniques for delivering persuasive messages provide only one-way communication (posters, banners, buntings, TV advertisements, radio announcements). Platforms which support custom software provide the unique opportunity to make information delivery a two-way process. This way, users can engage more in the information by providing input and tailoring the type of information which they receive. This type of interactivity could be achieved on mobile phones which support programs written in Flash, Java or the like. Designs that leverage the interactive capabilities of technology can help tailor information to user input and thus make it more persuasive.

A major barrier to information efficiency is the inability to be in constant contact with trusted information sources. Mobile phones obviously enable communication with these sources, and in addition could also allow for exchange of short audio clips or visuals (like animations), through which the system could provide requested information in a timely fashion. They can also provide a social networking platform for connecting users to one another. By sharing information, experiences, stories and questions, mobile phones can help generate a practice group that fosters a sense of support and inclusion. The society at large seems to perceive mobile phones as "hitech" quality. This perception itself could give the information presented as well as the carrier of the information more authority and confidence.

At present the mobile phone has grown to be an important tool in remote and rural areas and not only concentrated in urban areas and the trend is expected to continue at rapid pace. Ease of use and reducing the cost of devices make the mobile phone to become flexible tools for rural development Wireless communications, long battery life and low prices can make the mobile device a fast tool to be the best solution in rural than the computer. Various gadgets of modern information technology (e.g. mobile phones, CDs, DVDs, computers, internet, cable TVs, etc.) have qualitatively changed the Malaysia's rural information landscape [14].

The challenge ahead is the effective delivery and infusion of awareness to the target users. In view of increasing awareness and global pressure in most nations' economy, the government has considered various options in promoting greater awareness on environment sustainability. Deployment of appropriate ICT becomes one of the possible strategies for such purpose. Nowadays, ICT has made its presence in all kinds of businesses of all sizes and has a significant bearing in extending business productivity. With powerful and broad qualities, ICT has transformed rural community into knowledge society and local farming community is able to utilize ICT capability to protect, distribute, absorb and generate information and knowledge [18].

ICT offers critical means that can be utilized to disseminate, create awareness and promote the alternative sustainable agricultural practices such as SRI and popularization of information technology has opened up new opportunities for economic development and social change. Now, the question is: how this new information environment could be used to upgrade the level of information of farmers? It is increasingly desirable to recognize environmentally friendly behaviour and as such, environment protection has become an important domain for future persuasive technologies despite the availability of few technologies that encourage people to protect and save the natural environment [19].

These three landscapes involving ICT, persuasive technology and awareness of SRI as sustainable agriculture practice cannot help but cross the paths of each other to conceive the feasibility of leveraging ICT infrastructure and persuasive technology to increase the awareness of sustainable agriculture among the local agriculture community especially the farmers. The Malaysian government has taken all the possible initiatives to keep abreast of ICT and to ensure that all level of population in the country to benefit from it. The present ICT infrastructure and advancement of persuasive technology can certainly complement the government initiative to instil greater sustainable agriculture awareness to the population in general and agriculture community in particular.

#### 4. Persuasive Technology

Persuasive technology characteristically applied for effective interventions, seems to have the eminent values that make powerful motivational strategies and surmount some limitations that are traditionally inherent. The innovative technologies embedded in new multimedia create opportunities by making available the capability to develop and enhance sensory experiences to understand environments that are perceivable distantly, discover cause-effect relationships and increase awareness of distant and future concerns. In spite of what multimedia technology can offer in terms of possibilities, increasing awareness alone is not sufficient. The power of these supportive systems could be improved further by harnessing technology that intelligently and interactively communicate in personal manner and learn from the users. Although it is a formidable task, the effort to integrate psychological with technological means seems to be the most sensible direction for society to utilize the natural resources in sustainable way [20].

Influencing behaviours and human attitudes has become constant persuasive effort and normal human interaction from beginning of time until present-day digital and multimedia period. Using interactive persuasive techniques rather than one-way, the multimedia technology has developed into such a dominant tool and allowed modification and changes to the interaction form based on the persuaded party's action and characteristics of the target party via the context, needs and input of the user [21].

Being natural persuaders, humans have distinctive social impact and presence, and have the ability to sense and make decision with regard to context, mood and timing to take the opportunity to persuade the other party while at the same time humans also have the attributes of persuasion psychology such as authority, reciprocation, similarity and praise.

Fogg [4] however argues that there are unique persuasive advantages of computers as compared to humans. The characteristics of persuasive advantage of computer are the ability to access virtually huge amount of data with multiple formats such as animation, video clips, audio, text and rich graphics that can provide assuring experience. Computers also permit anonymity and are more insistent compared to humans. In addition, user can easily replicate the software

and distribute in unlimited way and as a result the persuasive technology can be made available at places where previously not accessible to humans.

Just-in-time in situ actionable information and relevant notifications that persuasive technology can bring may serve as tools that can become very useful to help people to familiarize and motivate behaviour. These features of persuasive technology are also suitable in the domain of environment preservation and education [21].

#### 5. Sustainable Agriculture

The world's food production is increasing due to the application of widespread external input-based conventional agriculture but at the expense of environment and socio-economy impact.

Exhaustion of natural resources due to conventional farming has triggered undesirable sustainability problem. Hence to resolve the situation, alternative practices of sustainable agriculture needs to be disseminated and advanced rigorously for acceptance. Severe effect on the eco-systems and natural resources by unethical human activity might steer to dangerous threat to civilization and human life [8], [22].

The management of sustainable agriculture is an important aspect for Malaysia to move towards achieving the status of developed nation. The country is rich in natural resources – fertile land, good geography, abundance of water and predictable all-year good weather that are very suitable for various types of crops. How to motivate the society to utilize the limited natural resources in a sustainable fashion?

Sustainable agriculture reflects production of sufficient food via raising crops and farm animals without diminishing and contaminating the resource and environment respectively. Having nourishing food available and affordable for every family member in the community of dynamic farming represents the values of socio-economy that support sustainable agriculture [23].

Community, social, environment and economic aspect are always correlated with sustainable agriculture. Sustainable agriculture can generate reasonable profit, help farming families to be independent financially and develop local community while at the same time maintaining and preserving the natural environment [24].

Various means such as information dissemination and education on conservation measures and methods are necessary to transform the mindset of the society to appreciate and accept sustainable agriculture [25].

Both sustainable aquatic ecosystems and food production are greatly challenged by global food demand. Useable lands globally being managed in principle by agriculturalists that will, perhaps in decades to come, permanently shape the earth surface. Not compromising public health and integrity of the environment, fresh policies and incentives are required to address the pressure to sustain increasing yields while safeguarding ecosystem and agriculture services. The

pressure to achieve food security and quality and simultaneously preserve the environment has compelled the need to shift the paradigm of local farming towards sustainable agriculture.

### 6. System of Rice Intensification

Rice among other food commodities is an essential food of the most population in the country hence it is only coherent that rice and paddy farming have become the most important crop and agriculture respectively in Malaysia. Rice and paddy farming is synonymous with rural area and provides main source of income to the many of the rural poor. One of the alternatives of sustainable agriculture is SRI which was introduced by French Jesuit Father Henri de Laulanie in Madagascar in 1983 [26]. The practice of SRI proposes that modification needs to be done in relation to the way nutrients, soil and rice plants are managed. Consequently by following the methods, it brings about remarkable effects on yield by 50-100% or more. Besides the higher yields, SRI also has other benefits that strongly support sustainable agriculture such as reduced use of water, discontinuation of herbicides and fertilizers, better seed quality and higher milling ratio. Farmers, government and donor agencies are urged to use or support the SRI practice [11], [22].

Research has shown that environmentally friendly rice farming method such as SRI has successfully produced remarkable increase in rice production while at the same time helps to sustain and preserve the environment by means of efficient utilization of natural resources [27]. The demands and needs for food security in Malaysia can be potentially addressed in sustainable way by SRI as the past evidence has shown (http://www.srimas.org).

The opportunity of income improvement and cost reduction that SRI method brings along has frequently inspired the farmers to adopt it and once the farmers are familiar and skilful at the method, it can also potentially alleviate the cost of labour [28].

In 2009, SRI was introduced in Malaysia by well-established SRI researcher Professor Norman Uphoff from Cornell University USA who came to this country to support the SRI awareness campaign initiated by a group of local advocates [29]. SRI adoption nevertheless is still at early stage in Malaysia even though it has been practiced more than 30 years ago with more than 50 countries worldwide have adopted and used this method in one way or the other. Result

The approach of the study is to explore the integration of persuasive technology and behavioural model and derive a framework that can be utilized to improve the sustainable agriculture awareness among the target stakeholders. The optimization of the framework as a result of integration of persuasive technology and behavioural model is achieved by employing action research methodology. The framework is further validated by the stakeholders via prototype. The following figure illustrates the framework .



Fig. 1: Sustainable agriculture awareness framework adopting action research methodology by Carr and Kemmis (1986)

# 7. Future Plan

The generics of the framework derived from the integration of persuasive technology and behavioural theory are expected to seamlessly address sustainability in other areas such as environment protection, recycling and waste management.

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# Comparative Study on Seedling Performance raised by New Single Seedling Nursery Tray and Conventional System

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Abstract: Raising of rice seedlings is among the important factors responsible for better growth and development of rice plants as well as increasing the grain yield. Conventional method of raising rice seedlings required larger space, time consuming (24 hours seed soaking and 34 hours in jute bag up to sprouting) and labour intensive procedure, which limits the production capacity of rice seedlings. Transplanted seedlings raised by new developed single seedling nursery tray have not been compared with the conventional system in the field. The objective of this study was to evaluate the average number of tiller per hill at 60-day after transplanting (DAT). The experimental design is one treatment [new developed single seedling nursery tray (T1)] and three replications. The age of transplanted seedlings raised by the new developed single seedling nursery tray was 8 days old. Number of tillers were randomly selected, counted and recorded at 60 DAT from each treatment plots for further analysis. Average number of tiller (32.27 tiller/hill) was collected from previous published article at 60 DAT using 8 days old seedlings. One sample T test was used to analyse the data using SPSS statistical analysis software (version 21) at 95% Confidence Interval of the Difference. The result of the analysis showed significant difference between them, and larger average number of tillers in T1 (68.56 tiller/hill) than the existing average number of tillers. The study depicted that using new developed single seedling nursery tray is one of the options to increase the number of tillers in SRI farming in order to increase the number of effective tillers, number of panicles, straw yield and grain yield of rice plants.

Keyword: Seedling Performance, Conventional System

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### **1. Introduction**

System of rice intensification, known as SRI is an innovation in rice farming cultural practice for increasing the productivity of water, capital, labour and land. SRI is all about altering the management of soil, water, rice plants and nutrients. It is environmentally friendly and makes the yield of rice to significantly increase, in addition to water productivity by using of less external inputs, which in turn will have a positive effect to the farmers, as well as, the country at large. Also, SRI plays important roles in term of water, land, labour and capital productivity in irrigated rice production area <sup>1</sup>. SRI comprises of various components to be followed. The components are transplanting of young and single seedlings per hill at wider spacing, applying of organic inputs (e.g. pesticide, fertilizer, herbicide and insecticide) and less use of water through alternate wetting and drying (AWD) to provide moist environments <sup>2</sup>, but it can be modified if the key components are adopted. System of rice intensification has many variations with conventional system of farming.

- Conventional practice of rice farming uses larger amount of rice seeds <sup>3,4</sup> than SRI practice which used lower seeds per hectare <sup>4</sup>.
- SRI practice transplants young seedling with ≤15 days old, while conventional practice transplants ≥3weeks old seedlings <sup>5</sup>.
- SRI practice transplants one seedling rapidly and prudently <sup>5</sup> while conventional practice transplants more than one seedling.
- SRI practice transplants using at least 25 × 25 cm planting geometry, leading to reduction of plants density from 80 to 90% while the conventional practice used close spacing <sup>5</sup>.
- Repeated weeding is being practice in SRI practice compared to conventional practice which suppresses weed infestation under permanent flooded situation <sup>4</sup>.
- Due to intermittent irrigation and repeated mechanical weeding in SRI, soil aeration improved <sup>5</sup> while conventional practice used flooded field <sup>4</sup>.
- SRI practice has robust root growth than the conventional practice <sup>6</sup>.
- Rice crop from SRI farm absorb higher amount of macronutrients through their roots than the conventional system of rice farming <sup>5</sup>.

Generally, uprooting of single seedling for transplanting causes stress to the seedling, which could be reduced when the endosperm stays attached <sup>7-9</sup>. In conventional practice, it has been reported that around range of 40 and 60% of the roots stay in the soil during removing or pulling up from the nursery bed. Cutting up to 60% of the rice root during transplanting significantly reduced subsequent rice root and shoot dry matter build up <sup>10</sup>. Therefore, there is need use the new developed single seedling tray for SRI in order to increase shoot and root dry matter accumulation by protecting root system during transplanting. This will also lead to increase of growth and development of rice plants. The main objective of this study was to evaluate the average number of tiller per hill at 60 day after transplanting (DAT).

### 2. Methodology

MR219 rise variety was used in the experiment. The treatment test (T1) consists of one treatment with three replications. Newly developed single seedling tray with seedling capacity of 924 seedlings was used for raising the seedlings (T1) up to 8 days <sup>11</sup>. The seed rate was 4.3 kg/ha. Best rice seeds were selected by socking the seeds in water and salt solution for six hours, after then, the salt and water solution was drained, and kept for 24 hrs for sprouting to initiate. The sprout seeds were sown in the seedling tray containing a mixture of soil to compost ratio of 1:1. The sown seeds were irrigated twice daily using hand watering jar to prevent drought and to sustain moist soil condition up to one day before transplanting. The study area was 8  $m^2$ . The size of each plot was 1 m<sup>2</sup> area. The rice plant planting geometry was 30 cm  $\times$  30 cm. Single seedling per hill was transplanted. Hence, every plot contained a total number of nine seedlings. One block containing 3 plots were manually made by means of hand hoe in order to design the field layout. The preparation of the experimental site was done using manual digging followed by weeds removal, after field layout design. Nitrogen fertilizer was applied. Single seedlings per hill were transplanted in each plot using the 8 days old seedlings at 30 cm  $\times$  30 cm planting geometry on. Nine seedlings were transplanted per plot and a total of 27 seedlings for all the three plots. Irrigation water was applied using alternate wetting and drying (AWD), in order to maintain moist soil or aerated condition. During the vegetative growing of the rice plants, the plots were left unirrigated for at least 2 to 4 days, until after the appearance of hairline cracks as a result of drying of the soils. The weeds of each treatment plot were control by means of mulching material known as "SRImat"<sup>12</sup> for reducing the competition against rice plants in term of nutrients, water, carbon dioxides and solar radiations. Number of tillers per hill was randomly selected from 3 hills of each treatment plots at 60 DAT during the growing stages. The tillers were counted and mean values were calculated and recorded.

The data collected was analysed using analysis of variance (ANOVA) by means of SPSS statistical analytical package (version 21). Means were compared using one sample T-test, to determine the significant difference between the seedling performance raised by the newly developed single seedling tray and the conventional practice.

### 3. Results and Discussion

### **3.1 Raising of Seedlings**

The rice seedlings were prepared using the newly developed single seedling tray by means of soil to compost ration of 1:1 as shown in Fig. 1. The age of seedlings used was 8 days old (Fig. 2).



Fig. 1: Soil to compost ratio (1:1) used in this study



Fig. 2: MR219 seedlings at 8 days old raised in the developed tray

### 3.2 Number of Tillers

The transplanted seedlings raised from the newly developed single seedling tray (T1) were able to grow and develop in good health. The conventional practice raises nursery seed beds with larger area than the area occupied by the newly developed single seedling tray for raising the seedlings. It consumed more time because seed soaking is done up to 14 hrs and kept for 34 hrs in jute bag for rapid germination of seed up to selected age of seedlings<sup>13</sup>. The roots are heard to separate during pulling for transplanting due to interconnection among the roots and compute with one another in term of nutrients, aeration, water and sunlight. The mean value of the number of tillers (68.56) for the seedlings raised by the newly developed single seedling tray (Table 1) is higher than the mean value of the number of tillers (32.27) for the seedlings raised by the conventional practice (Table 2). The effectiveness of the newly developed single seedling tray as shown by the one-sample t-test result, made the number of tillers per hill to be significantly higher than the conventional practice. This may be due to the absence of roots interconnection which leads to the transplanting of seedlings with healthier root and shoot than the conventional practice.



Fig. 3: Seedlings performance at 60 DAT

	N	Mean	Std. Deviation	Std. Error Mean
60 DAT	3	68.5556	7.95357	4.59200

Table 1: One-Sample Statistics

Table 2: One-Sample Test

	Test Value = 32.27								
	t	df	Sig. (2-tailed)	Mean	95% Confidence Interval of t				
				Difference	Difference				
					Lower	Upper			
60 DAT	7.902	2	.016	36.28556	16.5278	56.0433			

# 4. Conclusion

The number of tillers per plant varied significantly due to different methods of raising the seedlings for transplanting. The increment in the average number of tillers per plant was remarkably higher in the newly developed single seedling tray treatment than the conventional practice. Under the present day constraints of lower production of rice crops, this study depicted that using new developed single seedling nursery tray is one of the options to increase the number of tillers in SRI farming in order to increase the number of effective tillers, number of panicles, straw yield and grain yield of rice plants. The results from the experiment clearly revealed that younger seedlings raised by the newly developed single seedling tray resulted into significant higher number of tillers than the conventional practice. Thus, the above SRI technique can be extended to the farmers and thereby maximizing total production of rice, ultimately contributing to national food security.

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# Effects of Rice Husk Biochar (RHB) on Soil Properties, Rice Plant Growth and Nutrients Uptake

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**Abstract.** Report about possible soil acidification of SRI advocated biochar as additional organic soil amendment. The aim of this study was to study the effect of rice husk biochar (RHB) on soil properties, rice growth and nutrients uptake on a SRI rice field in Jembal, Kelantan. However, ten ton/ha of RHB was insufficient to alleviate soil pH. Soil salinity significantly decreased 29% with RHB addition and improved vegetative growth stages of rice plant; thus rice yield improved. Besides, RHB also provided supplementary C, N, Ca and increased soil cation exchange capacity (CEC). Therefore, biochar induced higher total nutrients uptake in SRI system except K. Moreover, the disparity of nutrients uptake were prevalent in tiller than grain; further proving positive effect of RHB enhancing rice plant vegetative growth. Incorporation of biochar in SRI system improved soil properties, rice growth and yield. Long-term study is needed to validate the duration of benefits bring upon biochar addition in SRI system.

Keywords: biochar, SRI, vegetative growth, nutrients uptake.

#### 1. Introduction

The system of rice intensification (SRI) is a concept formulated on principles of soil chemistry and biology, rice physiology and sustainability. Globally, there are a lot of records on high rice yield employing SRI compared to conventional paddy cultivation. However, the long-term SRI rice yield in Malaysia is still a mystery as no detail scientific study is conducted up to date. Sooksa-nguan et al. (2009) reported increased nitrification rates in SRI system and this could lead to soil acidification over certain time span. Thus, the SRI rice yield could diminished over time without proper management.

In order to ensure incessant high rice yield in SRI system, organic amendment should be added to the system to improve the soil. Biological charcoal or biochar is proven to exhibit limited liming effect increasing soil pH due to the mineral ash content and high surface area (Mao et al., 2012). Besides, biochar is also effective in capturing nutrients and reducing leaching loss especially under flooded or saturated condition. Hardwood biochar reduced N and P leaching by trapping them on the biochar surface (Laird et al., 2010). Moreover, biochar also adept to increase the upland rice yield in a conventional plot (Petter et al., 2012).

Thus, biochar could complement and fit the concept of sustainable soil fertility management emphasized by SRI while increase the C sequestration. The aim of this study was to determine the effect of biochar on the soil properties, rice growth performance and nutrients uptake. Rice husk biochar (RHB) was added into a SRI rice field (SRI-BC) and the soil properties, rice growth and yield and nutrients uptake were recorded and compared with regular SRI rice field for two rice plant cycle. However, only the results for the first cycle were reported as the experiment is still ongoing.

### 2. Materials and methods

### 2.1. Field experiment

The field experiment was carried out on silty clay soil at Jembal, Kelantan. Each site was separated into four 5 m x 5 m plots. The rice paddy variety used was MRQ 74. Besides, the rice husk biochar (RHB) was collected from BERNAS. The chemical properties of RHB were listed in Table 1. Rice straw and indigenous microorganisms (IMO) were applied to all plots before experiment as mulching. Standard organic SRI practices were employed for both organic SRI plots (SRI) and organic SRI plots with biochar (SRI-BC). The SRI-BC plots were applied with 10 t/ha of RHB before planting. Bone mill organic fertilizer was foliar applied after plowing as a mean to control pest.

Table 1: Chemical properties of rice husk biochar (RHB)							
Parameter	Rice husk biochar (RHB)						
Total C (%)	25.28						
Total N (%)	0.41						
Available P (mg/kg)	1148						
Exchangeable K (cmol <sub>(+)</sub> /kg)	1.07						
Exchangeable Ca (cmol <sub>(+)</sub> /kg)	2.64						
Exchangeable Mg (cmol <sub>(+)</sub> /kg)	4.86						

The rice plant was harvested after 120 days after transplanting (DAT) and plant growth parameters (yield, no of panicles perhill, no of tiller perhill, % of productive tiller, % of filled grain, weight of grain perpanicle and weight of 1000 grains) were recorded. Soil samples were collected after harvest for further analysis.

### 2.2. Soil and plant tissue analysis

The soil  $pH_{H2O}$  was determined with 1:2.5 ratio of soil:water and a pH meter. The total C was ascertained with a C analyzer (LECO CR-412 Carbon Analyzer). Meanwhile, the total N and available P was determined using Kjeldahl and Bray II method respectively established with

Auto Analyzer (LACHAT Instrument, QuikChem FIA+ 8000 series). The cation exchange capacity (CEC) and exchangeable bases (K, Ca and Mg) were determined with ammonium acetate method and atomic absorption spectrophometer (AAS; PerkinElmer AAnalyst 400).

2.3. Statistical analysis

All experimental data between SRI and SRI-BC was compared with t-test using SigmaPlot verson 12.0.

# 3. Results and discussions

3.1. Effects of biochar on SRI soil chemical properties

Addition of RHB was ineffective in alleviating soil pH value (Table 2) albeit the significantly higher amount of Ca supplied by biochar (Table 1). This could be partially attributed to the displacement of exchangeable acidity by the abundant  $H^+$  in SRI soil induced by the rich nitrification rate in SRI system (Sooksa-nguen et al., 2009). Higher amount of biochar was needed to reduce the soil acidity in a SRI system. Soil salinity was significantly reduced by 29% with application of RHB (Table 2). The decrease of soil salinity in conjunction with decline of Mg content and increased soil CEC implied removal of cations by biochar. The aptitude of biochar in reducing salinity (Thomas et al., 2013) suggested prospect to relief osmotic stress of rice paddy plant in SRI. Besides, RHB supplied C and N to the system and concurrent with soil aeration might promote microbial activities elucidating the higher paddy production in SRI-BC plots (Guo et al., 2011& Zhang et al., 2014).

Parameter	SRI	SRI-BC	
pH (H <sub>2</sub> O)	4.7±0.07 <i>a</i>	4.7±0.07 <i>a</i>	
Salinity (µS/cm)	76.40±0.89a	53.86±4.98b	
Total C (%)	1.30±0.18b	1.80±0.19a	
Total N (%)	$0.13 \pm 0.04 b$	0.18±0.02a	
Available P (mg/kg)	15.06±1.52a	16.89±0.68 <i>a</i>	
Exchangeable K (cmol <sub>(+)</sub> /kg)	$0.05 \pm 0.02a$	0.03±0.02 <i>a</i>	
Exchangeable Ca	$0.96 \pm 0.14b$	1.23±0.11a	
( <b>cmol</b> <sub>(+)</sub> / <b>kg</b> )			
Exchangeable Mg	0.17±0.02 <i>a</i>	$0.13 \pm 0.005 b$	
(cmol <sub>(+)</sub> /kg)			
CEC (cmol <sub>(+)</sub> /kg)	4.68±0.37b	5.57±0.33 <i>a</i>	

Table 2: Effects of RHB application on SRI soil properties

\*Means followed by the same letter within columns are not significantly different using t- test, P=0.05.

# 3.2. Effects of biochar on rice plant growth and nutrients uptake

The yield, number of panicle/hill and % productive tiller increased significantly with addition of biochar (Table 3). However, there was no significant effect of biochar in SRI system on grain production (% filled grain, weight of 1000 grains and weight of grain perpanicle). This indicated biochar influenced the vegetative growth stages of rice paddy plant possibly by decreasing the soil salinity. Primary growth stages of rice plant like panicle initiation were highly affected by salinity (Aref and Rad, 2012). Moreover, RHB was found to improve straw yield by 40% in a conventional rice paddy cultivation system due to soil improvement (Sokchea et al., 2013).

Parameter	SRI	SRI-BC
No of panicles/hill	37.45±5.23b	45.60±5.60a
No of tiller/hill	38.93±3.63 <i>a</i>	39.93±5.26a
% of productive tiller	90.57±4.05 <i>b</i>	97.48±1.26a
% filled grain	87.89±1.55 <i>a</i>	86.54±0.56a
Wt of 1000 grains (g)	21.21±0.78a	20.54±0.97a
Wt of grain/panicle	0.96±0.21a	1.05±0.27 <i>a</i>
Yield (t/ha)	12.80±1.34b	16.90±2.08a

# Table 3: Effects of RHB application on rice growth under SRI

\*Means followed by the same letter within columns are not significantly different using t- test, P=0.05.

The total nutrients uptake (grain+tiller) of SRI-BC was significantly higher than SRI (Table 4). This indicated RHB incorporation into SRI increased nutrient uptake efficiency. The N, P and Ca uptakes of tiller in SRI-BC were significantly higher than SRI. This could be attributed to surface sorption capability of biochar associated with the higher soil CEC (Table 2) improving nutrient recovery (Sika and Hardie. 2014).

Parameter	G	rain	T	Tiller Total uptake (Grain+T		
	SRI	SRI-BC	SRI	SRI-BC	SRI	SRI-BC
Total N	130.53	147.11	86.74	128.79	217.26	275.89
(kg/ha)	±5.31a	±10.92 <i>a</i>	±3.55b	±5.19a	±7.85b	±8.09a
Total P	30.31	34.22	11.91	19.02	41.24	52.70
(kg/ha)	±3.17b	±2.39a	±1.17b	±0.61 <i>a</i>	±2.79b	±2.87 <i>a</i>
Total K	39 58	41 26	177 02	212.00	213 63	253 27
(kg/ha)	±4.66 <i>a</i>	±2.80a	±3.97 <i>a</i>	±30.87 <i>a</i>	±7.13a	±32.61 <i>a</i>
Total Ca	7.74	10.00	22.00	30.01	29.74	40.07
(kg/ha)	±0.59a	±3.10a	±1.61 <i>b</i>	±5.77a	±2.11 <i>b</i>	±7.44 <i>a</i>
Total Mg	10.86	12.38	7.89	11.39	18.44	23.77
(Kg/IIA)	±1.63 <i>a</i>	±0.86a	±0.10b	±0.63 <i>a</i>	±1.94 <i>b</i>	±0.28a

 Table 4: Effects of RHB application on rice plant nutrients uptake

\*Means followed by the same letter within columns are not significantly different using t- test, P=0.05.

### 4. Conclusion

Incorporation of RHB into SRI further improved the rice plant growth and soil properties. However, higher rate of biochar was needed to reduce soil acidity. Besides, study covering longer time span is recommended to further examine the long-term benefits from biochar.

### 5. Acknowledgement

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# Phytoavailability of Arsenic, Cadmium, Lead and Mercury in Rice Grains of Paddy Plants Grown in Malaysia

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Abstract. Agronomic practices in rice should follow best management practices (BMP) due to evidence of heavy metals accumulation in the grains either from agricultural inputs and/or soil. The practices such as application of fertilizer, soil amendments, pesticides and herbicides either under organic farming (OFS) or flooded conventional condition or system of rice intensification (SRI), have not been well investigated to reflect their impact in the rice grains. Among the trace elements that have become a concern in the rice grains are arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg). Recently, high levels of arsenic (As) in rice grain are reported in several literatures. Variability in total As, Cd, Pb and Hg in rice was evaluated using 12 rice samples from paddy growing areas of Malaysia. The data set is compared with the Maximum Permitted Concentration (MPC) as stated in the Malaysian Food Act (1983) and Food Regulation (1985) for reference values. The results were also evaluated based on previous background studies on heavy metals accumulation in rice grown in Malaysian soils which are from <1 to 2.59 mg kg<sup>-1</sup> for As, 0.004-0.04 mg kg<sup>-1</sup> for Cd, 0.10-0.70 mg kg<sup>-1</sup> for Pb and 0.05-6 µg kg<sup>-1</sup> for Hg. Trace metals accumulation in rice grains samples are found to be in the range of 0.03 to 12.90 mg kg<sup>-1</sup> for As, 0.011 to  $0.612 \text{ mg kg}^{-1}$  for Cd, 0.09 to 3.33 mg kg<sup>-1</sup> for Pb and <1 to 253.7  $\mu$ g kg<sup>-1</sup> for Hg.

**Keywords:** Maximum Permitted Concentration (MPC), conventional flooded rice, aerobic rice, System of Rice Intensification (SRI), organic rice

### 7. Introduction

Rice (African rice) is the seed of the grass species. A large part of world population especially Asia consumed it as a staple diet. It is an agricultural commodity with the thirdhighest worldwide production after sugarcane and maize [2]. Recently, concerns arise among consumers on the issue of quality or safety of rice based products. Several reports warn against consumption of rice by local populations from plants subjected to prolonged heavy metals exposure which might pose potential health problems. Trace elements introduced into our environment could come from natural and anthropogenic sources. In the case of rice cultivation, the source of cadmium is mainly due to fertilizers usage [3]. The source of lead accumulation could be from agricultural inputs, industrial by-products, urban wastes and automobile gaseous emission. Even though, methyl mercury compounds are no longer used as fungicides nowadays, the history of extensive usage of it in agriculture has elevated the mercury metal level deposited in the rice grain [8]. On the other hand, susceptibility of rice towards arsenic accumulation is generally due to parent materials of soils and the flooded condition required for rice cultivation. This results in high mobility of arsenic from the soils [4]. The baseline As levels in rice grain can be 10-fold higher compared to other cereal grains [9]. This is speculated due to irrigation contamination, mineral exploration and processing industries and As based pesticide usage [5] [6]. Thus, with the threat these heavy metals possesses, organic and natural farming system are gaining attention due to its assurance in safety issues. Among organic/natural farming system in rice cultivation, System of Rice Intensification (SRI) is gaining attention these past few years due to rice safety issues. The main components of SRI include; 1) careful transplanting of young seedlings at wide spacing on a precise grid with only one seedling per hill, 2) water management that keeps the soil moist but not continuously flooded, 3) frequent (i.e. three to four times) manual or mechanical weeding before canopy closure, and 4) reliance on high rates of organic compost for fertilizer [7]. Reviewing the principles behind SRI which focused on non-flooded condition of rice fields plus usage of organic fertilizers and amendments, the prevalence of trace metals accumulation is postulated to be lower. Thus, the objective of this preliminary study is to assess heavy metals (Pb, Cd and Hg) with special emphasized on As levels in rice grains cultivated under organic and conventional production system.

#### 8. Materials and Methods

This assessment is carried out for 12 samples of rice grown under different cultivation method with 3 replicates. The samples are: 1) Flooded rice planted on acid sulfate soil, 2) Brown Bario aerobic rice, 3) White Bario aerobic rice, 4) SRI Rice CHIHERANG, 5) Organic SRI Rice-MRQ 74, 6) Organic Black Wild Rice,7) Organic Rice-SRI-Dept. of Agriculture,8) Organic Rice-SRI-Sunnah Tani Sdn.Bhd, 9)Flooded rice grain from peat soil, 10) Flooded rice grain from peat soil+20t/ha Biochar, 11)Flooded de-husk rice grain from peat soil and 12)Flooded de-husk rice grain from peat soil+20t/ha Biochar, All samples were ground into powder form (<500 micro) and extracted using aqua-regia method [11]. Trace metals (Pb, As and Cd) concentration were determined by the graphite furnace atomic absorption spectrophotometer (Perkin-Elmer) and Inductive Coupled Plasma-Mass Spectrophotometer (Perkin-Elmer), whilst mercury (Hg) was determined using cold vapor hydride generation technique (FIMS-400 Perkin-Elmer).

Statistical analysis: Descriptive statistical analysis were done using SAS statistical package (SAS 9.3).

# 9. Results and Discussion

**Table 1.** Maximum Permitted Concentration (MPC) in Malaysian Food Act (1983) and Food Regulation (1985) (Fourteenth Schedule-Regulation 38). The values indicate in mg kg<sup>-1</sup> and data based on produce "as consumed"

Food	As	Cd	Pb	Hg	$Cu^2$	$\mathrm{Sb}^2$	$\operatorname{Sn}^1$	$Zn^2$
Vegetable product and fruit product other than vegetable juice and fruit juice	1	1	2	0.05	30	1	40	40
Vegetable juice and fruit juice	0.1	1	0.5	0.05	10	0.15	40	5
Tomato-pulp, paste and puree	2	1	2	0.05	100	1	40	40
Tea, tea dust, tea extract and scented tea	1	1	2	0.05	150	1	40	40
Coffee, chicory and related product	1	1	2	0.05	30	1	40	40
Cocoa and cocoa product	1	1	2	0.05	70	1	40	40

<sup>1</sup> All canned foods

<sup>2</sup>Generally Expected Level (GEL)

Table 2. Trace element contents in soils and concentrations in rice grains grown under conventional flooded conditions

				0				
Rice(N=16)	6) As (mg/kg)		Cd (mg/kg)		Pb (mg/kg)		Hg (ug/kg)	
	Soil	Plant	Soil	Plant	Soil	Plant	Soil	Plant
Mean	8	1.27	0.07	0.011	28	0.24	0.07	2.8
Min	1	<1	0.03	0.004	19	0.10	0.02	0.05
Max	37	2.59	0.18	0.04	51	0.70	0.16	6

Source: [10]

Samples	Origin	(N=3)	Pb(mg/kg)	Cd(mg/kg)	As(mg/kg)	Hg(µg/kg)
Bario Rice	Sarawak	Min	0.18	0.014	0.17	nd
(Brown)		Max	0.44	0.021	0.35	1.5
		Mean	0.30	0.017	0.23	0.77
White Bario	Sarawak	Min	0.12	0.015	0.04	nd
Rice		Max	0.27	0.021	1.45	7.7
		Mean	0.20	0.018	0.56	4.57
SRI Rice	-	Min	0.09	0.059	0.03	nd
CHIHERANG		Max	1.11	0.062	2.42	nd
		Mean	0.44	0.061	0.91	nd
Rice grown on	Kelantan	Min	0.81	0.088	2.80	nd
acid sulfate soil		Max	3.33	0.132	3.73	nd
		Mean	2.08	0.104	3.20	nd
Flooded peat	Tg.	Min	0.27	0.011	1.37	nd
rice grain	Karang,	Max	0.62	0.045	3.35	8.3
	Selangor	Mean	0.44	0.026	2.26	2.7
Flooded peat	Tg.	Min	0.32	0.024	0.98	2.7
rice	Karang,	Max	0.71	0.032	2.56	27.1
grain+20t/ha	Selangor	Mean	0.45	0.028	1.83	10.97
RHB						
Flooded peat de-	Tg.	Min	0.47	0.025	2.08	nd
husk rice grain	Karang,	Max	0.60	0.039	3.38	22.8
	Selangor	Mean	0.54	0.032	2.52	13.4
Flooded peat de-	Tg.	Min	1.16	0.028	2.21	7.4
husk rice	Karang,	Max	1.81	0.124	2.25	93.8
grain+20t/ha	Selangor	Mean	1.56	0.061	2.24	36.73
RHB						

**Table 3:** Concentrations of heavy metals in rice grains grown under aerobic and saturated moisture condition (SRI)

<sup>nd</sup> not detected

RHBRice Husk Biochar

Table 4. Concentrations of heavy metals in rice grains of organic rice

Samples	Origin	(N=3)	Pb(mg/kg)	Cd(mg/kg)	As(mg/kg)	Hg(µg/kg)
Organic SRI	-	Min	1.29	0.038	0.16	7.9
Rice-MRQ		Max	1.68	0.612	0.61	61.3
74		Mean	1.44	0.229	0.35	25.9
Flooded	-	Min	1.39	0.015	0.44	3.8
Organic		Max	2.17	0.036	12.90	47.8

Black Wild		Mean	1.76	0.028	4.79	19.93
Rice						
Organic	DOA	Min	1.14	0.087	0.15	3.1
Rice-SRI		Max	1.74	0.105	0.30	3.7
		Mean	1.41	0.094	0.24	3.4
Organic	Sunnah	Min	0.95	0.028	0.34	3
Rice-SRI	Tani	Max	1.17	0.042	0.62	253.7
	Sdn.Bhd	Mean	1.06	0.034	0.45	88.43

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Trace metals analyzed from all samples are in the range of 0.03 to 12.90 mg kg<sup>-1</sup> for As, 0.011 to 0.612 mg kg<sup>-1</sup> for Cd, 0.09 to 3.33 mg kg<sup>-1</sup> for Pb and <1 to 253.7  $\mu$ g kg<sup>-1</sup> for Hg. There are incidences of higher value reported compared to MPC, such as As, Pb and Hg. On the other hand, Cd levels are still below MPC. Accumulation of As, Pb and Cd in the sample indicate contamination from agricultural inputs and/or from the soils.

Arsenic levels in some samples surpassed the MPC limits at 2 mg kg<sup>-1</sup>, which range of <1 to 2.59 mg kg<sup>-1</sup> obtained by (Zarcinas *et al.* 2004) previously. The samples that contained high total arsenic levels are; 1) Rice grown on acid sulfate soil, 2) peat grown rice, and 3) organic black wild rice. This accumulation could be due to natural or/and anthropogenic sources in the paddy fields. In an acid sulfate soil, arsenic level can be high due to the presence of arsenopyrite in minerals (Shamsuddin, 2006), the same goes to peat soil with an arsenopyrite builds up in their minerals. It is important to note that As phytoavailability also depend on the redox condition of the soil system. In aerobic soils, arsenate (As<sup>5+</sup>) is the predominant species and present in low quantity due to its affinity to minerals in soil. However, under anaerobic condition, the predominant species is As<sup>3+</sup>, which is more toxic and it's mobility in soil system is elevated by; 1) reductive dissolution of Fe oxides/hydroxides, and 2) As<sup>5+</sup> reduction (Takahashi, 2004).

Thus, As level in rice under flooded condition should be higher As in comparison with saturated water management as practiced by SRI. Based on this assessment, organic-SRI exhibited among the lowest mean values for As in comparison with flooded condition even without organic practices as indicated by SRI-CHIHERANG. Thus, suggesting management of water for SRI which focused on saturated condition might possibly reduce As uptake and accumulation in rice grains.

Accumulation of mercury can be seen in Organic-SRI from Sunnah Tani, which indicates mean value of 88.43  $\mu$ g kg<sup>-1</sup>. MPC for Hg stated is 50  $\mu$ g kg<sup>-1</sup>, whilst range of 0.02 to 0.16  $\mu$ g kg<sup>-1</sup> was obtained by (Zarcinas *et al.* 2004). Mercury accumulations in rice grains are assisted by micro-organisms under anaerobic condition of paddy fields. This reaction is mediated by anaerobic sulfate-reducers and iron-reducing microbes which are present in the rice roots and eventually turns inorganic mercury into available methyl mercury (Sarah *et al.* 2011).

The lead levels as reported in this study are higher in paddy grown on acid sulfate soil at 2.08 mg kg<sup>-1</sup>, whilst the MPC value is 2 mg kg<sup>-1</sup> as permitted concentration. Organic-SRI samples, which reported value around 1-2 mg kg<sup>-1</sup>, should be monitored due to possibly threat for consumers. Organic practices such as using animal manure or compost spreading has been reported to induce an increase in Pb contents in the receiving soils (Businelli *et al.* 2009). Thus, choosing "correct" soil amendments and organic fertilizer can lead to safety assurances in produce. In addition, due to rapid development in industry all around the world, the inputs of Pb to agricultural soils have been occurring through the combustion of gasoline containing Pb additives, the fugitive emissions from nonferrous metal, the widespread uses of fertilizers, herbicides, and pesticides, and the additions of sewage sludge to the soil. Thus, Pb can be a potential threat in the future and should be monitored along with other toxic trace metals.

Based on this study, the Cd accumulation in the rice grain for all samples are generally low. The major source of Cd can come from usage of phosphatic fertilizer. This Cd could be phytoavailable in the rice grain due to drainage; oxidation and potentially, acidification of paddy soils at the grain filling stage. Moreover, availability of Cd is high in acid soils, therefore, suggesting it's mobility from the soil to the rice grains.

### **10.** Conclusion

This preliminary report assessed availability of trace metals (As, Cd, Pb and Hg) accumulation in different rice grains grown in Malaysia under different cultivation system; either under organic farming (OFS) or flooded conventional condition or system of rice intensification (SRI). Based on the results, arsenic, lead and mercury might contribute to health hazard to consumers as some of the samples surpassed the Maximum Permitted Concentration allowed by Malaysian Food Act (1983) and Food Regulation (1985). Amongst the heavy metals, As in rice grains should be of particular concern due to its high accumulation in some of the samples. The As determination in this study focused on total arsenic, which apparently cannot give an accurate picture of the presence of toxic form of  $As^{+3}$ . Thus, speciation studies should be conducted to check on the levels of the toxic form in the rice grains.

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# Assemblages of Insects Species in an Organic Paddy Field in Tanjung Karang, Selangor, Malaysia

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**ABSTRACT:** The composition of insect species during mature stage in an organic paddy field in Tanjung Karang Selangor, Malaysia was investigated. The sampling was conducted using three sampling methods namely sweep net, handpicked and stem cutting. The specimens were collected and identified up to family and some to species level. A total of 404 individuals of insects have been identified, representing 19 families, viz. Cerambycidae, Coccinellidae (*Micraspis discolor*), Anthomyiidae, Calliphoridae, Phoridae (*Megaselia* sp.), Platypezidae, Platystomatidae, Sciomyzidae, Sepsidae, Alydidae (*Leptocorisa chinensis*), Pentatomatidae (*Scotinophara coarctata*), Delphacidae (*Nilaparvata lugens*), Apoidae, Braconidae (*Bracon hebetor, Xanthopimpla* sp.), Ichneumonidae (*Temeluca philippinensis*), Sphecidae, Trigonalidae, Pyralidae (*Chilo polychrysa*), and Tettigoniidae. The DNA from four larval stages has been isolated and amplified using cytochrome oxidase subunit I (*COI*). Based on BOLD and BLAST analyses, the larval stages have been identified and belong to the *Chilo polychrysa* species based on 98% of identical similarity.

Keywords: insects, molecular, COI, organic, paddy, Malaysia

### 1. Introduction

System of rice intensification (SRI) is a practice that helps in the increase of production yields of paddy crops (Sinha and Talati 2007). The practice functionally reduce the water supply in irrigated rice fields and since in arid regions have limited water resources, farmers shift to the cultivation of crops with low water demands and low infestation by insect pests (Sato et al. 2011). This practice also does not use pesticides and organic fertilizer for nutrient supplement (Horie et al. 2005). Paddy fields that use organic compounds are better for the environment and consumers, however they are more susceptible to pests and plant diseases (Reddy 2010). SRI uses the fauna surrounding the paddy field for the crops inhabitation and the effects can be both in good or bad ways. Thus, learning about the insect

species that occupy the paddy ecosystem will help in understanding the types of pests in the field and their predators for managing them in future applications.

Predators or parasitoids have been used in insect pest management (IPM) for crops by farmers and researchers all over the world (Ovruski et al. 2000). Biological control can be defined as the use of an organism to reduce population density in integrated pest management. This counteracts insecticide-resistant pests, and the withdrawal of chemicals, and minimizes the use of pesticides (Bale et al. 2007). According to Riechert and Lockley (1984), paddy crop studies have used biological methods to control insect pests. However, the information regarding the biological method control is still lacking in Malaysia. Thus, this study was performed to prepare preliminary data for further action in IPM for organic paddy fields.

# 2. Materials and Methods

### Sampling site

Insect species were sampled during the mature grain stage, in Tanjung Karang, Selangor, Malaysia, in a paddy field that practices SRI.

### Sampling method

The sampling was carried out during a day in May 2013 using sweep nets and handpicked. Zigzag sampling pattern was used during the day for 10 min during six sessions (replicates): 11:00–11:10, 12:00–12:10, 13:00–13:10, 14:00–14:10, 15:00–15:10, and 16:00–16:10 along four dikes. For the hand-pick method, observation with the naked eye along the bunds every 20 min was performed. All collected insects were placed in 75% alcohol. Roughly, 50 stems (bundle) was picked every 20 m along the dikes and were cut each to screen the stem borer larva and also adult stages of species inhabiting in the stem.

### **Species identification**

# Morphological identification

The samples were identified up to the family and species level by using insect keys, for example, Achterberg (1993), Borror et al. (1989) and Schaefer (2004).

# Molecular identification

Molecular identification was conducted only for the larval stages of stem borer collected from paddy stems.

### **DNA isolation and PCR amplification**

DNA of species was extracted from the larvae of stem borer using the DNeasy Blood and Tissue Kit (Qiagen, Valencia, CA, USA). MyGene MG96G Thermalcycler was used to run PCR amplification using combination of cytochrome oxidase subunit I (*COI*) primers referred to Folmer et al. (1994). A total of 25µl reaction volume was performed containing of 16.50µl ddH<sub>2</sub>0, 2.5µl PCR buffer 10X (Vivantis), 1.30µl 50mM MgCl<sub>2</sub>,0.5µl 10mM dNTPs, 0.5µl forward and reverse primers (10 pmol/µl),0.2µl *Taq* DNA polymerase (5U/µl) (Vivantis), and 3µl DNA template (10–15ng/µl). The PCR products were electrophoresed on a 1.5% agarose gel. The bands corresponding to the target PCR products were purified using the Geneaid Purification Kit (Axon Scientific, Malaysia).

### Sequencing, BLAST and BOLD analyses, and Clustering Analysis

All PCR products were then sent to the sequencing service company, First Base Sdn. Bhd., Petaling Jaya, Selangor, for sequencing. The sequences were manually edited using BioEdit version 7.0.4 (Hall, 2005). The basic local alignment search tool (BLAST) and Barcode of Life Data Systems (BOLD) were applied to narrow the classification and for rapid sequence comparisons to database sequences (Altschult et al. 1990).

### **Photographs of specimens**

Insects species was photographed with a Canon EOS 6D camera, attached with a stereo microscope Zeiss Stemi SV11.

### 3. Results and Discussions

A total of 404 individual adult insects and five individual larvae were successfully collected during the sampling duration (Table 1). Several species were successfully identified up to species level namely *Micraspis discolor*, *Leptocorisa chinensis*, *Scotinophara coarctata*, *Nilaparvata lugens*, *Bracon hebetor*, *Temeluca philippinensis*, *Chilopo plychrysa* (Figure 1). Each species has their own function in the ecosystem as pests, parasitoids, predators etc. The dominance of *Leptocorisa chinensis* in the organic paddy ecosystem is probably due to their important role as pest species that infesting paddy plant (Mandanayanake et al. 2014; Rahman et al. 2004) by sucking out the sap from developing rice grains (Nugaliyadda et al. 2000). Besides that, many stages of moth species, *Chilo polychrysa* is known as an important pest in Asia (Reissig et al. 1986) that damaging paddy plant (Yazumatsu 1976).

*Micraspis discolor* has shown its importance in insects pest management control. It was found to rule out *Nilaparvata lugens* as a predator (Samal and Misra 1985). The adult and larval stages of *Micraspis discolor* are said to show preference to the second and third instar of *Nilaparvata lugens*, a brown plant hopper (Begum et al. 2002). Interestingly, Braconids wasp (*Bracon hebetor*) has been recorded as parasitoid in paady field. The species is believed to parasitize the stem borer and in this study *Chilo polychrysa* (Yaakop and Aman 2013).

Interestingly, Orthopteran accounted for most of the individuals collected (40.8%), while Homopteran accounted for the least 0.5%. Orthopteran poses a constant threat to crop cereals, orchard, vegetables, and paddy fields and its prefer paddy seedlings and plants as their food, which may reduce yields (Haldar et al. 1995; Joshi et al. 1999).

No	Order	Family (species)	No. of Individuals
1	Coleoptera	Cerambycidae	1
		Coccinellidae (Micraspis discolour)	50
2	Diptera	Anthomyiidae	2
		Calliphoridae	1
		Phoridae (Megaselia sp.)	2
		Platypezidae	1
		Platystomatidae	3
		Sciomyzidae	2
		Sepsidae	40
3	Hemiptera	Alydidae (Leptocorisa chinensis)	100
		Pentatomatidae (Scotinophara coarctata)	4
4	Homoptera	Delphacidae (Nilaparvata lugens)	2
5	Hymenoptera	Apoidae	2
		Braconidae (Bracon hebetor, Xanthopimpla sp.)	2
		Ichneumonidae (Temeluca philippinensis)	2
		Sphecidae	1
		Trigonalidae	1
6	Lepidoptera	Pyralidae (Chilo polychrysa)	23
7	Orthoptera	Tettigonidae	165

Table 1 List of Order, Family and Total of Individuals of Insects in Tanjung Karang, Selangor, Malaysia

Figure 1 Species that has been identified until species level (1: *Bracon hebetor*, 2: *Chilo polychrysa*, 3: *Leptocorisa chinensis*, 4: *Micraspis discolour*, 5: *Nilaparvata lugens*, 6: *Scotinophara coarctata*) In this study, two stem borer larvae were isolated and its genetic information was obtained. Based on the BLAST and BOLD analyses, 98% and 98.36% identical similarity were presented in both specimens belong to *Chilo polychrysa*. Additionally, two individuals collected from MARDI, Pulau Pinang had the same identical similarity to the Kuala Selangor specimens, those all the specimens were classified under the same species.

At first stage, all four stem borers were not identified based on morphological characteristics due to the lack of taxonomic keys for the larval stages. Thus, molecular analysis was important because larva genetic information is identical to the adult stage (Fellous and Lazzaro 2011).

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# Biodiversity of Insects in Paddy Plots Planted under the system of Rice Intensification (SRI) using some Flowering Plants as Biological Control Agents against Paddy Pests: A Case Study at Kesang Tasek, Ledang, Johor

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#### ABSTRACT

A study was conducted to determine the biodiversity of insects in the organic rice plots planted under the System of Rice Intensification (SRI), and using the flowering plants, viz. Big-Sage or Bunga Tahi Ayam (Lantana camara), Sunflower (Helianthus annuus) and Zinnia (Zinnia elegans) as biological control agents against paddy pests in the rice fields of Kesang Tasek, Ledang District, Johor. Insect samplings were conducted on three occasions from November 2013 to January 2014 at two study plots, one of which was cultivated under SRI, while the other plot was conventionally planted to serve as the control plot. Samplings were done using six different methods, namely the light trap, malaise trap, pitfall trap, yellow pan trap, sticky trap and the sweeping net. A total of 3319 individual specimens were sampled and identified, representing 49 species in 29 families and 7 orders of insects. The most predominant pests represented by 460 individuals belonged to the family Cicadellidae (order Hemiptera), followed by Pyralidae (order Lepidoptera, with 369 individuals), and Coengrionidae (order Odonata) with 223 individuals sampled, respectively. Members of the family Staphylinidae (order Coleoptera) comprised the most dominant group of predators, represented by 176 individuals sampled in the study area. The Shannon-Weiner Diversity Index (H'), Shannon-Weiner Evenness Index (E') and Margalef Richness Index (R') gave higher values for the SRI organic plot compared to the control plot, i.e. H'=3.25, E'=0.84 and R'=7.47, respectively. However, one-way ANOVA showed no significant differences (p>0.05) in insect diversity between the three phases of rice growth in both plots. Using some flowering plants, i.e. Big-Sage or Bunga Tahi Ayam (Lantana *camara*), Sunflower (*Helianthus annuus*) and Zinnia (Zinnia elegans) as a protective plants or biological control agents against paddy pests instead of applying commercial chemical pesticides can restore the biological diversity and population abundance of parasitoids and predators (beneficial insects) in the SRI organic rice ecosystem.

Keywords: Biological diversity, organic rice, System of Rice Intensification (SRI), flowering plants, biological control agents.

#### **INTRODUCTION**

Issues on pesticide pollution (contamination) in crops of vegetables and fruits in Malaysia are gaining increased public attention in recent years. It has also become one of the main concerns of the Ministry of Health, Malaysia, which has actively been monitoring the quality and safety of livestock and agricultural produce, including rice. In the rice growing area of Barat Laut Selangor, the conventional agricultural method that depends heavily on the use of fertilisers and chemical pesticides is still widely practised. However, if widespread and uncontrolled usage of commercial pesticides remained unchecked, it would lead to adverse impacts on food safety and subsequently, would affect animal and human health. Rampant pesticide use would affect not only crop production in the long term, but in fact, the pesticide residues that are easily leachable could also contamine the soil, air, surface and ground water, with adverse impact on all forms of biota inhabiting the polluted habitats (Heong et al. 2007; Normile 2013; Sinha & Talati 2007). Furthermore, food safety should also be given serious attention, particularly in terms of public awareness at the levels of our local food producers and the consumers.

The rice field is a monoculture system for the production of our staple food, and which is always threatened by pest attacks. Typically, crop plants constitute the hosts that provide food, refuge and breeding sites for these pest insects, (Fujii et al. 2010). Some insects are attracted to a particular species of plants, whilst other plants act as repellents, inhibitors or deterrents of these pest insects, depending on the secondary compounds found in these plant species. Interactions and associations between plants and pest insects have specifically become the basis for using protective plants against crop pests in agricultural areas, which have been practised for decades by farmers since long ago (Altieri 1999). Therefore, the use of protective plants such as Big-Sage or Bunga Tahi Ayam (Lantana camara), Sunflower (Helianthus annuus), Zinnia (Zinnia elegans), Canada Balsam or Kaembung (Impatients sp.), Kekwa (Chrysanthemum coronarium) and many others could be effective in controlling the infestation and population rise of pest insects in agricultural areas. This method represents one of the alternative environmentally friendly methods to replace the conventional use of commercial chemical pesticides. There are many types of flowering plants included within two groups of crop protective plants or florasavers, i.e. (a) plants that serve as repellents or deterrents of pest insects and (b) plants that attract pest insects. This study focuses on identifying specific types of flowering plants with the potential to become effective biological control agents that are easily available and propogated in the continual efforts to seek for alternative measures to control paddy pests, specifically in the organic rice ecosystem under the System of Rice Intensification (SRI).

### **MATERIALS AND METHOD**

The study was conducted in two rice plots at Sawah Kesang Tasek in the Ledang District of Johor. The experimental plot was organically planted with paddy under the System of Rice

Intensification (SRI), while the control plot was conventionally planted with the application of agrochemicals (fertilizers and chemical pesticides). Comparative biodiversity and abundance of insects between the two plots were observed and recorded, where the SRI organic plot was naturally protected against pests by planting protective flowering plants, i.e. Big-Sage or Bunga Tahi Ayam (*Lantana camara*), Sunflower (*Helianthus annuus*) and Zinnia (*Zinnia elegans*) around the perimeter of this plot, while the control plot was not planted with any protective flowering plants and pests were controlled by spraying with commercial pesticides.

Observations and sampling of insects were conducted during three stages or phases of the paddy growth, i.e. vegetative phase (day 1-60), reproductive phase (day 60-90) and mature/ripened rice phase (day 90-120). Samplings were done starting from 10.00 a.m. (in the morning) until 11.00 p.m. (at night). Six different sampling methods were used, namely the light trap, malaise trap, pitfall trap, yellow pan trap, sticky trap and the sweeping net, to ensure that the overall biodiversity of the study area was represented and recorded. The collected insect specimens were preserved in 75% etanol and properly labelled according to plot, sampling date and method. Specimens caught by the sticky trap were not dislodged, and identification was done with the aid of a digital microscope (Dino-Lite) adjusted to focus at 10x~50x, 200x magnification. Taxonomic identification of insects was done up to the species level with the aid of standard references such as Borror & Delong (1971); Bottrell, et al. (1992); Holloway, et al.(1990); Southwood (1978), and many others.

Data analysis utilises the Shannon-Weiner Diversity index (H') to indicate the species diversity and Shannon Evenness index (E') to indicate the species uniformity, i.e. by showing the similarity or differences that exist in terms of species richness in a particular area, whilst the Margalef Richness index (R') indicates the number of individual species found in a particular community. Statistical analysis using the one-way ANOVA indicates significant differences in insect abundance and diversity when comparing data between plots planted with SRI organic rice and the conventional (control) plot at Sawah Kesang Tasek, Ledang District of Johor.

### **RESULTS AND DISCUSSION**

# Insect Abundance and Diversity (by Orders) Recorded During Three Phases of Paddy Growth in the Two Study Plots

Overall, a total of 3319 insect individuals representing 49 species in 29 families and 7 orders were successfully sampled during the study period. For the first sampling, i.e. the vegetative phase, our sampling results showed that insect abundance was highest for Diptera (with 132 individuals from the SRI organic plot and 131 individuals from the control plot), whilst the lowest abundance was for Odonata in the SRI organic plot (represented by 16 individuals) and Hemiptera in the control plot (with 24 individuals), respectively (Figure 1).

For the second sampling, i.e. the reproductive phase, our sampling results showed that insect abundance was highest for Hemiptera (with 175 individuals from the SRI organic plot and 142 individuals from the control plot), whilst the lowest abundance was for Orthoptera, (with 22 individuals from the SRI organic plot and 7 individuals from the control plot)(Figure 2).

For the third sampling, i.e. the mature or ripened rice phase, our sampling results showed that insect abundance was highest for Hemiptera (with 167 individuals from the SRI organic plot and 238 individuals from the control plot), whilst the lowest abundance was for Orthoptera (with 17 individuals from the SRI organic plot and 12 individuals from the control plot)(Figure 3).



Figure 1: Comparative insect abundance (according to orders) between the SRI organic plot and the control plot in Phase 1 (vegetative phase).



Figure 2: Comparative insect abundance (according to orders) between the SRI organic plot and the control plot in Phase 2 (reproductive phase).



Figure 3: Comparative insect abundance (according to orders) between the SRI organic plot and the control plot in Phase 3 (mature/ripened rice phase).

The overall sampling results of this study indicate that the biodiversity of insects at Sawah Kesang Tasek comprises seven main orders, i.e. Orthoptera, Coleoptera, Odonata, Hemiptera, Lepidoptera, Hymenoptera and Diptera. Herbivorous insects, that also represent the main crop pests are dominated by members of Hemiptera, Lepidoptera, Orthoptera and Diptera, whilst carnivorous insects that are also the natural enemies of paddy pests comprising predators and parasitoids, are mainly from the orders Odonata, Hymenoptera, Coleoptera and Diptera (Tables 2 & 3 and Figures 1-3). Some families belonging to Coleoptera and Diptera are identified as detritivores (Rizali et al. 2002; Herlinda et al. 2004). During our first sampling efforts, the highest insect abundance was recorded for Diptera in the SRI organic plot as well as in the control plot, whereby during the first or vegetative Phase, the age of the rice plants was between 1 to 60 days, and the plots were being irrigated and inundated. According to Daly et al. (1978), the abundance of Diptera could be due to environmental factors associated with an aquatic ecosystem, where the rice plots were dominated by aquatic insects, particularly the dipteran larvae. However, in the organic plot under SRI, the rice plots were only sparingly watered and not flooded at all as compared with the control plot. Another reason for the significant presence of dipteran larvae could also be due to the use of fish manure in the rice plots. According to the owner of the rice plots, Mr. Sulaiman, he would regularly spray the rice plots with fish manure once a week in the morning and evening during the first phase of paddy growth.

For the second and third sampling efforts, both study plots recorded the highest insect abundance from order Hemiptera. Although the total number of individuals under Hemiptera in the second growth phase was higher in the SRI organic plot compared to the control plot, however, the abundance of pest species had decreased by the third phase of rice growth. This indicates that the populations of natural enemies of pest insects in the SRI organic plot were in balance with those of the pest species, because the populations of the latter were being kept in check by the predators. In the absence of pesticide usage, the rice ecosystem would become rich in arthropod communities, including various types of natural enemies of rice pests (Greathead 1979; Rizali et al. 2002). Subsequent increase in the richness and abundance of natural enemies could provide the required check and balance to control the population of pest species in the rice field (Heong et al. 1991). Greathead (1979) also noted that parasitoid insects were capable of killing between 0-70 eggs and 0-20% nymphs of the brown planthopper, *Nilaparvata lugen*. In fact, the potential benefit of biological control in the rice agroecosystem has long been recognized and reported since the 1960s (Yasumatsu & Torii 1968).

High species diversity and richness of arthropods found in the SRI organic plot are summarized in Table 1, with the highest values for Shannon-Weiner Diversity index (H'=3.25), Shannon-Weiner Evenness index (E'=0.84), and Margalef Richness index (R'=7.47), respectively. However, one-way ANOVA test showed no significant differences in the total insect population distribution (p>0.05) between plots and between the three phases of paddy growth.

Table 1 Shannon-Weiner diversity index (H'), Shannon-Weiner Evenness index (E') and Margalef Richness index (R') for insect populations in the study plots based on overall sampling results.

Index	Phase 1		Phase 2		Phase 3	
	Organic SRI	Control	Organic SRI	Control	Organic SRI	Control
Н'	3.00	3.10	3.25	3.05	3.12	2.96
E'	0.83	0.82	0.84	0.82	0.83	0.80
R'	6.15	6.82	7.47	6.39	6.51	5.99

# Population Abundance of Beneficial Insects According to Families During Three Phases of Paddy Growth in the Two Study Plots

Total sampling results showed that the highest number of beneficial insects was from the family Coenagrionidae (represented by 223 individuals), followed by Staphylinidae (176 individuals), whilst the lowest number recorded was from Dytiscidae and Ichneumonidae (each represented by two individuals), and Eurytomidae (only one individual), respectively. Significant increase in the abundance of beneficial insects was observed in the SRI plot during all three phases of paddy growth, i.e. from 118 individuals sampled during first phase to 204 individuals in the third phase of paddy growth (Table 2).

Members of the family Coenagrionidae (order Odonata) and Staphylinidae (order Coleoptera) are well-known beneficial insects either in the form of nymphs or adults (Ansori 2008). The main species identified under Staphylinidae in this study is *Paederus fuscipes*, locally known as Kumbang Tomcat or Rove Beetle. Both families function as the main predators of paddy pests and play important roles in the rice ecosystem preying on ricehoppers (e.g. *Nilaparvata lugens*), stemborers (e.g. *Chilo supressalis*), and rice bugs (*Leptocorisa sp.*)(Bottrell et al. 1992; Arifin 2012).

The other main predators most abundantly encountered are from the families Coccinellidae (order Coleoptera) and Formicidae (order Hymenoptera). Among the beneficial insects sampled with the potential as parasitoids were members of the tiny wasp families, Braconidae and Ichneumonidae. These parasitoid wasps inject their eggs into the body of the paddy pest larva, hatching and absorbing nutrients from the host, until it subsequently died (Rizali et al. 2002). Thus, these beneficial insects serve as effective control agents of paddy pests. Rothschild (1971) reported that the parasitoids and predators had inflicted over 90% mortality of stemborers that often attack the rice fields of Sarawak.

The total number of beneficial insect individuals recorded in the SRI plot increased in tandem with the growth phase of the paddy plants, indicating that without usage of the chemical pesticides, the populations of natural enemies of paddy can be sustained and enhanced. Studies in the Phillipines have clearly demonstrated the efficacy of natural enemies in controlling the population of pest insects in the rice fields without the need for pesticide spraying (Way & Heong 1994). Likewise, using flowering plants as biocontrol agents was evidently effective and capable of retaining the natural features of the SRI plot and restoring the ecosystem balance (Way & Heong 1994). Flowering plants are rich in nectar as food source for various animal species, while at the same time they also serve as refuge for the natural enemies of paddy pests and attracting many beneficial arthropod species into the rice fields.

	Phase 1		Phase 2		Phase 3		
Family	Organic SRI	Control	Organic SRI	Control	Organic SRI	Control	Total
Tettigoniidae	4	7	3	1	6	1	22
Coccinellidae	11	2	18	2	25	22	80
Carabidae	9	15	1	0	0	1	26
Staphylinidae	36	7	15	2	59	57	176
Dytiscidae	0	0	1	1	0	0	2
Hydrophilidae	0	0	2	3	0	0	5
Coenagrionidae	8	40	52	26	66	31	223
Libellulidae	5	1	4	5	19	6	40
Formicidae	17	6	21	18	16	11	<b>89</b>
Braconidae	6	9	5	4	3	6	33
Sphecidae	2	4	3	3	2	4	18
Apidae	11	7	4	0	4	0	26
Ichneumonidae	0	0	0	2	0	0	2
Vespidae	9	2	6	6	3	5	31
Eurytomidae	0	0	0	0	1	0	1
Total	118	100	135	73	204	144	

Table 2 Number of beneficial insects according to families recorded in two types of study plots during the three phases of paddy growth.

# Abundance of Pest Insects According to Families in the Study Plots During Three Phases of Paddy Growth.

The highest abundance of pest insects in this study was from the family Cicadellidae (order Hemiptera), represented by 460 individuals in the total sampling, followed by Pyralidae (order Lepidoptera), with 369 individuals, Alydidae (order Hemiptera), with 187 individuals and Delphacidae (order Hemiptera) with 131 individuals, respectively. In contrast, the lowest abundance was recorded for Gryllotalphidae (represented by one individual only). There was a significant increase in total abundance of pests in the conventional (control) plot, i.e. from 126 individuals individuals sampled during first phase to 309 individuals in the third phase of paddy growth.

Four pest species under the family Cicadellidae (green planthoppers and white planthoppers), recorded in the rice plots of Sawah Kesang Tesak are: *Nephotettix virescens*, *N. nigropictus*, *Recilia dorsalis* and *Cofana spectra*. Likewise, six species under the family Pyralidae (stemborers or moth larvae) recorded in this study are: *Chilo supressalis*, *Herpetograma licarsisalis*, *Marasmia patnalis* Bradley, *Cnaphalocrosis medinalis*, *Scirpophaga incertulas* and *Sesamia inferens*. The main species under family Alydidae found here was *Leptocorisa sp.* or locally known as Pianggang or Kesing, while the main pest species under the family Delphacidae was *Nilaparvata lugens* or Bena Perang. All these species are among the major pests of paddy and also known as "hama padi" because of their feeding habit as herbivores that can cause great destruction and incur heavy losses in yield by sucking dry the plant sap and eventually killing the plants (Kirk-Spriggs 1990).

Referring to Table 3, the total pest individuals in the control plot continued to rise significantly from the first phase to the third phase of paddy growth. This indicated that the use of chemical pesticides had caused the death of both pest and beneficials, but the pests would later become more and more resistant. Study on the effects of insecticides on the development of arthropod communities by Heong et al. (1991) showed that pesticide use, especially in the early stage of paddy growth, could trigger significant infestation of herbivorous pest species.
Family	Phase 1		Phase 2		Phase 3		
	Organic SRI	Control	Organic SRI	Control	Organic SRI	Control	Total
Acrididae	5	3	6	2	5	1	22
Pyrgomorphilidae	1	4	0	0	0	1	6
Gryllidae	7	25	7	2	1	4	46
Gryllotalpidae	0	0	0	1	0	0	1
Scarabaeidae	3	0	0	0	6	0	9
Alydidae	0	1	20	27	20	119	187
Pentatomidae	1	2	1	0	2	0	6
Cicadellidae	5	9	130	85	131	100	460
Delphacidae	32	12	24	30	14	19	131
Pyralidae	14	58	89	109	42	57	369
Noctuidae	4	7	2	2	4	3	22
Lymantriidae	3	5	1	3	2	5	19
Total	75	126	280	261	227	309	

Table 3: Number of pests according to families recorded in the two study plots during three phases of paddy growth.

## CONCLUSION

In conclusion, the use of flowering plants such as Big-Sage or Bunga Tahi Ayam (Lantana camara), Sunflower (Helianthus annuus) and Zinnia (Zinnia elegans) as protective plants and biological control agents at the SRI organic plot in this study gave positive and beneficial effects on the biodiversity of insects in this area. Species diversity and distribution in the SRI plot was high and good interactions between predators and prey create equilibrium and a balanced ecosystem. The diversity of the main pest and beneficial insects in the paddy plots of Kesang Tasek, Johor has been taxonomically identified in this study. Increase in the abundance of pest insects during each phase of paddy growth in the conventional plot clearly indicate that the continued use of chemical pesticides would lead to rising infestations of pest insects and destroy the natural enemies of pests in the rice ecosystem. Increase in total abundance of beneficial insects in the organic rice plot during each phase of paddy growth indicated that the use of flowering plants can effectively restore the biodiversity of parasitoids and predators in the ecosystem due to their role as food source and refuge for these insects. Therefore, the rice farmers in Malaysia should be encouraged to embark on this environmental friendly and sustainable means of pest control and should abandon the use of chemical pesticides that could disrupt the ecosystem services, affect food safety and jeopardise human health.

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