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Impact of System of Rice Intensification (SRI) on Paddy Field Ecosystem: Case Study in Ledang, Johore, Malaysia

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System of Rice Intensification(SRI) is an agroecologically sound rice cultivation method that has been proven to improve yield and support Sustainable rice farming towards achieving green economy. A study was conducted to evaluate the impact of SRI practices from an agroecological perspective in Kampung Kesang Tasek, Ledang, Johore. The results showed that SRI significantly increases the number of rice tillers, plant height, filled grains and 1000 grain weight, and increase rice productivity up to 7.58 ton/ha, increase the number of soil beneficial microbes, as well as insect biodiversity. The results proven that SRI should be considered as a potential cultivation method for sustainable rice production. The volunteer of the farmers to try this cultivation method support the success of this effort.

Key words: System of Rice Intensification(SRI), agroecology, Sustainable rice farming, ecosystem services.

Conventional rice farming methods, which rely on the intensive use of chemical inputs introduced by the Green (chemical-inclined) Revolution, depletes agriculture's natural resource base, jeopardizing future productivity of the land (FAO 2011). FAO (2011) recommended that cropping systems should be based on low input (fertilizers and water) methods and optimizing ecosystem services to increase yield.

The concept of food sovereignty and agriculture based on agroecology has found attention among researchers and policy makers because this approach has been successful in bringing the positive changes in economic, environmental, small farmers, rural communities, and urban population. Agroecology as a new paradigm in agriculture is focused on the return of the condition of self-reliant local communities, conservation of natural and biodiversity, production of healthy food produced using a low amount of input and empowerment of rural communities (Altieri and Toledo, 2011). One of the agroecological practices is System of Rice Intensification (SRI), which relies on a set of principles of cultivation that has a major impact on the efforts to create sustainable farming towards the realization of a green economy.

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SRI methodology was synthesized in the early 1980s by Henri de Laulanié, S.J. To date, many farmers around the world are using SRI method to increase rice production. SRI has managed to reduce the use of chemical fertilizers and chemical pesticides, thereby reducing production costs. Scientists have shown interest in agriculture to understand how SRI can increase rice production up to 3 times more than a non-SRI cultivation techniques (Stoop *et al*., 2002). SRI is touted to be a good option to be practiced by farmers in order to bring about a new kind of green revolution, one that relies upon ecosystem services to increase yield (Uphoff, 2013).

System of Rice Intensification (SRI) is a remarkable innovation in the organic farming method that improves the productivity of land, labour, water and capital investment in the paddy cultivation. SRI can be a cost-effective system of labour as well as saving water (25-50 %) and seeds (80-90%), reducing costs (10-20%) and increasing crop yield at least 25-50%, sometimes 50-100% and there are sometime even more than 100%. SRI productivity has been proven in 28 countries, from China to Cuba, Peru to Philippines, Gambia to Zambia, and even Iraq, Iran and Afghanistan (Uphoff 2008).

SRI cultivation techniques starts with the preparation of the soil to allow the planting of rice seedlings (5-7 days old) planted one seedling per one square measuring (35 x 35) cm. It is recommended that seeds belong to the farmers themselves. The rice field does not have to be flooded with water, restricting to water levels of only two centimetres or less.

SRI was first practiced in Malaysiain 2006. Since then, the interest in using SRI has grown rapidly on the back of government agencies, universities, NGOs, andthe private sector. SRI's advantage is in the case of supporting sustainability and sustainable agriculture fields in Malaysia (Uphoff & Fisher, 2011).

Our previous studies have reported the experimental trials of SRI in Malaysia such as Tanjung Karang (Selangor), Beranang (Selangor), Tunjong (Kelantan), Lubok China (Melaka), and Kg. Lintang (Kedah) (Anizan *et al*., 2012). The objective of this study is to assess the impact of SRI froman agroecological perspective in Kesang Tasek, Ledang, Johor, Malaysia. For this purpose, the impact of the SRI method on the economic, environmental and social perspectives werestudied.

MATERIALS AND METHODS

Impact on Productivity

This experiment was conducted on a one-acre experimental plot at KampungKesangTasek, Ledang, Johore from October 2013 – January 2014. The fragrant rice seed variety MRQ74 was used in this study. After 125 days (harvesting phase) a total of 35 rice plants were selected randomly from the experimental plot. Measurement of yield components such as plant height (cm), productive tillers, unproductive tillers, biomass (g), filled and unfilled grains(g) and 1000 grain weight (g) were recorded. Measurement of yield (ton/ha) was done according to Casanova*et al*.(2002). A total of two species of flower, *Lantana camara* L. and *Helianthus annuus* L. planted on bunds surrounding rice fields around one-acre experimental plot toenhance the ecosystem with natural enemies, predators and parasitoids .

Impact on Environment

Beneficial Microbial Ecology

For microbial ecology sampling; soil samples were taken from SRI test plots. The samples wereplaced in labelled polyethylene bags and immediately transported to the lab where they were stored at 4^0 C until further processing. Each sample was serially diluted and plated on nutrient agar (for bacteria) and potato dextrose agar (for fungi). Bacterial isolates were identified based on gram staining, colonial morphology and biochemical test according to Buchanan & Gibbons (1974) and Al-Shorgani *et al*. (2013) while fungal isolates were identified based on the irmorphological, physiological and biochemical characteristics (Domsch *et al*., 1993;Samuels, 1996; Rahman*et al*., 2011; Devi *et al*., 2012).

InsectEcology

Sampling of insects in the rice field was conducted inKampungKesangTasek, Ledang, Johor, from October 2013 – January 2014 duringthreepaddy growthphases, namely the vegetative phase(day1-60), the reproductive phase(day60-90) and the mature phase(days90-120). Sampling was conducted from 10.00am to11.00 pm by four man-sampling efforts per day for a total of four days for each growth stage.Samples were collected by using six methods; namely the light traps, malaise traps, stickytraps, yellow pan traps, pitfall traps and sweeping net method. All specimens collected were put in containers and labelled in the field while relaxing, spreading and sorting to family levels were done in the lab after sampling. Species identification followedBorror *et al*. (1981), Barlow (1992) and cross-referenced to the Center of Insect Systematic (CIS), UniversitiKebangsaan Malaysia. Diversity index was determined by using bio~DAP programmes.

Impact on socio-economy

The social impact of the SRI method was measured by interviewing the SRI practioner. A series of non-structured interview of the SRI practioner was conducted after having completed twoseasons of SRI planting. The trigger used was a friendly chatting ambience at local eateries.A cost-benefit analysis was conducted to assess the economic impact of the SRI cultivation method.

RESULTS AND DISCUSSION

The results showed that paddy planted under SRI cultivation methods had significantly increased plant height, productive tiller, biomass, filled grain, 1000 grain weight and yield (Table 1). According to Thakur *et al*. (2010) the positive significant increase of rice physiological characteristics such as higher xylem exudation rates, deeper and better distributed root systems, higher water use efficiency; higher photosynthetic rate; lower transpiration, higher leaf chlorophyll content, delayed senescence and greater fluorescence efficiency are the major contribution of SRI management to the increase of plant growth and yield.The potential yield obtained, that is 7.58 tonne/ha was higher than the Malaysian average national yield of 3.64 ton/ ha (Chee-Wan and Meng-Chang, 2012).

The positive performanceof SRI methodin increasingrice growth and yield can beunderstood in terms ofthe interaction of rice plantsandmicrobes

Table 1. Yield Component Rice Variety MRQ74 under System of Rice Intensification Cultivation Method at KampungKesang Tasik, Ledang, Johor

Yield Component Parameters	Means
Plant Height (cm)	89.97
Productive Tillers	27
Unproductive Tillers	2.14
Filled Grains	110.37
1000 Grain Weight (g)	22.8
Yield (Ton/Ha)	7.58

n= 35

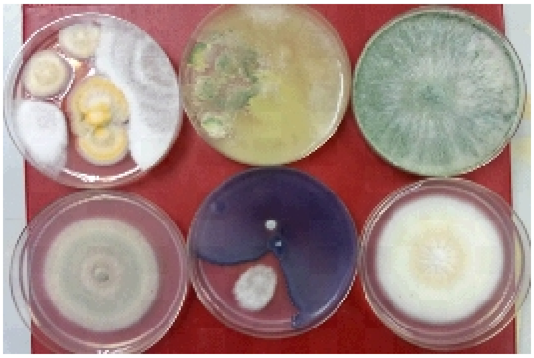

Fig. 1. Microbes isolated from SRI plot with colorful colony indicates the diversity of microbes

Table 2. Beneficial Microorganisms according to genus found in LedangSRI Field onthree different stages of rice growth.

Vegetativephase	Reproductivephase	Mature phase
Bacteria: Lactobacillus, Bacillus, Pseudomonas*, Azotobacter	Lactobacillus, Bacillus, Pseudomonas, Azotobacter, Clostrisdium*	Lactobacillus, Bacillus, Pseudomonas, Azotobacter, Clostrisdium
Fungi: Trichoderma**, Aspergillus, Candida, Penicillium, *Gliocladium*	Trichoderma**, Aspergillus, Candida, Penicillium, *Gliocladium*	Trichoderma**, Aspergillus, Candida, Penicillium, *Gliocladium*

*Isolates of *Pseudomonas* and *Clostridium* are able to enhance rice seedling growth under green house condition (Doni et al., 2014b); **Isolates of Trichoderma is able to enhance rice seedling growth under greenhouse condition (Doni et al., 2014a).

Table 3. Abundance and diversity of insects according to familyin LedangSRIplotonthree different stages of rice growth

Family	(Vegetativephase)	(Reproductivephase)	(Mature phase)	Total
		Number of Individual		
Tettigoniidae	4	3	6	13
Coccinellidae	11	18	25	54
Carabidae	9	1	0	10
Staphylinidae	36	15	59	110
Dytiscidae	0	1	0	1
Hydrophilidae	0	2	0	2
Coenagrionidae	8	52	66	126
Libellulidae	5	4	19	28
Formicidae	17	21	16	54
Braconidae	6	5	3	14
Sphecidae	2	3	2	7
Apidae	11	4	4	19
Vespidae	9	6	3	18
Eurytomidae	0	0	1	1
Acrididae	5	6	5	16
Pyrgomorphilidae	1	0	0	1
Gryllidae	7	7	1	15
Scarabaeidae	3	0	6	9
Alydidae	0	20	20	40
Pentatomidae	1	1	2	4
Cicadelidae	5	130	131	266
Delphacidae	32	24	14	70
Pyralidae	14	89	42	145
Noctuidae	4	2	4	10
Lymantriidae	3	1	2	6
Total	193	415	431	1,035

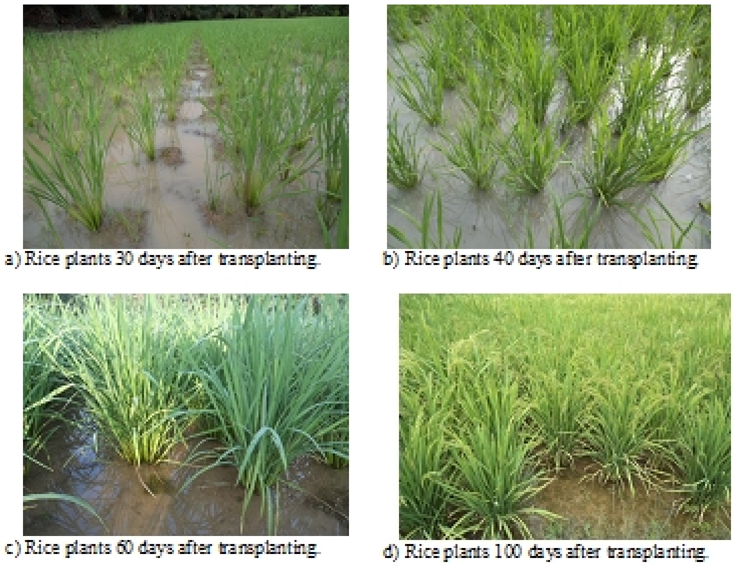

Fig. 2. Rice plants growth at experimental plot under SRI cultivation method. SRI (which maximized yield without chemical fertilizers and herbicides) reveals the optimum physiological characteristics of rice plants

in thesoil (Doni *et al*., 2013).Anas*et al*.(2011) have shown that SRI management can positively influence the soil microbiology. Furthermore, soil microbial activity can contribute to the enhancement of nutrient availability such as nitrogen(N) andphosphorus(P); carbon(C) andnitrogen(N) in the rice rhizosphere. Results by Al-Shorgani *et al*. (2013), Doni *et al*. (2014a),Doni *et al*. (2014b) and Doni *et al*.(2014c) reported that the abundance and diversity of beneficial soil microbes such as *Trichoderma*, *Clostridium*, and *Pseudomonas* are high in the SRI paddy field soils.Our study on microbes isolated from SRI soil plot (Figure 1 and Table 2) has colorful colonies that indicate the higher abundance and diversity of microbes which enablesthe enhancement of nutrient availability.

Table 3, Table 4, & Figure 2 shows our results. It shows the population of beneficial insects found in SRI cultivation method is balanced with the population of pests. Beneficial insects include insects that act as pollinators and predators or parasitoids are important for biological control in agricultural areas. Hence, enables to control the abundance of pests in the ecosystem. According to Greathead, (1979) without pesticides used, paddy ecosystem rich with arthropods community, including various types of insects' natural enemies and this can lead to the beneficial insects' abundance and richness than the pests (Heong *et al*. 1991). Furthermore, according to Greathead (1979), parasitoid larvae can kill 0-70 and 0-20% brown planthopper nymphs. This due to the natural ecosystem service in that area, as well as both plants (*Lantana camara* L. and *Helianthus annuus* L., encouraging natural enemies and provide nectar to the natural enemies. Furthermore, the colours (yellow and orange) generally regarded as attractive to many parasitoids (Gurr *et al*. 2004). Our finding is in agreement with Norela *et al*. (2013) that reported the organic cultivation of rice under the System of Rice Intensification (SRI) supported

Table 4. Insect Diversity Index

Index	Vegetativephase	Reproductivephase	Mature phase
Shannon-Weiner (H')	3.00	3.25	2.96
Shannon-Weiner (E')	0.83	0.84	0.80
Margalef (R')	6.15	7.47	5.99

Table 5. Interview with a pioneer of SRI Farmer

Category	
Agronomic	1. Planting:Initially challenged by drudgery but by the third season finds it a smooth operation. 2. Organic fertilizer application 3. Weeding.
Production	1. SRI gives good yield comparable to conventional in the area.
Farmer innovation	1. Likes to try different cropping methods. 2. Prefers to produce own fertilizer due to reduction in cost and satisfaction in observing the results.
Socio-economic	1. A chance to produce healthy and safe rice for owns family, the local community and other consumers at large. 2. An opportunity to market rice products to the local market. Support for the procurement of post-harvest and small-scale milling facilities comes from the local department of agriculture. 3. A chance to promote safe rice production to other farmers in the vicinity, especially for them to produce safe rice for own family consumption. 4. Observed an increase in the appreciation of organic food production in the community. 5. Tremendous reduction in cost of production. 6. Proof that rice production does not have to depend on input subsidies. 7. Opportunity to promote ecotourism in the vicinity. 8. There were many discouraging voices in the beginning of first season but were ignored.

a high diversity of insects which indicates a healthy, balance and safe agroecosystem.

Interviewed with Mr.SulaimanWagiman, the first farmer that volunteered to practise SRI in his paddy field at KampungKesangTasik mentioned about the problems that he faced to start SRI. He also had problem and failed to convinced other farmers from his village to practice SRI due to subside given by the government and comfortable with using pesticide. The first problem he faces is not enough seed due to lack of seed supplier, so he only planted one-quarter of his one acre plot with SRI. The result is so encouraging; the SRI plants were grown well compared to non SRI as well as produced a good yield. He found that weeding every 10 days for four times helps the plants grown well and look healthy. The results of the interview (Table 5) showed that SRI has made the farmer become more innovative, more choices: own produced fertilizers and own seeds, chance to market own product which in the Malaysian context thus far has been very limiting; short supply chainand not dependence on government subsidies.

CONCLUSION

The high productivity obtained by the SRI farmers and field trials has proven the suitability of the SRI method for sustainable farming in Malaysia. The enhanced soil microbial diversity and activitiescontributes to the growth of the rice plantsand productivity as attest by the high yield components under SRI cultivation method. The agro-ecosystem also supports the existence of a balance between pest and non-pest insect population. The volunteers of farmers to try different cropping methods are key success of this cultivation method. This augurs well with the good agricultural practice methods in sustainable rice farming.

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