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Rice Production Technology Improvements for Higher Productivity Along with the Sustainable Agriculture Process in the Mekong Delta

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ABSTRACT—*This study examines sustainable agricultural development in the Mekong Delta, Vietnam by focusing on technology improvement for minimizing the environmental load in rice production with sufficient yield and quality. Among rice-producing countries, Vietnam is the third-largest rice export country worldwide. High-yield rice production is still a critical issue in Vietnam. However, in recent years, quality improvement and low environmental load agriculture have been fundamental issues.*

In this research, we conducted rice cultivation experiments in 2014, 2015, and 2017 under different conditions of planting density, fertilizer volume, rice variety, use of fertilizer applicator mounted on a transplanter, and use of high-density seedling mat called "Mitsunae." We conducted 7 seasons with 79 planting patterns in experiments to compare yield, quality, and fertilizer volume in rice production.

As a result of productivity achievement, high-density transplanting does not always produce a high yield. Each performance depends on transplanting density, rice variety, fertilizer volume, or other factors. In general, transplanting machine with a planting width of 25cm achieved a significant yield with short growing duration rice varieties. Those varieties are popular in the Mekong Delta.

We conducted experiments of "high-density seedling mat" called "Mitsunae", a new nursery technology developed in Japan, to reduce the environmental load and operating costs in rice production. With the "Mitsunae" method, we can reduce the number of rice seedling trays up to three times that of conventional seedling mats. Then, we can minimize the nursery surface area, nursery materials, and total working time, including transplanting time. The "life cycle assessment (LCA)" method is practical for correctly quantifying environmental load reduction. We investigated environmental load reduction caused by "Mitsunae" rice nursery process using LCA method in this research. We could achieve about 20% – 30% reduction of the "greenhouse gas (GHG)" emission volume and economic benefits created by the "Mitsunae" nursery process.

Keywords – Mekong Delta, High-density seedling mat, GHG, LCA method

1 INTRODUCTION

Currently, Vietnam is the third largest rice exporting country worldwide. However, Vietnam experienced difficult wartime until 1975. Therefore, the priority in Vietnam was to produce high-yield rice, not high quality rice. The average yield in 1985 was 2.8 tons/ha, reaching 5.32 ton/ha in 2010 [1, 2]. Annual rice paddy production in Vietnam was 19 million tons in 1990, reaching 42.3 million tons in 2011 [3]. Vietnam accomplished its yield target after the war.

In our previous research, we first surveyed basic information about Mekong Delta rice farming [4]. In the second research, we examined the economic benefits of introducing machine transplanting compared with manual transplanting and manual direct seeding, and proved the clear advantage of machine transplanting. We observed that high-density planting, such as planting width of 20 cm or 25 cm, performed better yield than low-density plantings, such as a planting width of 30 cm. In that research, we also tried rice straw composting on the paddy fields to reduce chemical fertilizer consumption [5].

This time, we carried out rice cultivation experiments with more precise conditions. These were the comparison of (1) planting density, (2) fertilizer volume, (3) method of fertilizer application, (4) rice variety, and (5) high-density seedling mat (Mitsunae). We used a total of seven seasons with 79 patterns. For our experiments, we chose rice varieties of AGPPS103, AGPPS135, Loc Troi5, OM6976 and IR504. Those varieties are considered as high-value rice in the international market, except for IR504.

As an environmental load reduction approach, we can find several directions, such as reducing artificial fertilizer and agrochemical volume, reducing labor working load and saving consuming material volume, and reducing exhaust gas emissions to the atmosphere. Reducing artificial chemical fertilizer volume is a keenly required issue. Most Vietnamese farmers use enough or exceeding volume of chemical fertilizer. According to World Bank Group's report, the exceeding amount of fertilizer in Vietnam is about 140,000 tons of N, 82,000 tons of P, and 66,000 tons of K that are wasted in the Mekong Delta annually, which has a value of 150 million USD. It also increases the burden of farmers [5]. In our previous research [4], we tried rice straw composting after rice harvesting on a paddy field, accelerated by *Trichoderma* organic chemical. This could reduce the consumption of artificial fertilizers. This time we investigated suitable fertilizer volumes in our experiments.

"life cycle assessment (LCA)" method is a quite practical way to quantify the environmental load reduction level, especially in measuring "greenhouse gas (GHG)" emission measurement in the agricultural process. In our experiments, we compared the GHG emission volume between the "Mitsunae" and conventional seedling mats in the rice transplanting process by using the LCA method.

2 MATERIALS AND METHODS

2.1 Rice cultivation experiment location

We conducted rice cultivation experiments in the Mekong Delta because this region is responsible for producing more than 90% of rice exports from Vietnam. The monthly average temperature of the Mekong Delta is between 27℃ to 34℃, and the rainy season is from May to October. There are three rice cultivation seasons. However, three crops areas comprise about 50 % of all of the Mekong Delta (Figure 1). The three seasons are known the Sumer-Autumn (SA), Autumn-Winter (AW), and Winter-Spring (WS). As the definition of rice cultivation seasons, approximately the SA season is April to August, the AW season is from August to November, and the WS season is December to March. however, actual cultivation schedule differed depending on location or climate (Figure 2). We rented paddy fields at Dinh Thanh Agricultural Research Center (DTARC) of An Giang Plant Protection Joint Stock Company (AGPPS, currently renamed as Loc Troi Group) in An Giang province for our experiments.

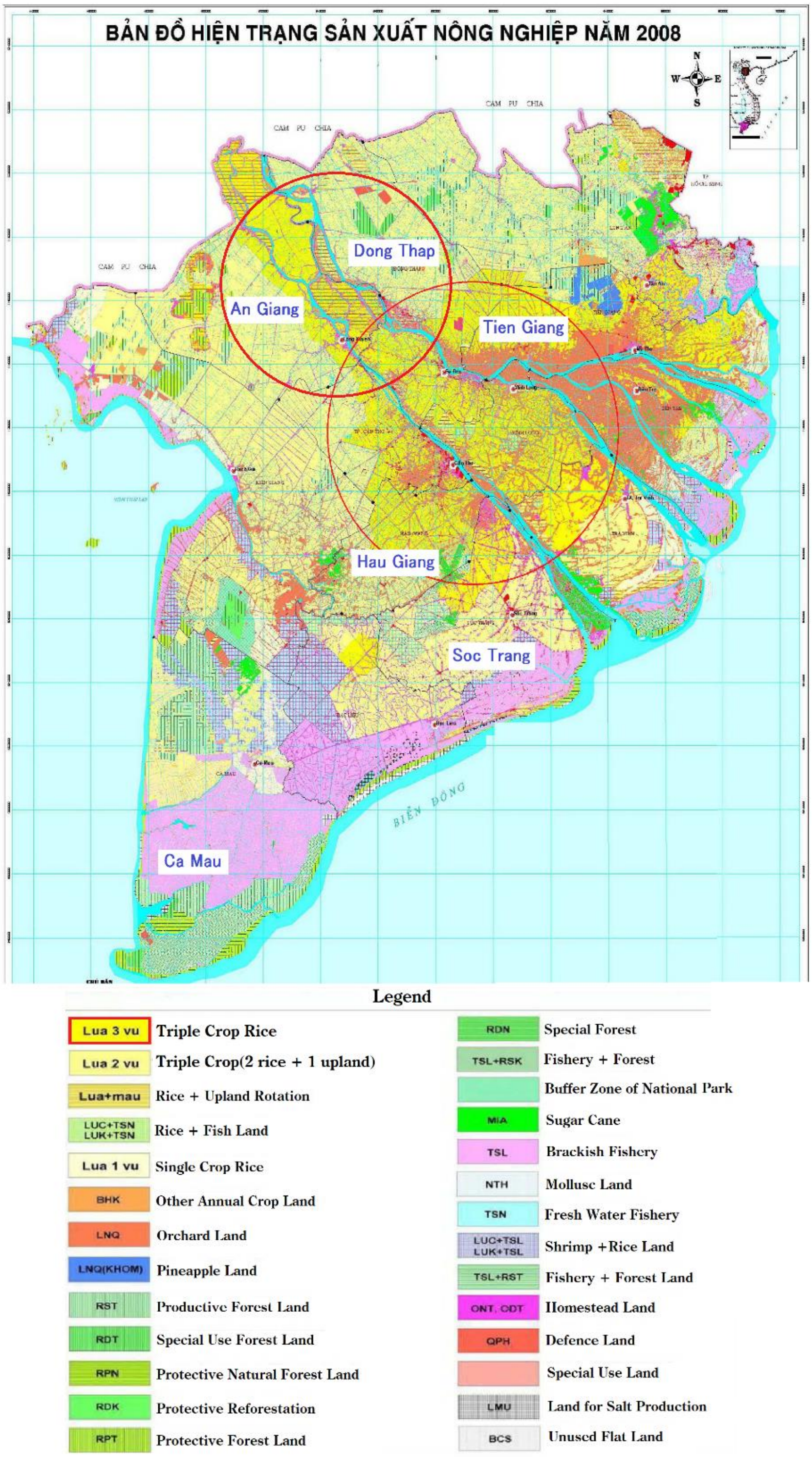

Figure 1: Mekong Delta Agricultural land use map (2008).

Notes: The yellow-colored area is for rice cultivation, and the circled areas are mostly triple cropping areas. Land use areas have not changed for most of the Mekong Delta areas since this 2008 map up to 2014, except for some expansion of triple cropping areas from two cropping areas by irrigation system improvements.

Source: Southern Institute for Water Resources Planning (SIWRP) [6], modified by the author

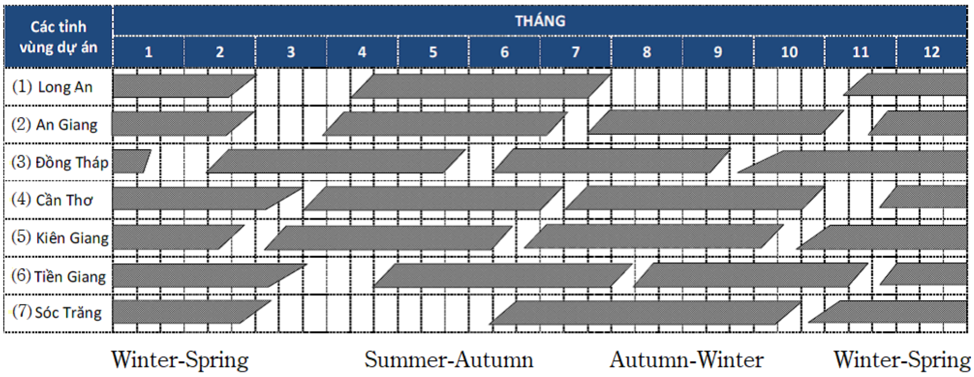

Figure 2: Rice crop calendar in the Mekong Delta.

Source: Agriculture Competition Project in 2013, implemented by the Ministry of Agriculture and Rural Development (MARD) and the Mekong Delta Development Research Institute of Can Tho University (MDI-CTU).

2.2 *Rice cultivation experiment conditions*

We conducted experiments with a total of seven seasons with 79 planting patterns from 2014 to 2017 at the test field of DTARC. The comparison of rice growing performance was made with different approaches, such as planting density, rice variety, fertilizer volume, method of fertilizer application, and the use of a high-density seedling mat "Mitsunae." The following six experiment conditions are related to the "Results and discussions" mentioned later;

2.2.1 2014 experiment second season:

Period: SA season, from May 2014 to August 2014. Comparison of planting density: Six planting patterns. Planting density(row width × pitch): 30 cm × 20 cm, 30 cm × 15 cm, 30 cm × 12 cm, 25 cm × 22 cm, 25 cm × 12 cm, and 20 cm × 20 cm. The transplant method was machine transplanting (riding type 6 row rice transplanters), and manual transplanting. Rice variety: AGPPS103

2.2.2 2014 experiment third season:

Period: AW season, from August 2014 to November 2014. Comparison of planting density and fertilizer volume control: 20 planting patterns Planting density(row width × pitch): 30 cm × 17 cm, 30 cm × 28 cm, 30 cm × 15 cm, 30 cm × 12 cm, 25 cm × 22 cm, 25 cm × 18 cm, 25 cm × 14 cm, and 20 cm × 20 cm. Fertilizer control:100% (three times total: N=167 kg/ha, P=130 kg/ha, K=50 kg/ha), and 70% (three times total: N=117 kg/ha, P=92 kg/ha, K=36 kg/ha). The transplant method was machine transplanting (walk behind type 4 row and riding type 6 row rice transplanters), manual transplanting, manual sowing by drum seeder, and manual direct seeding called "Broadcasting." Rice variety: Jasmine85

2.2.3 2015 experiment first season:

Period: SA season, from April 2015 to July 2015. Comparison of planting density and fertilizer volume control: Five planting patterns. Planting density (row width × pitch): 30 cm × 28 cm, 30 cm × 12 cm, and 20 cm × 20 cm. Fertilizer control: 120 % (N = 120 kg/ha, P= 72 kg/ha, K = 30 kg/ha), and 100% (N = 100 kg/ha, P = 60 kg/ha, K = 30 kg/ha). The transplant method was machine transplanting (by riding type 6 row rice transplanter), and manual transplanting. Rice variety: AGPPS135.

2.2.4 2015 experiment second season:

Period: AW season, from August 2015 to November 2015. Comparison of planting density and fertilizer volume control: Five planting patterns. Planting density (row width × pitch): 30 cm × 28 cm, 25 cm × 22 cm, and 20 cm × 20 cm. Fertilizer control: 140 % (N = 140 kg/ha, P= 84 kg/ha, K = 30 kg/ha), 120 % (N = 120 kg/ha, P= 72 kg/ha, K = 30 kg/ha), and 100% (N = 100 kg/ha, P = 60 kg/ha, K = 30 kg/ha). The transplant method was machine transplanting (by riding type 6 row rice transplanters), and manual transplanting. Rice variety: AGPPS135.

2.2.5 2017 experiment first season :

Period: SA season, from April 2017 to July 2017. Comparison of planting density, and high-density seedling mat "Mitsunae": Seven planting patterns. Planting density (row width × pitch): 25 cm × 12 cm, 25 cm × 16 cm, 25 cm × 22 cm, and 20 cm × 20 cm. Fertilizer control: 100 % volume with three times. The transplant method was machine transplanting (by riding type 6 row rice transplanter) with conventional seeding mat + conventional planting nail, high-density seeding mat "Mitsunae" + high-density seedling planting nail, and manual transplanting. Rice variety: Loc Troi 5

2.2.6 2017 experiment second season:

Period: WS season, from November 2017 to February 2018. Comparison of the rice variety, planting density, high-density seedling mat "Mitsunae", and fertilizer applicator for the soil beneath to apply: 24 planting patterns. Planting density (row width x pitch): 30 cm × 12 cm, 30 cm × 15 cm, 30 cm × 17 cm. Fertilizer control: 100% (three times), application for beneath the soil or not. The transplant method was machine transplanting (by riding type 6 row rice transplanter). Rice variety: IR504 (short duration) and OM6976 (long duration).

In the above experiments, we collected the following data;

A) Rice growing indicators: tiller height, stem length, number of tillers, panicle length, number of panicle, root length, ripened rate

B) Rice quality indicators: number of grains per panicle, number of good grains per panicle, and 1000 grain weight at the harvesting stage.

C) Productivity indicators: paddy weight in wet and dry conditions by potential measurement and practical measurements.

2.3 Challenge for the reducing environmental load in rice cultivation

We introduced new rice transplanting technology, the "High-density seedling mat (Mitsunae)," It was developed in 2015 and became a prevalent technology in Japan [7]. With this technology, we could reduce the number of seedling trays from nursery to transplanting almost three times that of the conventional method (Figures 3, 4). With this method, it is possible to save nursery space, reduce material costs, reduce transporting cost from a nursery place to a paddy field, and reduce number of seedling trays during transplanting. We conducted an adoptability experiment using the "Mitsunae" method at DTARC with different planting density and rice varieties.

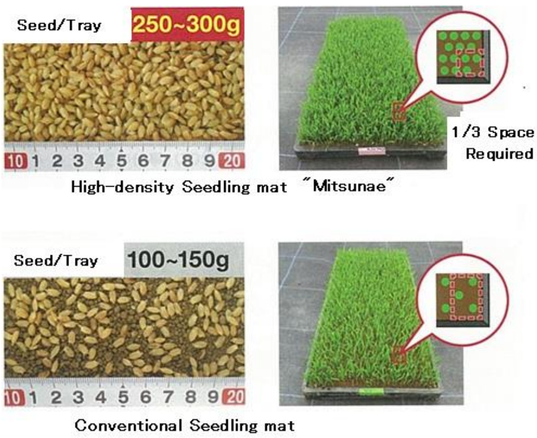

Figure 3: High-density seedling mat "Mitsunae"

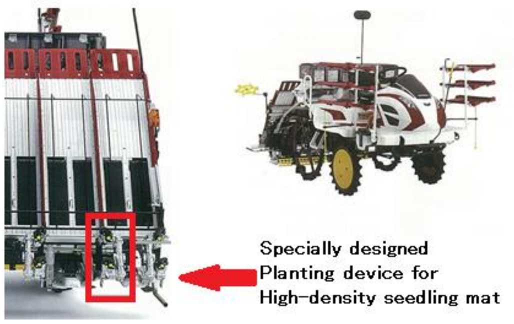

Figure 4: Rice transplanter specialized for "Mitsunae"

The "Mitsunae" method contributes not only to reducing cultivation cost, but also GHG emissions and other environmental factors. We compared the environmental load created in rice transplanting processes between "Mitsunae" and conventional seedling mats. For the measurements, we followed the manual "Life Cycle Assessment (LCA) of agricultural practices" issued by National Institute for Agro-Environmental Sciences (NIAES, currently merged to National Agriculture and Food Research Organization: NARO) [8] and other LCA instructions [9, 10].

3 RESULTS AND DISCUSSION

3.1 *Results of growing performance*

Among the 79 different pattern of planting experiments, three or four different conditions were crossed over in most of case. We obtained the following results from the six previously explained experiments:

3.1.1 Planting density comparison:

We found a clear trend in the second and third seasons of 2014 experiment with long duration varieties AGPPS103 and Jasmine85. Among the 26 patterns of different planting conditions, lower side planting density plots showed high yield compared with higher density plots in same variety and normal fertilizer applying volume (Figures 5 and 6).

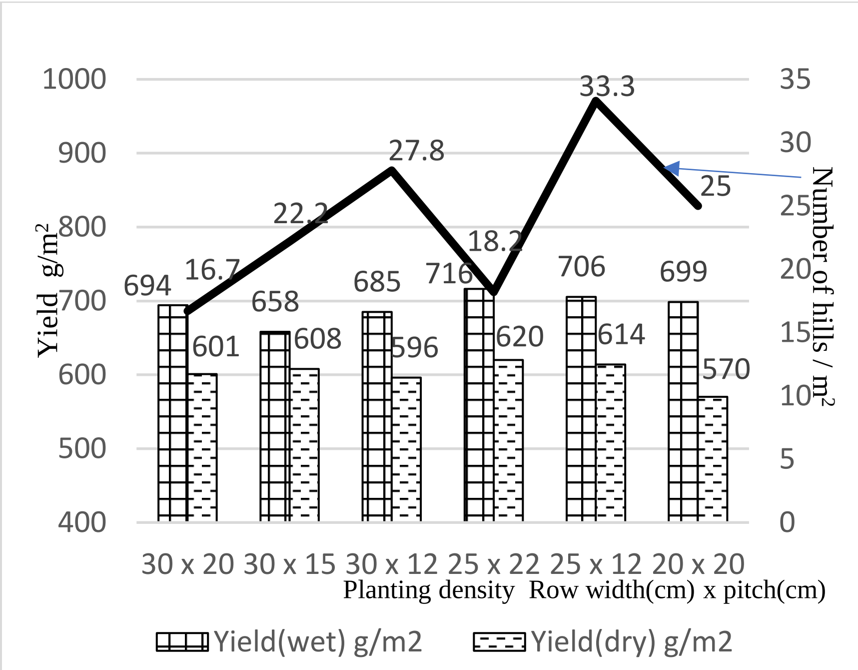

Figure 5: The second season 2014 experiment:
Comparison of yield by planting density
Rice variety: AGPPS103
20 x 20: Manual transplanting
Others are machine transplanting

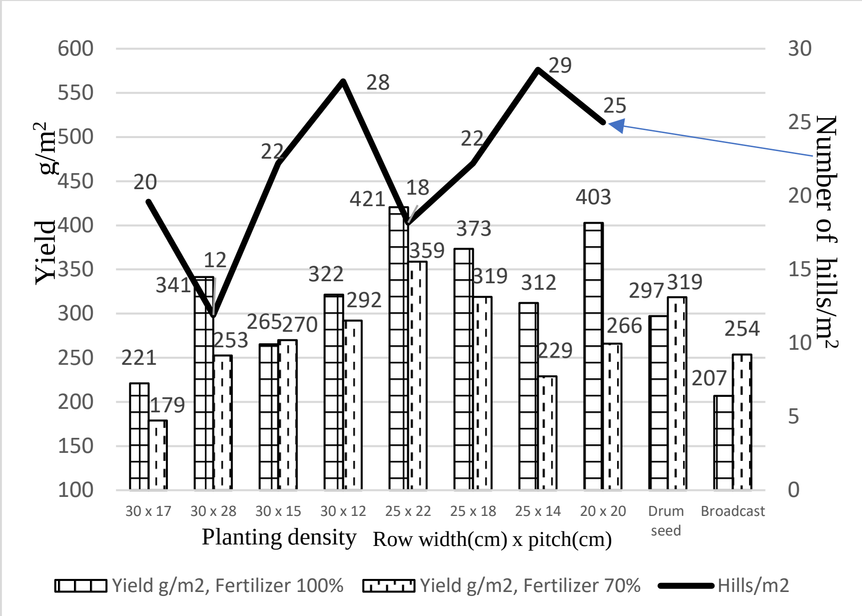

Figure 6: The third season 2014 experiment:
Comparison of yield by planting density and fertilizer control of 100% and 70%
Rice variety: Jasmine85
20 x 20: Manual transplanting
Drum seed: Manual direct row sowing by drum seeder
Broadcast: Manual direct seeding
Others are machine transplanting

In the second season of the 2014 experiment, a planting density 25cm × 22cm plot resulted in a yield of 716 g/m^2, and a 30cm x 20cm plot resulted in a yield of 694 g/m^2 (Figure 5). The third season of the 2014 experiment was affected by a severe disease, and average yield was low. However, the planting density plot of 25 cm × 22 cm resulted in a 421 g/m^2 yield. The 30 cm x 28 cm plot yielded 341 g/m^2. These results were much better than other higher density plots (Figure 6).

On the other hand, the 2015 experiment was conducted with a short-duration variety AGPPS135. The high-density transplanting plot of 30 cm × 12 cm (27.78 hills/m^2) performed a higher yield of 9,035 kg/ha (wet condition) compared with a low density plot (11.9 hills/m^2) with a yield of 8,095 kg/ha (120% fertilizer) and 7,395 kg/ha (100% fertilizer) (Table 1).

Table 1: The results of the first harvesting season in the 2015 experiment.

Planting density width x pitch	30cm x 28cm	30cm x 28cm	30cm x 12cm	30cm x 12cm	20cm x 20cm
Planting density (hills/m^2)	11.9	11.9	27.78	27.78	25
Fertilizer volume (N: kg/ha)	120	100	120	100	100
Transplanting method	Machine	Machine	Machine	Machine	Manual
Rice variety			AGPPS135		
Stem length (mm)	89.81	83.44	81.94	85.39	86.28
Panicle length (mm)	24.42	23.53	24.33	24.19	24.58
Root length (mm)	12.67	15.50	14.44	14.33	13.44
Ripened rate (%)	84.07	82.31	86.39	86.29	87.66
Number of panicle / m^2	256.90	244.49	298.25	293.12	276.39
Number of grain / panicle	103.56	103.80	106.19	94.35	96.06
Moisture (%, wet)	17.75	16.60	17.33	17.60	17.02
Grain mass (g/m^2, wet)	772.71	718.04	780.11	827.42	797.21
Potential yield (kg/ha, wet)	7,727.12	7,180.42	7,801.10	8,274.22	7972.05
Practical yield (kg/ha, wet)	8,095.74	7,394.50	8,533.62	9,035.22	8299.09
Moisture (%, dry)	13.47	12.27	11.20	11.10	9.50
Grain mass (g/m^2, dry)	705.19	660.80	693.04	736.20	706.61
Potential yield (kg/ha, dry)	7,051.93	6,608.00	6,930.43	7361.95	7066.12
Straw mass (g/m^2)	2,535.90	2,265.00	2,418.40	2,581.20	1,859.70
Total mass above ground /m^2	3,241.09	2,925.80	3,111.44	3,317.40	2,566.31
Weight of 1000 grains (g)	27.68	26.60	27.35	28.07	27.98

Fertilizer volume: 120 plot N: 120kg / ha, P_2O_5: 72 kg / ha, K_2O: 36 kg / ha
100 plot N: 100kg / ha, P_2O_5: 60 kg / ha, K_2O: 30 kg / ha
Each described record is the average of 5 measured samples.

3.1.2. Comparison of fertilizer volume control:

In the first and second seasons of the 2015 experiment, we conducted each of the five patterns of experiments with different fertilizer volumes. We set a 100 % volume standard as N = 100 kg/ha, P = 60 kg/ha, and K = 30 kg/ha from the habits and experiences of the farmers. Then, we compared the results with 100 %, 120 %, and 140 % fertilizer volumes. In the first season of the 2015 experiment, high-density 30 cm × 12 cm plot performed a satisfactory result of 9,035 kg/ha of practical yield (wet) with 100 % fertilizer volume. In this plot, 1,000 grains weight was also adequate at 28.07 g (Table 1).

However, in the second season of the 2015 experiment, the medium density 25 cm × 22 cm plot with 100 % fertilizer, yield was adequate with 7,642 kg/ha. Nonetheless, the 1,000 grain weight was the worst in five plots, reaching only 19.9 grams. In this experiment, the plot with 25 cm × 22 cm with 120 % fertilizer and the plot with 30 cm × 28 cm with 140 % fertilizer yielded adequate results of 7,308 kg/ha and 7,672 kg/ha (Table 2). The manual transplanting with a high-density 20 cm × 20 cm plot yielded adequate results in both the first and second season experiments.

We confirmed that, in high-density plots, such as over 25 hills/m^2, 100 % fertilizer could perform a good yield and quality, but in medium or low-density plots, such as from 10 to 20 hills/m^2, 100 % fertilizer could not perform a good yield and quality in case of short-duration variety.

Table 2: The harvesting results for the second season of the 2015 experiment.

Planting density width x pitch	30cm x 28cm	30cm x 28cm	25cm x 22cm	25cm x 22cm	20cm x 20cm
Planting density (hills/m^2)	11.9	11.9	18.18	18.18	25
Fertilizer volume (N: kg/ha)	140	120	120	100	100
Transplanting method	Machine	Machine	Machine	Machine	Manual
Rice variety			AGPPS135		
Stem length (mm)	83.09	80.44	78.24	79.67	81.59
Panicle length (mm)	24.24	23.96	23.32	22.91	24.67
Root length (mm)	118.33	121.89	116.11	118.33	114.44
Ripened rate (%)	90.64	90.19	89.49	89.35	89.35
Number of panicle / m^2	204.17	191.12	193.52	215.32	241.25
Number of grain / panicle	106.11	92.45	118.61	130.61	119.51
Moisture (%, wet)	16.00	16.57	15.60	15.35	15.60
Grain mass (g/m^2, wet)	806.32	730.54	735.38	744.60	892.63
Potential yield (kg/ha, wet)	8,063.20	7,305.40	7,353.80	7,446.00	8926.30
Practical yield (kg/ha, wet)	7,672.33	7,220.78	7,308.69	7,642.36	8532.97
Moisture (%, dry)	13.70	13.20	12.65	11.30	12.10
Grain mass (g/m^2, dry)	773.74	694.40	695.45	706.80	812.01
Potential yield (kg/ha, dry)	7,737.40	6,944.00	6,954.50	7068.00	8120.10
Straw mass (g/m^2)	1,265.20	1,140.70	1,018.00	1,143.50	1,336.00
Total mass above ground / m^2	2,038.94	1,835.10	1,713.45	1,850.30	2,148.01
Weight of 1000 grains (g)	21.57	21.33	21.87	19.90	21.77

Fertilizer volume: 140 plot N: 140kg / ha, P_2O_5: 84 kg / ha, K_2O: 42 kg / ha
120 plot N: 120kg / ha, P_2O_5: 72 kg / ha, K_2O: 36 kg / ha
100 plot N: 100kg / ha, P_2O_5: 60 kg / ha, K_2O: 30 kg / ha
Each described record is the average of 5 measured samples.

3.3. For sustainable agricultural in rice cultivation, we have tried several improvement methods.

3.3.1. Adoptability of high-density seedling mat (Mitsunae) and LCA analysis

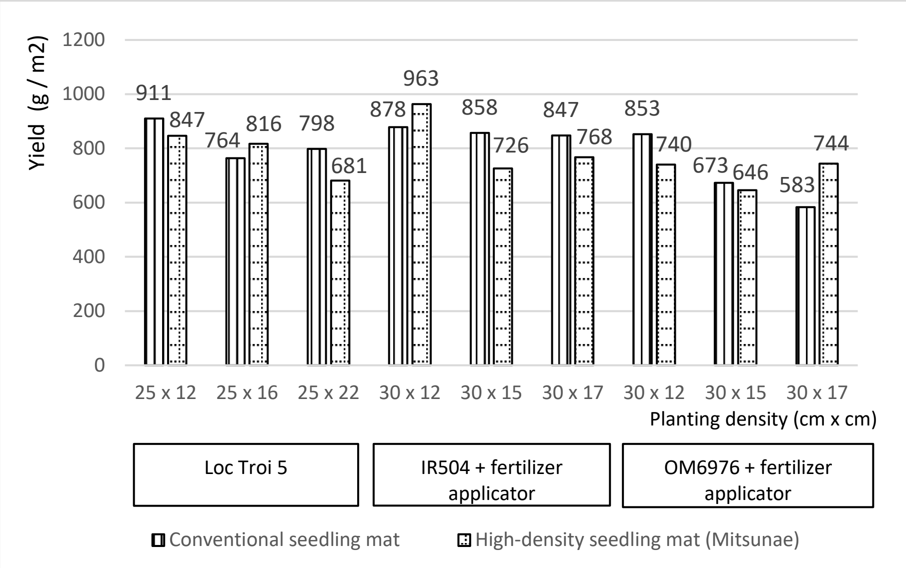

Figure 7: 2017 experiment, yield comparison of conventional seedling mat and "high-density seedling mat (Mitsunae)" among different planting density and rice varieties
Rice variety: Loc Troi 5 (short duration), IR504 (short duration), OM6976 (long duration)

As a result of Mitsunae experiment, there was almost no yield difference between the cultivation results of conventional seedling mat and Mitsunae seedling mat (Figure 7).

We used LCA method to quantify each related item to compare the environmental load and economic benefit between "Mitsunae" and conventional seedling mats, from seedling nursery to transplanting work. For this comparison, we referred the manual "Life Cycle Assessment (LCA) of agricultural practices" issued by NIAES [8].

Related basic numbers picked up from the manual and our test conditions are shown in Table 3.

Table 3: Basic numbers to calculate LCA from nursery to transplanting work

description	unit	quantity
Nursery tray surface area	m^2/tray	0.1624
Seed volume per tray, conventional	g/tray	180
Seed volume per tray, Mitsunae	g/tray	250
Planting density (width x pitch)	cm	25 x 22
Working ability of transplanter, conventional	ha/hour	0.27
Working ability of transplanter, Mitsunae	ha/hour	0.34
Working ability of transplanter, conventional	min/ha	222
Working ability of transplanter, Mitsunae	min/ha	177
Fuel oil consumption	liter/hour	3.1
CO_2 emission volume	g/liter	2619
NOx emission volume	g/liter	18.3
SOx emission volume	g/liter	6.34
Fuel oil price	USD/liter	0.606

Notes: Transplanter is 6-row riding type

The diesel fuel price was 13,600 VND/liter, with an exchange rate of 22,541 VND/USD in 2017

Table 4: LCA comparison results between "Mitsunae" and conventional seedlings, from nursery to transplanting work

per ha

description of work	unit	Conventional seedling	"Mitsunae" seedling
Nursary area	index	100	72
	number of tray	389	280
	m^2	51.9	37.4
Labor cost at nursery	index	100	72
Transportation from nursery to paddy: Can Tho City - Dinh Thanh, An Giang two ways total: 160 km, 240 min	index	100	71
	truck rental cost two ways (USD)	150	107
Transplanting time	index	100	80
	min	222	177
Fuel consumption of Transplanter	index	100	80
	litre	11.5	9.2
	fuel cost(USD)	6.97	5.57
GHG emission from Transplanter calculated by LCA method	CO_2 (kg)	30.12	24.09
	NOx (g)	210.45	168.36
	SOx (g)	72.91	58.33

Figure 8: Location map of Nursery and Experiment Paddy field

The “Mitsunae” process performance yielded a 20 % - 30 % deduction in all the cost and environmental load data against transplanting process with conventional seedling mat. This included nursery area, the number of trays, labor cost at nursery, seedling transportation cost from nursery station to paddy field, transplanting time, fuel cost, and each emission volume (Tables 3 and 4). In this research, the distance between our seedling nursery center and the paddy field was quite far (Figure 8). However, such case is not a rare. Because large-scale rice cultivation companies or seedling service companies are recently available, the distance between nurseries and paddy fields is not in close locations in many cases.

4 CONCLUSIONS

We conducted distinct categories of rice cultivation experiments, totally 79 patterns of experiments for better data accuracy, to discover the best conditions for maximizing rice yield. The categories were (1) transplanting density, (2) fertilizer application volume, (3) fertilizer application to the beneath of soil by a new device, (4) high-density seedling mat (Mitsunae), and (5) rice variety.

Concerning transplanting density, we found rice growing duration is deeply related with transplanting density, which produces a good yield. In our experiments, in the case of long-duration variety, low-density transplanting, such as between 12 hills/m^2 (30cm × 28cm) to 18 hills/m^2 (25cm × 22cm) plots, reached an adequate yield and quality. However, the short-duration variety, high-density transplanting reached a more significant yield.

In fertilizer volume control, we confirmed that conventional standard fertilizer volume, such as N: 100 kg/ha, P_2O_5: 60 kg/ha, K_2O: 30 kg/ha performed acceptable yield results. Lower fertilizer volume, such as 70% of the standard volume, reached a lower yield. However, when applying a high volume of fertilizer, such as 120 % or 140% of the standard volume, yield results were not significant high and were close to 100 % plot results. This means that the designed fertilizer volume of 100% is correct.

We tried to reduce the environmental load several ways for sustainable agriculture solutions and achieved specific results.

In experiments with the high-density seedling mat “Mitsunae” with various transplanting densities or different rice varieties, the yield results were almost the same as conventional seedling mat transplanting. We proved that “Mitsunae” method of transplanting could adopt most rice cultivation conditions in the Mekong Delta. “Mitsunae” has several advantages, such as reducing nursery area and numbers of trays, labor cost at nursery, seedling transportation cost, transplanting time, and fuel cost. We also analyzed the comparison of environmental load between “Mitsunae” seedlings and conventional seedling using the LCA method [10, 11]. We found that the “Mitsunae” method could contribute to reducing not only related costs, but also other factors, such as reduction of exhaust gas emissions, working load, and other improvements of environmental indicators.

Our future target is to quantify the achievement level of each environmental load reduction challenge. In this research, we measured the transplanting process improvements by “Mitsunae.” However, other environmental load reduction challenges, such as rice straw composting on paddy fields to reduce fertilizer consumption, or planting repellent flowers on the paddy side as organic pesticides to reduce chemical pesticide consumption. It is still challenging to quantify these achievements. We recognized LCA methods as interesting tools and partly used them in this research. In the case of organic repellent flowers, “Integrated Pest Management (IPM)” method also seems beneficial for quantification [12].

However, environmental load reduction challenges should be profitable for farmers and should be welcomed, not bothersome.

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