Factors influencing the adoption of "One must do, five reductions" in rice production in the Mekong River Delta: A case study in Soc Trang province, Vietnam

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ABSTRACT

After years of experimenting, the "One must do, five reductions" (1M5R) (in Vietnam referred to as 1P5G), is being promoted by Vietnam's Department of Crop Production as an advanced technique in rice production. Nevertheless, a certain proportion of rice farmers in the Mekong Delta are reluctant to implement 1M5R. This study collected data from 116 rice farming households in Soc Trang province to assess factors influencing the decision to adopt the new technique. The results showed that the 1M5R model offered better economic efficiency than the traditional producing model in terms of profit, revenue/cost ratio, and profit/cost ratio. The estimated Binary Logistic model revealed that labor, production experience, and production area significantly contributed to farmers' adoption of 1M5R. These results are the empirical evidence of the potential of 1M5R, supporting its promotion in Vietnam's Mekong River Delta.

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1. Introduction

Sustainable agriculture is a long-term objective of Vietnam since agriculture has always been a vital role in the country's economy. Among primary export agricultural commodities, rice is the most essential product because it significantly contributes to Vietnam's GDP and food security. The Mekong River Delta is called the rice bowl of Vietnam, as it accounts for more than 50% of the country's output (GSOV, 2021). For decades, farming methods have been continuously improved to achieve the efficiency of rice production in the delta, which enabled Vietnam to become one of the most rice exporters in the world. Nevertheless, rice production in the Mekong River Delta is fragmented and vulnerable to external pressures (Nguyen et al., 2015; Hoang et al., 2018; Hoang et al., 2019). The average farm size per household is 1 ha, in which 48% of the rice fields are 0.5 to 2 ha, 38% less than 0.5 ha, and 10% more than 2 ha (Connor et al., 2020). Small scale farming is less likely to achieve economies of scale, and they are less resilient to disturbances, especially natural climate extremes. Moreover, the excessive use of inputs to boost production generated adverse externalities on the environment and human health (Chau

et al., 2015) and diminishing marginal returns (GSOV, 2021). Thus, to ensure that rice production is sustainable, advanced farming techniques are continuously researched and developed.

The "One Must Do, Five Reductions" (1M5R) is an integrated technology package that evolved from the "Three Reductions, Three Gains" (3R3G) program. "One Must" means the use of certified seeds, and "Five Reductions" encompasses the reduction of seed rate, fertilizer use, pesticide use, water use, and post-harvest losses (Stuart et al., 2018). 1M5R is developed to minimize negative impacts from excessive input uses as well as to increase rice productivity, raise incomes for farmers, expand economically effective rice cultivation models, ensure human safety and environmental sustainability. After years of experimenting in many southern provinces, Vietnam's Department of Crop Production has acknowledged 1M5R as an advanced technique in rice farming. As a result, 1M5R was certified by a Presidential decree (532 - QD - TT - CLT) as the national program after 3R3G to implement best rice cultivation practices (Stuart et al., 2018). A great amount of effort has been used to promote it through workshops, trainings, focus group discussions and demonstration sites (Connor et al., 2020), but not every rice farmer is willing to adopt and implement it.

Therefore, understanding farmer behaviors and decision making is necessary to promote sustainable agriculture (Feola et al., 2015). Many studies attempted to investigate factors influencing the adoption of new farming technologies, resulting in various factors from economics, environment, and psychology. For example, Dessart et al. (2019), examined the positive effects of behavioral factors and social and cognitive factors in increasing the adoption of environmental practice. Bopp et al. found significant influences of socio-economic characteristics, personal needs, and environmental factors on adopting sustainable agricultural practices in Chile. Besides, farmers' perceptions of easiness, benefit, satisfaction and expectation can affect the willingness to implement advanced farming technologies and models (Ekane et al., 2016; Connor et al., 2020; Wehmeyer et al., 2020).

In the Mekong River Delta, the capability of 1M5R in reducing negative environmental impacts and increasing profitability has already been examined (Truong et al., 2013; Stuart et al., 2018). Its adoption increases together with improved levels of educational, participation in cooperatives, and training attendance (Le et al., 2021). By contrast, factors that hinder adoption include difficulties to apply the desired best practices, the suitability for cropping patterns, and weather conditions (Connor et al., 2020). As previous findings indicate that adoption behaviors are different depending on the agricultural context, it is necessary to have more insights into the technical package so that appropriate policies can be made. In such context, this study was conducted to provide an additional empirical understanding of the economic potential of 1M5R along with factors influencing its adoption.

2. Materials and Methods

2.1. Study site

Soc Trang is an agricultural province where more than 60% of the province's labor concentrates in agricultural production. The total land area of Soc Trang is 322,330 ha, of which the rice-cultivated area is 171,200 ha.

This study was conducted in Nga Nam Town, one of the primary rice producers of Soc Trang province. The local rice production area is 18,176 ha (accounting for 83.47% of the agricultural land area). However, in recent years, local rice farmers repeatedly have to face many risks in production, resulting in precarious income. The most concerning menace in the Mekong River Delta are the increasing impacts of climate change, in which saltwater intrusion is most evident (Hoang-Phi et al., 2021). Besides, market prices of agricultural inputs and outputs have been fluctuating in a detrimental direction to farmers.

2.2. Data collection

This study uses primary data collected from 116 rural households. The survey employed a random sampling method and a semi-structured questionnaire. There were three categories of collected information: (1) household information (including gender, age, educational levels, production experience, and demographic characteristics); (2) information on farming techniques and financial efficiency (including crop types, seed usage, fertilizer, and pesticides, water management, crop care, harvesting and cultivation costs, yield, selling price); and (3) information regarding farmers' knowledge of 1M5R.

2.3. Methods

2.3.1. Participatory rural appraisal (PRA), focus group discussion (FGD), and key informant panel (KIP)

The PRA, FGD, and KIP are common techniques that are utilized to study farmers' perception and adoption of advanced technologies (Ngoan & Howeler, 2007; Pandey et al., 2011; Abakemal et al., 2013). The FGDs was conducted with six groups in three communes of Nga Nam Town. The interviewees encompassed people who either participated or did not participate in the 1M5R program. The participants were those who have experience and understanding of rice production at the study site. The author also employed KIP to interview ten key informants, including farmer collaborators (3 people), representatives of farmers' associations (3 people), and locally knowledgeable elders (4 people). Discussed contents covered the history and current development of rice production in the area; encountered advantages and difficulties in applying 1M5R; factors influencing people's decision to implement 1M5R; and their potential solutions.

2.3.2. Binary logistic regression

Because surveyed households can be categorized into groups of those that implemented and those that did not implement 1M5R, Binary logistic regression was suitable to assess factors affecting the adoption of the new technology package. The formula of the model is:

$$\ln\left[\frac{\mathrm{P(Y{=}1)}}{\mathrm{P(Y{=}0)}}\right] = \beta_0 + \beta_1\mathrm{X}_1 + \beta_2\mathrm{X}_2 + ... + \beta_i\mathrm{X}_i$$

Where in:

Y=0 means the household did not adopt 1M5R

Y=1 means the household adopted 1M5R

X_i are the explanatory variables (Table 1)

3. Results and Discussion

3.1. Rice production and the development of 1M5R at the study site

The 1M5R program that is currently applied in Nga Nam town was developed from former farming system programs starting in the early 1990s. These programs were received and appreciated by farmers and exhibited positive outcomes. In 2009, Soc Trang province conducted

Table 1. Explanatory variables in the regression model

Variables	Expected Correlation	Unit	Explanation
X_1	+	Years	The educational level of the household head. The more years of schooling the householder, the more knowledge he/she obtains, leading to greater awareness of 1M5R's benefits and higher participating possibilities.
X_2	+	People	The number of laborers within the family. Families with more laborers have more incentives to apply a new farming model to increase income.
X_3	+	Hectare	Rice production area. Greater production scales have better cost-efficiency when applying advanced technologies
X_4	+	Years	Rice production experience

Table 2. Results from PRA discussions

Year	Program/Event
1994	Integrated Pest Management (IPM)
1996	Introducing NES: no early spray for leaf-eating insects Occurrence of Yellow snail pandemic
2001	Occurrence of Brown aphids, seedless crops
2009	Introducing the Three Reductions, Three Gains" (3R3G) program
2012	Occurrence of Barley yellow dwarf, ragged stunt virus – RRSV, and hoarfrost The province declared a state of emergency
2013	Introducing the "One must, five reductions" program

Table 3. Rice production area

Production area	Adopting 1M5R		Non-adopting 1M5R		Total sample	
	Count	Percentage	Count	Percentage	Count	Percentage
< 1 ha	10	18.87	18	28.57	28	24.14
1 - 2 ha	11	20.75	29	46.03	40	34.48
2 - 3 ha	16	30.19	9	14.29	25	21.55
3 - 5 ha	11	20.75	7	11.11	18	15.52
5 - 8 ha	2	3.77	0	0.00	2	1.72
≥ 8 ha	3	5.66	0	0.00	3	2.59
Sum	53	100.00	63	100.00	116	100.00

the pilot implementation of the 3R3G program in some selected districts. In order to reduce greenhouse gas emissions, Soc Trang Provincial Agricultural Extension Center, in collaboration with the National Agricultural Extension Center, organized 18 training courses for farmers on applying 3R3G and SRI rice cultivation techniques. In addition, there were training, technical transfer, and demonstration of water-saving irrigation rice farming models in 2 districts of Nga Nam and Long Phu. As a result, the local government and farmers evaluated water-saving irrigation techniques as highly feasible. Currently, rice farmers in My Tu, Tran De and Nga Nam have partly started participating in the 1M5R program (Table 2).

In the study site, the rice planting schedule consists of 2 seasons, of which Winter-Spring is the main farming season in a year. The Winter-Spring rice crop usually begins in November and harvests in February of the following year. The Autumn-Summer crop is from May to August.

There were 53 households adopted 1M5R in the sample and 63 households did not adopt the technique. Households with a 1 - 2 ha production area accounted for the highest proportion of 34.48%, followed by less than 1 ha (24.14%) and 2 - 3 ha (21.55%) (Table 3). Households whose rice fields were larger than 5 hectares or more only accounted for a relatively low proportion. There is a noticeable difference in the production scale between the two groups. Farmers adopted 1M5R had larger average fields and concentrated in larger production scale categories. Also, 54.31% of the households cultivated on slightly alum-contaminated alluvial soil. Other types of soil included mildly salt-contaminated alluvial soil, alluvial soil, and clay.

Water sources for rice farming were similar in both groups. Almost all of the surveyed households obtained water from local rivers and canals by self-invested pumping systems. Only 10% of the sample utilized water provided by cooperatives.

Rice varieties also showed no differences as farmers mainly use highly adapted varieties to alum-contaminated and salt-contaminated fields such as RVT fragrant rice, OM 4900, OM 5451 (Table 4). The RVT fragrant rice was especially favoured in both planting seasons thanks to its high resistance to extreme climate conditions and various pests and diseases such as brown aphids, rice blast, and sheath blight.

Household heads graduated from secondary school accounted for 48.28% of the total sample, high school 22.41%, and elementary school 19.83%. Such educational levels revealed that farmers in Nga Nam town dropped out of school

Table 4. Popular rice varieties

Varieties	Adopting 1P5G households				Non-adopting 1P5G			
	Winter-Spring	%	Summer-Autumn	%	Winter-Spring	%	Summer-Autumn	%
OM 4900	10	18.87	8	15.09	15	23.81	15	23.81
OM 5451	4	7.55	10	18.87	3	4.76	12	19.05
RVT 33	62.26	30	56.60	36	57.14	30	47.62	
Others	6	11.32	5	9.43	9	14.29	6	9.52
Sum	53	100	53	100	63	100	63	100

early. Educational standard is comparably low in both 1M5R adopted and non-adopted groups. On average, each family had two to three people engaging in rice farming activity and they had 20 - 30 years of experience.

All households participating in the program were trained in the 1M5R technique. However, the number that was supported to implement the model was limited (12 households) (Table 5). Nevertheless, many of them were self-invested in deploying the model, which indicates that farmers genuinely recognize the benefits of the 1M5R program and are willing to adopt it. Thus, more support from the authorities are required to encourage and attract more farmers to participate in the program. Currently, in the study area, 1M5R is not the sole farming technique applied by farmers as it is combined with other programs to enhance production efficiency. For example, from 2018 to 2019, a project titled "Adaptive livelihoods ensure food security and climate change response for vulnerable communities in Vietnam" was implemented in Nga Nam district by the Bread for the World, Action on Poverty, The Consultative Institute for Socio-Economic Development of Rural and Mountainous Areas. This project helped farmers adapt to salt intrusion in Nga Nam district by combining the five reductions of 1M5R with 5 must, including 1) Record production logs, input origins, and products; 2) Products are not contaminated with banned substances; 3) Have community and environmental responsibility, honesty and transparency in production; 4) Achieving the certificate of registered organic standards (being tested and evaluated); 5) Harmonize socio-economic and environmental efficiency. This technique helped reduce financial vulnerability from climate change, and adaptability is also better both financially and ecologically.

The collected data revealed variances in production costs between the traditional farming model and the 1M5R model (Table 6). For example, for every 1000 m^2, the differences between non-adopting and adopting families were 94.96 thousand VND and 128.88 thousand VND in the Winter-Spring and Summer-Autumn crops, respectively. The divergences can be attributed to advances in planting stages such as line sowing and selected fertilizing and spraying in reasonable periods. Specifically, the seed cost of the 1M5R model was 175.81 thousand VND/1000

Table 5. Implementation of 1M5R

Participation	Count	Percentage
Households participating in the 1M5R program	53	
Trained households	53	100
Of which		
Supported to implement	12	22.64
Self-invested to implement	33	62.26
Unsuccessfully implement	8	15.09

m^2 for both planting seasons, while the traditional farming practice had to pay 198.54 thousand VND and 201.55 thousand VND/1000 m^2 for Winter-Spring seasons and Summer-Autumn seasons, respectively. The total expenses of fertilizer and pesticide showed a similar trend as it cost non-adopting households 40 to 60 thousand VND/1000 m^2 more than adopted households. In addition, farmers who applied 1M5R had lower expenses in hiring laborers for sowing, fertilizing, and spraying.

In general, the 1M5R model resulted in better returns for farmers participating in the program 1M5R adopting families earned 76 to 223 thousand VND/1000 m^2 more than non-adopting families. Ratios of revenue/cost and profit/cost were also higher in the participant group. The above analysis is mainly based on the cost and revenue data of the rice production process. On the other hand, the 1M5R program also helps farmers identify and be aware of the impacts of climate variations, facilitates cooperation and large-scale centralized production.

3.2. Factors affecting the adoption of 1M5R

Among the proposed explanatory variables, educational level had a significant level of 0.366, indicating no correlation between schooling and the possibility of adopting the 1M5R program. According to the survey, most households only reached elementary and secondary school, so this variable has little variation and shows no influence on farmers' decisions.

On the other hand, laborers, experience, and production area all had significant correlations with the dependent variable (Table 7). The labor variable was positively correlated with 1M5R adoption, indicating that households with more laborers are more likely to adopt the model. Phases in the model require human efforts to perform optimally, so it is easier for households with more workers to apply the technology package successfully. Production experience also helps increase the chances of implementing 1M5R. Thus, the more experienced rice producers are, the more likely they will accept new farming models to improve productivity and reduce costs. According to the survey results, households participating in 1M5R whose production experience over 40 years accounted for 23% of the sample. Therefore, local rice farmers had a lot of experience and were well aware of the disadvantages of traditional farming practices, so they were willing to accept new production models. Lastly, the adoption of 1M5R increases together with the production area.

The estimated model implies that the state needs to have policies to retain experienced agricultural workers in rural areas instead of letting them switch to non-agricultural activities or migrate to big cities in search of employment. In fact, the application of 1M5R technology requires labor resources to meet the production stages according to the process. Besides, because many households use a small and fragmented land area, it is necessary to propagate to the people to understand the meaning of "Canh Dong Mau Lon", aiming toward forming and expanding the high-quality rice production region.

4. Conclusions

The area of rice cultivation in the study area is generally stable. From 2009 to the present, there is just a slight increase in the production area. The access and application of scientific and technical advances of the majority of farmers have been enhanced. Moreover, agricultural mechanization was promoted; the canal system was gradually dredged, and there have been constructions of irrigation pumping stations. These improvements created favorable settings for the application of the 1M5R program.

Currently, more than 40% of the rice cultivat-

Table 6. Average costs and economic efficiency per 1000 m^2 of rice field

	Criteria	Adopting 1M5R		Non-adopting 1M5R	
		Winter-Spring	Summer-Autumn	Winter-Spring	Summer-Autumn
Costs (thousand VND)	Seeds	175.81	175.81	198.54	201.55
	Fertilizers	498.69	496.92	520.54	520.92
	a. NPK 16 - 16 - 8	19.50	27.69	17.66	15.84
	b. NPK 20 - 20 - 15	136.26	135.20	131.97	149.24
	c. NPK 24 - 24 - 20	7.92	7.13	7.27	8.89
	d. DAP	86.40	86.04	69.06	71.35
	e. Nitrogenous	51.50	51.38	61.21	62.35
	f. Phosphate	17.57	17.73	8.34	8.44
	g. Potassium	45.29	45.81	31.86	32.61
	h. Organic	0.00	0.00	0.00	0.00
	i. Manure	0.00	0.00	0.00	3.17
	j. NPK 25 - 25 - 5	129.53	116.51	165.74	149.31
	k. Others	4.72	9.43	27.42	19.72
	Pesticides	320.34	299.92	359.44	359.66
	Irrigation	127.50	44.79	124.48	43.39
	Hired Soil preparing	18.12	18.24	17.40	15.94
	Rented tillage machines	117.22	120.87	129.82	141.62
	Hired Sowing	17.86	17.66	33.78	22.96
	Hired Fertilizing	37.75	33.79	23.82	23.69
	Spraying	81.76	74.93	66.51	71.44
	Harvest	240.78	246.53	256.48	257.19
Efficiency	Cost (thousand VND)	1635.84	1529.48	1730.81	1658.35
	Revenue (thousand VND)	4660.80	2597.38	4532.38	2649.96
	Profit (thousand VND)	3024.96	1067.90	2801.57	991.61
	Revenue/Cost	2.85	1.70	2.62	1.60
	Profit/Cost	1.85	0.70	1.62	0.60

Table 7. Estimated regression model

	B	S.E.	Wald	Df	Sig.	Exp(B)
X_1	0.059	0.065	0.818	1	0.366	1.061
X_2	0.944	0.274	11.895	1	0.001	2.569
X_3	0.030	0.018	2.761	1	0.097	1.031
X_4	0.010	0.010	5.164	1	0.023	1.000
Constant	-3.984	0.971	16.838	1	0.000	0.019

ing area applies the 1M5R model, but each household's adoption level is different. The application of 1M5R requires regular monitoring and relatively flat rice fields, but some farmers are still familiar with traditional farming practices. There are sites with rough field conditions, incomplete irrigation systems, and limited training provided to farmers, making it difficult to expand the program.

The comparison proved that 1M5R adopted households need fewer investments but gain better returns than traditional farming practices. In addition, laborers, experience, and production area were shown to contribute to adopting the technology package significantly.

In conclusion, 1M5R is a technique that helps rice farmers produce more effectively. Economically, it reduces investment costs, improves profits and incomes for farmers. In terms of environment, the 1M5R technology lessens environmental pollution by reducing the quantity of chemical fertilizers and pesticides in stages of production. Moreover, the efficiency of water use in rice cultivation has been considerably improved from the application of 1M5R. Finally, 1M5R is socially efficient because it enhances farmers' technical skills as well as reduces labor cost requirements.

Conflict of interest

The authors declare no conflict of interest.

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