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Factors Affecting Organic Fertilizer Adoption in Rice Production in Vietnam

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베트남 쌀 생산에서 유기질 비료 사용에 영향을 미치는 요인

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ABSTRACT: The adoption of organic fertilizers is one of the measures of sustainable agricultural production in Vietnam. This research evaluates the effectiveness of organic fertilizer application and the factors affecting adoption of organic fertilizers in rice production. The data of 3,972 rice farmers from the 2014 Vietnam Household Living Standards Survey dataset are used in the analysis. The results show that yield, revenue, and cost of rice production for farmers using only inorganic fertilizers are greater than those forf farmers applying organic fertilizers. However, there is a consistent profit between the two groups of farmers. Use of organic fertilizers improves the financial efficiency of rice production for farmers. The amount of inorganic fertilizers required decreases when farmers apply organic fertilizers. Farmers who are Kinh people, have loans for rice production, or have large land areas tend to use less amount of organic fertilizers. Meanwhile, farmers with higher education, who join the Farmer's Association, or have more household members, are more likely to use organic fertilizers for rice production. This study implies that farmers should apply organic fertilizers to increase the financial efficiency and sustainability of rice production. The government needs to design policies to motivate the production and utilization of organic fertilizers.

Key words: Organic fertilizer, Rice production, Vietnam rice sector

INTRODUCTION

The total cultivated land area of rice in Vietnam is 7.47 million hectares, and rice production is 43.45 million tons in 2019 (General Statistics Office, 2020). Thanks to the “Doi Moi” policy in 1986, Vietnam has become one of the world's largest rice exporters from a rice importer (Khai & Yabe, 2011). In the period 1980-2000, Vietnam's rice production increased by 5% per year. In which productivity increases contributed 3.5% and increased cultivation area contributes 1.5% (Ut, 2002). Fertilizers contribute significantly to increasing crop yields and ensuring food security. Fertilizer significantly increases crop nutrients' availability, improves soil ecosystem services, directly and indirectly, affects 95% of global food production (FAO, 2019). However, if not appropriately used, fertilizers will degrade soil, water sources, air quality, deplete soil nutrients and harm human and animal health.

There are two main types of fertilizers: inorganic fertiliz-

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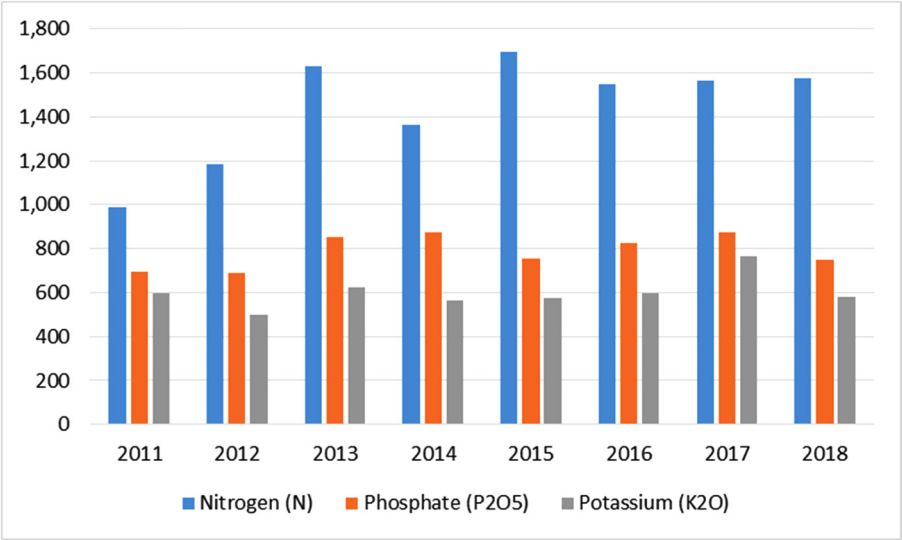

Fig. 1. Fertilizers by the nutrient used in Vietnam (1,000 tons)
Source: FAO, 2021

ers and organic fertilizers. Inorganic fertilizers, also known as synthetic fertilizers or chemical fertilizers, are artificially produced and contain minerals or synthetic chemicals. The three main macronutrients of inorganic fertilizers are Nitrogen (N), Phosphorus (P_2O_5), and Potassium (K_2O). According to FAO (2020), the use of inorganic fertilizers has increased dramatically in Asia over the past six decades. The area accounted for 20% of the total world fertilizers in the 1960s and in the 2010s, it accounted for more than 50% for all three nutrients (N, P_2O_5, and K_2O). However, over the past decade, the use of N and P_2O_5 appears to have stabilized or even decreased. In Vietnam, the amount of nitrogen fertilizer used tends to increase slightly, while the amount of phosphate and potassium used is almost unchanged (Figure 1) (FAO, 2021).

Recognizing the harmful effects of inorganic fertilizers on sustainable production, some farmers have used more organic fertilizers to reduce the volume of inorganic fertilizers. Using organic fertilizers in agricultural production is one of the goals of sustainable agricultural development in Vietnam. The application of organic fertilizers in agricultural production balances soil nutrients improves the absorption efficiency of water and inorganic fertilizers, reduces pests and diseases, and increases farm productivity and quality (Nghia & Tam, 2000). Organic fertilizers include two groups: traditional organic fertilizers and industrial organic fertilizers. Traditional organic fertilizers are fertilizers derived from animal wastes, by-products of cultivation, husbandry, agricultural, forestry, aquatic products, green manure, organic waste, and peat processed according to the traditional annealing method. Industrial organic fertilizers are fertilizers processed from various organic sources to form fertilizers better than the original raw materials (Ministry of Agriculture and Rural Development, 2018). However, the expansion of organic fertilizer use to all farmers is limited as the amount of traditional organic fertilizers meets less than 20% of the country's organic fertilizer needs (Nghia & Tam, 2000). According to the Ministry of Agriculture and Rural Development (2018), Vietnam has about 180 industrial organic fertilizer producers with a total capacity of 2.5 million tons/year. Meanwhile, the number of enterprises and the total output of inorganic fertilizers ten times larger also negatively impact the farmers' utilization of organic fertilizers.

Inorganic nitrogen fertilizers' operational efficiency on rice plants can be increased by 30-40% on organic fertilized substrates (Ministry of Agriculture and Rural Development, 2018). However, due to lightweight, fast-acting, inorganic fertilizers are preferred by farmers to apply in rice production. Vietnamese farmers often use traditional organic fertilizers according to their experience and apply industrial organic fertilizers following the seller's instructions. There is no orientation, systematic training for farmers on the effects of organic fertilizers, and how to balance inorganic and organic fertilizers in Vietnam. Farmers have few opportunities to access and learn about efficient, balanced organic fertilizer use formulas. Therefore, several Vietnamese farmers are still hesitant to apply organic fertilizers because they are afraid of reducing rice yield.

Providing evidence of the effectiveness of organic fertil-

izer adoption and the influencing factors is needed to promote farmers' organic fertilizers in rice production. Thus, the article's critical contributions are as follows: (1) Evaluate the financial efficiency of applying organic fertilizers in rice production; (2) Analyzing the factors affecting the adoption of organic fertilizers in rice production and proposing policies towards sustainable production.

The article's remainders are organized as follows: Section 2 presents Theoretical Framework; Data and Model outlined in Section 3; Section 4 details the Results and Discussion; Finally, Conclusions and Recommendations are summarized in Section 5.

THEORETICAL FRAMEWORK

Based on the synthesis of research papers by Mwangi & Kariuki (2015), factors explaining technology application behavior in agricultural production include personal characteristics and assets, imperfect information, risks, uncertainties, institutional constraints, input availability and infrastructure. However, this study only considers farmers' attributes to the application of organic fertilizers in rice production. Based on the literature review, this study's factors include age, sex, ethnicity, education level, main job, participation in Farmers Association, agricultural credit, and household size and rice acreage.

Older farmers have increased risk aversion, so they often produce according to traditional and experienced methods. Meanwhile, young farmers are often less risk-averse and willing to try new technologies (Adesina & Zinnah, 1993). Lavison (2013) found that older farmers tend to use more fertilizer in agricultural production. Gender discrimination in some countries leads to limited access to productive resources by women, thus affecting the adoption of new technologies by women (Muzari *et al*., 2013). According to Obisesan (2014), the probability of men applying new technologies to agricultural production is higher than that of women. Lavison (2013) recognized that men use more organic fertilizers in agricultural production compared to women. There are differences in the farming production methods of ethnic groups. Therefore, the amount of fertilizer used may also vary.

The degree of impact of education on applying new agricultural technologies has not been consistent across studies (Mwangi & Kariuki, 2015). Research results of Obisesan (2014) indicate that education positively affects applying new technologies in agricultural production. However, education negatively impacts the use of genetically modified varieties (Uematsu & Mishra, 2010). According to Ajewole (2010), education positively affects farmers' use of organic fertilizers. If farmers have the primary income from rice production, they will pay more attention to production efficiency. Therefore, the strategies for using the inputs of farmers are also inconsistent. Lavison (2013) research results indicate that full-time farmers used more organic fertilizers in vegetable production than part-time farmers.

Uaiene (2011) found that joining the Farmers' Association positively affects applying new technologies in production by farmers. Farmers reduce their fertilizer use when entering the Farmers Association (Lavison, 2013). Credit has a positive impact on the farmers' adoption of new technologies in agricultural production (Uaiene, 2011). The agricultural credit increases the farmer's fertilizer use in their production but reduces the amount of organic fertilizer used (Lavison, 2013).

A large-scale household can reduce the labor constraints in applying new technology (Mwangi & Kariuki, 2015). Following Ajewole (2010), the probability of using organic fertilizer increases as household size enlarged. Uaiene (2011) argued that large land farmers are more willing to apply new technology because they can afford to dedicate a portion of their land to try new technology compared to small land farmers. Land area positively affects fertilizer use but negatively impacts organic fertilizer use (Lavison, 2013). Research results of Muzari *et al*. (2013) support that acreage reduces the applicability of organic fertilizers used.

DATA AND MODEL

The research uses the 2014 Vietnam Household Living Standards Survey (VHLSS) dataset. This survey is conducted by the General Statistics Office of Vietnam works with the World Bank's technical assistance. The dataset collected information from 9,189 households from 3,063 communes across Vietnam. Stratified random sampling is applied in this survey to be representative of the population. After removing insufficiently informed observations from the 2014 VHLSS data set, data from 3,972 rice farmers in Vietnam are extracted for analysis. The number of farmers in the two groups using only inorganic fertilizers and using organic fertilizers is 2,366 and 1,608, respec-

Table 1. The number of farmers in each group

Group of farmers	Frequency	Percent (%)
Use only inorganic fertilizers	2,364	59.5
Have using organic fertilizers	1,608	40.5
Total	3,972	100.0

Source: 2014 Vietnam Household Living Standards Survey

tively (Table 1).

Descriptive statistical methods are used to analyze farmers' and rice production characteristics. The t-test is applied to compare farmers' financial performance using only inorganic fertilizers and farmers using organic fertilizers. In this study, the adoption of organic fertilizers in rice production is divided into two cases: using (1) and not using (0) organic fertilizers. It means that the dependent variable has a binary choice. The Probit (Bliss, 1934) or Logit (Berkson, 1944) regression model is often used when the dependent variable has a binary option, taking either zero or one. The binary choice analysis aims to estimate the conditional or response probability P(x)=P [Y=1|X=x]=E[Y|X=x] on a given set of variables Xs (Hansen, 2021). The marginal effect equals to the regression derivative is expressed as follows:

$$\frac{\partial P(x)}{\partial x} = \frac{\partial P[Y=1|X=x]}{\partial x} = \frac{\partial E[Y|X=x]}{\partial x} \quad (1)$$

The Probit and Logit model produces similar estimates for response probabilities and marginal effects. However, one advantage of the Logit model is that the distribution function is available in a closed form, which accelerates the calculation (Hansen, 2021). Therefore, this study uses the Logit regression model to consider factors affecting farmers' probability of using organic fertilizers in rice production. The Logit model is represented as follows:

$$Prob(Y=1) = \frac{\exp(x'\beta)}{1+\exp(x'\beta)} \quad (2)$$

Where Y is the dependent variable that takes a value of one if farmers apply organic fertilizers in rice production and equals zero otherwise. x'β is performed as follows:

$$x'\beta=\beta_0+\beta_1 Age+\beta_2 Gender+\beta_3 Ethnicity+\beta_4 Education+\beta_5 Job+\beta_6 Association+\beta_7 Credit+\beta_8 Householdsize+\beta_9 Acreage+\varepsilon \quad (3)$$

Where Age is the years old of the person in charge of the household's rice production. Gender takes the value of one for male and zero if it's female. Ethnicity takes the value of one if the farmer is of the Kinh ethnicity and zero otherwise. Education indicates the number of years of schooling of the farmer. Job is the farmer's main job, takes a value as one if the farmers spend the most time on rice production and zero otherwise. Association takes a value of one if a farmer joins the Farmers' Association and zero otherwise. The credit equals one if the farmer has borrowed money for rice production and zero otherwise. Household size is the number of household members. Acreage is the annual rice cultivated land area of the household. βi are the regression parameter, and ε is the error of the model. The variables are statistically described in Table 2.

Table 2. Descriptive statistics of the variables

Variable	Mean	SD	Min	Max
Use organic fertilizers (yes=1)	0.40	0.49	0.0	1.0
Age (years)	47.30	11.98	19.0	84.0
Gender (male=1)	0.67	0.47	0.0	1.0
Ethnicity (Kinh=1)	0.72	0.45	0.0	1.0
Education (years)	6.90	3.42	0.0	12.0
Job (rice production=1)	0.62	0.48	0.0	1.0
Farmer Association (yes=1)	0.47	0.50	0.0	1.0
Credit (yes=1)	0.04	0.20	0.0	1.0
Household size (persons)	4.11	1.55	1.0	11.0
Rice acreage (ha)	0.80	1.64	0.0	42.0

Source: 2014 Vietnam Household Living Standards Survey

RESULTS AND DISCUSSION

Characteristics of the farmers

Table 3 presents the characteristics of the two groups of rice farmers in the sample. There is a similar structure between the two groups in terms of age, sex, education level, main job, agricultural credit, and household size. However, the proportion of farmers in the group using organic fertilizers participating in the Farmer Association (54%) is more significant than the farmers' group using only inorganic fertilizers (42%).

Rice production characteristics

Table 4 details the costs of rice production by farmers in Vietnam. The average production cost of rice per hectare is about 14.5 million VND. In which the cost of inorganic fertilizers accounts for the most significant proportion, about 33.9%. The second-largest expense is the cost of hiring machinery, which accounts for 20.5%. The cost of renting machines includes plow, cultivator, rice thresher, and combine harvester. The seed cost is about 10.6% of the total cost. Farmers in Vietnam apply two main sowing methods: direct seeding and seedling, so the seed cost is the total expenditure of these two inputs. The cost of hiring outsourced labor and pesticides account for 7.9% and 7.6%, respectively. The average cost of organic fertilizers per hectare of rice production in Vietnam is only about 460 thousand VND, accounting for about 3.2%. This statistical result indicates that the ratio between inorganic and organic fertilizers used by the farmers in the study sample

Table 3. Characteristics of rice farmers

Items	Group	Use only inorganic fertilizers		Have using organic fertilizers	
		Frequency (n=2,364)	Percentage (%)	Frequency (n=1,608)	Percentage (%)
Age	19-40	673	28.5	537	33.4
	41-60	1,316	55.7	890	55.4
	>=61	375	15.8	181	11.2
Gender	Male	1,560	66.0	1,088	67.7
	Female	804	34.0	520	32.3
Ethnicity	Kinh	1,870	79.1	972	60.5
	Others	494	20.9	636	39.5
Education	No qualification	581	24.6	363	22.6
	Primary	683	28.9	466	29.0
	Lower secondary	825	34.9	592	36.8
	Higher secondary	242	10.2	172	10.7
	College	9	0.4	7	0.4
	University	24	1.0	8	0.5
Main job	Rice production	1,351	57.2	1,120	69.7
	Others	1,013	42.8	488	30.3
Join Farmer Association	Yes	993	42.0	868	54.0
	No	1,371	58.0	740	46.0
Credit	Yes	127	5.4	38	2.4
	No	2,237	94.6	1,570	97.6
Household size	1-5	2,025	85.6	1,298	80.7
	6-10	337	14.3	306	19.0
	>=11	2	0.1	4	0.3

Source: 2014 Vietnam Household Living Standards Survey

Table 4. Rice production cost per hectare in the sample (n=3,972)

Costs (1,000 VND/ha)	Mean	SD	Min	Max	Percentage (%)
Seed	1,540.1	900.5	110.0	10,272.7	10.6
Inorganic fertilizers	4,916.2	2,248.4	0.0	18,000.0	33.9
Organic fertilizers	460.3	952.9	0.0	20,000.0	3.2
Pesticides	1,097.1	1,148.4	0.0	10,938.2	7.6
Herbicides	317.6	352.6	0.0	6,916.7	2.2
Small tools	367.5	377.5	0.0	5,000.0	2.5
Small repairs	42.6	166.4	0.0	3,200.0	0.3
Asset depreciation	349.4	954.6	0.0	11,363.6	2.4
Land rental	314.8	1,198.0	0.0	16,000.0	2.2
Hire machines	2,973.2	2,421.7	0.0	15,000.0	20.5
Hire cattle	165.7	732.9	0.0	11,737.1	1.1
Hire outsourced labor	1,141.9	1,826.7	0.0	15,899.1	7.9
Irrigation	203.8	366.9	0.0	3,250.0	1.4
Interest on loans	35.9	291.5	0.0	5,787.0	0.2
Fuel	204.4	565.1	0.0	16,666.7	1.4
Other costs	361.9	618.4	0.0	12,666.7	2.5
Total cost	14,492.3	5,522.7	380.0	42,439.3	100.0

Note: Exchange rate on January 13, 2021: 1 USD=23,065 VND
Source: 2014 Vietnam Household Living Standards Survey

is 10:1. However, the research results of Van Bo *et al*. (2019) argued that the 70:30 combination ratio between inorganic and organic fertilizers gives the highest marks. Therefore, farmers need to simultaneously reduce the amount of inorganic fertilizer and increase the amount of organic fertilizer to achieve higher production results. The remaining expenses account for a negligible proportion.

Table 5 compares rice production costs between farmers who only apply inorganic fertilizers and farmers who use organic fertilizers. The total rice production cost by farmers using only inorganic fertilizers is greater than that of farmers using organic fertilizers. However, expenses such as seeds, organic fertilizers, small tools, minor repairs, asset depreciation, and hiring cattle of farmers using organic fertilizers are larger than those of farmers who only use inorganic fertilizers. It means that farmers who use organic fertilizers in rice production apply more manual methods instead of using chemicals and machines. There is no difference in fuel costs and other costs between the two groups of farmers.

Information on yield, revenue, cost, and profit per hectare of rice is presented in Table 6. The farmer's average rice yield in the sample is about 5.1 tons/ha. Average revenue and profit are about 34 million VND/ha and 19.5 million VND/ha, respectively. The return to sale (ROS) ratio is 56.5%, which is higher than the government's minimum profit requirement for rice farmers (30%). However, in terms of scale, the profit of 19.5 million VND/year for a household of four members is smaller than the average income per capita in Vietnam.

Table 7 shows a comparison of the financial performance between the two groups of farmers. Yield, revenue,

Table 5. Comparison of rice production costs between inorganic and organic fertilizer farming

Costs (1,000 VND/ha)	Use only inorganic fertilizers (n=2,364)	Have using organic fertilizers (n=1,608)	t-test
Seed	1,483.9	1,622.6	-4.78***
	(835.4)	(982.8)	
Inorganic fertilizers	5,233.4	4,449.8	10.94***
	(2,206.8)	(2,228.3)	
Organic fertilizers	0.0	1,137.0	-45.53***
	(0.0)	(1,214.1)	
Pesticide	1,362.5	706.9	18.39***
	(1,278.3)	(774.7)	
Herbicide	353.7	264.6	7.87***
	(398.7)	(262.0)	
Small tools	333.4	417.8	-6.96***
	(344.5)	(416.4)	
Small repairs	31.6	58.6	-5.04***
	(138.9)	(199.1)	
Asset depreciation	148.2	645.3	-16.66***
	(617.7)	(1,242.4)	
Land rental	386.2	209.8	4.57***
	(1,363.3)	(891.7)	
Hire machines	3,437.1	2,291.1	15.05***
	(2,310.3)	(2,421.0)	
Hire cattle	137.7	206.7	-2.92***
	(642.5)	(847.0)	
Hire outsourced labor	1,292.7	920.2	6.34***
	(1,912.8)	(1,668.2)	
Irrigation	252.7	131.8	10.33***
	(406.8)	(283.9)	
Interest on loans	51.8	12.5	4.18***
	(348.1)	(175.6)	
Fuel	200.8	209.8	-0.49
	(587.4)	(530.8)	
Other costs	352.8	375.3	-1.13
	(622.2)	(612.7)	
Total cost	15,058.6	13,659.8	7.90***
	(5,424.1)	(5,562.4)	

Note: The numbers in parentheses are the standard deviation; *** significant at 1%
Source: 2014 Vietnam Household Living Standards Survey

Table 6. Financial indicators of rice production per hectare

Items	Mean	SD	Min	Max
Yield (kg/ha)	5,106.6	1,182.9	550.0	10,500.0
Total revenue (1,000 VND/ha)	34,021.3	9,064.8	2,750.0	81,576.4
Total cost (1,000 VND/ha)	14,492.3	5,522.7	380.0	42,439.3
Profit (1,000 VND/ha)	19,529.0	7,898.0	-6,556.8	52,145.0
ROS (%)	56.5	15.9	-35.9	94.3

Source: 2014 Vietnam Household Living Standards Survey

and cost in rice production of farmers using only inorganic fertilizers are upper than those of farmers using organic fertilizers. However, the t-test result indicates no difference in profits between the two groups of farmers. The ROS index of farmers using organic fertilizers in rice production greater than those of farmers using only inorganic fertilizers. Therefore, rice farmers in Vietnam need to pay attention to using organic fertilizers to increase financial efficiency and sustainability in production. Vietnamese farmers conceive of producing higher yields, the richer they are. However, the results demonstrate that high yields are not synonymous with giant profitability and financial efficiency. Therefore, farmers need to focus more on efficiency, product quality, and sustainability in production instead of quantity.

Use of fertilizers in rice production

Table 8 compares the number of inorganic fertilizers used in rice production between the two groups of farmers. Urea (46.3-0-0), Super Lan (0-16-0), Kali (0-0-61), NPK (16-16-8), and DAP (18-46-0) are the fertilizers commonly used in rice production in Vietnam. Except for Kali and NPK fertilizers, farmers who only apply inorganic fertilizers use more fertilizers than farmers who adopt organic fertilizers. In other words, utilize of organic fertilizers reduces the number of inorganic fertilizers used in rice production.

Depending on the type of fertilizer contains different primary nutrients Nitrogen, Phosphorus, and Potassium. Table 9 compares the number of fertilizers by nutrition used by the two farmer groups. The results show that the farmers applying only inorganic fertilizers used more Nitrogen and Phosphorus than those using organic fertilizers. However, the amount of Potassium used by the two groups of farmers is equivalent.

The supply source of organic fertilizer to farmers is represented in Figure 2. The organic fertilizers used are mainly self-sufficient by farmers, accounting for 85% of organic fertilizers. Farmers take advantage of animal

Table 7. Comparison of financial indicators of rice production between inorganic and organic fertilizer farming

Items	Use only inorganic fertilizers (n=2,364)	Have using organic fertilizers (n=1,608)	t-test
Yield (Tons/ha)	5,306.4	4,812.9	13.18***
	(1,176.5)	(1,130.3)	
Total revenue (1,000 VND/ha)	34,629.7	33,126.8	5.15***
	(9,136.6)	(8,885.8)	
Total cost (1,000 VND/ha)	15,058.6	13,659.8	7.90***
	(5,424.1)	(5,562.4)	
Profit (1,000 VND/ha)	19,571.2	19,467.0	0.41
	(8,258.5)	(7,338.1)	
ROS (%)	55.2	58.5	-6.33***
	(16.4)	(14.9)	

Note: The numbers in parentheses are the standard deviation; *** significant at 1%
Source: 2014 Vietnam Household Living Standards Survey

Table 8. The amount of inorganic fertilizers used per hectare

Items (kg/ha) (N-P_2O_5-K_2O)	Use only inorganic fertilizers (n=2,364)	Have using organic fertilizers (n=1,608)	t-test
Urea (46.3-0-0)	164.1	147.7	4.41***
	(119.6)	(107.8)	
Super Lan (0-16-0)	111.5	100.9	1.72**
	(194.3)	(185.2)	
Kali (0-0-61)	54.2	50.6	1.35
	(91.1)	(68.2)	
NPK (16-16-8)	243.8	250.6	-0.82
	(261.5)	(249.8)	
DAP (18-46-0)	33.8	28.0	1.71**
	(101.2)	(109.4)	

Note: The numbers in parentheses are the standard deviation; ** and *** are significant at 5% and 1% respectively
Source: 2014 Vietnam Household Living Standards Survey

manure from livestock and agricultural by-products to compost organic fertilizers. The purchase of industrial organic fertilizers for use in rice production is limited, accounting for 15%.

Factors affecting organic fertilizer adoption

Table 10 presents the Logit regression model results of factors affecting the adoption of organic fertilizer by rice

Table 9. The amount of inorganic fertilizers by the nutrients used per hectare

Items (kg/ha)	Use only inorganic fertilizers (n=2,364)	Have using organic fertilizers (n=1,608)	t-test
Nitrogen (N)	121.1	113.5	3.46***
	(66.8)	(68.5)	
Phosphorus (P_2O_5)	72.4	69.1	1.75**
	(54.6)	(62.1)	
Potassium (K_2O)	52.6	50.9	0.95
	(57.9)	(46.9)	

Note: The numbers in parentheses are the standard deviation; ** and *** are significant at 5%, and 1% respectively
Source: 2014 Vietnam Household Living Standards Survey

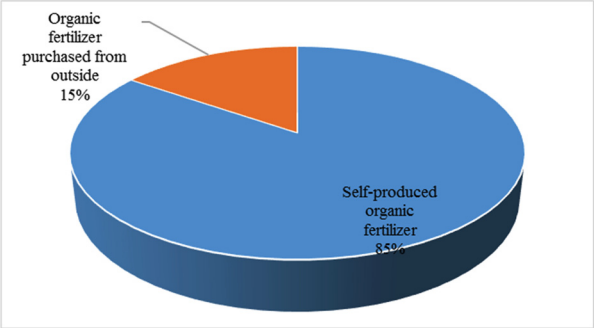

Figure 2. Sources of organic fertilizers
Source: 2014 Vietnam Household Living Standards Survey

farmers. The results show that explanatory variables in the model such as Education, Main job, Join the Farmers' Association, and Household size positively impact the ability to apply organic fertilizers in rice production by farmers. This study reinforces the results of previous studies on the adoption of organic fertilizers in agricultural production. Farmers with higher education increase the probability of using organic fertilizers (Ajewole, 2010). Farmers whose primary job is rice production are more probable to use organic fertilizers than other farmers (Lavison, 2013). Joining the Farmers' Association boosts the farmers' ability to use organic fertilizers (Uaiene, 2011). Households with several members are more likely to use organic fertilizers (Ajewole, 2010).

The found results indicate that Ethnicity, Credit, and Rice acreage variables negatively impact rice farmers' ability to use organic fertilizers. The negative Ethnicity variable implies that the Kinh people are less likely to apply organic fertilizers in rice production than other ethnic groups. Possible explanations could be that the produc-

Table 10. Results of the Logit regression model

Items	Co-efficient	Standard Deviation	t-ratio
Age (years)	-0.001	0.003	-0.46
Gender (male=1)	-0.008	0.075	-0.11
Ethnicity (Kinh=1)	-0.768***	0.088	-8.76
Education (years)	0.038***	0.011	3.52
Job (rice production=1)	0.331***	0.075	4.40
Farmer Association (yes=1)	0.338***	0.070	4.84
Credit (yes=1)	-0.570***	0.208	-2.74
Household size (persons)	0.111***	0.023	4.89
Rice acreage (ha)	-0.435***	0.052	-8.31
_cons	-0.569***	0.214	-2.65
Number of observation	3,972		
LR chi2(9)	398.530		
Prob > chi2	0.000		
Pseudo R2	0.074		

Note: *** significant at 1%

tion practices of ethnic minorities often use agricultural by-products to make organic fertilizers more than those of Kinh people. The Kinh ethnicity accounts for more than 70% of the farmers in this survey sample. Therefore, the change in Kinh farmers' rice production habits will substantially impact promoting sustainable organic production. Support Lavison's (2013) research results, the Credit variable's negative effect implies that farmers who get loans for rice production tend to use less organic fertilizer. In the absence of capital for production, farmers have to use by-products from livestock to fertilize rice. However, when borrowing money, farmers are willing to buy inorganic fertilizers to fertilize rice. The Rice acreage variable's coefficient indicates that farmers with a larger land area have a lower probability of using organic fertilizers. This result is consistent with the researches of Lavison (2013) and Muzari *et al*. (2013). The limited supply and bulky volume of organic fertilizers make it challenging to apply on a large scale. Therefore, the government should have supportive policies to promote industrial organic fertilizers' supply while encouraging farmers to use organic fertilizers in agricultural production. The results show that organic fertilization has no difference between men and women and between ages.

CONCLUSIONS

From the VHLSS 2014 dataset, 3,972 rice farmers are extracted to analyze factors affecting organic fertilizers' application in rice production by farmers in Vietnam. The statistical results show that rice production cost is about 14.5 million VND/ha, of which inorganic fertilizer cost accounts for the most significant proportion (33.9%). The average rice yield in Vietnam is 5.1 tons/ha. The profit from rice production is about 19.5 million VND/ha, and the ROS index is about 56.5%. The t-test results show that the yield, revenue, and cost of farmers using only inorganic fertilizers are greater than those of farmers using organic fertilizers. However, there is no difference in profit between the two groups of farmers, and the farmers using organic fertilizers has a greater ROS index. The adoption of organic fertilizers reduces the inorganic fertilizers used in rice production. However, the supply of organic fertilizers is still limited, with 85% self-sufficient by farmers. The Logit regression model results show that the explanatory variables such as Education, Main job, Farmer Association participation, and Household size have a positive impact on the ability of organic fertilizers in rice production by farmers. In contrast, variables such as Ethnicity, Credit, and Rice acreage negatively affect rice farmers' ability to use organic fertilizers.

Applying only inorganic fertilizers in rice production help farmers raise productivity and revenue but decline financial efficiency compared to using organic fertilizer combined. Multi-crop production and high use of inorganic fertilizers harm the sustainability of rice production in Vietnam. Therefore, farmers should consider using organic fertilizers to increase financial efficiency and sustainability in production. The Farmers' Association plays an essential role in encouraging farmers to apply organic fertilizers in rice production. Therefore, the role of the Farmers' Association should be promoted. However, the supply of industrial organic fertilizers in Vietnam has not met the demand. Thus, the organic fertilizer market in Vietnam is a potential market that businesses can exploit.

Towards the goal of sustainable agricultural production, the Government of Vietnam needs to issue policies to promote organic fertilizers' production and application in agricultural production. Policies on credit, taxes, transfer of technological advances, production and use of organic fertilizers are necessary to promote sustainable agriculture in Vietnam. Besides, the government needs to issue a set of technical regulations specifically for industrial organic fertilizers' quality. There should be studies on the appropriate rates between organic and inorganic fertilizers for each crop in each locality for farmers to have a basis for reference. Thereby, it contributes to promoting the adoption of organic fertilizers in rice production by farmers in Vietnam.

적 요

1. 본 연구는 유기질 비료 사용의 효과와 쌀 생산에 유기질 비료 채택에 영향을 미치는 요인을 평가하였다.

2. 2014년 베트남 가계생활수준조사 결과를 활용하여 분석한 결과 무기질 비료만을 사용하는 농민의 쌀 생산량, 수익 및 비용이 유기질 비료를 사용하는 농민의 경우보다 더 크다는 것이 발견되었다.

3. 반면 쌀 생산에 있어 재정적 효율성은 유기질 비료를 사용한 농민이 더 높은 것으로 나타났으며, 융자가 있거나 넓은 토지를 가진 농민들은 유기 비료를 덜 사용하는 경향이 있음이 분석되었다.

4. 한편, 높은 교육 수준의 농민이나 조합에 가입한 농민의 경우 유기질 비료를 사용할 가능성이 더 높은 것으로 분석되었다.

5. 본 연구는 베트남 농민들이 쌀 생산의 재정적 효율성과 지속 가능성을 높이기 위해 유기질 비료를 적용해야 함을 시사하며, 이에 베트남 정부는 유기질 비료의 생산과 활용에 동기를 부여하는 정책을 도입할 필요가 있다.

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