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Factors affecting farmers' adoption of rice production technology from the collaborative farming project in Phrae province, Thailand

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Abstract The factors affected farmers' adoption of rice production technology from the Collaborative Farming (CF) project in Phrae province, Thailand was investigated. It was found that farmers adopted rice production technology at a rate of 56.4%. The farmers had mostly adopted were chemical fertilizers that the application based on soil analysis, using the breeding rice seeds, and leguminous crop growing to maintain soil fertility, While rice growing based on Good Agricultural Practice (GAP), which own making fertilizers, and Trichoderma bioformulation were adopted at low rate. Results from logistic regression analysis revealed that six factors influenced the farmers' adoption of technology. These were gender, rice farming experience, household income, agricultural extension officers, attendance of rice production technology training, and problems relating to the project. Farmers were female with high income, extensive rice farming experience, and frequent contacts with agricultural extension officers tended to adopt rice production technologies. The female farmers attended rice production technology training and facing fewer problems related to the project. It is recommended that the CF project officers informed participating farmers on the benefits of the rice production technologies which are promoted. The farmers should be encouraged to attend training, and form a farmer group where knowledge and experiences can be exchanged. It is suggested that the farmers would be supported by using advanced technology, and monitoring.

Keywords: rice production technology, technology adoption, Thailand

Introduction

Rice is an important economic crop in Thailand and rice farming is a major occupation of Thai farmers. In 2015-2016, Thailand had a rice production area of 69.25 million *rai* (1 *rai* = 0.16 ha) with around 4.16 million

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rice farmer households. The country earned revenue of 200 billion Baht annually (20% of GDP) from rice exports (Ministry of Agriculture and Cooperatives, 2017). With intense international competition, rice production in a large quantity and high quality, matched with the needs of importing countries, is crucial. Thus, it is necessary for Thailand's government to promote and support farmers to achieve such requirements. In Thailand, most rice farmers are smallholders who practice agriculture on an individual basis. Farmer groups are few and scattered. As such, product costs are high as the farmers obtain their production inputs individually rather than collectively. Moreover, support in terms of rice production technology has not widely reached these smallholders.

In oerder to support smallholder rice farmers the Ministry of Agriculture and Cooperatives (MOAC) initiated a collaborative farming (CF) project to support rice production to meet market standards and to increase yields using efficient production technology. With this project it is expected that farmers would gain more income and be self-reliant. The CF project supports farmers to form a group to which MOAC provides training, production inputs, and rice production technology. In this group, appropriate technology is recommended to be applied so as to reduce production costs and increase product quality. Members of the group have to collectively sell their products and buy production inputs. As a group, the farmers would also have more negotiation power vis-s-vis traders (MOAC, 2017).

The CF project has promoted production technology such as Good Agricultural Practice (GAP), soil analysis, and organic fertilizer. From an assessment of the CF project in 2016, it was observed that for those farmes adopting rice production technology, their rice yields/ *rai* had increased from 573.06 kg to 655.63 kg. The farmers also reduced their rice production costs from 4,213 Baht/ *rai* to 3,268 baht/ *rai* (Thirapong, 2018). This assessment also indicates that one of the CF project's success factors is technology adoption (Thirapong, 2018). The adoption of rice production technology is vital. However, since the CF project was implemented in 2015, participating farmers have not widely adopted such technology.

Phrae is a northern province of Thailand in which the CF project has been implemented since 2016. According to the Rice Department (n.d.), a large number of farmers in this province used production inputs improperly. Before the CF project was put in place, Phrae's farmers also had the highest rice production costs (5,803 Baht/ *rai*) compared to farmers in other provinces who participated in the project (Thirapong, 2018). Since the CF project was launched, there has been no research on the adoption of rice production technology in this context (see Janthong and Sakkatat, 2015; Bunsong, 2017;

Paowsrakoo1 and Wongsamun, 2018). Thus, this study focused on the adoption of this technology, particularly its influencing factors. Insights gained from this research could be used by concerned government offices to promote rice production technology to achieve a high adoption rate.

Materials and Methods

Data for this research were collected in Phrae province in 2018. It is a correlational research design aiming to identify factors affecting farmers' rice production technology adoption. The target population was 407 rice farmers in three districts of Phrae province who participated in the collaborative farming (CF) project in the fiscal year 2016 (Phrae Provincial Agricultural Extension Office, 2017). Sampling size of 202 farmers was calculated using Taro Yamane's formula (Yamane, 1973). Proportional stratification sampling technique was employed to select 57 farmers from Muang district, 85 farmers from Sung-men district, and 60 farmers from Song district for a structured interview.

Statistics used for data analysis were descriptive statistics (frequency distribution, percentage, mean, and standard deviation) and inferential statistics (binary logistic regression analysis). To analyze factors affecting the farmers' technology adoption, the independent variables included gender, age, education, number of household members, rice farming experience, number of farm machines, number of agricultural laborers in the household, household income, agricultural group memberships, information received relating to the CF project, contacts with agricultural extension officers, training attendance on rice production technology traning, farmers' attitude towards the project's benefits, farmers' attitude towards support provided by the project, and problems relating to the project. The dependent variable was the adoption of rice production technology.

In this research, binary logistic regression analysis was applied, which can be specified as:

$$P(Y_i=1) = \log \frac{P}{1-P} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p \quad (1)$$

$$P = \frac{1}{1+e^{-(\beta_0+\beta_1 x_1+\beta_2 x_2+\ldots+\beta_p x_p)}} \quad (2)$$

$$\text{Odds} = \frac{\text{P(Adoption)}}{\text{P(Non-adoption)}} = \text{Exp(B)} \quad (3)$$

Where P is the probability of at least one rice production technology strategy being adopted, ranging between 0 and 1; Y is the dependent variable (1 = adoption; 0 = non-adoption); β_0 is the Y intercept; β_1 to β_p are the coefficients of the independent variables x_1 to x_p; e is a natural log; and, i = 1 - n (n is number of observations). The description of all variables used for this study is presented in Table 1.

Table 1. Variables used in the empirical model

Variable name	Measurement
Dependent variable (Y)	
Adoption of rice production technology	1 = Adoption 0 = Non-adoption
Independence variables (X)	
- Gender (x_1)	1 = Male, 0 = Female
- Age (x_2)	Years
- Education (x_3)	Years of formal education
- Household members (x_4)	Number of household members
- Rice farming experience (x_5)	Years
- Farm machinery (x_6)	Number of farm machines
- Household's agricultural laborers (x_7)	Number of agricultural laborers
- Household income (x_8)	Baht/Year
- Agricultural group membership (x_9)	Number of group memberships
- Information received relating to the CF project (x_{10})	Average score
- Contacts with agricultural extension officers (x_{11})	Times/month
- Attendance of rice production technology training (x_{12})	Times/year
- Farmers' attitude towards the CF project's benefits (x_{13})	Average score
- Farmers' attitude towards support from the CF project (x_{14})	Average score
- Problems relating to the CF project (x_{15})	Average score

The dependent variable, the adoption of rice production technology was measured by followed the method of Rogers and Shoemaker's adoption process (1971), which consisted of five stages to determine whether farmers adopted any rice production technology. The stages are awareness, interest, evaluation, trial, and adoption. If farmers answered to accept rice production technology into practice (i.e. the adoption state), the researcher would identify whether they fully adopted the technology. However, if the farmers' answers were in other stages (e.g. interest or trial), this would be considered as non-adoption. There are seven technologies promoted by the CF project. These are the use of breeder rice seed from the CF project, leguminous crop growing to maintain soil fertility, own fertilizer making, chemical fertilizer use based on soil analysis, organic fertilizer application, bio-based substance utilization, and rice-growing based on Good Agricultural Practice (GAP). Therefore, a farmer would be identified as a technology adopter if he or she accept at least five of the seven rice production technologies into practice and would be assigned as value 1. If farmers who accepted into practice less than five technologies that would be identified as non-adopters and would be assigned as value 0.

Results

Socio-economic characteristics of farmers participating in the CF project

It was found that 57.4% of the farmers were female, and nearly 50% were aged between 51–60 years, with an average age of 55.7 years. A majority of the farmers completed their study at the primary education level (71.7%). The farmers had four household members on average, while a large number of them (64.9%) had two agricultural laborers in their household. They had rice farming experience of 24.31 years on average. More than half of the farmers (56.4%) had 1-10 *rai* of land for rice production, and a number of farmers (60.9%) had no agricultural machinery. The household income of the farmers was 56,1845 Baht/year on average, with 61.4% of them having an income of 50,000 Baht or less per year.

Regarding group memberships, it was found that 55.9% of farmers were members of groups other than the CF project. Many were members of agricultural cooperatives. A number of farmers (60.4%) contacted agricultural extension officers once or twice a month; however, only 40.6% of them attended rice production technology training four to six times a year (Table 2).

Farmers' attitude towards the CF project

The study explored farmers' attitudes towards the CF project in four aspects (Table 3). It was found that farmers were rather positive about the projects as indicated by the perceived benefits ($\bar{x}$ = 3.92) and support ($\bar{x}$ = 3.81) from the CF project. Farmers received information on the project at a moderate level ($\bar{x}$ = 3.28). They obtained this information from various sources, such as agricultural extension officers and community leaders, as well as the CF project's training. Farmers did not encounter severe problems relating to the project ($\bar{x}$ = 2.74). Farmers suggested only one issue that seriously concerned as inadequate provision of production inputs from the project.

Farmers' adoption of rice production technology from the CF project

The CF project has promoted seven rice production technologies as previously mentioned. From the results, it was found that for each type of technology, 54.4% – 65.4% of the farmers adopted the technologies. Overall, a little over half of the farmers (54.6%) adopted into practice at least five technologies. The top three technologies which the farmers had mostly adopted were chemical fertilizer application based on soil analysis, breeding rice seeds from the project, and leguminous crop growing to maintain soil fertility. Technology which farmers had least accepted into practice was Trichoderma bioformulation as shown in Table 4.

Table 2. Socio-economic characteristics of rice-growing farmers the three districts of Phrae province

n = 202

Characteristics	Categories					$\bar{X}$ (S.D.)
Gender	Male 42.6%	Female 57.4%				
Age (years)	≤ 30 2.0%	31-40 3.5%	41-50 22.7%	51-60 42.1%	≥ 61 29.7%	55.68 (9.314)
Education	Primary 71.7%	Secondary 13.4%	High School 10.4%	Diploma 3.0%	Bachelor's Degree 1.5%	
Household members (persons)	1–3 37.6%	4–6 55.9%	7–10 6.5%			3.98 (1.588)
Rice farming experience (years)	1–10 22.8%	11–20 28.2%	21–30 27.7%	31–40 14.9%	41–50 6.4%	24.31 (12.438)
Land for rice-growing (*rai*)	1–10 56.4%	11–20 33.7%	21–30 5.9%	≥ 31 4%		11.48 (9.169)
Household's agricultural laborers (persons)	1 18.8%	2 64.9%	3 10.8%	≥ 4 5.5%		2.06 (0.847)
Agricultural machinery	No 60.9%	Yes 39.1%				
Household income (Baht/year)	≤ 50,000 61.4%	50,001 – 100,000 23.2%	100,001–150,000 10.4%	150,001 – 200,000 2.0%	≥ 200,001 3.0%	56,184.66 (56,189.718)
Group memberships	No 44.1%	Yes 55.9%				
Contact with agricultural extension officers (times/month)	1–2 60.4%	3–4 32.7%	5–6 6.9%			2.33 (1.343)
Attendance of rice production technology training (times/year)	1–3 25.7%	4–6 40.6%	7–9 25.3%	11–12 7.9%	13–15 0.5%	5.41 (3.015)

Table 3. Farmers' attitude towards the CF project

n = 202

Item	$\bar{x}$ (S.D.)	Indicator
Benefits of the CF project	3.92 (0.72)	Agree
Support from the CF project	3.81 (0.80)	Agree
Information on the CF project	3.28 (0.64)	Moderate
Problems relating to the CF project	2.74 (1.08)	Moderate

Table 4. Farmers' adoption of rice production technology

n = 202

Rice production technology	Adoption Process				
	Awareness stage frequency (%)	**Interest stage** frequency (%)	**Evaluation stage** frequency (%)	**Trial stage** frequency (%)	**Adoption stage** frequency (%)
Use of breeding rice seeds from the project	16 (7.9)	31 (15.3)	7 (3.5)	17 (8.4)	131 (64.9)
Leguminous crop growing to maintain soil fertility	19 (9.4)	30 (14.8)	4 (2.0)	19 (9.4)	130 (64.4)
Own making fertilizer	31 (15.2)	25 (12.3)	15 (7.3)	20 (9.8)	111 (55.4)
Chemical fertilizer based on soil analysis	22 (10.9)	18 (8.9)	13 (6.4)	17 (8.4)	132 (65.4)
Organic fertilizer application	12 (5.9)	21 (10.4)	14 (6.9)	26 (12.9)	129 (63.9)
Trichoderma bioformulation	25 (12.4)	29 (14.4)	14 (6.9)	24 (11.9)	110 (54.4)
Rice growing based on GAP	19 (9.4)	28 (13.8)	22 (10.9)	9 (4.5)	124 (61.4)

Factors affecting farmers'adoption of rice production technology

The logistic regression resulted that the factors influenced in farmers' adoption of rice production technologies from the CF project are shown in Table 5. The Hosmer and Lemeshow test showed a Chi-Square value of 10.79 and a *p*-value of 0.214. This means that the logistic regression model was suitable for explaining the relationship between variables in the equation. The value of the model Chi-Square statistics was 68.70 and *p*-value was 0.000 revealing that the probability for farmers' adoption of rice production technologies depended on at least one independent variable in the model. The calculation of Pseudo R^2 yielded Cox and Snell R Square and Nagelkerke R Square values of 0.288 and 0.387 respectively, indicating that all predictive variables supported a prediction of 28.8% and 38.7% that the farmers would adopt rice production technologies.

From data analysis, six variables were found to be statistically significant in relation to the dependent variable in the logistic regression equation. Rice farming experience, household income, and training attendance had positive effects on technology adoption and statistically significant at a 5% level. Contact with agricultural extension officers had a positive effect and statistically significant at a 1% level. Farmer's gender and problems relating to the project had a negative effect on technology adoption and were statistically significant at 5% and 1% level, respectively.

Table 5. Results of logistic regression analysis of factors affecting farmers' adoption of rice production technology

n = 202

Predictor Variables	Model					
	B	**S.E.**	**Wald**	**df**	**Sig**	**Exp(B)**
- Gender	-0.911	0.391	5.422	1	0.020*	0.402
- Age	-0.027	0.025	1.107	1	0.293	0.974
- Education	-0.117	0.078	2.232	1	0.135	0.890
- Household members	-0.055	0.123	0.198	1	0.656	0.947
- Rice farming experience	0.036	0.018	4.040	1	0.044*	1.037
- Farm machinery	-0.085	0.178	0.229	1	0.632	0.918
- Household's agricultural laborers	-0.368	0.234	2.471	1	0.116	0.692
- Household income	0.000	0.000	4.314	1	0.038*	1.000
- Group membership	-0.088	0.142	0.383	1	0.536	0.916
- Information on the CF project	-0.106	0.319	0.110	1	0.740	0.900
- Contacts with agricultural extension officers	0.489	0.157	9.737	1	0.002**	1.631
- Attendance of rice production technology training	0.151	0.067	5.084	1	0.024*	1.163
- Farmers' attitude towards the CF project's benefits	0.759	0.474	2.563	1	0.109	2.137
- Farmers' attitude towards support from the CF project	0.313	0.384	0.666	1	0.414	1.368
- Problems relating to the CF project	-0.629	0.240	6.844	1	0.009**	0.533
Constant		**2.390**	**0.226**	**1**	**0.635**	**0.321**

Note: *p-value <0.05; **p-value <0.01

Hosmer and Lemeshow Test: Chi-square = 10.79 Sig = 0.214

Chi-square = 68.70 Sig = 0.000, -2 log-likelihood = 207.98

Cox and Snell R square = 0.288, Nagelkerke R square = 0.387

Discussion

The study revealed that 54.4%-65.4% of farmers adopted seven rice production technologies which is promoted by the CF project, only 54.6% adopted at least five of these technologies. The top three of well-received technologies were chemical fertilizers which based on soil analysis, use of breeder rice seed from the CF project, and leguminous crop growing to maintain soil fertility.

It can be seen that the adoption rate was relatively low (54.6% adoption). Various factors might have contributed to this situation. Chi and Yadama (2002) found that farmers' technology adoption depended on their education level, lower age, and high savings. Moreover, the low education, older age, lack of belief in new technology and lack of consideration of different dimensions of technology were found to be factors which inhibited technology adoption. For the present study, it was observed that most farmers who joined the CF project were relatively senior with an average age of 55.68 years. Indeed, the majority (71.8%) was at the age of 50 years or older (Table 2). Generally, they had a low level of formal education (i.e. a primary education), and low household income (4,682.05 Baht/month)[*]. Following Chi and Yadama (2002), farmers' older age, as well as low education level and low household income might influence the adoption of rice production technologies promoted by the CF project.

Regarding rice production technologies adopted by the farmers, chemical fertilizers use based on soil analysis, breeding rice seeds from the project, and leguminous crop growing to maintain soil fertility were the most accepted to practice. This may be involved in these technologies that appropriated to apply. The technology of chemical fertilizers based on soil analysis seems to be complicated. However, the farmers learned from training that applying chemical fertilizers helped to reduce production costs and increased yields. Moreover, government officers provided the service for soil analysis.

Rogers (1983) stated that transfer of appropriate technology to farmers should be valuable or have relative advantages compared to traditional ones. They should also not be difficult or complicated to apply. Thus, it is not surprising to observe that technologies such as Trichoderma bioformulation, rice growing based on GAP, and own making fertilizer were least adopted. For Trichoderma bioformulation, farmers had to prepare a recommended Trichoderma bioformulation for plant disease control on their own. This process is rather complicated, and farmers might find it difficult and inconvenient to accept into practice. To make own mixing chemical fertilizer also involves a complicated process. GAP is a technology based on a number of strict regulations, farmers may lack the comprehension and capacity to observe these regulations, resulting in low adoption.

This study found that six significant factors affected the farmers' adoption of rice production technology. They are discussed as follows:

Gender: Female farmers had a higher possibility of technology adoption from the project than their male counterparts. It was deducted that they had a

[*]Approximately 153 US$/month; 1 US$ = 30.52 Baht (as of 9 October 2019)

prediction of technology adoption of 59.8% which higher than male farmers. This is in accordance with Traiyawong *et al.* (2017) who found that female farmers adopted technology more than male farmers. They considered that may be due to females were gentle, and careful, including working and take care of family. Thus, adoption occurred more in females than males. Tanellari *et al.* (2014), observed the opposite in their study on groundnut production technology adoption, where female adopted the technology less than male.

Rice farming experience: Farmers who had more experience in rice farming had a higher possibility of adopting technology than those with less experience. The farmers with extensive rice farming experience had a prediction of adopting technology 1.037 times more than those with less experience. This may be due to more experience, and understand the problems relating to rice production. Training on rice production technology, farmers would realize the benefits of the technology and accepted to practice to solve their rice production problems or to improve their rice production. The finding was agreed with Abubakar *et al.* (2016) who found that agricultural experience was a significant factor influencing a decision to adopt technology.

Household income: Farmers with a high household income had higher possibility of appling the technology than low household income. The high household income that might have money to invest in production inputs which required for applying the promoted technologies, e.g. chemical fertilizers to be applied following soil analysis, or materials to compost their own chemical fertilizers. Similarly, Devi and Ponnarasi (2009) who studied the adoption behavior of farmers in Tamil Nadu, India, found that farming income affected the adoption of modern rice production technology.

Contacts with agricultural extension officers: Farmers who frequently communicated with agricultural extension officers were more adopted the technology than less communicated ones. The farmers with many communication with the officers had a prediction of technology adoption more than their counterparts with fewer communication. The farmers would have an opportunity to ask questions to agricultural extension officers for knowledge and experiences, and discussed the particular problems. Therefor, farmers would gain more knowledge and confidence in applying the promoted technologies. This finding is in accordance with that of Devi and Ponnarasi (2009) who found that for every one time that farmers contacted officers, the rate of adoption increased to 2.2 times. Likewise, Donkoh and Awuni (2011) discovered that contacts with officers had a positive effect on transplanting rice cultivation technology which keep in touch with relevant officers, farmers had opportunities to learn, prepared and practiced new technology in their farms.

Attendance of rice production technology training: Farmers who had more participated in training which organized by the CF project had high possibility of technology adoption than less participation.The farmers with more training attendance are adopted technology 1.163 times which more than less training attendance. Some technologies, such as rice growing based on GAP and own compossing fertilizer, can be difficult to learn. Thus, training would enhance knowledge and understanding, as well as skills in rice production technologies, resulting in farmers' increased confidence and appreciated the benefits of promoted technologies. A similar result was observed by Abubakar *et al.* (2016) who stated that training participation was found a positive and statistically significant correlation to farmers' technology adoption. They indicated that farmers who frequently attended in training would gain technical skills and additional detailed knowledge necessary for better usage of technology.

Problems of participating farmers: Farmers who had many problems were less adopted technology than those with fewer problems. The farmers with few problems are predicted to adopt technology at 53.3% which more than those with several problems.

This study found that farmers who participated in the CF project did not adopt rice production technology as much as expected. This may be due to farmers' lack of the benefits, they expected to receive technology adoption. Therefore, the CF project officers should inform participating farmers about these benefits. The farmers should also be encouraged to participate in training where simplified technology content is provided. Moreover, the CF project officers should be followed up technology by assistance to promptly provided in case of the farmers needed. A farmer group should be formed, where farmers can share their knowledge and experiences. It is suggested that unity and trust can be key factors leading to the success of farmers' technology adoption (Rahimi and Moghaddam, 2014). Therefore, the CF project officers should encourage the farmers to work together to help each other in adopting the technology. With these suggestions, rice production technology would be widely adopted.

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