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Factors affecting farmers' decisions on utilization of rice straw compost in Northeastern Thailand

Poungchompu Supaporn [a,*], Tsuneo Kobayashi [b], Chantanop Supawadee [c]

[a] *Dept. of Agricultural Economics, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand*
[b] *Dept. of Coastal Bioenvironmental Center, Saga University, Saga, Japan*
[c] *Dept. of Economics, Northeast University, Khon Kaen, Thailand*

Abstract

Rice straw is used in Northeastern Thailand as an alternative to organic fertilizer for crop production. This enables farmers to reduce the use of chemical fertilizers which leads to a decrease in production costs. In spite of the beneficial effects in agricultural production, rice straw compost cannot be produced in large amounts because the burning of rice straws is a common farming practice. The decisions of farmers who use rice straw compost have been investigated by interviewing 120 households belonging to the members of an organic fertilizer user group using a household questionnaire. The study was conducted to evaluate the factors that affect the use of rice straw compost in Khon Kaen Province in Northeastern Thailand. Results of the logit model showed that the farmers' education, number of rice straw compost trainings in which the farmer participated, lack of knowledge about technology, insufficient labour and difficulty in making rice straw compost had a significant impact on the farmer's decision to use rice straw compost. Difficulty in making rice straw compost appeared to be the root cause because the procedure of making rice straw compost is complex and labour intensive. Repeated trainings thus, will have a positive and significant influence on farmers' adoption of the technology. Training provides more knowledge and will presumably change the perception of the farmers towards new technologies and the awareness of positive effects of rice straw compost utilization.

Keywords: compost, logit model, organic fertilizer, rice straw

1 Introduction

During the green revolution, chemical fertilizer use in the world increased from 27.4 million tons in 1959/60 to 143.6 million tons in 1989/90 (Bumb & Baanante, 1996). In relation to total world consumption, Asia's share of fertilizer use increased from 14 % in 1965-66 to 47 % in 1992–93 (Hossain & Singh, 1995). In recent years, the amount consumed increased from 3.4 million tons in 1996 to 3.65 million tons in 2003, making Asia the world's largest user of chemical fertilizers (Office of Agricultural Economics, 2009). Although the intensive use of chemical fertilizers has brought about a dramatic increase in rice production it has somehow resulted in a negative impact on the chemical, physical and biological properties of the soils which has led to a gradual decline in crop productivity. To alleviate this problem, governments in Asian countries have been promoting the utilization of several forms of organic fertilizers due to their great potential to increase crop yields, reduce production costs, and improve soil conditions. For example, Japan uses sludge (food processing wastes) to make compost in accordance with the recycling of agro-industrial wastes policy. Livestock manure is produced in huge quantities in Asia. In Korea about 35 million tons of manure are produced each year. The annual figures are 97 million tons of livestock manure in Japan and 6.6 million tons in Taiwan. Also compost is derived from crop by-products such as the residue from oil palm in Malaysia (Food and Fertilizer Technology Center, 2002). However, the frequency of adoption of

* Corresponding author
Email: psuppap@kku.ac.th

organic fertilizers by farmers in Asia is still low probably due to the worldwide food crisis, a greater demand for food as well as feed production (Food and Fertilizer Technology Center, 2010). An understanding of the factors that influence farmers' decision to use organic fertilizers is of great importance in order to promote the technology in Northeastern Thailand.

In 2008 the Thai government established an organic fertilizer promotion project in Khon Kaen Province with the aim of reducing the use of chemical fertilizer by farmers. Trainings on bio-fertilizer and compost making, including rice straw compost, were provided to several groups of farmers in the area. Regarding the making of rice straw compost, the rice straw is first soaked in water, then broadcasting manure and urea fertilizer on top of the straw layers and covering with plastic. The compost must be moistened frequently every 7 days. It is left unturned and within three months it has matured.

In order to enrol in this project, farmers from each village are required to form a bio-fertilizer group, which must consist of about 50 members. Once the group is formed, the Khon Kaen Land Development Centre (KK LDC) then provides the members with trainings on the creation and utilization of organic and biofertilizers. There are several kinds of organic materials available in Northeastern Thailand. Of these materials, rice straw shared the largest proportion (48.2 %), followed by plant leaves (25 %), animal droppings (12 %), and crop stubble (10 %) (Land Development Department, 2011). Nonetheless, burning rice straw is still a common practice in this area, causing a loss in organic matter and contributing to air pollution and global warming (Danutawat & Nguyen, 2007). The evidence from local farmers who have used compost, including rice straw compost, has indicated that the utilization of compost has reduced the need for chemical fertilizers (Environmental Protection Agency, 2012) and has improved soil fertility (Pairson *et al.*, 2007) and consequently led to a decrease in fertilizer costs (Environmental Protection Agency, 2012). It has increased crop yield such as the increasing percentage of rice yield of 13 percentages with chemical fertilizer application (Suthep *et al.*, 2001) and total NPK uptake in rice plant grown in acid sulfate soil with chemical fertilizer application (Jongruk *et al.*, 1992). Despite its beneficial effects and strong support from the government, rice straw compost is still not widely used in this area. Therefore, in order to form a more effective promotion strategy for the utilization of rice straw compost, a better understanding of the decision-making process of the farmers regarding rice straw compost utilization is needed. It has been well recognized that adopting the technology is influenced by socio-economic (Feder *et al.*, 1985; Neupane *et al.*, 2002; Rogers, 2003).

Although the factors that affect farmers' decisions to adopt new technology have been widely reported, in the factors that influence farmers' decision on the utilization of rice straw compost in Northeastern Thailand, are not known. Therefore, this study has been conducted to determine the factors that influence farmers' decision on the adoption of rice straw compost in the Khon Kaen Province of Northeastern Thailand. The study will also explore the hypothesis that older farmers, higher education levels, larger farm sizes, higher levels of training on rice straw compost-making, and sufficient government support will have a positive impact on the adoption of the rice straw compost technology. Conversely, insufficient labour, a lack of knowledge on straw compost, and difficulty in making straw compost will have a negative impact on the adoption of the technology.

2 Materials and methods

2.1 Data collection

This study was carried out in Khon Kaen Province in the upper Northeastern region of Thailand that is located in the northeast of Bangkok and lies 16° 26' 0" North, 102° 50' 0" East (KhonKaen, 2012). Trainings on bio-fertilizer and compost making have been provided to several groups of farmers in the area. The sites selected are located in the Muang Khon Kaen, Phrayun and Chumphae Districts of Khon Kaen Province. These are the areas where the KK LDD has provided trainings on rice straw compost for farmers and has organized organic fertilizer groups in the villages. Six villages were chosen where farmers use rice straw compost after obtaining training from the KK LDD. Manure and organic fertilizers are also the two most important types of fertilizers used in the studied villages. A formal survey with a questionnaire interview was conducted between April 2008 and March 2009. In the six villages, a total of 268 households were a member of an organic fertilizer user group from which 120 households were selected randomly and farmers interviewed. The numbers of sampled households in each village were 23, 31, 34, 8, 5, and 19 for Noontoon Village of Muang Khon Kaen District, Chard Village of Phrayun District, Nonthonglang Village of Chumphae District, Nonsaowlao Village of Chumphae District, Wangyaow Village of Chumphae District, and Dontad Village of Muang Khon Kaen District, respectively. The data obtained was analyzed using a logit regression model while descriptive statistics were analyzed using the SPSS 17.0 statistics software (SPSS Inc., 2011).

2.2 The study approach

The logit regression method was used to determine the factors that have significant influence on the adoption of rice straw compost in the studied area. This method was chosen because it is a standard method of analysis when the outcome variable is dichotomous (Hosmer & Lemeshow, 2000), and when the adoption of agricultural technologies is measured as a dichotomous response variable having a value of 0 or 1, where 0 = non-adoption and 1 = adoption of the innovation. The logit linked function was employed in the analysis. The equation is as follows:

$$Y = ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon \quad (1)$$

Where P_i is a probability of adopting the use of rice straw compost, $P_i = 0$ indicates no adoption and $P_i = 1$ indicates adoption.

Y = probability of adopting a use of rice straw compost
β_0 = intercept
$\beta_1 - \beta_8$ = regression coefficients of the dependent variables
X_1 = farmer's age
X_2 = farmer's education
X_3 = rice cultivated area
X_4 = number of rice straw compost trainings
X_5 = insufficiency of labor
X_6 = a lack of knowledge on straw compost
X_7 = governmental support
X_8 = difficulty in making rice straw compost
ε = disturbance term

Adoption probability by the present of each factor (X_i) was estimated by:

$$\hat{P}_i = \frac{e^{\beta_0+\beta_m}}{1+e^{\beta_0+\beta_m}} \quad (2)$$

Where β_0 is the intercept; β_m is the regression coefficient for the m variable estimated from equation [1]; and e is the exponential constant.

The dependent variable Y is the probability of a dummy variable that takes on the value of 1 if the farmer has used rice straw compost for agricultural production and 0 if the farmer has not used rice straw compost. Eight independent variables (X_1 to X_8) were included in the model. These include variables that relate to each farmer's characteristics (age and education), the characteristics of each farm (cultivated areas), the source of information, and each farmer's attitude towards the creation and application of rice straw compost (Table 1).

Table 1: *Variables used in the empirical model*

Variable name	*Value or unit of measurement*
Dependence variable (Y)	1, if farmer use straw compost 0, if farmer do not use straw compost
Farmer and farm characteristics	
Farmer's age (X_1)	Number of years
Farmer's education (X_2)	Number of years
Rice cultivated area (X_3)	Number of hectares
Source of information	
Rice straw compost training (X_4)	Number of times attended
Attitude toward rice straw compost application	
Insufficient labor (X_5)	1, if farmer agrees that it is a problem 0, if otherwise
Lack of straw compost knowledge (X_6)	1, if farmer agrees that it is a problem 0, if otherwise
Sufficient encouragement from government on rice straw compost application (X_7)	1, if farmer agrees 0, if otherwise
Difficulty in making straw compost (X_8)	1, if farmer agrees that it is difficult 0, if otherwise

3 Results

3.1 *Characteristics of user and non- user of rice straw compost*

Of the 120 households interviewed, only 28.3 % used rice straw compost while the remaining 71.7 % did not use the technology (Table 2). The main motivation of using compost is the advantage of rice straw compost for agricultural production (41.1 %) followed by a promotion of related agent (32.4 %) and an application of residual crop for organic fertilizer (26.5 %). On average, there were no significant differences between the farmers who used and those who did not use rice straw compost in age (52.5 years vs. 55.3 years for users and non-users, respectively), education (5.6 years vs. 4.8 years in school for users and non-users, respectively) and rice cultivated area (1.78 ha vs. 1.73 ha for users and non-users, respectively). However, the farmers utilizing rice straw compost had received three times more training sessions on rice straw compost making and utilization than those who did not use the technology (Table 2). Both users (31 of 34 farmers) and non-users (51 of 86 farmers) of compost agreed that a lack of knowledge regarding the production of compost is a problem for the utilization of rice straw compost. However, the proportion of farmers who agreed that knowledge is important was significantly ($p<0.01$, χ^2) greater for those who used straw compost (91.2 %) than those who did not use rice straw compost (59.3 %). About 70 % of the farmers, who used straw compost, believed that insufficient labour is a significant factor ($p<0.05$, χ^2) that determines the utilization of rice straw compost as compared to 52.9 % of farmers who did not use straw compost. Both users (10 of 34 farmers) and non-users (24 of 86 farmers) of compost agreed that the encouragement from the government regarding rice straw compost utilization was sufficient. Although farmers viewed that encouragement from the government was insufficient, this factor had no significant influence on their decision to utilize rice straw compost. A significant ($p<0.05$, χ^2) percentage (55.9 %) of rice straw compost users, agreed that the difficulty in making rice straw compost is an obstacle to its utilization since much effort is needed (Table 2).

3.2 *Factors affecting farmers' decision on rice straw compost utilization*

The results of the logit regression analysis (Table 3) show the overall percentage of case correctness for the model stands at 71.1 %. The model correctly predicted 87.2 % of the users of rice straw compost. Goodness of fit measures indicated that the model is acceptable. The likelihood ratio was significant ($p<0.05$), indicating that the amount of variation explained by the model is significantly different from zero. The generalized R^2 value, a commonly used measure for goodness of fit for binary choice models was 0.336, which means that 33.6 % of the total variation in the dependent variable could be explained by the X variables that were included in the logit model. This value is within the commonly acquired range of R^2 values (0.2–0.5) for logit models with respect to an analysis of cross-sectional data (Capps Jr. & Kramer, 1985). A Hosmer-Lemeshow statistical test gave a p-value of 0.694, which indicated that the model fits reasonably well.

The results of the logit regression analysis indicated that among the eight independent variables included in the model, five were statistically significant in influencing a farmer's decision to utilize rice straw compost. These variables were farmer's education (X_2) (0.020^{**}), number of rice straw compost trainings (X_4) (0.015^{**}), insufficient labour (X_5) (0.074^{**}), a lack of knowledge on rice straw compost (X_6) (0.015^{**}), and the difficulty of making rice straw compost (X_8) (0.069^{**}). Farmer's educational level and the number of trainings attended had positive values on the coefficient estimates, indicating their positive influences on adoption. Conversely, insufficient labour, lack of knowledge, and the difficulty in making the compost had negative values on the coefficient estimates, indicating their negative influences upon the adoption of rice straw compost by farmers. Farmer's age (X_1) (0.128^{ns}), cultivated area of rice (X_3) (0.305^{ns}), and governmental support (X_7) (0.754^{ns}) had no significant influence on farmers' decision to adopt this technology. The results also indicated that the odds of adopting rice straw compost increased 1.294 times with an increase in educational level of the farmers (X_2), and increased 1.712 times with an increase in the number of trainings the farmers had received on rice straw compost production and utilization (X_4). On the contrary, the odds of adoption decreased 0.420 times due to insufficient labour (X_5), 0.174 times due to insufficient knowledge (X_6), and 0.407 times due to the difficulty in making rice straw compost.

4 Discussion

About 28 % of the respondents used rice straw compost partly due to 1) the advantage of rice straw compost for agricultural production, 2) a promotion of related agent and 3) an application of residual crop for organic fertilizer. In contrast, 72 % did not use rice straw compost probably due to: 1) the complex procedure of making rice straw compost, 2) longer period for decomposition and 3) insufficient straw. To produce rice straw compost, a large amount (1,000 kg) of rice straw is re-

Table 2: *Characteristics of adopter and non-adopter of rice straw compost in Khon Kaen Province, Thailand*

Variable	*Farmers who used rice straw compost (N= 34)*		*Farmers who did not use rice straw compost (N = 86)*		*t-statistic*
	Mean	*SD*	*Mean*	*SD*	
Farmer's age (years)	52.5	10.6	55.3	11.2	1.3 NS
Farmer's education (years)	5.6	3.1	4.8	1.6	–1.9 NS
Rice cultivated area (ha)	1.78	1.28	1.73	1.06	–0.2 NS
Rice straw compost training (times)	3.4	0.9	2.7	1.2	–2.9 *
Variable	Number of farmers	Percentage of farmers	Number of farmers	Percentage of farmers	χ^2
Insufficient labour					3.9 *
Disagree	16	47.1	24	27.9	
Agree	18	52.9	62	72.1	
Lack of knowledge on rice straw compost					11.3 **
Disagree	3	8.8	35	40.7	
Agree	31	91.2	51	59.3	
Sufficient encouragement from government on rice straw compost utilization					0.03 NS
Disagree	24	70.6	62	72.1	
Agree	10	29.4	24	27.9	
Difficulty in making rice straw compost					3.8 *
Disagree	15	44.1	22	25.6	
Agree	19	55.9	64	74.4	

NS = not significant; *, ** = significant at p<0.05 and p<0.1, respectively.

Table 3: *Results of logit regression analysis to study factors affecting farmers' decisions on utilization of rice straw compost in Khon Kaen Province, Thailand*

Variable [1]	*Estimate*	*SE*	*Sig.*	*Wald*	*Odd ratio* [2] *of adopting*	*Asymptotic 95 % CI*	
						Lower	*Upper*
X_1	–0.035	0.023	0.128 NS	2.316	0.966	0.924	1.010
X_2	0.257	0.110	0.020 **	5.442	1.294	1.042	1.606
X_3	0.034	0.033	0.305 NS	1.053	1.035	0.969	1.105
X_4	0.538	0.220	0.015 **	5.962	1.712	1.112	2.637
X_5	–0.868	0.485	0.074 **	3.198	0.420	0.162	1.087
X_6	–1.748	0.717	0.015 **	5.944	0.174	0.043	0.070
X_7	0.175	0.537	0.754 NS	0.106	1.191	0.416	3.409
X_8	–0.898	0.493	0.069 **	3.318	0.407	0.155	1.071
Intercept	–0.983	1.530	0.520	0.413	0.374	–	–

[1] See Table 1 for description of the X variables
[2] Odds ratio is the Exp(β)
NS not significant; *, ** significant at p<0.05 and p<0.01, respectively.
Number of observation: 120.00;
Likelihood ratio test (d.f. = 8): 31.984*; Nagelkerke R square: 0.336; Hosmer and Lemeshow test: 0.694;
Overall case correctly: 71.1; Correctly predicted: 87.2; Correctly predicted non: 44.1; –2 Log likelihood: 111.07

quired. In some instances farmers have to buy rice straw from other farmers in order to make compost.

The difficulty in making rice straw compost could be considered as the initial key factor influencing the adoption of the technology. In Northeastern Thailand, the procedure for making rice straw compost is rather complicated. In short, a pile of rice straw is soaked with water, sprinkled with urea and manure and covered on top with a plastic sheet to reduce moisture loss and enhance microbial activities. The pile is turned after every seven days until it is matured. The whole process can last for about ninety days (approximately three months). In such a long and complicated procedure, a thorough knowledge and sufficient labour force is required to produce rice straw compost. Additional labour is also needed to carry the compost to the field. These results are in line with the theoretical expectation that an innovation which is perceived as difficult to understand and to use and which requires the adopter to develop new skills and understandings will be adopted more slowly than a simple and easy technology (Rogers, 2003).

Considering all the necessary steps to produce rice straw compost, this can be regarded as a knowledge-intensive technology (Harryson *et al.*, 2007; Chong *et al.*, 2009). Knowledge and understanding about a certain technology has been viewed as an indicator of the level of adoption (Hadi *et al.*, 2010). The higher levels of education and experience have led to higher rates of utilization of new agricultural technologies (Khanna, 2001). The findings of the present study confirmed that the level of knowledge is an important factor in determining the adoption of rice straw compost. The results revealed that farmers with higher levels of education have adopted the rice straw compost technology more than those with lower levels of education probably due to the fact that a new technology is perceived as difficult to understand and therefore requires the adopter to develop new skills and understandings (Rogers, 2003). Also, this is partly due to the fact that the higher education levels had received more exposure to sources of technical information on fertilizer use (Omamo *et al.*, 2002; Omamo & Mose, 2001). The result is also consistent with the findings of Cooke (1982); Asomonye (1991), and Amanze *et al.* (2010).

Sources of information, including extension and training, also enhance the adoption of technology (Abebaw & Belay, 2001). Training on rice straw compost making and utilization has been used in the study area as a means of disseminating knowledge on the technology. However, farmers have not received enough training probably due to a limitation of time and budget from the local agency KK LDC promoting and demonstrating the technology on soil improvement. Single training was not sufficient for farmers to comprehend the complex procedure of rice straw making and utilization and to change their attitudes toward the technology. Thus, repeated trainings for either the same group or a new group of people are necessary. Repeated trainings, however, are costly and therefore the involvement of government and other funding agencies is deemed necessary. Improved training procedures should be devised as a part of monitoring and evaluation because it is a way of collecting and analyzing information about the trainings in order to improve them and to plan exercises. This would increase the effectiveness of both transferring knowledge and of changing farmers' attitudes. Activities such as the creation of a learning centre and a network to provide participatory learning, the sharing of knowledge and experiences on rice straw compost making and utilization should be organized. Moreover, such activities could serve as means to raise awareness about the positive effects of rice straw compost utilization. Because the process of making rice straw compost requires man-power for transport rice straw from field to compost site and back to the fields as well as for turning regularly the compost pile, over 70 % of the respondents who used rice straw believed that insufficient labour is one factor determining the utilization of rice straw since this labour must be paid additionally.

5 Conclusion

The study has concluded that the difficulty in making rice straw compost is one of the major factors influencing the adoption of the technology in Northeastern Thailand. Additional labour is also needed to carry the compost to the field. The number of training needs to be increased in order to comprehend the complex procedure of rice straw making and utilization and to change farmers' attitude toward the technology. Although the present study was limited to only those farmers who were the members of the organic fertilizer groups in the project villages, the findings should also be applicable to the other general farmers inside and outside the borders of Northeastern Thailand.

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