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https://doi.org/10.5109/6770297

出版情報：九州大学大学院農学研究院紀要. 68 (1), pp.101-109, 2023-03. 九州大学大学院農学研究院
バージョン：

J. Fac. Agr., Kyushu Univ., **68** (1),101–109 (2023)

Farmers' Use Intention Toward Environmentally Friendly Fertilizer: A Case Study of Bio–Concentrated Liquid Fertilizers

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(*Received October 28, 2022 and accepted November 2, 2022*)

In recent years, in the context of increasing environmental concerns in Japan, a growing number of consumers are more likely to purchase environmentally friendly agricultural products and foods, which gives a positive meaning for farmers to use environmentally friendly technology for agricultural production, such as using environmentally friendly fertilizers. A bio–concentrated liquid fertilizer (Bio–CLF), an innovative and environmentally friendly fertilizer derived from the current methane fermentation digested liquid fertilizers, was developed. However, producers' evaluation of Bio–CLF, especially the intention of farmers to use Bio–CLF, has not yet been clarified. To fill this gap, a logistic regression analysis was used in this study to analyze farmers' use intention toward Bio–CLF. The data were collected through an Internet survey administered in Japan by a market research company, and the final sample size was determined to be 263. The results indicated that farmers who had experience in using methane fermentation digested liquid fertilizer, and farmers with more knowledge of SDGs, were found to have a high intention to use Bio–CLF. Additionally, when compared with other management style farmers, outdoor vegetable farmers were found to be more likely to use Bio–CLF. Based on these results, we propose sales strategies for future Bio–CLF sales development.

Key words: Bio–Concentrated Liquid Fertilizers, Environmentally Friendly Technology, Farmers' Use Intention, Logistic Regression Analysis

INTRODUCTION

In recent years, in the context of increasing environmental concerns in Japan, an increasing number of consumers are more likely to purchase environmentally friendly agricultural products and foods. A consumer survey conducted by the Ministry of Agriculture, Forestry and Fisheries in November 2021 revealed that among the 5,000respondents, 15% declared that they "always choose" environmentally friendly agricultural products and foods, and the percentage of the respondents who "sometimes choose" is over 50%. Furthermore, the Ministry of Agriculture, Forestry and Fisheries has set a goal of increasing the percentage of people who choose environmentally friendly agricultural products and foods to 75% or more by 2025[1]. The results of the survey indicate a certain degree of purchase intention on the part of the consumer when environmentally friendly agricultural products are supplied. We believe that this viewpoint provides a positive meaning for farmers to use environmentally friendly technology for agricultural production, such as using environmentally friendly fertilizers.

One type of environmentally friendly fertilizer is methane fermentation–digested liquid fertilizer. Watanabe *et al*. (2012) emphasized that using methane fermentation–digested liquid fertilizer instead of inorganic fertilizers can indirectly reduce greenhouse gas emissions. Moreover, the raw materials of methane fermentation, such as animal waste, kitchen food waste, slaughterhouse waste, and so on, are emerging everywhere as waste and tend to cause environmental pollution (Zackariah and Tanaka, 2019). However, the area allocated for paddy fields in Japan is small; hence, processing animal waste, kitchen food waste, slaughterhouse waste, etc. involves high costs and challenges (such as handling the waste, and transportation) (Haga *et al*., 1979) to produce methane fermentation–digested liquid fertilizer. Consequently, in Japan, the utilization rate and spreading efficiency of methane fermentation–digested liquid fertilizers remain low.

In an effort to address the aforementioned issues, Yabe (2019) developed an innovative technology known as a bio–concentrated liquid fertilizer (Bio–CLF), which is based on methane fermentation digested liquid fertilizer derived from methane fermentation digested liquid. Referring to Yabe (2019), the benefits of Bio–CLF are listed in Table 1 as a comparison with methane fermentation–digested liquid fertilizer:

In addition to the advantages depicted in Table 1, Yabe (2019) highlighted that Bio–CLF will help farmers save the spread cost by 2,000 yen/ton at the laboratory level, and it will become easier to transport as it is in a concentrated form. Bio–CLF can also be spread in a horticultural facility as well as in hydroponic soil cultivation, where methane fermentation–digested liquid fertilizer

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[1] According to *The Japan Agricultural News*, 04/24/2022.

Table 1. Comparative of current and Bio–CLF technology digested liquid treatment

	Current digested liquid treatment	Bio–CLF technology digested liquid treatment
Solid Part	1. Hard degradability 2. Used as compost 3. Provide Industrial waste	1. Easily degradable 2. Used as Quick–acting fertilizer
Liquid Part	1. High suspended substance 2. High cost to discharge	1. Less suspended substance 2. Low cost to discharge 3. Provide Bio–CLF

Source: Yabe, (2019)

could not spread with ease before[2].

Because the problems of using methane fermentation digested liquid fertilizer are expected to be solved by using Bio–CLF, it is meaningful to determine farmers' use intention toward Bio–CLF. There has been some previous research on consumer purchase intent or resistance factors toward Bio–CLF products. For example, according to Wu *et al*. (2022a), even though rice cultivated using Bio–CLF (food waste, sake brewing waste, and milk waste) had a negative reputation among consumers when compared to rice grown using regular organic fertilizer, the marginal willingness to pay (MWTP) for Bio–CLF rice is still higher than that of most chemical fertilizer–cultivated rice. Additionally, when considering consumers' income, knowledge of organic fertilizer raw materials, and green product purchase intention, the MWTP of Bio–CLF rice will be significantly higher (Wu *et al*., 2022a). Wu *et al*. (2022b) found that perceived risk, complexity, and attitude toward existing products were found to have a positive and direct impact on consumer resistance to Bio–CLF products, while motivation and purchase intention was found to have a negative and direct impact on consumer resistance to Bio–CLF products.

However, producers' evaluation of Bio–CLF, especially the intention of farmers to use Bio–CLF, has not yet been clarified. To disseminate Bio–CLF, it is essential to clarify the intentions of farmers who will use Bio–CLF. Consequently, the objective of this study was to identify the attributes of farmers who are willing to use Bio–CLF and to identify the reasons why farmers are not willing to use it.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Based on previous research, we hypothesized the attributes that influence the intention to use Bio–CLF.

Compatibility is defined as "the degree to which an innovation is perceived as consistent with the existing values, past experience, and needs of the receiver" (Ram, 1987). Ram (1987) pointed out that the lower the perceived compatibility of an innovation, the higher its resistance. Mannan *et al*. (2017) found that among the relative advantages, compatibility, complexity, observability, and trialability factors, only compatibility has an impact on green fertilizer technology adoption among farmers. In the Bio–CLF spray method, the fertilizer is diluted with water and used on the crops or directly sprayed on farmland without dilution, which is similar to the spray method used in the current methane fermentation digested liquid fertilizer. Hence, it is considered that Bio–CLF is highly compatible with the current methane fermentation–digested liquid fertilizers. Therefore, farmers who have previously used methane fermentation–digested liquid fertilizer may easily use Bio–CLF.

Consequently, we hypothesize the following:

H1: Farmers who have experience in using methane fermentation–digested liquid fertilizer will have a high intention to use Bio–CLF.

We believe that the more knowledgeable farmers are about Sustainable Development Goals (SDGs), the more likely they are to use Bio–CLF. The SDGs were submitted at the United Nations Summit in September 2015, and the objective was to achieve17 goals and 160 targets by 2030. The SDGs are presented as "a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity," and the SDGs combine economic, social, and environmental dimensions, with a particular emphasis on social inclusion (Agarwal, 2018). Amadou (2020) conducted a survey of 69 farmers in Tahoua State and found that, among the 17 goals, the ninth goal (industry, innovation, and infrastructure), following gender equality, is the second most preferred SDG among farmers. The ninth goal includes the promotion of sustainable industrialization, such as the improvement of resource utilization efficiency and the expansion of the introduction of environmentally friendly technologies and industrial processes, as well as the promotion of innovation. This result suggests that farmers who know about SDGs may be interested in improving resource utilization efficiency and environmentally friendly technologies. As Nakamura *et al*. (2018) pointed out, a resource recycling system centered on methane fermentation can contribute to the achievement of SDGs. In addition, as mentioned above,

[2] Because ordinary methane fermentation digested liquid fertilizer contains suspended substance that may lead to the problem of horticultural facilities' pipes clogging. Hence, currently, it is mainly used to spray large–scale land–use crops.

because Bio–CLF has solved the problem of methane fermentation–digested liquid fertilizer, the spread of Bio–CLF can improve the effective utilization of organic waste and indirectly contribute to improving the agricultural environment. Therefore, it can be inferred that farmers with more knowledge of SDGs are more likely to have a positive evaluation of Bio–CLF.

Consequently, we hypothesize the following:

H2: Farmers with more knowledge of SDGs will have a higher intention to use Bio–CLF.

Income influences farmers' use intention toward Bio–CLF. Fall *et al.* (2015) mentioned that income can be a decisive factor in the adoption of new technology (mobile banking). Fall *et al.* (2015) also pointed out that the people who have a good income are those who work in manufacturing or sales businesses and clearly see an interest in using this type of innovation to facilitate business management as well as to reduce certain transaction costs. Additionally, to investigate the impact of the culture and individuals' cosmopolitanism on consumer innovativeness and innovation adoption behavior, Lim and Park (2013) conducted an online survey in the U.S. and South Korea, and the results indicated that respondents' income has a positive influence on their adoption of innovation in both countries. In addition, in the field of agriculture as well, there are previous studies that have revealed a relationship between income and the adoption of innovation. For example, Singha and Baruah (2011) highlighted that farmers' annual income had a significantly positive relationship with the extent of adoption of improved rice cultivation practices under different farming systems.

Based on the studies mentioned above, we hypothesize the following:

H3: Farmers with a high income will have a higher intention to use Bio–CLF.

METHODOLOGY

Analysis Model

Logistic regression analysis is a statistical analysis method used to predict a binary outcome, such as the results of a surgery or an entrance examination. A logistic regression model predicts those binary outcomes by analyzing the relationship between one or more independent variables. In this study, the outcome of farmers' intention to use Bio–CLF is a binary objective variable; hence, logistic regression analysis was applied. In reference to the study by Cramer (2004), the functions of the logistic regression model are described as follows:

Suppose that the probability of farmers' use intention toward Bio–CLF can be represented by the probability function $P(Z)$ as follows:

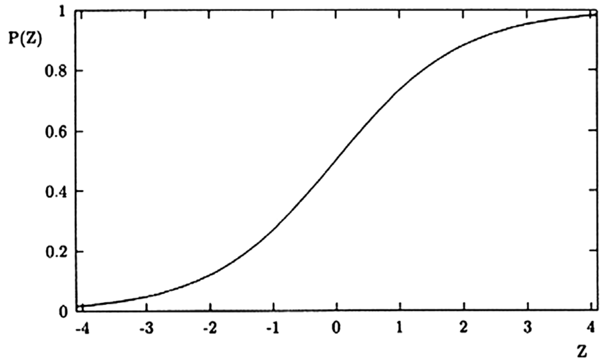

Fig. 1. The logistic curve
Source: Cramer (2004)

$$P\,(Z) = \frac{\exp Z}{1+\exp Z} \tag{1}$$

As Z moves through the real number axis, P rises monotonically between the bounds of zero and one and thus behaves like a distribution function, as depicted in Figure 1.

whereas, the function of Z is presented as follows:

$$Z = x^{T}\beta \tag{2}$$

where β is the coefficient and x is an independent variable such as sex, age, etc.

Data collection and sample characteristics

We collected data through an Internet survey administered in Japan by a market research company, Cross Marketing Inc. The data collection period was from February 9 to February 14, 2022. The target monitors were aged between 20 and 90 years and answered that their occupation was "agriculture, forestry, and fisheries." Furthermore, under the occupation "agriculture, forestry, and fisheries," there are five additional sub–occupations, which are presented below. We screened the monitors who selected agriculture. Subsequently, the monitors were randomly stratified according to the age ratio, and the collected sample size was 400[3].

Among these samples, the responses to the question "What is the main crop that you produce at your farm? (multiple answers allowed)" are presented in Figure 2. As can be observed from Figure 2, many respondents selected the options "Rice Farming" and "Outdoor Vegetables."

In addition, the targets of this research were farmers. According to the Ministry of Agriculture, Forestry and Fisheries[4], a "Farmer" is defined as a "Household engaged in farming with 1,000 m^2 or more of cultivated

[3] To estimate the potential demand for Bio–CLF, this questionnaire survey used part of the data collected from farmers, allotment gardens, and gardeners who are considered to be potential users of Bio–CLF. Therefore, we screened 5,000 monitors and obtained responses from 800 gardeners and allotment gardeners and 400 farmers. In addition, when registering as a monitor, we sent screening questions mainly to those who registered their occupation as farmers, forestry and fisheries.

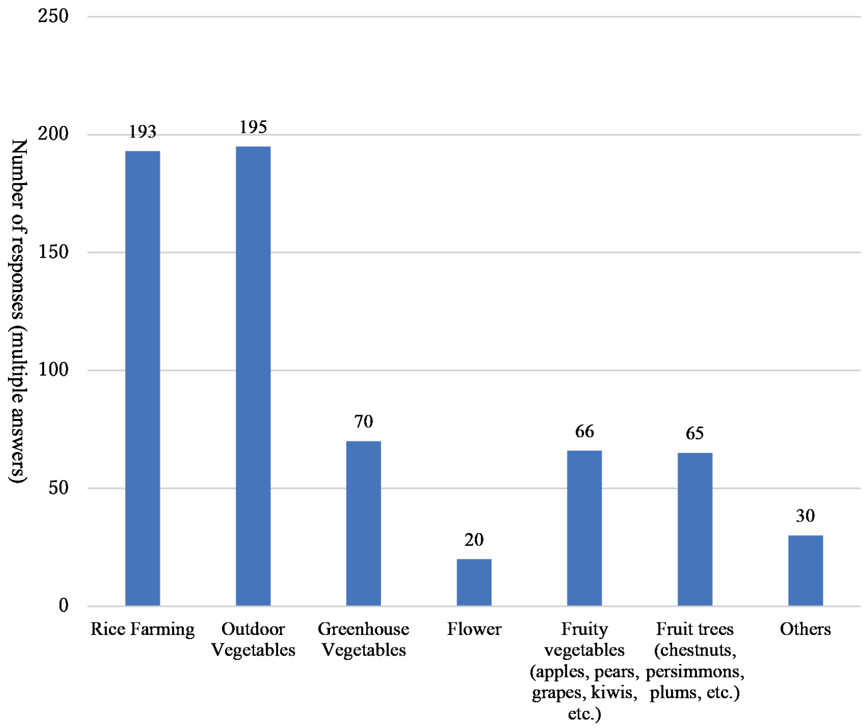

Fig. 2. Main crop type of the sample size

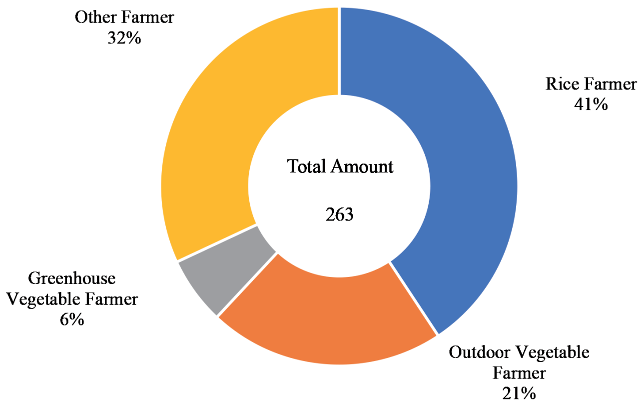

Fig. 3. Management type of sample farmers

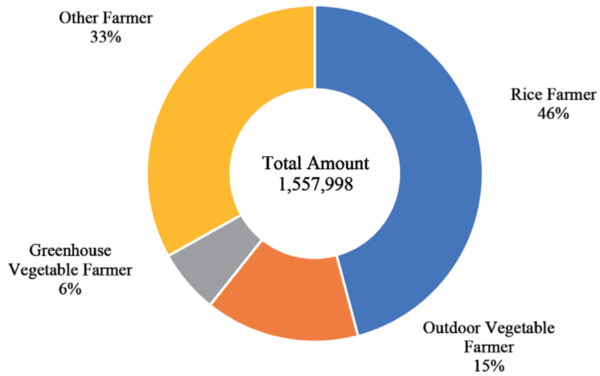

Fig. 4. Management type of farmers nationwide
Source: Japan Agriculture and Forestry Census 2020

land under management or households with sales of agricultural products amounting to 150,000 yen or more per year." Therefore, we screened samples with a cultivated area of 1,000 m^2 or less. Moreover, we also screened the samples that did not respond to household income. Finally, a sample size of 263 was used for the analysis. These 263 people were named "farmers" in this study[5]. Additionally, to grasp the characteristics of the target of analysis, we compared the management style of the target farms with that of farms nationwide based on the

[4] Ministry of Agriculture, Forestry and Fisheries "Explanation of Terms."
https://www.maff.go.jp/j/wpaper/w_maff/h22/pdf/z_all_8.pdf (in Japanese) Accessed on August 10, 2022

[5] These respondents were considered "farmers" for the following reasons. The area of cultivated land under management is 1,000 m^2 or more, and the occupation is "farming (rice farming, vegetables, fruits, flowers)." Therefore, even if household members of farming households registered as monitors, it is unlikely that the actual situation would be significantly different. However, as this questionnaire survey did not ask about the income from the sale of agricultural products, farmers could not be defined considering the income from the sale of agricultural products. On the other hand, "people who revealed their household income" were included in the category "household income" as an explanatory variable in the analysis.

[6] Referring to the Agriculture and Forestry Census 2020, the total, 1,557,998, includes Rice farmers (714,341), outdoor vegetable farmers (231,526), greenhouse vegetable farmers (95,761), and other farmers (516,370). Farmers included in the category "others" produce fruit trees (172,528), flowers (42,784), others (including rice for feed, 63,131), barley (40,422), cereals (24,413), potatoes (54,529), beans (67,388), and industrial agricultural products (51,175).
https://www.e–stat.go.jp/stat–search/file–download?statInfId=000032132502&fileKind=0 Accessed on August 10, 2022

Table 2. The definitions of the items in the questionnaire survey

Variable	Definition
Intention	Farmers' intention to use Bio–CLF. 0 = No, 1 = Yes.
Sex	0 = Female, 1 = Male.
Age	Year.
Family	Family members.
Income	Household income. 1 = under 2 million yen, 2 = above 2 million, under 4 million yen, 3 = above 4 million, under 6 million yen, 4 = above 6 million, under 8 million yen, 5 = above 8 million, under 10 million yen, 6 = above 10 million, under 12 million yen, 7 = above 12 million, under 14 million yen, 8 = above 144 million, under 16 million yen, 9 = above 166 million, under 18 million yen, 10 = above 18 million, under 20 million yen, 11 = above 20 million yen.
Area	The total area of agricultural products grown. Unit: 100 m^2.
Experience	The experience of using liquid fertilizer. 0 = No, 1 = I am still using or used in the past.
Well–known	0 = Else, 1 = I know more than half of the 17 development goals of the SDGs.
known	0 = Else, 1 = I know or have heard of some of the development goals of the SDGs.

Note: 1) Sample size is 263.
2) In the questionnaire, respondents were asked about their "annual household income," which was the same as the respondents' annual household income.
Source: Author

data from the Agriculture and Forestry Census 2020. The ratios of the management styles of the sample farms in this study are indicated in Figure 3.

Second, the ratio[6] of the management style of farmers nationwide is presented in Figure 4.

From Figures 3 and 4, we can observe that when compared with the data from the Agriculture and Forestry Census 2020, the percentage of rice farmers in this sample is slightly lower, whereas the percentage of outdoor vegetable farmers is slightly higher. Overall, the two structures were found to be similar.

The definitions of the items in the questionnaire survey are presented in Table 2. The dependent variable "*Intention*," comes from the question "If Bio–CLF is sold at the same price as the fertilizer you are using, would you like to use it?" The response to the question was evaluated on a 5–point scale, where "1" stands for "I do not want to use it at all" to "5," which indicates "I want to use it a lot, " and the variable "*Intention*" is equal to 1 when the responses are "4" (I want to use it) and "5" (I want to use it a lot) otherwise, it was equal to 0. Social attributes, such as gender, age, number of household members, and annual household income, were used as explanatory variables.

RESULTS

The results of the cross–tabulation are presented in Table 3. Among the 263 farmers, 36% intended to use Bio–CLF. More than half of the farmers had experience using methane fermentation–digested liquid fertilizer. In addition, only 11% of the farmers answered that they knew more than half of the 17 goals of the SDGs, while most of the farmers knew or had heard of some of the development goals of the SDGs. Moreover, from the perspective of the farmers by crop type, half of the outdoor vegetable farmers intend to use Bio–CLF. Regarding household income, the maximum annual income of greenhouse vegetable farmers was 4 million yen (above 6 million and under 8 million yen), which is lower than that of other farmers. In terms of the total area of agricultural products grown, it was found that farms of rice farmers were larger on average than other farmers.

Next, to clarify the reasons for farmers' resistance toward Bio–CLF, 169 farmers who had no intention of using Bio–CLF were selected from the sample, and a simple tabulation was performed. The results are presented in Table 4.

As can be observed in Table 4, the reason that accounts for the highest proportion is "1" (Ordinary fertilizers are sufficient), which was 56.8%. It was followed by "2" "Because it is a new or unknown technology, I am vaguely worried," which was 18.3%. After that, the reasons were "5" "As it is a liquid, it seems inconvenient to store and handle" (If it is in a granule or powder form, it is ok for me to use)," "3" "It is doubtful whether it is effective as a fertilizer," "4" "Because the same price as regular fertilizer is too expensive (if it is cheap, I will use

Table 3. The results of cross–tabulation by farmers' management style

Variable	Rice Farmer (*N* = 107)	Outdoor Vegetable Farmer (*N* = 56)	Greenhouse Vegetable Farmer (*N* = 16)	Other Farmer (*N* = 84)	Total (*N* = 263)
Intention					
Yes	30 (28.0%)	28 (50.0%)	7 (43.8%)	29 (34.5%)	94 (35.7%)
No	77 (72.0%)	28 (50.0%)	9 (56.3%)	55 (65.5%)	169 (64.3%)
Sex					
Male	90 (84.1%)	43 (76.8%)	10 (62.5%)	57 (67.9%)	200 (76.0%)
Female	17 (15.9%)	13 (23.2%)	6 (37.5%)	27 (32.1%)	63 (24.0%)
Age					
Mean (SD)	57.3 (12.2)	51.1 (13.5)	50.0 (11.6)	54.0 (10.5)	54.5 (12.2)
Median [Min, Max]	59.0 [26.0, 80.0]	49.5 [24.0, 74.0]	50.5 [22.0, 65.0]	54.0 [31.0, 78.0]	55.0 [22.0, 80.0]
Family					
Mean (SD)	2.35 (0.715)	2.29 (0.706)	2.44 (1.09)	2.29 (0.704)	2.32 (0.734)
Median [Min, Max]	2.00 [1.00, 5.00]	2.00 [1.00, 4.00]	2.00 [1.00, 5.00]	2.00 [1.00, 4.00]	2.00 [1.00, 5.00]
Income					
Mean (SD)	3.33 (1.84)	3.11 (1.64)	2.69 (1.20)	3.02 (1.92)	3.14 (1.79)
Median [Min, Max]	3.00 [1.00, 10.0]	3.00 [1.00, 8.00]	3.00 [1.00, 4.00]	3.00 [1.00, 11.0]	3.00 [1.00, 11.0]
Area (Unit: 100 m^2)					
Mean (SD)	363 (652)	220 (576)	173 (326)	246 (600)	283 (605)
Median [Min, Max]	140 [10.0, 4500]	50.0 [10.0, 3000]	33.5 [10.0, 1000]	65.0 [10.0, 4000]	90.0 [10.0, 4500]
Experience					
Yes	54 (50.5%)	34 (60.7%)	11 (68.8%)	49 (58.3%)	148 (56.3%)
No	53 (49.5%)	22 (39.3%)	5 (31.3%)	35 (41.7%)	115 (43.7%)
Well–known					
Have	11 (10.3%)	7 (12.5%)	4 (25.0%)	7 (8.3%)	29 (11.0%)
Else	96 (89.7%)	49 (87.5%)	12 (75.0%)	77 (91.7%)	234 (89.0%)
Known					
Have	86 (80.4%)	42 (75.0%)	11 (68.8%)	67 (79.8%)	206 (78.3%)
Else	21 (19.6%)	14 (25.0%)	5 (31.3%)	17 (20.2%)	57 (21.7%)

Note:1) For the classification standard of farm management style, we separated the main crops that the farmers state. Note that when multiple main crops are responded to, the crop with the largest cultivation area (e.g., rice) is taken as the management form of the farmer (e.g., rice farmers).
2) "Other Farmer" refers to farmers who grow flowers, fruit vegetables (apples, pears, grapes, kiwis, etc.), fruit trees (chestnuts, persimmons, plums, etc.), and other agricultural products.

it)," "6" "I do not know how to use it (if a user manual is enclosed, I will use it)." "8" "This is because there is resistance to the raw materials," and "7" "Because it is made from organic waste, it has an image that it smells bad."

In this study, we used the free software R (version4.1.2) and RStudio (version: 2022.02.0 + 443) for logistic regression analyses. The R packages used in the analysis were "DescTools" and "tidyverse." The results of the logistic regression analysis are presented in Table 5.

According to Table 5, because the value of the standard error of each independent variable is close to the value of the robust standard error, we can confirm that there are no problems with the model settings. Additionally, the results of the Hosmer–Lemeshow test indicated that the logistic regression model was adequately fitted to the data in this study.

Based on Table 5, we found that when the *family* increases by one unit, the probability of using Bio–CLF increases by 49%. In addition, when compared with their counterparts, farmers with prior experience using methane fermentation–digested liquid fertilizer were 3.951 times more likely to use Bio–CLF. Moreover, the coefficient of the odds ratio of the factors *Well–known* and *Known* indicated that farmers who were more knowledgeable about the SDGs were more likely to use Bio–CLF. Furthermore, when compared with other styles of farmers, outdoor vegetable farmers were around two times more likely to use Bio–CLF.

Table 4. The reasons for farmers' resistance toward Bio–CLF

Item	Percentage (%)
1. Ordinary fertilizers are sufficient.	56.8
2. Because it is a new or unknown technology, I am vaguely worried.	18.3
3. Because it is doubtful whether it is effective as a fertilizer.	14.8
4. Because the same price as regular fertilizer is too expensive (if it is cheap, I will use it).	14.8
5. As it is a liquid, it seems inconvenient to store and handle (If it is in the form of granules or powder, it is ok for me to use).	16.6
6. I do not know how to use it (if a user manual is enclosed, I will use it).	13.0
7. Because it is made from organic waste, it has an image that it smells bad.	2.4
8. Because there is resistance to raw materials.	9.5

Note: 1) Because multiple selections were allowed, the sum of the percentages exceeded 100%.
2) Sample size is 169.
3) There is almost no difference in the reasons for farmers' resistance depending on the planted area.

Table 5. The results of logistic regression analysis

Variable	Odds ratio	Coef.	SE	*p* value	Robust SE	*p* value
ASC	0.021	–3.850	1.042	0.000	1.052	0.000
Sex	1.244	0.218	0.359	0.544	0.361	0.546
Age	1.006	0.006	0.013	0.643	0.013	0.636
Family	1.490	0.399	0.206	0.053	0.199	0.045
Experience	3.951	1.374	0.309	0.000	0.308	0.000
Well–known	5.568	1.717	0.667	0.010	0.680	0.012
Known	2.899	1.064	0.539	0.048	0.539	0.048
Income	0.961	–0.040	0.085	0.641	0.082	0.627
Area	1.000	0.000	0.000	0.589	0.000	0.697
Rice	0.698	–0.359	0.349	0.304	0.350	0.305
Outdoor Vegetables	2.023	0.704	0.390	0.071	0.388	0.069
Greenhouse Vegetables	1.126	0.119	0.602	0.843	0.615	0.847
McFadden Pseudo R^2						0.136
AIC						320.167
Hosmer–Lemeshow test *p*–value						0.667
N						263

DISCUSSION

The purpose of this study was to identify the attributes of farmers who intend to use Bio–CLF, and in particular, to clarify what kinds of differences in farmer attributes, such as management styles, cause differences in the intention to use Bio–CLF. At the same time, the resistance factors associated with the use of Bio–CLF were identified.

Regarding the factors influencing farmers' resistance toward Bio–CLF, Table 4 indicates that, on the one hand, more than half of the farmers were satisfied with the current fertilizer. On the other hand, it was revealed that farmers were dissatisfied with the price of Bio–CLF, worried about the new technology, and were skeptical about its effectiveness. This factor coincided with the document presented by the Ministry of Agriculture, Forestry and Fishery, which mentioned that "farmers place importance on stable quality and low prices when selecting fertilizer suppliers (Ministry of Agriculture, Forestry, and Fishery, 2016)." In addition, farmers' resistance is perhaps influenced by the image of conventional methane fermentation–digested liquid fertilizer. Because the Bio–CLF is in a liquid form, as opposed to the conventional methane fermentation digested liquid fertilizer, the latter is perceived to be inconvenient to store and handle.

The results of the logistic regression analysis indicated that the main factors that influence farmers' intentions to use Bio–CLF were 1) the experience of using methane–fermentation–digested liquid fertilizer, and 2) the knowledge of SDGs.

First, it became clear that farmers who continue to use methane fermentation digested liquid fertilizer nowadays or have used methane fermentation digested liquid fertilizer in the past, were more likely to exhibit a higher probability of using Bio–CLF. This result supports hypothesis 1. As mentioned in the hypothesis, the usage of Bio–CLF is similar to that of conventional methane fermentation digested liquid fertilizer; in other words, Bio–CLF and conventional methane fermentation digested liquid fertilizer are highly compatible. Hence, for farmers who have experience using conventional methane fermentation digested liquid fertilizer, it is considered to be a low hurdle (which means it is easy to use) to use Bio–CLF. Consequently, they had a high intention to use Bio–CLF. When we divided the sample into two groups based on whether or not they had experience using methane fermentation digested liquid fertilizer, we compared the answers for "Farmers' intention to use Bio–CLF," and the average value of farmers who had experience was 3.49, while the average value for those who did not have experience was 2.81. Additionally, based on the t–test results, there was a significant difference between the responses of the two groups at 1%. This result also supports hypothesis 1.

Second, Hypothesis 2, which states that farmers with more knowledge of SDGs will have a higher intention to use Bio–CLF, is supported. Both *Well–known* and *Known* factors had significantly positive effects on *intention*. We believe that farmers with more knowledge of SDGs are more interested in environmental issues and have a higher evaluation of new technologies that lead to improvements in environmental issues. As mentioned above, Bio–CLF solves the problems of conventional methane fermentation–digested liquid fertilizer, improves the effective utilization rate of organic waste, and indirectly improves the agricultural environment. Hence, we considered that Bio–CLF might have been positively evaluated by farmers who were familiar with SDGs.

Third, Hypothesis 3 was not supported by the result for *income*, which was not significant. We considered that it may be possible to obtain significant results by using the data for agricultural product sales instead of household income. This remains a topic for future research.

Finally, as for the management style, the coefficient of *Outdoor Vegetables* indicated that when compared with other management style farmers, the outdoor vegetable farmer was more likely to use Bio–CLF. As we can observe from Table 3, 50% of outdoor vegetable farmers intend to use Bio–CLF, which is higher than that of other management style farmers. Tokuda *et al*. (2010) pointed out that outdoor vegetables (e.g., cabbage) require a large number of chemical fertilizers, and the conventional methane fermentation digested liquid fertilizer contains a large amount of fast–acting nitrogen components, which can be expected to be used as substitutes for chemical fertilizers in the organic cultivation of outdoor vegetables. However, due to the problems of transportation and spraying, there are not many examples of actual use in farmland. As mentioned above, Bio–CLF can be expected to solve the problems of conventional methane fermentation–digested liquid fertilizer by concentrating liquid fertilizer while blending and adjusting nitrogen, potassium, and phosphorus. Therefore, we consider that Bio–CLF might have been positively evaluated by outdoor vegetable farmers.

CONCLUSION

Based on the above results, the following recommendations are made for future Bio–CLF sales development: First, as farmers who have experience in using methane fermentation digested liquid fertilizer were shown to be more likely to use Bio–CLF, it is thought that comparing Bio–CLF with conventional methane fermentation digested liquid fertilizer while advertising and selling the usage and effects of Bio–CLF in an easy–to–understand manner will be useful for the dissemination of Bio–CLF. Second, farmers with more knowledge of SDGs will have a higher intention to use Bio–CLF; hence, it is a good choice to consider environmentally conscious farmers who have a wealth of knowledge about SDGs, as the target for Bio–CLF sales. Third, when compared with other management style farmers, outdoor vegetable farmers have a higher intention to use Bio–CLF, and it is conceivable that when developing the market for Bio–CLF, targeting outdoor vegetable farmers for sales will help spread the benefits of Bio–CLF.

This study has some limitations. First, as the data in this study were obtained in the form of an internet questionnaire and the samples were collected from the survey company's monitor, the survey subjects were limited to those who registered with the survey company's monitor. Consequently, for future research, we suggest that a representative survey method (e.g. mail questionnaires) should be used. Second, because farmers' household income did not display a significant effect on farmers' intention to use Bio–CLF, in future research, it is necessary to analyze not only farmers' household income but also the income from the sale of agricultural products as independent variables.

AUTHOR CONTRIBUTIONS

Y. Takahashi and Z. Wu designed this study. Z. Wu analyzed the data and wrote the manuscript. M. Yabe participated in the study design and supervised the study. Y. Takahashi assisted with editing the manuscript and approved the final version.

ACKNOWLEDGEMENTS

This work was supported by MAFF (PRIMAFF) Research with the collaboration scheme: Contracting research on policy for agriculture, forestry and fisheries–Grant Number: JPJ009417. We would also like to thank Editage (www.editage.com) for the English language editing.

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